Poskin Lake Comprehensive Lake Management Plan

Phase 3: Water and Nutrient Budgeting, Lake Modeling, and Lake Management and Education

Barron County, Wisconsin

WDNR Grant No. LPL-1343-10
SEH No. POSKI 106161

January 2011

January 3, 2011

RE: Phase 3: Water and Nutrient Budgeting, Lake Modeling, and Lake Management and Education
Poskin Lake Comprehensive Lake Management Plan
Barron County, Wisconsin
WDNR Grant No. LPL-1343-10
SEH No. POSKI 106161

Mr. Larry Kahl
Poskin Lake Association
856 15th Avenue
Almena, WI 54805

Dear Larry:

Please accept the following Comprehensive Lake Management Plan for Poskin Lake on behalf of the Poskin Lake Association and SEH. This plan is the end result of a multi-phased lake management planning project. A large amount of data has been analyzed, and recommendations based on that data have been made that encompass aquatic plant, nutrient, watershed, and near shore management. While no management plan can effectively cover every variable, it is believed that this plan provides what is necessary for beginning the process of implementing activities to improve the quality of Poskin Lake and its watershed. The plan acknowledges the need for additional information while using what is currently available to make recommendations that are reasonable and feasible.

Future plans related to this Comprehensive Lake Management Plan include the application for lake protection and aquatic invasive species control grant funding by the Poskin Lake Association.

Sincerely,

Dave Blumer
Lake Scientist

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Poskin Lake Comprehensive Lake Management Plan

Phase 3: Water and Nutrient Budgeting, Lake Modeling, and Lake Management and Education
Barron County, Wisconsin

Prepared for:
Poskin Lake Association

Prepared by:
Short Elliott Hendrickson Inc.
1701 West Knapp Street, Suite B
Rice Lake, WI 54868-1350
715.236.4000

Dave Blumer Lake Scientist	Date
Jake Macholl Lake Scientist	Date

Distribution List

No. of Copies	Sent to
1	Larry Kahl Poskin Lake Association 856 15th Avenue Almena, WI 54805
1	Pamela Toshner Wisconsin Department of Natural Resources 810 West Maple Street Spooner, WI 54801
1	Tyler Gruetzmacher Barron County Soil and Water Conservation Department 330 E. LaSalle Ave, Room 221 Barron, WI 54812

Executive Summary

Poskin Lake is located in central Barron County, Wisconsin in the Town of Clinton. Poor water quality conditions in the lake drove the Poskin Lake Association (PLA) to pursue a series of Wisconsin Department of Natural Resources (WDNR) Lake Management Planning Grants to complete a comprehensive management plan with the intention of improving water quality. The this study was initiated to identify the sources of the nutrients fueling algal blooms, assess the aquatic plant community of the lake, determine historic lake conditions, and evaluate potential management scenarios. This comprehensive lake management plan is the end result of the study.

Sediment core analysis indicates that Poskin Lake was historically a eutrophic lake and phosphorus levels are likely not much higher now than before European settlement occurred in the area. Although it is unlikely that Poskin Lake will ever become an oligotrophic, or clear-water, lake system, current conditions can be improved upon and a shift to blue-green algae-dominated conditions prevented by the implementation of management activities.

The following six goals, each associated with a number of objectives and actions, will guide management efforts on Poskin Lake:

1. Reduce the number of days the lake experience nuisance algal blooms by implementing phosphorous reduction activities in the watershed, near-shore area, and within the lake;
2. Develop a better understanding of the lake and the factors affecting lake water quality through continued and additional monitoring efforts;
3. Reduce the impact of the non-native invasive plant species curly-leaf pondweed and enhance the native plant population through aquatic plant management activities and improvements in water clarity;
4. Prevent new, undesirable non-native invasive species from entering and establishing in the lake by implementing a prevention and early detection program that includes watercraft inspection, in-lake monitoring, and rapid response planning;
5. Maintain the current fishery by working closely with WDNR fisheries management to help minimize impacts that may be caused by lake management activities; and
6. Educate lake residents and users about the lake ecosystem and engage them to actively help protect, maintain, and improve the lake.

Goal 3 is addressed in the Poskin Lake Aquatic Plant Management Plan, a companion document to this comprehensive plan. The objectives and actions associated with these goals vary in cost, level of difficulty, level of impact, and in the amount of additional study or assessment needed to begin implementation. While some of the recommended actions to improve the lake water quality are found throughout this report, the specific objectives and actions are fully developed in the Implementation Plan section. A general timeline of events are included in the implementation plan. We recommend that the PLA begin steps aimed at forming a Lake District to help with these and future management activities.

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Poskin Lake Comprehensive Lake Management Plan

Poskin Lake, Barron County, Wisconsin

Prepared for the Poskin Lake Association

1.0 Introduction

Poskin Lake (WBIC 2098000) is located in central Barron County, Wisconsin, approximately one mile north of the town of Poskin in the Township of Clinton (Figure 1). The lake provides numerous recreational activities to the area and is frequented for boating, fishing, rest and relaxation and wildlife viewing. Concerns about the poor water quality in the lake interfering with lake uses drove the Poskin Lake Association (PLA) to pursue a series of Wisconsin Department of Natural Resources (WDNR) Lake Management Planning Grants. The PLA was awarded a three-phase Lake Management Planning grant in the fall of 2008 to complete a comprehensive management plan a focus on improving water quality. Phases 1 and 2 were completed in the 2009 open water season. This comprehensive lake management plan is the end result of the study and includes hydrologic and nutrient budget analyses and lake modeling to determine potential effects of various management scenarios.

2.0 Understanding How a Lake Works

Understanding the processes going on in a given body of water is essential for making reasonable management decisions. Lakes respond similarly to environmental factors, but each lake is unique in its specific response. Studying how a lake works is called limnology.

2.1 Basic Limnology

A lake typically turns green due to algae, tiny plant species known as phytoplankton, becoming the dominant vegetative growth the waterbody. When this happens, many larger aquatic plants, called macrophytes, may disappear or their diversity changes. Only a few macrophytes do well under degraded conditions and in some cases the plants that remain may be non-native invasive species. As more macrophytes disappear, certain species of phytoplankton become even more dominant and further degrade the system.

All plants large or small need certain things to grow. Sunlight is necessary to trigger the process called photosynthesis whereby carbon dioxide is converted into organic plant building material and oxygen in the green cells of plants that contain chlorophyll. It is chlorophyll that gives plants their green color. Plants also require about twenty other elements for growth. Of particular importance are nitrogen and phosphorous because their natural supply is generally low. Both are considered limiting nutrients in an aquatic setting, because often the amount of plant or algae growth that can occur is limited by their availability.

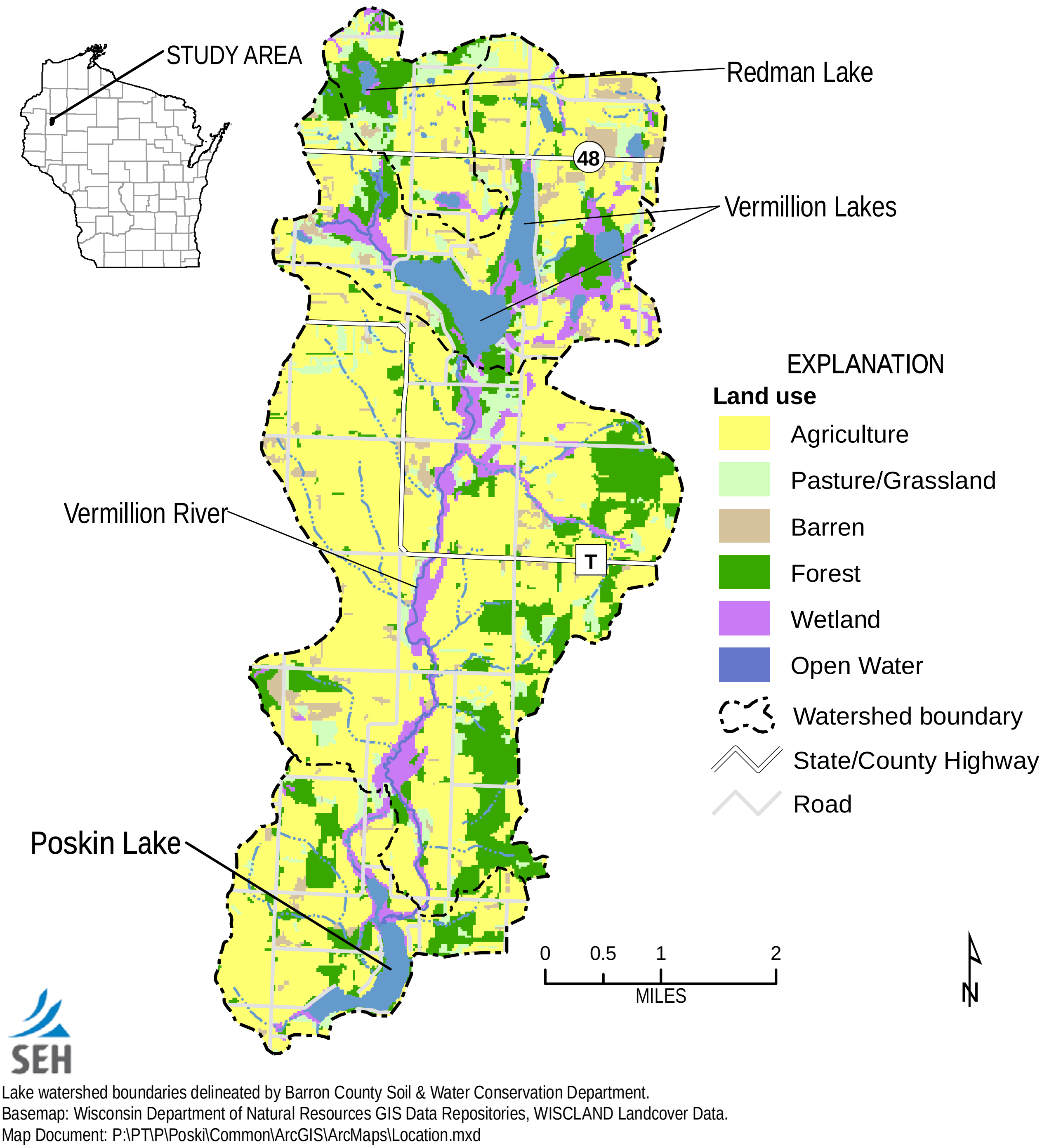

Figure 1 – Location of Poskin Lake

There is a huge reserve of nitrogen in the atmosphere; however, only a few plant species are capable of pulling nitrogen directly from this source. In most cases, plants and algae take in nitrogen from other forms including ammonium, nitrate, and nitrite that are not as plentiful. These three forms of nitrogen are collectively known as dissolved inorganic nitrogen. Phosphorous is relatively scarce in natural environments. It is bound to clay and soil particles, and when in its dissolved state is, known as phosphate, is it immediately available for use by plants (Moss et al, 1996).

Both nitrogen and phosphorous, in a variety of forms, are in the water that runs off from the land and into lakes. Dissolved inorganic compounds, small particles of soil that contain absorbed phosphates, and fragments of dead and dying plant and animal material referred to as detritus all contain nitrogen and phosphorous that may become available for the growth of algae or plants in a lake, either directly or by following simple chemical reactions or transformations that occur naturally under the right conditions. Collectively, these nutrients are referred to as total nitrogen (TN) and total phosphorous (TP).

The amount of nitrogen and phosphorous naturally available in a lake is often the result of the type of catchment or watershed the lake is situated in. A catchment or watershed in an upland or highland area that has little soil build up through weathering or erosion and a natural or undisturbed environment tends to have large, deep, oligiotrophic lakes. Oligiotrophic lakes generally have clear deep water and limited aquatic plant growth. A catchment or watershed that is in a lowland generally has more soil build up through weathering or erosion and tends to contain shallow eutrophic (high in nutrients) lakes with lots of plant material. This type of catchment may contain rivers with wider floodplains and cut-off meanders known as oxbow lakes, glacial lakes left when ice chunks buried under glacial deposits melted, and many shallow depressions that collect surface runoff. These lakes may not be suffering negative consequences from nutrient enrichment if still in a natural state.

A natural state implies that land cover is generally in an undisturbed state. Land cover is an important natural regulator of the total amount of nitrogen and phosphorous that makes it to a water body. Natural catchments generally contain large areas of undisturbed plant growth from grasses to forests. This plant growth holds soil in place preventing erosion, and uses up large amounts of the available nutrients before they can reach a lake. Natural wetlands may also be present on the landscape. Wetlands are areas where surface or ground water pools up on the landscape creating shallow, highly fertile, areas where plant growth is abundant. A wetland may have previously been a lake that has now filled in, or a natural shallow depression in the landscape. Wetlands can lock up huge amounts of phosphorous and nitrogen before they reach a lake, and provide habitat for thousands of creatures. Increasing the amount of disturbance in a watershed either from development or agriculture generally increases the amount of phosphorous and nitrogen that comes off the land and into water bodies.

Phosphorous that enters a lake, in its dissolved form, can immediately be used up by certain plants and algae. Much of this phosphorous however is attached to the soil particles and eventually settles to the bottom of the lake and remains in the sediment. Iron in the sediment binds with the phosphorous, immobilizing or locking it up in a form where it cannot be used by algae, but only when there is oxygen present at the water/sediment interface. Rooted aquatic plants pull some of this phosphorous from the sediment as they grow.

Oxygen, or specifically dissolved oxygen in the lake water is a vital component of a lake or aquatic setting. Most underwater creatures still need to “breathe” oxygen like their land counterparts. The oxygen these creatures breathe is dissolved in the lake water itself. Plants on the land make oxygen when the green portions of them convert carbon dioxide into organic building material used to grow new plant matter and pure oxygen which is released back into the air. Plants, including the tiny phytoplankton or algal species in an aquatic setting do the same thing. Thus oxygen is both pulled into the lake water from the air at the surface of the lake, and released into the lake water by plants growing in the water.

But in a lake, it is possible to lose oxygen more rapidly than it is replaced when there is a large amount of organic material present in the bottom of the lake. When that plant and animal material decays the process uses up available oxygen. When the oxygen is used up more rapidly than it is replaced lots of things can happen. Fish leave the area for more oxygen rich water, decay of plant and animal material may stop, and chemical reactions with iron that formerly locked up the available phosphorous can be reversed, releasing phosphorous back into the lake. The longer bottom waters of a lake remain devoid of oxygen, the more likely it is that this internal release of phosphorous will negatively impact the lake.

Water temperature also plays an important role in how a lake works. Water at different temperatures has different densities. Warm water is generally lighter or less dense than cold water, until the water freezes. Ice is less dense than water in its liquid form, which is why it floats. Water in the summer warms up on the surface, but remains cooler deeper down. Water in the winter freezes on the surface but remains warmer deeper down. Deeper lakes will often form two separate areas of water called stratification during the open water season; warmer water near the surface (epilimnion) and colder water near the bottom (hypolimnion). When this occurs a barrier is formed called the thermocline that keeps the two areas separated. The same barrier will often prevent any new oxygen pulled in from the air or made by plants in the water from reaching the colder bottom waters. In Wisconsin lake water cools in the fall, and warms up in the spring. At some point during each of these times, a state is reached where all the water in the lake is the same temperature and density. When in this state, referred to as turnover, mixing occurs in the entire lake recharging oxygen throughout the water column. At the same time, available nutrients are also distributed throughout the water column often causing short-lived but potentially heavy algal blooms and very turbid conditions.

Mixing of the water column can occur at other times during the open water season to the extent that a lake may remain mixed throughout the season. Turbulence in the water column can temporarily or continuously cause a lake to mix. Turbulence can be caused by natural events like wind and waves, or from manmade events such as boat and personal watercraft use. The increased wave activity and motorboat propeller wash can stir up a lake, breaking the thermocline, or simply prevent the thermocline from establishing. As long as oxygen is present at the sediment-water interface, iron can bind with the phosphorous and lock it up in a form that cannot be released back into the water column.

Boating in shallow water can disturb the sediment-water interface at the bottom of the lake re-suspending sediment in the water column. Large storm events can stir up tremendous amounts of sediment from the bottom of a lake.

Even under conditions where oxygen is present at the sediment-water interface, a substantial amount of phosphorous can be released from the sediments under high pH conditions. The degree of acidity or alkalinity of lake water is measured in pH units on a scale of 1 to 14. Values of 1 to less than 7 are considered acidic, 7 is considered neutral, and values greater than 7 to 14 are considered alkaline. Elevated pH values in the water column arise when photosynthetic activity is very high. High pH values reduce the ability of iron to bind with phosphorous, promoting the release of more phosphorous into the water column (Scheffer, 1998). Photosynthetic activity is high when a lot of plants or algae are present in the lake.

Shallow lakes may not stratify and oxygen is available all the way to the bottom of the lake. The rapid decay of plant and animal material, however, may still use up oxygen faster than it can be replaced. When this happens, there may be a short time period from a few minutes to a few days when phosphorous is released into the lake. In both shallow and deep lakes, events occur, some natural and some man-made, that allow oxygen rich water to be circulated into the entire column of water.

Large storm events and windy days can sometimes cause a lake to mix, even if it is stratified. Boating can stir up a lake and cause mixing in some lakes. Waves also mix sediment from the bottom with the water up above. This kind of mixing can make a lake look muddy and also trigger a release of phosphorous into the lake. Whenever more phosphorous than a lake can handle is introduced to the lake, be it from runoff from the land or from internal sources, increased levels of algal growth called an algae bloom, generally occur. The severity of this surge in algae growth can range from barely noticeable to levels considered toxic to those that would use the water.

Two lakes in a catchment or watershed are seldom if ever the same. All of the water in a lake comes directly from precipitation (rain and snow) falling directly onto the lake or running off the surface of the land (runoff, streams, or rivers), or enters the lake from below the ground surface (groundwater or springs). Within the watershed, there are different types of soil and sediment and various topographic features that affect the lake. Groundwater and the soils that surround a lake may or may not be high in phosphorous content. The morphometry of a lake, its shape, area, maximum and mean depths, and volume, also affects the lake (Moss et al, 1996). Shape and depth are important in determining the potential for aquatic plants and algae to grow in a lake.

The area of a lake where enough sunlight penetrates to the bottom to allow rooted plants to grow is referred to as the littoral zone. The littoral zone can be impacted by the morphometry of a lake. A deep lake with steeply sloping shores may have a very small littoral zone. A lake that is shallow may be considered all littoral zone. In addition, light penetration in a lake can be impacted by what is dissolved in the lake water and by what is suspended in the water. Stained water limits light penetration. Suspended particles including sediment (soil) or algae in the water can limit light penetration, and light penetration can be blocked by excessive large plant growth. In many lakes, a point is reached where light penetration is no longer adequate to allow rooted plant growth from the bottom of the lake. Where this occurs is essentially the end of the littoral zone. Free floating algal species, and free floating or non-rooted larger plants are often not as impacted by restricted light penetration, as they are able to move around and remain in that portion of the water column that provides enough light to grow.

Many lakes have an inlet (river or stream flowing in), an outlet (river or stream flowing out), or both. Inorganic particles including clay, sand, and minerals; and organic particles including plant and animal remains are carried into a lake by an inlet. Most of these particles settle to the bottom of a lake to become sediment. Many things are attached to or contained in the particles that get carried into a lake including nitrogen and phosphorous. Some of the nitrogen and phosphorous settles to the bottom with the particles where it can be used by rooted plants. Some is left dissolved in the water and used up by a variety of plants (both rooted and non-rooted) and algae. Still more is carried through and out of the lake by an outlet, if one exists, a process known as flushing. As more nutrients become available more plants often grow. As more plants grow, more organic debris is deposited on the bottom adding to the level of organic sediment in a lake, in most cases known as muck. More muck often grows more plants, binds up more nutrients, and in deeper portions of the lake use up more oxygen. Eventually a lake may get completely filled in or become a shallow wetland. This natural aging of a lake generally takes hundreds if not thousands of years.

The amount of phosphorous and nitrogen that gets into a lake only becomes a problem when the naturally occurring processes in that lake can no longer handle the input. If more phosphorous gets into a lake than it can naturally handle, conditions in the lake may change substantially. Plant growth may increase or decrease. The diversity of that plant growth and the area it can grow in may decrease. Oxygen levels in the water may decrease or disappear all together. Algae blooms may occur. These and other changes can cause a shift from a clear water plant dominated system to a free-floating plant and algae dominated system with very green water.

A common method of classifying the nutrient condition lakes in Wisconsin is by calculating the Wisconsin Trophic State Index (WTSI) values based on total phosphorus and chlorophyll *a* concentrations, and Secchi depths (Lillie and others, 1993). The WTSI is used to compare lakes in the same region and for assessing changes in the trophic status over time. Oligotrophic lakes (WTSI less than 40) have oxygenated, clear water and many algal species in low populations. Mesotrophic lakes (WTSI 40 – 50) have moderate water clarity, may become oxygen depleted in deep areas, and are prone to moderate algal blooms. Eutrophic lakes (WTSI greater than 50) have poor water clarity, frequent algal blooms, and oxygen depletion is common in the deeper portions of the lake. In lakes with WTSI values greater than 60, blue-green algae become dominant and may cause algal scums and summer fish kills. The tropic state of lakes is related to water quality. Generally, oligotrophic lakes are considered to have excellent water quality, mesotrophic lakes good water quality, and eutrophic lakes poor water quality.

2.2 Human Influence

The natural processes that give a lake its characteristics can and are severely altered by human activity. Changes to the landscape around lakes and within the watershed by development, farming, logging, etc. affects the amount of soil and nutrients that run off these areas and into a lake. With changes in runoff often come increased or more rapid sedimentation or filling in of lakes caused by increased erosion from the watershed or by erosion of the near shore area around the lake. Phosphorous and other things attached to the sediment are carried into a lake in increased amounts. Sewage associated with human development, manure from animal faming, and commercial fertilizers applied to lawns and fields can add more phosphorous and nitrogen to surface runoff and ground water. Dirt and dust from roads, open areas, and fields can be blown over and into the water or cleansed from the air by precipitation. This too is a source of phosphorous and other contaminants. Changes in climate may be fueling changes in the amount of precipitation received or in the number and severity of large rain events that carry with them tremendous erosion and runoff potential.

Natural and man-made sources of phosphorous, nitrogen, and other things can be classified into two categories, point and nonpoint sources. Point sources can be easily identified and quantified and may be easily targeted for mitigation or removal. They may include a discharge pipe from a factory or municipal wastewater treatment plant, a direct pipe carrying human waste or grey water from a residential home to a lake or river, or even runoff directly from a large livestock operation. Nonpoint sources may be easily identified, but not necessarily easily quantified. Examples of nutrient and pollutant nonpoint sources include transportation by groundwater, falling from the sky via precipitation or settling dust, traveling with runoff from across the landscape, or recycling from within a lake. While relatively easy to identify, these sources are generally very difficult to quantify, and in some cases very difficult to manage. Generally, as phosphorous and nitrogen levels increase in a lake, the amount of algae (measured by determining the amount of chlorophyll *a* in a water sample) also goes up. As the amount of algae goes up, water clarity goes down.

Increased development around lakes and human use of lakes can bring with it plants, animals, diseases, and other things never before known to exist in a given body of water. Called non-native species, these things can come from across the ocean or from a neighboring lake. Of the thousands of non-native plants, animals, insects, bacteria, viruses, etc. that have been spread around by human activity, only a few are considered to be problematic, and in some cases may be so only under certain conditions. A non-native species is considered invasive if it is capable of replacing species that native or beneficial to the environment. A non-native, invasive species may out-compete native species for light, nutrients, food, or habitat; may prey on a desirable species so much as to remove that species entirely; alter habitat by changing the chemical and/or biological make-up of that habitat; or simply dominate an area so that nothing else can exist there unless the invader is removed.

3.0 Lake User Concerns and Perceptions

In August 2009 a survey was sent to property owners around Poskin Lake as part of Phase 1 of this project. The survey was designed to determine lake uses and perceived water quality issues and assess the knowledge and attitudes of lake property owners related to aquatic plants, aquatic invasive species, plant management strategies, and shoreline best management practices. The survey was sent to 60 landowners and 31 were completed and returned for a 52% response rate. The results of the survey are briefly discussed below and a complete summary of the survey can be found in the Poskin Lake Aquatic Plant Management Plan.

Most property owners indicated that they participate in rest and relaxation, fishing, swimming, wildlife viewing, pontoon boating, and other boating activities. The lake activities participated in the most often by property owners are pontoon boating, fishing, and rest and relaxation.

According to the survey, lake users equate high TSIs (productive, nutrient-rich water) with poor water quality. The lake issues determined to be of most concern were icky, green water and too much weed growth. The majority (62%) of survey respondents feel that the water quality in the lake has gotten worse since they started using it. Respondents believe water quality is worst in July and August and indicated that the poor water quality interferes with swimming, fishing, relaxation, wildlife viewing and boating.

Property owners were asked numerous questions about current and potential shoreland best management practices aimed at improving the water quality in Poskin Lake. Property owners indicated that the most common existing shoreland best management practices include refraining from using fertilizers, protecting shoreline buffers and native plantings, restoring shorelines, and if fertilizing, using only zero-phosphorous fertilizers. Respondents indicated that the best management practices that hold the most interest are shoreline buffers, natural shoreline restoration, native plantings, and runoff reduction practices.

When asked what would motivate a land owner to employ shoreland best management practices, improving water quality in the lake, providing better fish and wildlife habitat, increasing the natural beauty of their property, getting a tax credit for doing so, and obtaining technical and financial assistance in designing and installing such practices were the most common responses. When asked what one thing would motivate them the most, improving water quality in the lake came out on top.

4.0 The Lake and Its Watershed

Poskin Lake is a eutrophic drainage lake located in central Barron County, Wisconsin near the town of Poskin (Figure 1). According to the WDNR Wisconsin Lakes bulletin (2005), the lake covers 150 acres, is 30 ft deep at its deepest point and averages 16 ft deep. A summary of the lake's physical characteristics can be found in Table 1. Poskin Lake has two distinct basins, with the larger southern basin locally referred to as Poskin Lake and the smaller northern basin referred to as Little Poskin Lake; where necessary, this report follows the same naming convention.

Table 1
Physical Characteristics of Poskin Lake

Lake Area (acres)	150
Watershed Area (acres)	14,446
Watershed to Lake Ratio	95:1
Maximum Depth (feet)	30
Mean Depth (feet)	15.7
Volume (acre-feet)	2348.2
Residence Time (years)	0.5
Elevation (feet AMSL)	1,155
Maximum Fetch (miles)	0.9
Miles of Shoreline	4.6
Lake Type	Drainage

Lake depth, or bathymetric, mapping of Poskin Lake was done by the WDNR in 1968. The map shows sharp drop offs on the east and west sides of the lake to depths of 25 feet (Figure 2). The near-shore substrate in these steep areas is composed primarily of sand, gravel and cobbles (Berg, 2009). Both the northern and southwestern ends of the lake have more gradual slopes and muck bottoms. The channel connecting Poskin Lake to Little Poskin Lake is generally three feet deep or less, making navigation difficult to near impossible. Little Poskin Lake is a bowl-shaped basin with a relatively shallow sloping bed and a maximum depth of approximately 15 feet.

The Vermillion River is the primary tributary to Poskin Lake and enters at the north end of the larger southern basin (Figure 2). The outlet of the Vermillion River is on the east shore of the lake where a small dam controls the lake level. Because of the river and the presence of a dam at the lake outlet, Poskin Lake is subject to frequent and often significant water level fluctuations, particularly during spring snowmelt and storm runoff events.

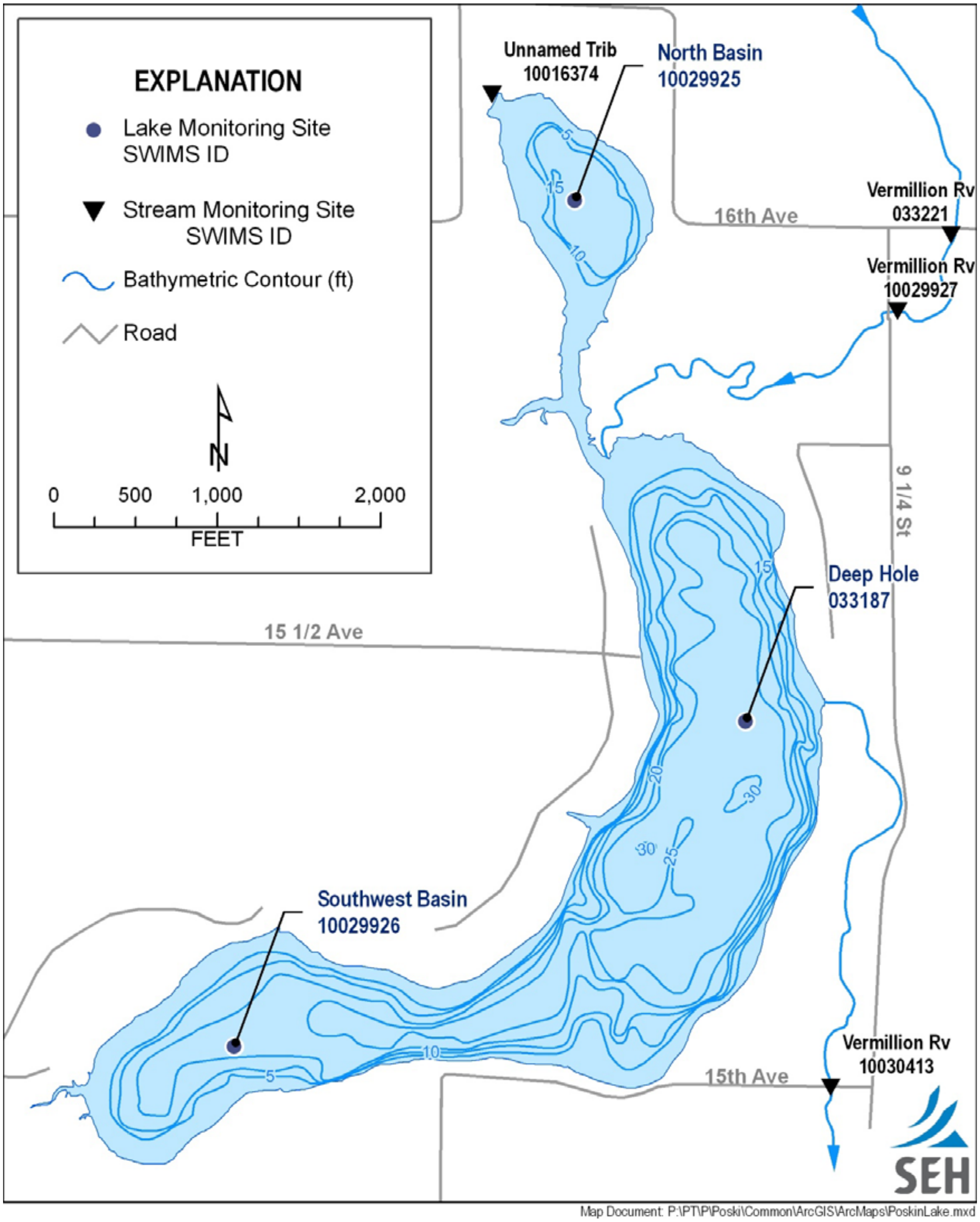

Figure 2 – Monitoring Sites and Bathymetry of Poskin Lake

The Vermillion River watershed drains approximately 19 square miles to Poskin Lake (Figure 1). The watershed includes the Vermillion Lakes and groundwater flow from the Redman Lake subbasin. The Redman Lake subbasin is a closed depression in which surface water runoff does not have a path to the Vermillion River; rather it drains to Redman Lake. Groundwater flow, however, is towards the Vermillion River (Zaporozec, 1987). A near-lake area, which includes unnamed tributaries and a small stretch of the Vermillion River, drains and additional 3.6 square miles to Poskin Lake (Figure 1).

A lake is a reflection of the topography, geology, soils, and land use in its watershed. The ratio of the watershed area to lake area provides an indication of potential water quality. In general, water quality decreases with and increasing ratio. This occurs because as the drainage area increases, there is an increase in sources of runoff and therefore an increase in nutrients and sediments delivered to the lake. Lakes with a ratio greater than 10:1 tend to have problems related to excessive nutrients and (or) sediments; the watershed to lake ratio for Poskin Lake is 95:1.

4.1 Land Use

The land use in the Poskin Lake watershed is primarily classified as agricultural (row crops, pasture, etc.) and a mix of forests, wetlands, and barrens. Land use in the Vermillion River watershed, Redman Lake watershed, near-lake area and entire Poskin Lake watershed is summarized in Table 1. Residential and agricultural areas, especially row crops, increase surface runoff which leads to increased pollutant loading. Forested and other uncropped areas produce very little runoff. The Barron County Soil and Water Conservation Department (SWCD) has identified 7.3 miles of waterways in fields that are currently cropped. The SWCD also found that highly erodible croplands make up 27% of the total agricultural land in the watershed. Converting these lands to grassed waterways and implementing other runoff best management practices can slow the runoff from these areas and increase infiltration to groundwater.

Table 2
Land Use Distribution in the Poskin Lake Watershed and Subbasins

	Vermillion River Watershed		Redman Lake Watershed		Near-Lake Area		Entire Watershed	
Land Use	**Area (acres)**	**Percent**	**Area (acres)**	**Percent**	**Area (acres)**	**Percent**	**Area (acres)**	**Percent**
Agriculture	6,744	60.8	544	50.7	1,426	62.6	8,714	60.3
Pasture/Grassland	715	6.4	185	17.3	84	3.7	985	6.8
Rural Residential	119	1.1	0	.0	68	3.0	187	1.3
Forest	1,769	15.9	240	22.3	355	15.6	2,364	16.4
Lakes and Streams	380	3.4	21	2.0	160	7.0	562	3.9
Wetland	838	7.6	56	5.2	121	5.3	1,015	7.0
Barrens	529	4.8	26	2.4	61	2.7	616	4.3
Total	**11,096**	**100.0**	**1,072**	**100.0**	**2,276**	**100.0**	**14,445**	**100.0**

4.2 Riparian Land Use and Shoreline Condition

Although residential areas only make up a small percentage of the total land use, nearly half of the residential areas are concentrated around Poskin Lake. Because of the impact near-shore land use has on water quality, we assessed the land use within 200 feet of Poskin lake (108.7 acres) and evaluated the shoreland condition, preliminary results of which were presented in the Phase 2 project summary. The land use was assessed using high-resolution digital orthophotography and GIS. Land use was classified into the following disturbed land uses: cropland, lawn and impervious surfaces (including roads and rooftops); and the following natural land covers: forest, shrub/grassland, wetland and open water. The results of this mapping are shown in Figure 3 and Table 3. Half of the land use within the 200 foot buffer is currently in a natural state and the other half is in a disturbed state. These data were used to estimate the nutrient loading provided by the near-lake area.

Table 3
Riparian Land Use within 200 feet of Poskin Lake

Land Use	Area (acres)	Percent
Disturbed		
Lawn	31.8	29.3
Agriculture	13.0	12.0
Impervious	8.6	7.9
Natural		
Forest	17.8	16.4
Shrub	7.3	6.7
Wetland	29.4	27.1
Water	.8	.8
Total	**108.7**	**100.0**

The shoreland condition was evaluated by an on-the-water survey using a GPS and canoe. This inventory was done to identify areas where conservation practices can be implemented and to provide a means to measure success. A total of 4.24 miles of shoreline were inventoried. Points were marked to designate the start and end of four different shoreland categories: wetland, shrub, forest, or lawn. Points were also marked to delimit shoreland buffers and riprap and at the location of severe erosion. Three sites of erosion were also documented.

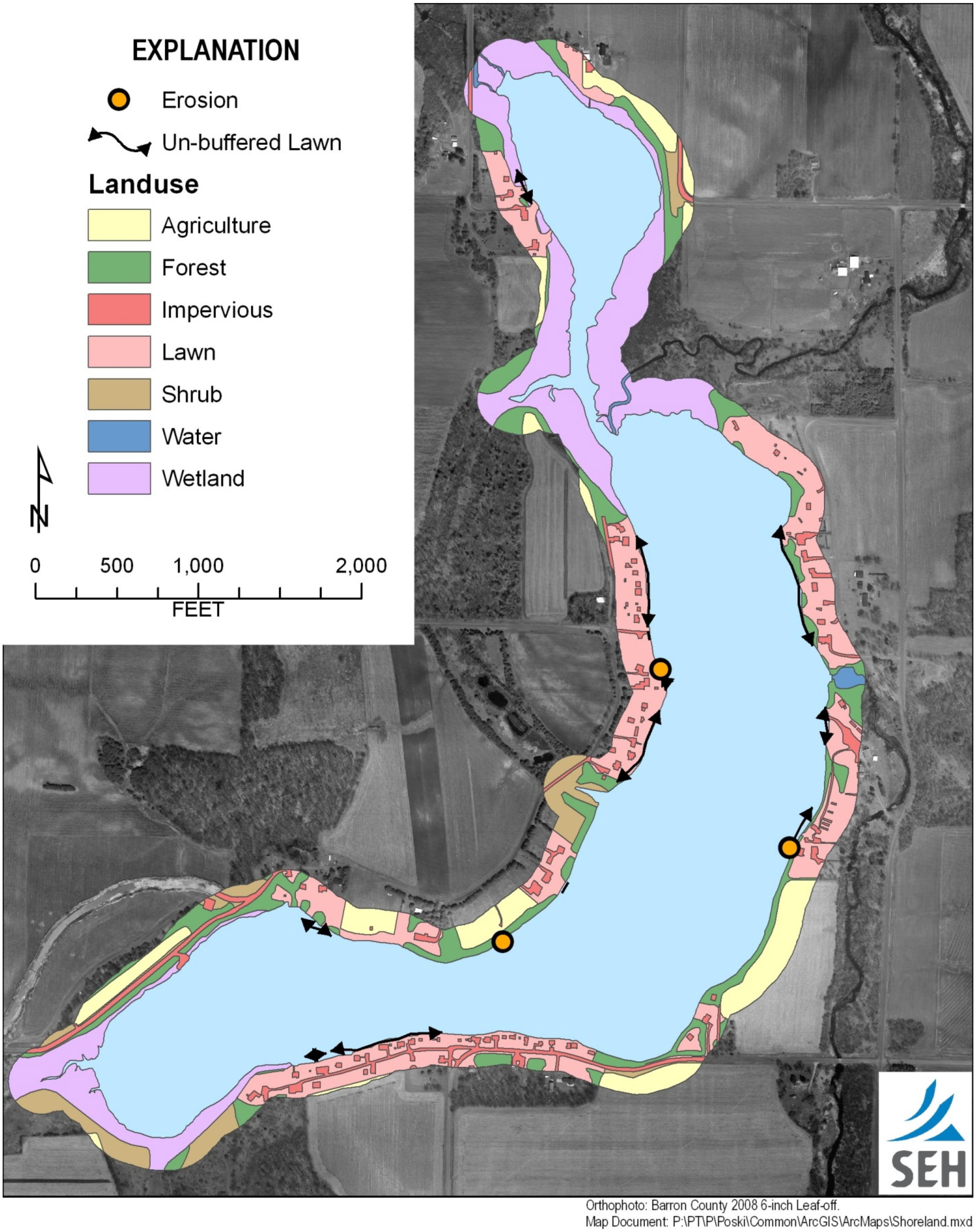

Figure 3 – Shoreland Land Use within 200 feet of Poskin Lake

The results of the shoreline inventory are shown in Table 4 and the distribution of lawns lacking buffers can be found in Figure 3. Of the 1.21 miles of lawn bordering Poskin Lake, 63% (0.76 mile) are currently not buffered. Riprap was found primarily on shores lacking a buffer between the lake and lawn and along the steeply sloped southern shoreline. Although riprap offers bank stabilization, it can be detrimental to near-shore lake habitat.

Table 4
Shoreline Conditions of Poskin Lake

Shoreline Condition		Length (feet)	Length (miles)	Percent of Total Shoreline
Lawn	bare	4,017	0.76	18.0
	buffered	2,367	.45	10.6
Wetland		6,879	1.30	30.7
Shrub		6,065	1.15	27.1
Forest		3,049	.58	13.6
Total		**22,377**	**4.24**	**100.0**
Riprap		3,751	.71	16.8

4.3 Watershed Connectivity

The landscape through which water flows and the distance traveled by surface runoff affects its quality. Natural landscapes in the watershed have the soil conditions and biota necessary to infiltrate runoff and utilize nutrients. On the other hand, developed lands often have compacted soils which increase runoff and bare surfaces which allow nutrients and sediments to flow uninhibited. Human changes to the landscape can affect the path water takes and in turn its quality. For example, channelization can quickly shuttle water to drainage systems, preventing infiltration and nutrient uptake. Fill placed for roadways or other construction and culverts installed to direct water can be beneficial or have adverse impacts to a water body, depending on the land use of the area affected.

A survey of culvert placement was conducted by members of the PLA in 2009. The survey was done to identify potential impacts to water quality brought on by either the presence or absence of culverts and to assess potential improvements. Culverts can be beneficial or have adverse impacts to water quality. For example, fill placed for roadways or other construction may connect additional areas and a culvert is necessary to maintain the natural drainage system. The areas of concern identified by the survey (shown as Potential culverts in Figure 4) are addressed below.

Site A is located at 9 ¼ Street where road fill forces an unnamed intermittent stream to make a 90 degree turn and flow straight along the road for approximately 1000 feet into the Vermillion River (Figure 4). This stream drains an agricultural and forested subbasin of approximately 260 acres. The Poskin Lake Sportsman’s Club has indicated willingness to have a settling pond constructed on their property. As of yet, little is known about the quality or quantity of water coming from this channel. Appropriate design of a detention basin or settling pond would require this information. For this reason, we recommend monitoring flow and water quality for at least one year prior to taking action at this site.

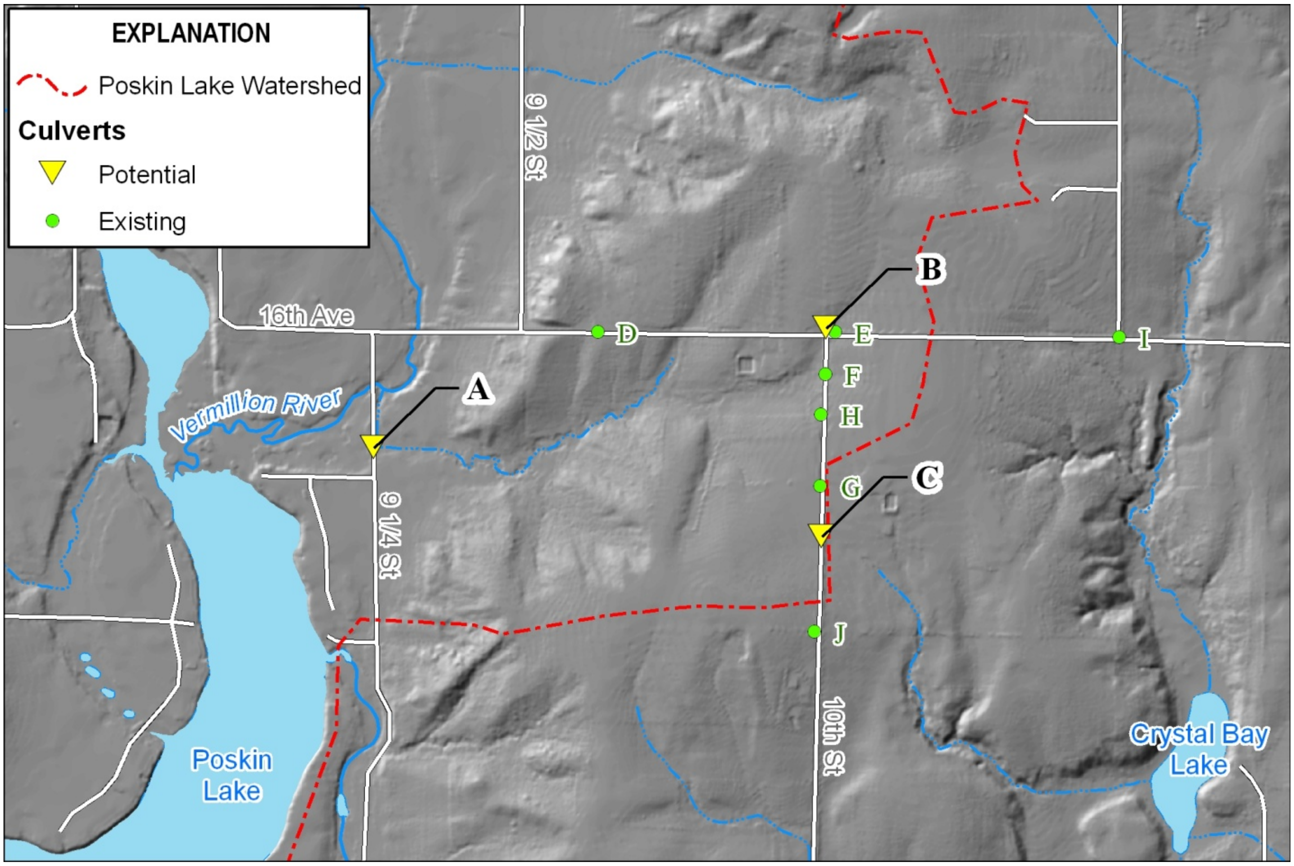

Figure 4 – Culverts and Areas of Concern East of Poskin Lake

Unless flooding is a problem at site B (Figure 4), it appears that installing a culvert would potentially have a negative effect by short-circuiting the relatively longer existing flow path. Maintaining a grassed waterway in the field immediately to the east of this site would likely have larger positive effect on water quality.

Adding a culvert to site C (Figure 4) would likely be beneficial to water quality. At this site, road fill is preventing runoff from following its historic flow path east to Crystal Bay Lake. The runoff is causing flooding of an agricultural field and, during extreme events and snowmelt, drains to the unnamed stream and eventually Poskin Lake. A culvert here would remove approximately 15 acres from the Poskin Lake watershed, a limited but nonetheless beneficial outcome.

4.4 Groundwater

An important route of water in the Poskin Lake watershed is via groundwater flow. As with surface water, land use in the groundwater basin (the area from which groundwater flows to the lake) and the path groundwater takes to the lake both affect groundwater quality. Figure 5 shows the general groundwater flow directions in the vicinity of the Poskin Lake watershed. The movement of groundwater is very slow and in the Poskin Lake watershed is on the order of 2 feet per day (Zaporozec, 1987). Groundwater recharge occurs in areas of higher water-table elevation from which the groundwater flows downhill and is discharged into the lower elevation lakes, streams and wetlands. Groundwater likely enters Poskin Lake along its western shore and leaves the lake along the eastern shore where it then discharges to the

Vermillion River. Groundwater discharge maintains the flow of the Vermillion River during dry periods of the year and throughout the winter months.

Groundwater management is an important component of lake management because groundwater provides a pathway for dissolved nutrients and pollutants, including phosphorus, nitrates and pesticides. We recommend groundwater pollution potential maps and local-scale water-table maps be developed for the Poskin Lake watershed. These maps will identify potential hotspots of groundwater pollution and can assist with rule making and management, such as for septic system permitting. For example, holding tanks may be required for a new house located on the western shore of the lake because groundwater discharge is to the lake, whereas a drain field may be permitted on the eastern shore where groundwater flow is away from the lake.

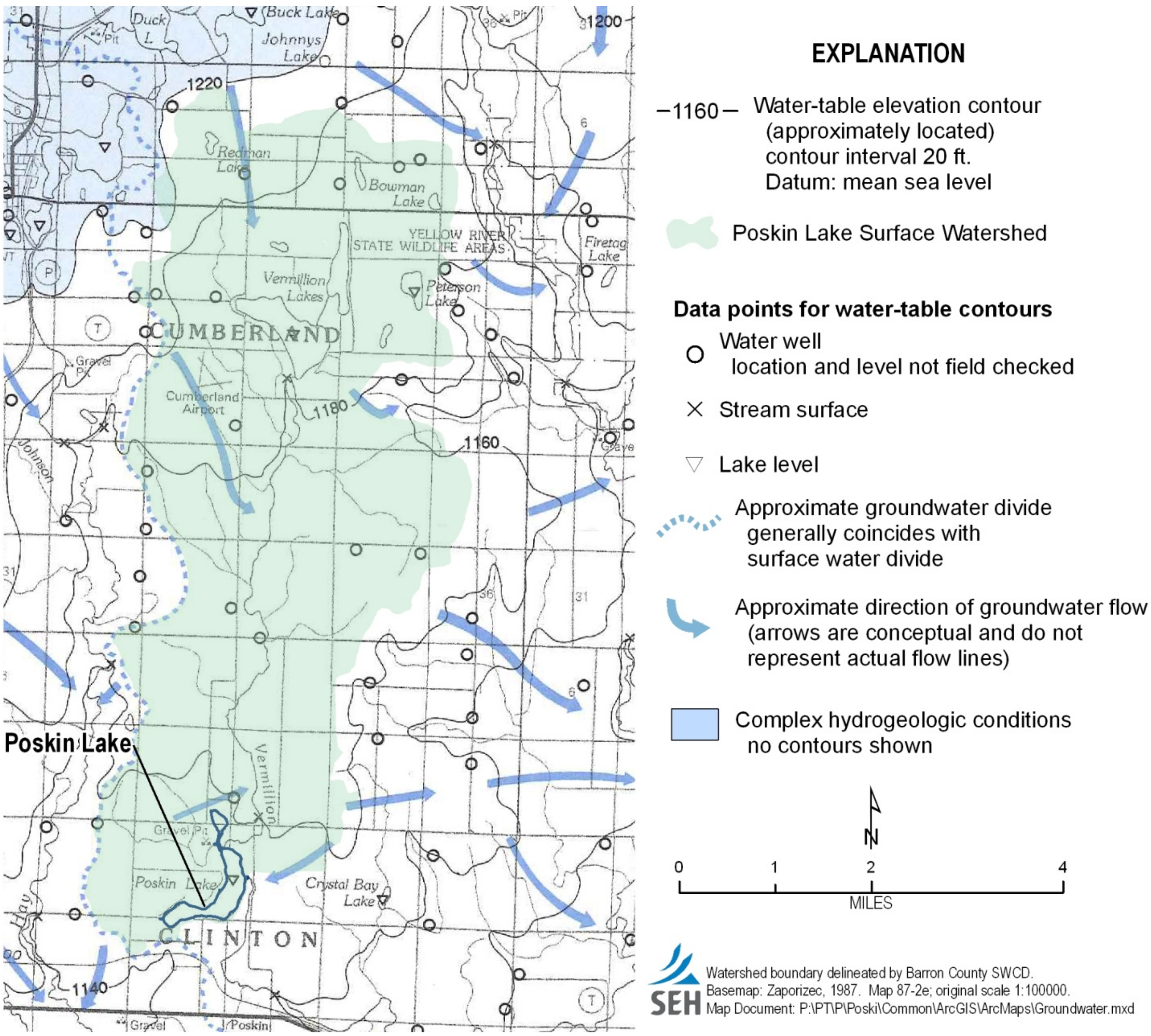

Figure 5 – Generalized Groundwater Flow in the Poskin Lake Watershed

4.5 Soils

Most of the soils in the Poskin Lake watershed are derived from the Sylvan Lake member, which is sediment formed by meltwater streams and lakes during the end of the last glaciation approximately 10,000 years ago. This sediment has moderate-high phosphorus levels (Muldoon and others 1990) and dominates the near-stream and near-lake areas in the watershed.

The primary soil type in the Poskin Lake watershed is the Anigon silt loam with a 0 to 2% slope. It is well-drained and deep, up to 90 inches or more when including the surface layer, subsoil, and substratum. Moisture permeability is moderate in the surface layer and rapid to very rapid in the substratum. The poor filtering capacity of the soil can result in the pollution of groundwater. Areas of steeper slopes (2 to 6%) along the Vermillion River are more susceptible to erosion and produce more runoff during rainfall events.

Because the geologic materials surround Poskin Lake can have high phosphorus, we recommend the natural or background phosphorus contribution to the lake should be assessed via a groundwater study to better understand the limits of management strategies. This requires an examination of site-specific geologic and hydrologic information, including development of a potentiometric surface map and collecting water samples from shallow wells.

4.6 Wetlands

In Wisconsin, a wetland is defined as an area where water is at, near or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation and which has soils indicative of wet conditions (WDNR). Wetlands serve many functions that benefit the ecosystem surrounding Poskin Lake. Wetlands with a higher floral diversity of native species support a greater variety of native plants and are more likely to support regionally scarce plants and plant communities. Wetlands provide fish and wildlife habitat for feeding, breeding, resting, nesting, escape cover, travel corridors, spawning grounds for fish, and nurseries for mammals and waterfowl.

According to the National Wetland Inventory, emergent, forested and aquatic bed (lake, freshwater pond, and riverine) wetlands are present in the watershed. The majority of the wetlands located in the Poskin Lake watershed are associated with the Vermillion River (Figure 1). Poskin Lake has a 17.6 acre emergent wetland at its southwestern terminus and Little Poskin Lake is completely encircled by wetlands. A large 28 acre forested and emergent wetland complex connects the two lake basins.

Emergent wetlands are wetlands with saturated soil and are dominated by grasses such as redtop and reed canary grass, and by forbs such as giant goldenrod. Forested wetlands are wetlands dominated by mature conifers and lowland hardwood trees. Forested wetlands are important for stormwater and floodwater retention and provide habitat for various wildlife. Aquatic bed wetlands are wetlands characterized by plants growing entirely on or in a water body no deeper than six feet.

Wetlands provide flood protection within the landscape. Due to the dense vegetation and location within the landscape, wetlands are important for retaining stormwater from rain and melting snow moving towards surface waters, and for retaining floodwater from rising streams. This flood protection minimizes impacts to downstream areas. Wetlands provide water quality protection because wetland plants and soils have the capacity to store and filter pollutants ranging from pesticides to animal wastes.

Wetlands also provide shoreline protection to Poskin Lake by acting as buffers between the land and water. They protect against erosion by absorbing the force of waves and currents and by anchoring sediments. This shoreline protection is important in waterways where boat traffic, water current, and wave action may cause substantial damage to the shore. Wetlands also provide groundwater recharge and discharge by allowing the surface water to move into and out of the groundwater system. The filtering capacity of wetland plants and substrates help protect groundwater quality. Wetlands can also stabilize and maintain stream flows, especially during dry months. Aesthetics, recreation, education and science are also all services wetlands provide. Wetlands contain a unique combination of terrestrial and aquatic life and physical and chemical processes.

4.7 Habitat

Every body of water has areas of aquatic vegetation or other features that offer critical or unique fish and wildlife habitat. Such areas can be mapped by the WDNR and designated as Critical Habitat. Areas are designated as Critical Habitat when they include important fish and wildlife habitat, natural shorelines, physical features important for water quality (e.g., springs) and navigation thoroughfares. These areas, which can be located within or adjacent to the waterbody, are particularly valuable to the ecosystem or would be significantly impacted by most disturbances or development.

Currently there are no officially designated Critical Habitat areas on Poskin Lake. Some examples of potential Critical Habit areas include the gravel beds within Poskin Lake, rice beds in Little Poskin Lake, wetlands adjacent to the north and south ends of the lake, and steep shorelines along the southern half of Poskin Lake. These areas provide spawning habitat, sensitive aquatic plant and wildlife habitat, and, in the case of steep shorelines, are prone to erosion.

4.8 Aquatic Plant Surveys

An early season curly leaf pondweed (CLP) density and bed mapping survey was conducted on Poskin Lake on May 27, 2009 and a point-intercept survey of the whole lake was completed on July 13, 2009 by Endangered Resource Services, LLC (ERS). CLP is an aquatic invasive plant known to inhabit Poskin Lake; the CLP survey was done to assess the level of infestation in order focus plant management efforts. The whole lake point-intercept survey was done to determined if Eurasian water milfoil (EWM), another aquatic invasive plant, is present in the lake and to assess the aquatic plant community in Poskin Lake. A brief summary of the aquatic plant surveys follows, with a more comprehensive analysis in the Poskin Lake Aquatic Plant Management (APM) Plan completed as part of this project. The APM Plan also compares the surveys completed as part of this project to a transect-based survey completed by the Beaver Creek Reserve in 2009.

In May 2009, CLP was widespread in Poskin Lake, but not considered abundant. The survey work completed on Poskin Lake by ERS and additional surveying by SEH has identified two areas with CLP at densities high enough to be considered beds. The beds are located on a shallow peninsula off the southeast corner of the lake and south of where the Vermillion River enters the lake. It is likely that CLP has overtaken all habit it is suitable for and CLP does not appear to be causing substantial negative effects on the overall plant community of Poskin Lake.

Eurasian water milfoil was not found in Poskin Lake, but it remains a concern because of its presence in the watershed and in nearby lakes. EWM has been found in Lower Vermillion Lake, which, due to its upstream location, may be a source for natural introduction of EWM. Also, the proximity of Poskin Lake to Lower Vermillion and other Barron County lakes including, Echo, Horseshoe, Shallow, Beaver Dam, and Duck Lake make Poskin Lake a candidate for introduction via boat traffic.

Wild rice (*Zizania* spp.) is an aquatic grass that grows in shallow lakes and slow moving streams. During early growth stages, the plant is sensitive to water level fluctuations and survival is limited when levels change by more than 6 inches (NRCS, 2001). The wild rice seed is a nutritious source of food for both wildlife and people. It is afforded many protections in Wisconsin due to its ecological significance and its cultural importance to the Native American community. The point-intercept survey in July 2009 found wild rice in Little Poskin Lake, but it was in a small area and mostly clipped by geese (Berg, 2009). We conducted a survey in September 2010 and found a much higher wild rice density, with rice nearly encircling Little Poskin Lake in water up to 3 feet deep.

Plant management should focus on preventing the introduction of new invasive species and on protecting native plant species. We recommend this be accomplished with targeted CLP reduction through chemical treatment and continued mapping.

Native plant habitat can be improved by removal of the top timbers and gate at the outlet dam. This modification will increase the discharge area over the dam, thereby decreasing water level fluctuations. A positive consequence of this will be a reduction in the length of periods of high water. Periods of high water can drown out wild rice and causes shoreline erosion. Eroding shorelines not only provide potential habitat for invasive species to colonize, but also releases phosphorus from sediments. This additional phosphorus can fuel algal blooms that inhibit light penetration and reduce plant growth. It is strongly recommended that the PLA investigate removal of the top timbers and gate at the outlet dam.

4.9 Fishery and Wildlife

The lake property owners survey identified angling as the second most popular use of the lake. The Wisconsin Lakes Bulletin (WDNR, 2005) indicates that common fish in Poskin Lake include northern pike (*Esox lucius*), largemouth bass (*Micropterus salmoides*) and panfish (*Lepomis* spp., *Pomoxis* spp.), and that walleye (*Sander vitreus*) are present. Fish stocking records show that walleye fingerlings were planted in the lake in 1984, 1986, 1989 and each even-numbered year since 1990 plus 1997. During this time a total of 75,322 fish have been stocked, the most in 2004 when 11,250 small fingerling were released. On average, about 5,000 fish are stocked per event.

Due to the importance of the fishery to lake users, it is recommended to continue stocking walleye on an alternate year basis. An adult walleye population of 104 fish (0.7 adults per acre) was reported in the WDNR 2010 Ceded Territory Adult Walleye Population Estimate. Creel surveys or comprehensive fishery surveys were not found for Poskin Lake. A survey should be completed to gain a better understanding of the fish community and population dynamics within the lake. Walleye and northern pike spawning areas should be located and afforded the appropriate protections (e.g. sensitive area listing) in order to maintain a sustainable sport fishery.

The invasive Chinese mystery snail, *Cipangopaludina chinens,* was discovered in the Poskin Lake watershed in the summer of 2009. The snail was found in both Poskin Lake and Lower Vermillion Lake. The Chinese mystery snail first reached Wisconsin 50 years ago and has become well established in many northern Wisconsin lakes. Not much is known about the species; however, the snails appear to have a negative effect on native snail populations by out-competing the native species for food and habitat.

The Natural Heritage Inventory (NHI) database contains recent and historic observations of rare species and plant communities. Each species has a state status including Special Concern (SC), Threatened (THR) or Endangered (END). There are three fish species (least darter, *Etheostoma macroperca*, SC; Ozark minnow, *Notropis nubilus*, THR; weed shiner, *Notropis texanus*, SC), one turtle species (wood turtle, *Glyptemys insculpta*, THR) one frog species (American bullfrog, *Lithobates catesbeianus*, SC), and one bird species (bald eagle, *Haliaeetus leucocephalus*, SC) that have been documented in or near the Poskin Lake watershed. These observed species are current as of October 6, 2009.

5.0 Lake Water Quality

Citizen Lake Monitoring Network (CLMN) volunteers have collected water quality data from the Poskin Lake deep hole since 1999 (Figure 2). Volunteers measured quantitative parameters such as temperature, dissolved oxygen, and Secchi depth, and collected water samples which were sent to the Wisconsin State Lab of Hygiene for analysis of total phosphorus, chlorophyll a, nitrogen, and other constituent concentrations. Qualitative observations such as lake level, color, and user perception of water quality were also recorded. Additional nutrient samples were collected by volunteers from the north and southwestern basins (Figure 2) during the 2009 field season to determine if spatial differences exist in the water quality of Poskin Lake.

5.1 Water Clarity

Water clarity was measured by CLMN volunteers using a Secchi disk. The Secchi disk measurement is the average of the depth that when lowered the disk just disappears from sight and the depth that when raised the disk is just visible. Secchi depths vary throughout the year, with shallower readings in summer when algae become dense and limit light penetration and deeper readings in spring and late fall. Because light penetration is usually associated with algae growth, a lake is considered eutrophic when Secchi depths are less than 6.5 feet.

Figure 6 shows the Secchi measurements taken in Poskin Lake from 2003 through 2010. The data show that the deep hole, north, and southwest lake basins behave similarly throughout the year. The average summer (July through August) Secchi depth in Poskin Lake from 2003 through 2010 is 3.3 feet, with depths varying as much as 8.8 feet in a single growing season. During this time period the average summer Secchi depths show a slight, though insignificant, increase. Single measurements of 2.0, 5.2, and 3.3 feet taken in 1990, 1999, and 2000, respectively also suggest there has been little change in water clarity over the past two decades.

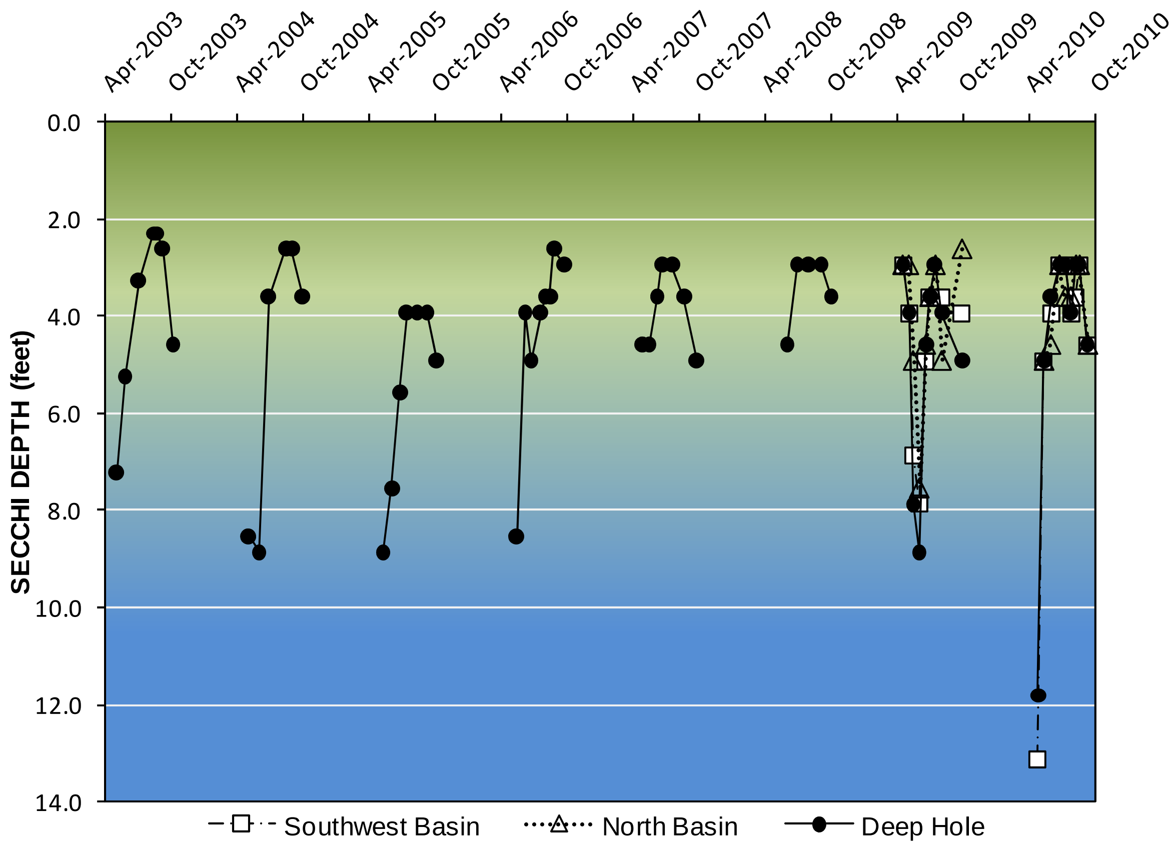

Figure 6 – Poskin Lake Secchi Depth from 2003 through 2010

5.2 Temperature and Dissolved Oxygen

CLMN data indicate that Poskin Lake is a dimictic lake, which means that the lake stratifies during the summer and mixes during spring a fall overturn. By late spring, Poskin Lake is stratified into three layers with warmer, oxygenated water at the top (epilimnion), cooler, oxygen-depleted water at the bottom (hypolimnion), and an abrupt transition zone in between (thermocline). Figure 7 shows the different stratification schemes that occur throughout the course of the year.

Summer temperatures in the bottom of the lake remain at about 50º Fahrenheit while temperatures at the top are about 70º Fahrenheit. The depth of the layers varies in different parts of the lake, but in general the thermocline develops 11.5 to 14.8 feet below the lake surface. Thermal stratification is reversed under the ice; bottom temperatures are near 40º Fahrenheit whereas temperatures just below the ice are very near freezing. The lake remains frozen for an average of 130 days each year, with ice-on typically occurring in early December and break-up in mid-April.

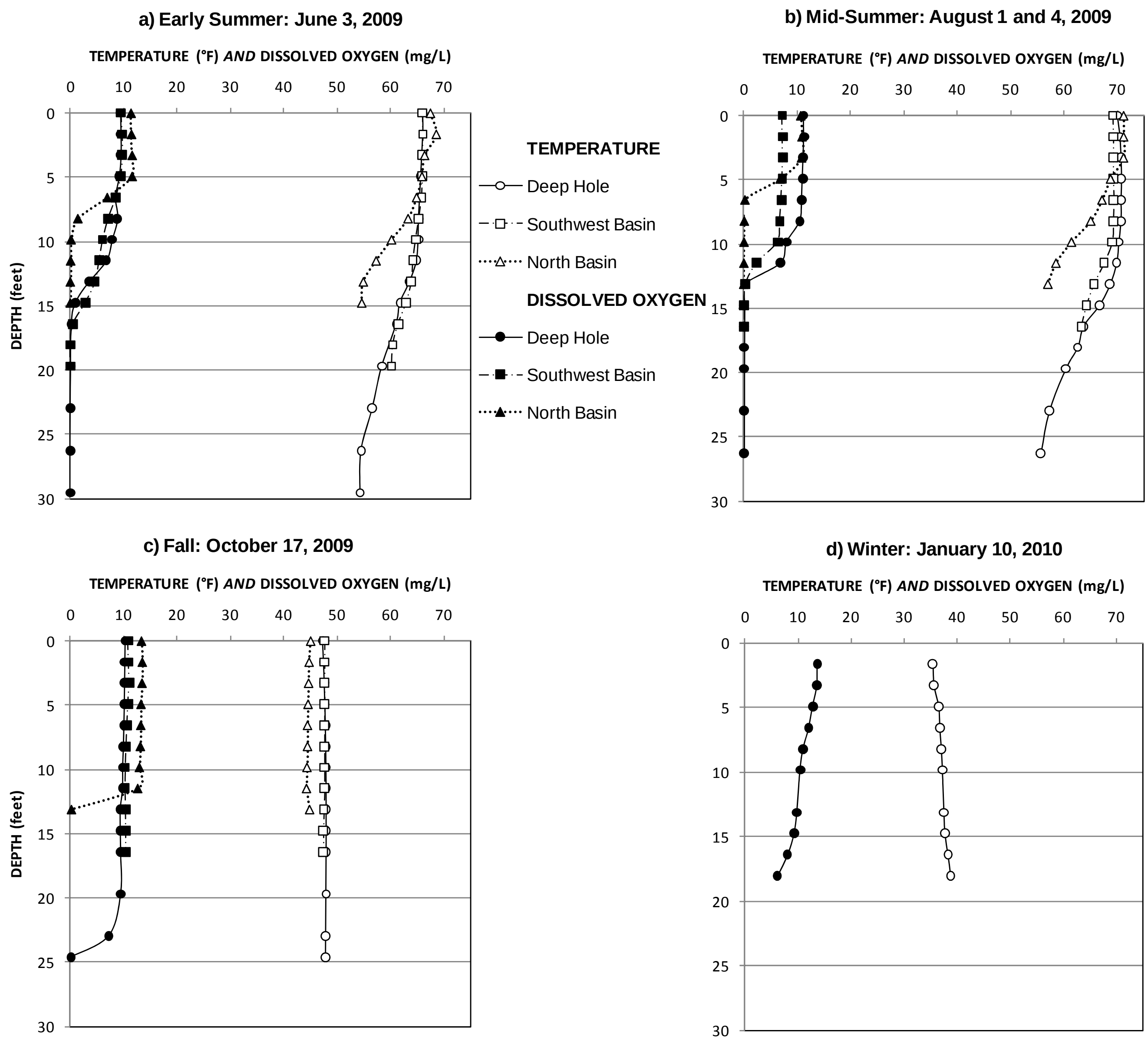

Figure 7 – Seasonal Temperature and Dissolved Oxygen Profiles for Poskin Lake

Oxygen depletion can have many adverse impacts to the biology and chemistry of the lake. When Poskin Lake is stratified, oxygen levels at depths greater than about 13 feet are anoxic, or too low (<2 mg/L) to support many forms of aquatic life, including fish. The loss of benthic plants and animals due to anoxic conditions can lead to an increase in the release of phosphorus from sediments. If the phosphorus released from sediments reaches the upper part of the lake, it can provide a significant internal source of phosphorus and fuel algae blooms.

5.3 Chlorophyll *a*

Chlorophyll *a* is a measurement of algae in the water. The concentration varies throughout the year, generally peaking in lake summer. The preferred method of determining the trophic status of a lake is by converting the measured concentration to the chlorophyll *a* WTSI ($WTSI_{CHL}$). Based on an average summer $WTSI_{CHL}$ of 60, Poskin Lake is considered eutrophic (Table 5). As is the case with Poskin Lake, most eutrophic lakes generally have low clarity, poor water quality, and nuisance algal blooms affecting boating, swimming and other recreation.

General statements about the composition and quality of algal communities in lakes based off chlorophyll *a* are difficult make. For this reason, we recommend an integrated sample be collected from Poskin Lake to be sent to the State Labe of Hygiene for identification and enumeration of the algae present in the lake. This information will determine if species of concern exist in the lake and can be used to evaluate environmental factors such as the quality of the food source of small fishes. An assessment of the zooplankton (which eat algae) should also be completed to provide an indication of the controls on the algae populations. These samples should be collected in late-spring and early-, mid-, and late-summer to characterize the seasonal changes in the assemblages.

Table 5
The Wisconsin Trophic State Index and Description for Poskin Lake

TSI	Description of Associated Conditions
<30	Classical oligotrophy: clear water, many algal species, oxygen throughout the year in bottom water, cold water, oxygen-sensitive fish species in deep lakes. Excellent water quality.
30 - 40	Deeper lakes still oligotrophic, but bottom water of some shallower lakes will become oxygen-depleted during the summer.
40 - 50	Water moderately clear, but increasing chance of low dissolved oxygen in deep water during the summer.
50 - 60	Lakes becoming eutrophic: decreased clarity, fewer algal species, oxygen-depleted bottom waters during the summer, plant overgrowth evident, warm-water fisheries (pike, perch, bass, etc.) only.
60 - 70	Blue-green algae become dominant and algal scums are possible, extensive plant overgrowth problems possible.
70 - 80	Becoming very eutrophic. Heavy algal blooms possible throughout summer, dense plant beds, but extent limited by light penetration (blue-green algae block sunlight).
>80	Algal scums, summer fishkills, few plants, rough fish dominant. Very poor water quality.

POSKIN LAKE
$WTSI_{CHL}$ 60

Algae growth in Poskin Lake is related to the amount of phosphorus in the lake and is the primary reason for low summer clarity. The relationships are shown in Figure 8. These relationships show that as phosphorus increases in the lake, there is an associate increase in chlorophyll *a*, and as chlorophyll *a* increases, water clarity (and perceived water quality) decreases. Therefore, management efforts should focus on reducing the phosphorus loading to the lake.

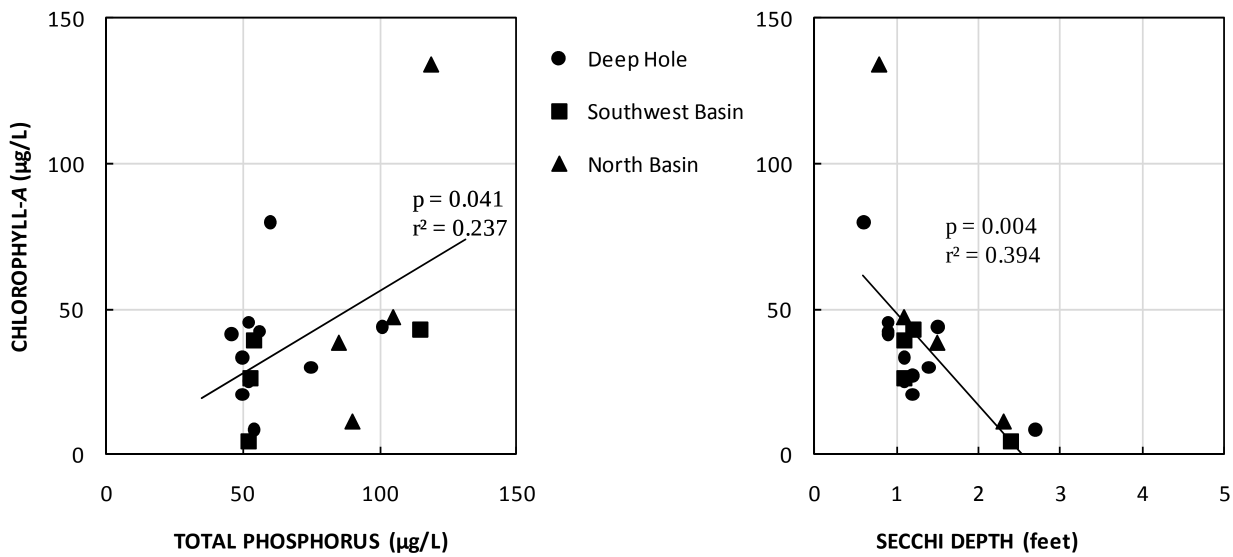

Figure 8 – Relationship of Chlorophyll *a* to Phosphorus and Water Clarity in Poskin Lake

5.4 Phosphorus

Phosphorus is an important nutrient for plant growth and is commonly the nutrient limiting plant production in Wisconsin lakes. When phosphorus is limiting production, small additions of the nutrient to a lake can cause dramatic increases in plant and algae growth.

The total phosphorus levels indicate that Poskin Lake is eutrophic. In 2009, phosphorus at the deep hole site was 131 µg/L in the spring, averaged 52.6 µg/L in the summer and was 101 µg/L in the fall. The north basin site consistently had higher phosphorus than the other sites. The high spring and fall values are due to the lake over-turning and mixing the high phosphorus water from the hypolimnion throughout the water column.

Phosphorus samples from both the lake surface and near the lake bottom were used to evaluate phosphorus release from the lake sediments during anoxic conditions. Samples were collected in June, July and August 2009 at each site, with only a bottom sample collected at the deep hole in August (Table 6). Phosphorus release by anoxic sediments at the north basin and deep hole sites is evident by the increase in the bottom phosphorus over time.

Table 6
Top and Bottom Total Phosphorus at Poskin Lake Monitoring Sites in 2009

Site	Sample Location	Total Phosphorus (µg/L)		
		June 20	July 19	August 22
Deep Hole	top	54	52	NS
	bottom	299	706	692
Southwest	top	52	54	53
	bottom	73	55	54
North	top	90	105	85
	bottom	71	164	127

NS = not sampled

5.5 Nitrogen to Phosphorus Ratio

The ratio of the total nitrogen to total phosphorus (N:P) is used to determine the nutrient that likely limits aquatic plant growth. Phosphorus is interpreted as the limiting nutrient when N:P is greater than 16:1. Poskin Lake has an average N:P ratio of 18:1, indicating phosphorus is the potential limiting nutrient. The WTSI values calculated from total phosphorus and chlorophyll *a* are very similar, which further suggests that phosphorus is the key nutrient in determining the trophic state of Poskin Lake. Because phosphorus is likely limiting, reducing phosphorus loading to the lake should be the focus of management done with the intention of improving water quality.

5.6 Historic Water Quality

In August of 2009, a sediment core was retrieved from near the Poskin Lake deep hole for analysis of the diatom community to assess the historic water quality. Analysis was completed by Paul Garrison of the WDNR as part of Phase 2 of this project. The core was approximately 1.5 feet long with the top representing current conditions and the bottom representing conditions approximately 100 to 130 years ago.

The diatom assemblage at the bottom of the core indicated that phosphorus levels were historically in the eutrophic range and there has been only a small increase of in-lake phosphorus of around 5 to 10 µg/L. Nitrogen levels were also found to be higher at present compared with 100 years ago, very likely due to nitrogen fertilizer use in the watershed. The full results of the paleocore analysis can be found in the Phase 2 Summary report.

5.7 Comparison with Regional Lakes

Lillie and Mason (1983) divided Wisconsin into five lake regions in order to compare lakes between and within geographic areas of the state. Poskin Lake is located in the northwest region of the state where 282 randomly selected lakes were analyzed by Lillie and Mason. Relative to the sampled lakes, Poskin Lake has poor water quality. The average total phosphorus and chlorophyll *a* measured in northwestern Wisconsin lakes were 28 µg/L and 12.4 µg/L, respectively. The growing season average total phosphorus and chlorophyll *a* measured at the Poskin Lake deep hole were more than double the regional averages with values of 59 µg/L and 35.4 µg/L, respectively. The average Secchi depth in Poskin Lake was 4.4 feet, substantially lower than the regional average of 6.9 feet.

The water quality of lakes can also be compared within ecoregions. Ecoregions are defined as areas of general similarity in ecosystems and the type, quality, and quantity of environmental resources. Poskin Lake is located in the North Central Hardwood Forests (NCHF) ecoregion. Although lakes in the NCHF are typically mesotrophic to eutrophic, Poskin Lake at times is near hyper-eutrophic and has relatively poor water quality by comparison.

The poor water quality of Poskin Lake relative to other lakes in both its region of the state and ecoregion is likely due to the size and make-up of its watershed; the watershed is large relative to the lake size and contains soils with natural moderately-high fertility. These factors are associated with and can lead to poor water quality. To compound the natural factors, development is concentrated near the lake and agriculture is the primary land use throughout the watershed. Unless best management practices are implemented, these land uses are detrimental to water quality.

6.0 Inflow Water Quality

Inflow to Poskin Lake includes surface runoff, groundwater flow and precipitation. Surface runoff is carried to the lake by numerous perennial streams (flow throughout the year), intermittent streams (flow during wet portions of the year) and ephemeral channels (flow only during and immediately after rain events). During this study the nutrients entering Poskin Lake via its primary tributary, the Vermillion River, were monitored. Samples were collected from the Vermillion River at 9 ¼ Street (Figure 2).

6.1 Biotic Index

Biotic index work was done on the Vermillion River at 16th Avenue (Figure 2) in 1990 and 1998. During both instances, the Hilsenhoff Biotic Index (HBI), which is based off a survey of macroinvertibrates (aquatic insects), was used to evaluate water quality. The data collected can be found online in the WDNR SWIMS database. The HBIs in 1990 and 1998 were 4.61 and 4.97, respectively. In 1990, an HBI of 4.67 was also determined for the unnamed tributary entering the north basin. Each of these HBI values fall in the range of good water quality with some organic pollution. This is not surprising as the Vermillion River flows through an agricultural landscape and has many riparian wetlands (Figure 1) which can utilize some but not likely all excess nutrients.

We recommend the PLA investigate whether a volunteer base for this type of monitoring exists. The Wisconsin Citizen-Based Water Monitoring Network will train interested groups on how to conduct macroinvertibrate surveys. The surveys provide information on habitat conditions and water quality.

6.2 Nutrients and Sediment

The water quality samples collected from the Vermillion River in 2009 were analyzed for soluble reactive phosphorous (SRP) total phosphorus (TP), nitrate + nitrite as Nitrogen (NO_3-N), ammonia as nitrogen (NH_3-N), total Kjeldahl nitrogen (TKN), and total suspended solids (TSS) and volatile suspended solids (VSS). Samples were collected monthly from May through October, excluding September, during baseflow conditions. The results of the nutrient and sediment analyses are shown in Table 7.

Table 7
River Water Quality Sample Results

Date	SRP (µg/L)	TP (µg/L)	NO_3-N (mg/L)	NH_3-N (mg/L)	TKN (mg/L)	TSS (mg/L)	VSS (mg/L)
5/5/2009	35	86	0.237	0.024	0.52	6	NS
6/20/2009	73	144	0.208	0.036	0.47	3	2
7/19/2009	41	81	<0.019	<0.015	0.68	<2	<2
8/22/2009	43	86	<0.019	<0.015	0.35	154	50
10/17/2009	11	38	0.288	0.029	0.44	150	<50

NS = not sampled
< = below limit of detection

The limited water quality samples collected from the Vermillion River in 2009 provide a basic assessment of water quality. Total phosphorus in the Vermillion River is high, averaging 87 µg/L which is above the WDNR water quality standard for small streams of 75 µg/L. The phosphorus concentrations were converted into daily loads and used in the lake model described below. The NO_3-N ranged from high in the early and late portions of the growing season to below analytical detection limits in summer. The summer lows are likely due to plants fully utilizing the available nutrients at the height of the growing season. The sediment carried in the stream is relatively low with TSS ranging from below detection limits to 150 mg/L. The VSS, which is the organic material transported in the stream, ranged from near 0 to 67% of the TSS.

We suggest a stream sampling regime be developed and implemented to characterize the water quality entering and leaving Poskin Lake. Characterizing surface runoff will provide a background condition to which the effect of management efforts can be compared to. An example monitoring regime that characterizes water quality is to collect samples twice a month and during rain events throughout the growing season and collect at least one sample during winter. We strongly suggest the sampling regime includes event sampling because the majority of a stream's annual nutrient and sediment loading occurs during rainfall events. In a nearby stream, the USGS (2010) found that nearly 80% of the phosphorus load and 90% of the sediment load was contributed during events. This sample regime also requires continuous stage monitoring of water level (both in-lake and in-stream).

Additional monitoring should be completed at the Poskin Lake outlet and at the intermittent streams and ephemeral channels around the lake. Outlet monitoring is important because as the water moves from mid-lake to the outlet and passes through the littoral zone, plants and differences in temperature and dissolved oxygen can substantially transform the water. The non-perennial streams in the watershed may be providing a substantial amount of nutrients to the lake and should be sampled when flowing during spring snowmelt and during rain events. These sites can be located by identifying culverts around that lake that have no obvious flow for most of the year.

7.0 Lake Hydrology

Based on N:P ratios, productivity in Poskin Lake is likely limited by the input of phosphorus. A reduction in phosphorus input to the lake would therefore improve water quality. Since most of the phosphorus enters the lake by water inputs, the amount water entering the lake must be quantified in order to quantify the amount of phosphorus. The water inputs to Poskin Lake were quantified for the 2009 study period (growing season of May – October) by calculating a water budget. The water budget is represented in its simplest form as

Change in Lake Storage = (Water In) – (Water Out).

The change in lake storage, or volume, can be observed as changes in the lake level; the lake level remains the same when water-in is equal to water-out, increases when water-in is greater than water-out, and decreases when water-in is less than water-out. Water enters Poskin Lake as precipitation falling directly on the lake surface, surface water inflow (from both the Vermillion River and near-lake areas), and groundwater inflow through the lake bed. Water exits the lake through evaporation and transpiration by plants, surface water outflow as the Vermillion River, and groundwater outflow.

Measurements and estimates of the variables for the water budget came from a variety of sources. Volunteers near the lake measured precipitation on a daily basis, lake stage approximately semi-monthly, and streamflow monthly from April through October. The lake stage at the start of the 2009 monitoring period was 1.00 ft (above an arbitrary datum), reached a measured low of 0.74 ft August 1, and at the end of the monitoring period was at 0.94 ft. The small 0.06 ft net change in lake level over the study period equates to a loss of approximately 9 acre-feet (roughly 3 million gallons) of water from the lake.

Streamflows measurements taken by this consultant were used to develop stream rating curves (depth-discharge relationships) for the Vermillion River inflow and outflow. The rating curves were applied to volunteer measured stream stages and daily flows were linearly interpolated to estimate the total volume of water flowing into and out of Poskin Lake. Both surface and groundwater flows into the lake from the ungauged area contributing directly to Poskin Lake were estimated using runoff coefficients computed from the monitored portion of the watershed. Evaporation was estimated to be 26.3 inches and was based off the long term average estimate of Farnsworth and others (1982).

The Vermillion River is the largest source of water to Poskin Lake (Figure 9). During the 2009 monitoring period, the Vermillion River provided 72% of the total inflow to the lake. Precipitation was the next largest contributor (16%) followed by runoff and groundwater inputs from the ungauged contributing area (12%). Water outputs were calculated to be the same as water inputs. This is acceptable because there was only a small change in the lake storage (9 acre-feet, equal to a depth change of 0.06 ft) relative to the water budget. The majority (72%) of the water leaving the lake was via the Vermillion River. Evaporation was the second largest water output at 20%. Differences in stream baseflow measurements taken at the lake outlet and downstream of the outlet at 15th Avenue suggest that discharge to groundwater accounted for 8% of the water output.

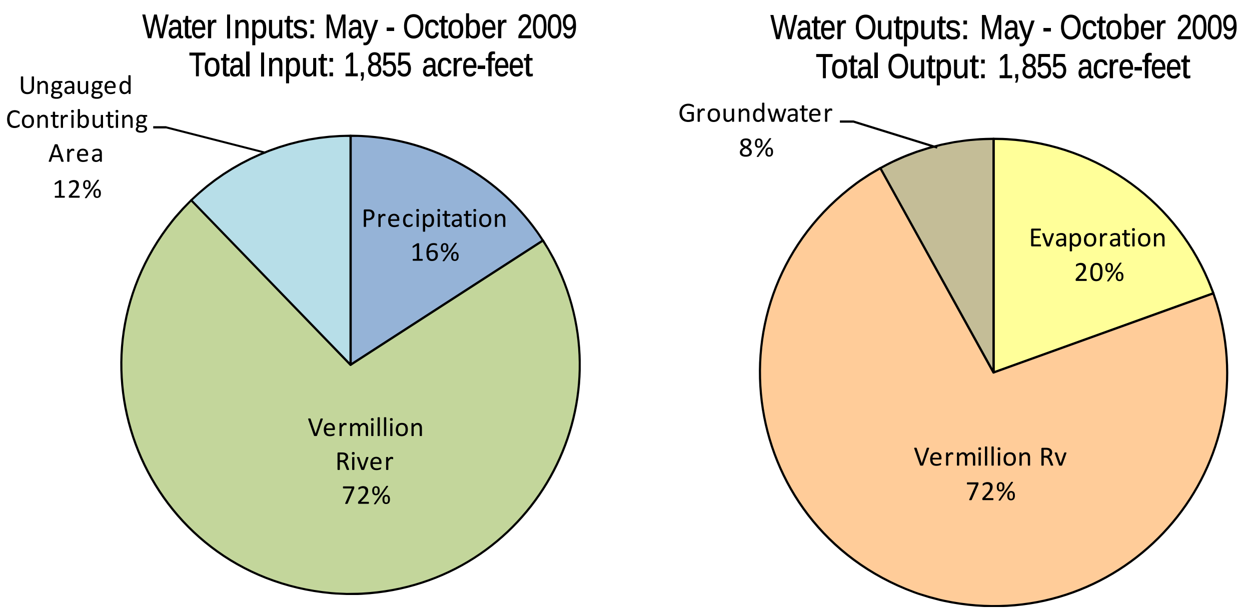

Figure 9 – Poskin Lake Water Budget for the May through October Monitoring Period

8.0 Modeling

Modeling allows lake managers to predict the effect of various scenarios on lake water quality. We used the Wisconsin Lakes Modeling Suite (WiLMS; Panuska and Kreider, 2002) to predict the expected changes in water quality in Poskin Lake due to changes in phosphorus loading. WiLMS uses a number of empirical models to estimate the spring overturn, growing season mean, and average annual phosphorus concentration in a lake. Phosphorus is the focus of the model because is it the limiting nutrient for algal growth in many Midwest lakes.

The model that best represents the current conditions in Poskin Lake is the Canfield and Bachman (1981) natural-lake model (Appendix A) which predicts growing season mean phosphorus. The Canfield and Bachman model predicts the 2009 growing season mean phosphorus to be 69 µg/L and the observed value was 67 µg/L. WiLMS was also used to estimate the lake sediment release of phosphorus. The internal load is assumed to be relatively substantial for two reasons: (1) moderately-high phosphorus soils are abundant in the watershed; and (2) substantial nutrient loading from decades of agricultural land use has likely impacted the lake. Based on the average of the four methods available in WiLMS, an additional 284 pounds of phosphorus is released by anoxic sediments on an annual basis. Although the internal loading from sediment is significant, the nutrient model indicates that loading from external (i.e. watershed) sources is sufficient to support algal blooms and therefore management efforts aimed at lake sediment treatments (e.g. alum application) will likely have only short-term effects at a large cost. For this reason, reducing the internal loading from sediment was not evaluated as a practical management scenario below, but is included in the phosphorus budget.

Knowing where the phosphorus is coming from allows managers to focus efforts on the locations most likely to have the largest impact on water quality. Currently, an estimated 2116 pounds of phosphorus are entering the lake each year. Figure 10 shows the percent of the load contributed by each source. The phosphorus budget can be improved by increasing monitoring efforts. Stream monitoring could be improved with sub-daily stream stage measurements and a sampling regime that captures both rainfall event and baseflow concentrations. Groundwater phosphorus was not measured as a part of this study so the contribution of phosphorus to the lake is only known to be some fraction of the ungauged near-lake contributing area load. We recommend an evaluation of groundwater be completed that assess both groundwater flow conditions around the lake (i.e., inflow, outflow, no-flow) and groundwater nutrient concentrations.

8.1 Model Scenarios

We used the model to evaluate an increase in the phosphorus load by 25%, reductions in the phosphorus load by 12%, 25% and 50%, removal of point sources including septic systems and curly leaf pondweed, and scenario where loading is reduced by different percentages between the near-lake contributing area and throughout the remainder of the watershed. Figures 11 and 12 show the modeling results.

According to the paleocore analysis, Poskin Lake was eutrophic prior to European settlement with in-lake phosphorus concentrations around 50 µg/L, or a WTSI of 58. It is therefore unlikely that Poskin Lake will ever be free of algal blooms, but limiting nutrient loading to the lake will likely result in improved conditions relative to the current state (i.e. fewer algae blooms). Model results discussed below suggest a management goal of an average summer WTSI below 60 is practical. Although Poskin Lake will still be classified as eutrophic at this level, blue-green algae dominance, algal scums, and summer fish kills will be avoided.

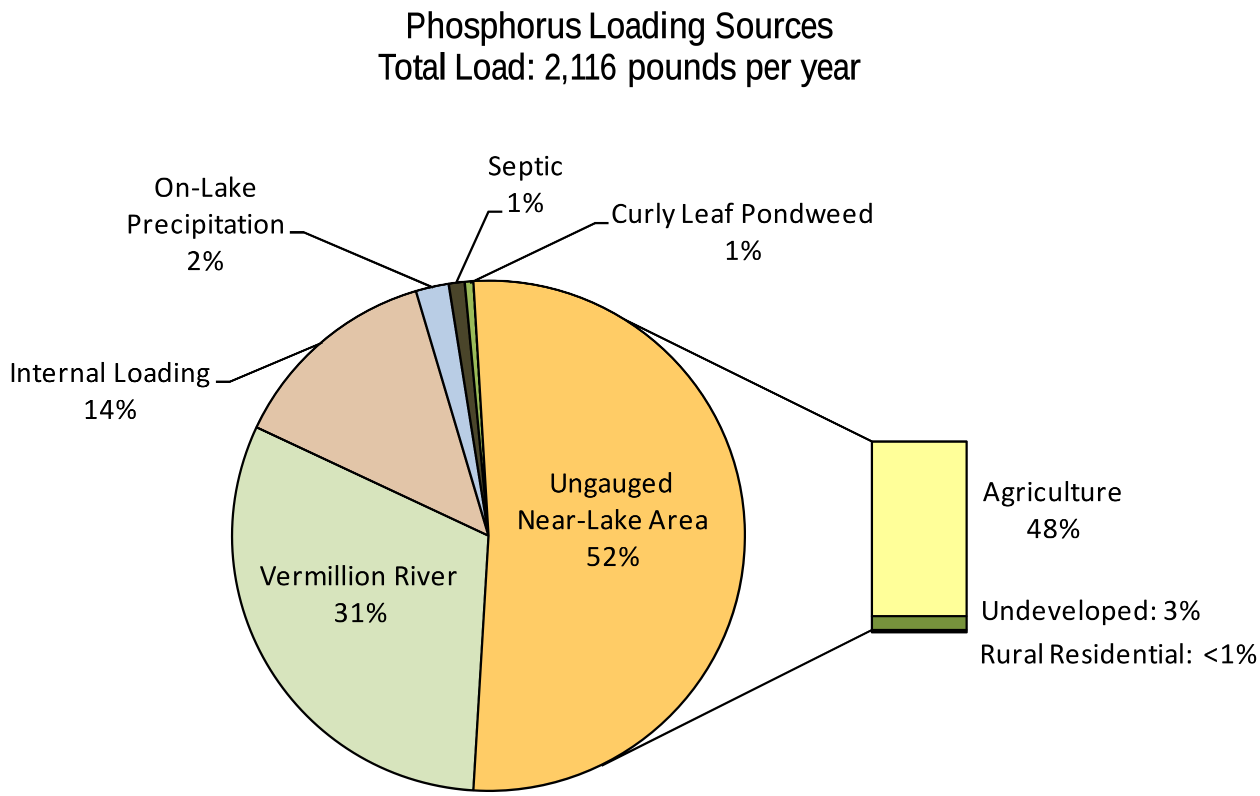

Figure 10 – Phosphorus Budget for Poskin Lake

The WiLMS model predicts that the lake will respond relatively quickly to increases in the phosphorus load (Figure 11). For example, a 25% increase in loading would put the lake in the highly eutrophic category (WTSI 62) where blue-green algae become dominant and algal scums are possible. Reducing phosphorus loading from all sources except precipitation and internal sediment release by 50% will potentially return the lake to moderately eutrophic conditions with phosphorus concentrations lower than historic levels. This is assuming that management practices focused on shoreline development, agriculture, plant management, and other sources will reduce the nutrient loading to the lake. However, a 50% reduction of phosphorus loadings is not feasible due to environmental, social, and economic constraints.

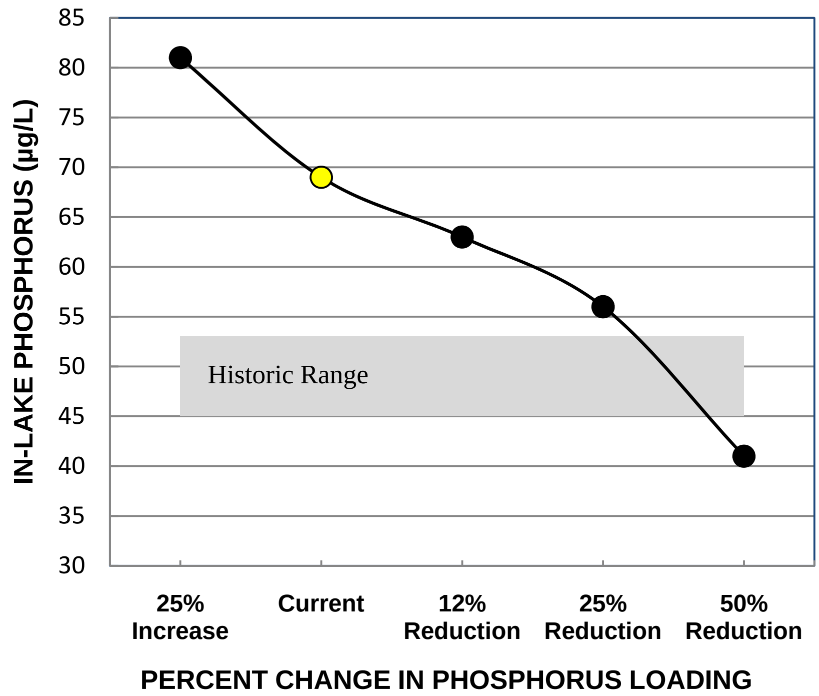

Figure 11 – Response of Poskin Lake to Phosphorus Loading Reductions

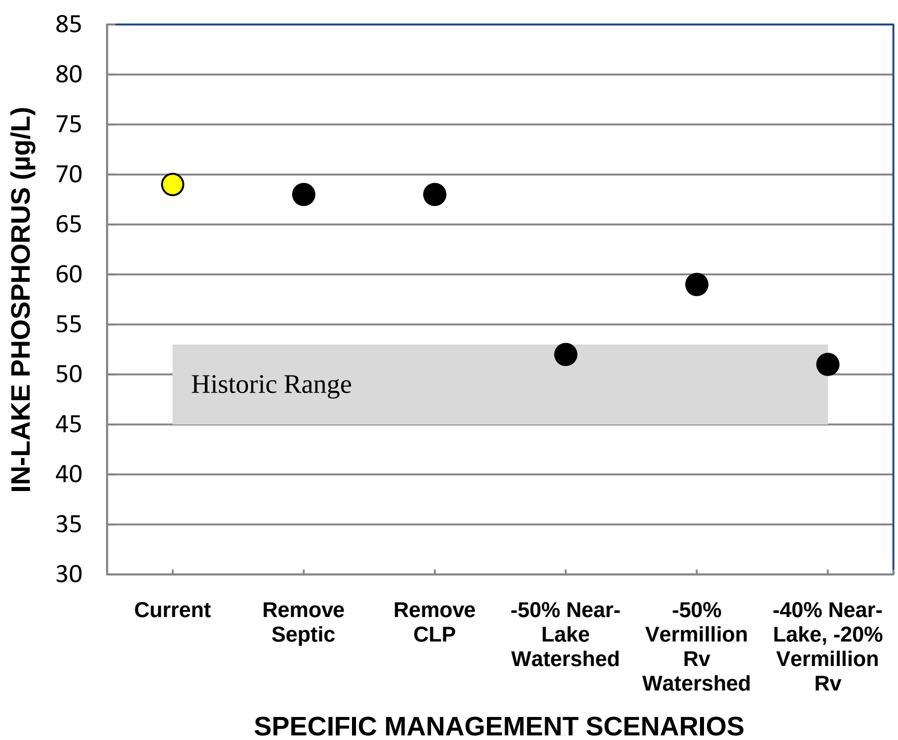

Figure 12 – Response of Poskin Lake to Specific Management Scenarios

A practical management goal with nearly the same result as a 50% reduction in the total loading is a 40% reduction of the load from the near-lake contributing area and a 20% reduction from the upstream Vermillion River watershed (Figure 12). A larger loading reduction in the near-lake area is warranted by the phosphorus budget, which indicates the near-lake area as the primary source of phosphorus to the lake. Although curly leaf pondweed contributes to only a small fraction of the phosphorus budget, plant management focused on removal or elimination will only benefit Poskin Lake.

Management practices that can reduce the nutrient loading from the both the near-lake area and Vermillion River watershed include shoreline restoration and erosion control, conservation tillage, conservation buffers including grassed waterway, and establishing resource-conserving covers (e.g., the Farm Service Agency's Conservation Reserve Program). In-lake management practices include creating no-wake zones in areas prone to sediment re-suspension, which releases phosphorus bound to soil particles, and not removing near-shore emergent aquatic vegetation, which anchors lake sediments and protects from erosion.

9.0 Lake Management Goals and Recommendations

Changing Poskin Lake from a nutrient rich, algae dominated system to a clear water plant dominated system is not a reasonable goal, given the historic water quality and watershed characteristics. Goals for lake improvement must be socially and economically feasible. The goals for Poskin Lake are base on the following:

- The lake was eutrophic prior to European settlement and has not significantly changed over time;
- The majority of lake users would like to see some improvement in water quality that will decrease the number of days lake us is impaired;
- The majority of lake users feel that if something can be done to improve water quality, something should be done.
- Aquatic invasive species, such as Eurasian water milfoil, are not desirable in the lake;
- The existing fishery is satisfactory;
- A better understanding of what drives lake water quality will facilitate the implementation of management efforts.

The following six management goals, each associated with a number of objectives and actions, will guide management efforts on Poskin Lake:

1. Reduce the number of days the lake experience nuisance algal blooms by implementing phosphorous reduction activities in the watershed, near-shore area, and within the lake;
2. Develop a better understanding of the lake and the factors affecting lake water quality through continued and additional monitoring efforts.
3. Reduce the impact of the non-native invasive plant species curly-leaf pondweed and enhance the native plant population through aquatic plant management activities and improvements in water clarity;
4. Prevent new, undesirable non-native invasive species from entering and establishing in the lake by implementing a prevention and early detection program that includes watercraft inspection, in-lake monitoring, and rapid response planning;

5. Maintain the current fishery by working closely with WDNR fisheries management to help minimize impacts that may be caused by lake management activities;
6. Educate lake residents and users about the lake ecosystem and engage them to actively help protect, maintain, and improve the lake.

Public awareness, knowledge, and skills will serve as integral components for the successful implementation of the plan.

10.0 Implementation Plan

The lake and aquatic plant management activities recommended in this comprehensive plan are to be implemented over the course of the next five years and will exceed the current financial resources of the PLA. A timeline for the implementation of individual actions within this plan is provided in Appendix B. The plan is intended to be and flexible to accommodate future changes in the needs of the lake and its watershed, and those of the PLA.

Included with the timeline in Appendix B are the intended facilitator for each action and the availability for grant funding. Each of the grant programs requires some level of match that the PLA or one of its partners would be responsible for making. A portion of the match required for these various grant programs could be covered by volunteer and donated services. Water craft inspection, AIS monitoring, water quality sampling, Lake Fair organization and participation, project activity administration time, donated materials, donated professional services, county services, and services provided by schools, businesses, the U.S. Army Corps of Engineers, and the NRCS are all potential match sources. We recommended that the PLA pursue the formation of a Lake District would provide a continuous funding source for current and future lake and aquatic plant management activities.

10.1 Goal 1: Reduce the number of days the lake experiences nuisance algal blooms

Because phosphorus is the nutrient limiting algae growth in Poskin Lake, phosphorus loading from both internal and watershed sources must be reduced in order to reduce the number of days the lake experiences nuisance algal blooms. Modeling suggests that a growing season mean total phosphorus concentration of 50 µg/L or less in Poskin Lake, which is near the pre-European settlement concentration, is a reasonable goal that can be reached by reductions in the phosphorus loading from the watershed.

10.1.1 Objective 1: Reduce phosphorus loading from the lake’s watershed

External sources of phosphorous to Poskin Lake include sources that can and cannot be readily managed. Overall, 85% of the phosphorus loading is coming from external sources. External sources of phosphorus measured or estimated include the atmospheric deposition, groundwater, near shore contributions (including septic systems), and contributions through surface water runoff from the watershed. Little can be done to reduce the amount of phosphorous carried in by groundwater or blown over and carried into the lake by wind and precipitation. The contribution of these sources is estimated to be less than 10% of the total phosphorus budget. Runoff from the ungauged near-lake area and from the Vermillion River accounts for 83% of the phosphorus loading and are manageable sources. Modeling shows that a reducing the near-lake watershed and Vermillion River loads by 40 and 20%, respectively, will return the lake water quality to near pre-European settlement conditions.

10.1.1.1 Action 1: Identify, promote and implement best management practices (BMPs) in the watershed that reduce phosphorus loading

Agricultural land use is the primary source of nutrients in the watershed. Model results suggest agricultural land supplies from 50 to 75% of the phosphorus load to the lake. Best management practices including no till crop farming, grassed buffers along the intermittent tributaries to Poskin Lake, and livestock feeding and manure management strategies to reduce overland runoff can help to reduce phosphorus loading from these lands. Reducing the average phosphorus concentration in the Vermillion River from the current 87 µg/L to approximately 70 µg/L (which is also below the WDNR water quality standard of 75 µg/L) will potentially reduce the phosphorus load to the lake by nearly 20%. The PLA should work closely with the Barron County Soil and Water Conservation Department (SWCD) to identify the areas suitable for implementation of BMPs and the landowners willing to participate.

10.1.1.2 Action 2: Identify, promote and implement BMPs in the near-shore area that reduce phosphorus loading

The phosphorus load from the near-shore area is low relative to other sources, contributing only 2% of the total load; however the phosphorus contributed per acre in developed near-shore area is 5 times greater than the contribution of undeveloped areas. Phosphorus loading can be reduced by restoring disturbed shorelines, leaving no-mow or more substantial shoreland buffers, refraining from using lawn fertilizers or using no-phosphorus fertilizer, diverting runoff from hard surfaces, such as rooftops and driveways, away from the lake, preventing shoreland erosion, and ensuring septic systems are in working order. Most of these BMPs can be implemented at relatively low costs and should be actively promoted by the PLA.

10.1.2 Objective 2: Reduce internal phosphorus loading

Internal phosphorus loading from bottom sediments and the decay of CLP contribute an estimated 14 and 1% of the total phosphorus load to the lake, respectively. Prior to considering sediment treatment (e.g. alum application), external sources of phosphorus must be reduced and maintained at lower concentrations. Also, the loading from natural sources of phosphorus must be considered. Because the phosphorus load from the Vermillion River is large enough to support algal blooms and the sediment in the watershed is naturally moderately-high in phosphorus, we do not recommend sediment treatments be considered as a means to reduce in-lake phosphorus concentrations. Other methods of reducing the internal load, such as hypolimnetic withdrawal (using large capacity pumps to remove water from the hypolimnion) and aeration, are also not recommended at this time due to their high cost and likely small return.

10.1.2.1 Action 1: Increase the lake flushing rate by removing the outlet dam top timbers and gate

The flushing rate of a lake is related to its retention time. The longer water stays in a lake, the more opportunity there is for the phosphorous in that water to settle out to the bottom sediments or to be utilized for growing algae. Scheffer (1998) suggested that blue-green algal dominance is never observed in lakes where hydraulic retention time is shorter than five days, even though such lakes can have very high nutrient concentrations. Flushing a lake with relatively low phosphorus water can decrease nutrient levels and may wash out certain slow-growing algal groups.

In drainage lakes such as Poskin Lake, there is often a noticeable reduction in algae following a large rain event because the retention time is shortened by the added runoff; however, this effect is negated when a dam is located at the outlet. The Poskin Lake outlet dam currently has an opening width of approximately 6.5 feet. The opening can be widened to approximately 20 feet by removing the top timbers and metal gate. A larger area will allow high flows to pass more quickly, thereby increasing the lake flushing rate. This will also shorten the length of time the lake is at high water; during high water periods, shoreline erosion can mobilize phosphorus from sediments.

10.1.2.2 Action 2: Evaluate zooplankton and algal communities to determine feasibility of biological manipulation

Biological manipulation or biomanipulation is any adjustment of the biological community in an ecosystem to achieve a desired end. For lakes, it principally means altering the fish community to increase the numbers of grazer zooplankton (tiny water creatures that feed on algae), particularly Daphnia species. The goal is to reduce the amount of algae in a system by increasing the number of zooplankton that feed on algae.

No official work has been completed to identify the current make-up, distribution, and size structure of the zooplankton and algal populations in Poskin Lake. Both zooplankton and algae must be assessed to identify if the algal species present are even a food source for Daphnia. For biomanipulation to be considered in the future, a study of this nature needs to be completed. If results suggest biomanipulation is a potential management action, discussion with fisheries managers and lake users would be required before attempting to manipulate the fishery.

10.2 Goal 2: Develop a better understanding of the lake and the factors affecting lake water quality

Volunteers in the Citizen Lake Monitoring Network (CLMN) already collect some water quality data at Poskin Lake. There are three CLMN monitoring sites at Poskin Lake; one located in Little Poskin Lake and two in the larger basin. As of 2010, only the site at the deep hole in Poskin Lake is monitored. These sites should have the full complement of expanded water quality testing offered by the program including total phosphorous and chlorophyll *a* from May through August, and water clarity, temperature and dissolved oxygen ice out to ice on. Additional water quality testing could be added, funded either by a grant or the Lake Association to include fall sampling for total phosphorous and chlorophyll *a* , and potentially other parameters including total nitrogen and the dissolved states of both phosphorous and nitrogen.

Volunteers should also collect water quality data from the Vermillion River through the Citizen-based Stream Monitoring Program (CBSM), a part of the Water Action Volunteer (WAV) program. The CBSM has three levels of involvement to accommodate the availability and interest levels of volunteers. Initially, volunteers participate at Level 1 and learn the basics of water quality monitoring. After a season at level one, volunteers can select between Level 2 and Level 3 monitoring.

CBSM monitoring will involve citizens with water quality conditions and concerns and collect valuable data for resource assessment; however, evaluation of the effect of management efforts on the watershed requires more detailed monitoring of the Vermillion River. Identifying the quality and quantity of both surface water and groundwater entering the lake helps guide planning, protection and implementation of best management practices.

10.2.1 Objective 1: Participate in and expand citizen-based water quality monitoring

10.2.1.1 Action 1: Include all three monitoring sites in expanded CLMN surface water quality testing

Secchi, total phosphorous, chlorophyll a, temperature and dissolved oxygen monitoring should be completed on a more regular basis. Spring and Fall overturn sampling should also be conducted at all there monitoring sites.

10.2.1.2 Action 2: Set up a Citizen-based Stream Monitoring (CBSM) program

We recommend the PLA identify a volunteer base and contact the UW Extension to develop a citizen-based stream monitoring program to learn more about and aid in the improvement of water quality in the Poskin Lake watershed. Monitoring activities include, but are not limited to, measuring stream water quality and streamflow, organizing cleanups along waterways, and performing biotic index surveys.

10.2.2 Objective 2: Increase knowledge of the quantity and quality of groundwater and surface water entering Poskin Lake

Characterizing the local water quality and understanding the watershed hydrology will assist the PLA in evaluating and selecting strategies to for improving water resources quality. A study should be initiated that links land use management and water quality through an assessment of the physicochemical and biological characteristics of surface water and groundwater. The study would require substantial funding and professional resources to develop and carrying out. The volunteer monitoring base should be active participants in the study.

10.2.2.1 Action 1: Develop a hydrologic understanding of the water resources in the Poskin Lake watershed

Understanding where the water is coming from and where it is going is valuable information for proper lake management. This study would include continuous monitoring of streamflow into Poskin Lake, changes in lake level, and streamflow out of the lake. Groundwater flow into and out of the lake should also be assessed.

10.2.2.2 Action 2: Develop an understanding of lake and stream water quality locally and on a watershed scale

When, where, and how much nutrient and pollutant loading is occurring needs to be evaluated to establish baseline conditions from which to measure changes and to identify nutrient and pollution hot spots in the watershed. The primary sources to be investigated are surface runoff during rain events and groundwater through stream monitoring and a groundwater study.

10.3 Goal 3: Reduce the impact of the non-native invasive plant species curly-leaf pondweed and enhance the native plant population

10.3.1 Objective 1: Implement activities in the Poskin Lake Aquatic Plant Management Plan

Activities that address plant management are discussed in the Poskin Lake Aquatic Plant Management Plan, a companion document to this comprehensive plan.

10.3.1.1 Action 1: Review the APM plan at least annually and update as necessary

10.4 Goal 4: Prevent new, undesirable non-native invasive species from entering and establishing in the lake.

Currently, the only aquatic invasive species know to inhabit Poskin Lake are curly leaf pondweed and the Chinese mystery snail. It is desirable to keep other aquatic invasive species, such as Eurasian water milfoil, out the lake. Watercraft inspection at all lake access points during periods of high use will help reduce the chance that a new AIS is introduced to the lake. Regular monitoring for EWM and other AIS in the lake is also important. A plan for what to do if a new aquatic invasive species is identified in the lake is included in the Poskin Lake Aquatic Plant Management Plan. This plan identifies the procedures to follow to collect and voucher a suspect plant or animal sample, designate where and to whom that sample should go to, and outlines what should happen if a positive identification is made.

10.4.1 Objective 1: Watercraft inspection at all public access points during high use periods

One of the best things that can be done to prevent the introduction of new invasive species is to set up a regular watercraft inspection program at the public access points around the lake. Watercraft inspection involves placing people at the boat landings during busy times to talk to boaters using the lake about aquatic invasive species and what they can do to prevent their spread. Watercraft inspectors also check boats for incoming or out-going material attached to boats or in live wells to help boaters stay within the laws in Wisconsin that make it illegal to launch a boat with foreign material attached to it, or to drive down a public highway with aquatic invasive species material attached to a boat or trailer. Watercraft inspectors also collect general lake use information from boaters that helps determine statewide actions related to AIS.

10.4.1.1 Action 1: Reinitiate Clean Boats Clean Waters (CBCW) watercraft inspection program with trained volunteers and paid inspectors

The University of Wisconsin Extension Lakes program offers training and materials for watercraft inspection through the Clean Boats Clean Waters (CBCW) program. During a CBCW workshop, people are trained to set up and operate watercraft inspection programs. After completion, they are recognized as trainers themselves, able to take what they know to others. PLA volunteers participated in the CBCW program in 2009, spending a total of 75 hours at the public access and contacting 6 boaters; this front-line approach to monitoring the system should be continued. Consider holding CBCW picnics, where volunteers are able to socialize and monitor concurrently, which would likely increase interest in the program.

Some lakes have been installing boat landing monitoring cameras at their public access points. A commonly used system is I-LIDS (pronounced “eyelids”); a camera films activity at the boat landing and streams it to a local computer for viewing. The purpose is to provide additional incentive for boaters to do what is necessary to comply with the illegal-to-launch law when a watercraft inspector is not present. The cameras have not been wholly determined to be effective, and only a few individuals have received citations for disobeying the law based on being caught on camera. Also, even if a person is caught bringing EWM or another invasive species into a body of water, once in the lake, the damage has already been done. Camera monitoring is not a substitute for actual watercraft inspectors, but may be used to support an overall watercraft inspection program.

10.4.2 Objective 2: In-lake AIS monitoring during the entire open water season

Providing regular in-lake monitoring for EWM and other AIS could identify a new AIS introduction before it has a chance to become a significant problem in Poskin Lake. Early identification can lead to early intervention, offering more management options at a lower cost.

10.4.2.1 Action 1: Set up a Citizen Lake Monitoring Network (CLMN) AIS monitoring program with trained volunteer and paid monitors

Regular monitoring of Poskin Lake for EWM and other AIS should be completed. Public access points should be monitored every couple of weeks during the open water season, and the entire plant growing zone of the lake should be monitored for AIS at least once a month during the open water season. The Citizen Lake Monitoring Network offers volunteer training and support for aquatic invasive species identification and monitoring. As with the CBCW program, a training session is offered by CLMN AIS Monitoring personnel that helps organizations set up and operate an in-lake AIS monitoring program. The training session teaches the skills necessary for identification of the species of concern, and provides material support and guidance on making the program successful. After completion, attendees are recognized as trainers themselves and can take what they know to others.

An official AIS In-Lake Monitoring Program should be designed or implemented as soon as possible. Officially recognized monitors should be trained in AIS identification and monitoring procedures. These monitors could be volunteer or paid. Monitors should be given the necessary equipment and materials to complete this monitoring on regular basis and submit the information they collect to the appropriate people and places.

10.4.2.2 Action 2: Provide informal AIS identification training to all interested lake users

All lake users and riparian owners should be given the opportunity to learn in-lake AIS monitoring techniques to be employed in their daily use of the lake.

10.5 Goal 5: Maintain the current fishery

According to the Lake Property Owners Survey, there is a general satisfaction with fishery in Poskin Lake. Management alternatives chosen for the lake should have this in mind. Increasing native plant diversity, reducing CLP, and reducing phosphorous loading will likely have little negative impact to the current fishery given that rapid shifts in the lake condition are unlikely as a result of this plan.

10.5.1.1 Objective 1: Minimize impacts that may be caused by lake management activities

Although not intentional, some management activities can have adverse impact to the fishery. For example, chemical application could potentially destroy habitat for gamefish. Certain erosion control structures, such as riprap, can have adverse effects on habitat and spawning areas.

10.5.1.2 Action 1: Identify Sensitive and Critical Habitat areas in Poskin Lake

Currently there are no officially designated Sensitive or Critical Habitat areas on Poskin Lake. Some examples of potential Critical Habit areas include the gravel beds within Poskin Lake, rice beds in Little Poskin Lake, wetlands adjacent to the north and south ends of the lake, and steep shorelines along the southern half of Poskin Lake. These areas provide spawning habitat, sensitive aquatic plant and wildlife habitat, and, in the case of steep shorelines, are prone to erosion. The PLA should work with the WDNR to identify these areas and ensure the long-term health of Poskin Lake.

10.6 Goal 6: Educate lake residents and users about the lake ecosystem and engage them to actively help protect, maintain and improve the lake

The success of any lake management plan depends on the involvement of stakeholders throughout the process of data collection, planning, implementation and maintenance. Without buy-in from the general public, those who use and benefit from the lake, management will likely fall short of expectations. For users and benefactors of Poskin Lake, one of the most important things to learn is the limitations for making substantial changes in the overall perceived quality of the lake. It is important to recognize that Poskin Lake has likely always been a nutrient rich system with green water; turning it into a clear water lake is very unlikely at this time due to economic, social, and scientific constraints.

Users and property owners would like to improve the system and there are things that can be done. Lake users, riparian owners, and the local community need to be educated and informed as to what these things are and how they can help make them happen. Some management activities will be inexpensive and can be implemented by the general public. Others will be very expensive and only implementable under very strict guidelines. All management activities come with limited guarantees that they will accomplish the goals set for them. Stakeholders need to be involved in decisions made to spend what could be thousands of dollars a year to improve the system, and help decide if the costs to do so are reasonable under the assumed risk.

10.6.1 Objective 1: Promote good lake stewardship activities for lake users and lake riparian owners

Lake Stewardship is defined as an attitude that recognizes the vulnerability of lakes and the need for citizens, both individually and collectively, to assume responsibility for their care. A good lake steward will learn what they can about how to protect and enhance the body of water entrusted to their care, and show this by way of the activities in which they participate. The Poskin Lake Association, while not the only entity to be charged with taking care of the lake, is in a position to provide education and information to its members and others about the activities considered good lake stewardship. The PLA has and continues to attempt to involve the public in activities related to the lake.

10.6.1.1 Action 1: Identify, highlight, showcase, and reward examples of new and existing good lake stewardship activities being completed by lake users and riparian owner throughout the lake

Membership in an association like the PLA is voluntary and the number of people who choose to become members is likely determined by what it is perceived that the association accomplishes on behalf of the lake and lake users. Showcasing what the PLA and its members do to practice good lake stewardship is important.

10.6.1.2 Action 2: Sponsor an annual Lake Fair for all lake users and the surrounding community

A Lake Fair is a means to accomplish the activities in Action 1 and serves as a venue to promote more lake stewardship. A date should be set each year when all lake residents and users in the community are invited to attend a Lake Fair sponsored by the PLA. A Lake Fair provides a forum for many different topics to be discussed, put on display, or made available for hands on learning. The PLA should invite other local lake groups, the Barron County Soil and Water Conservation Department and the WDNR and other lake professionals to showcase what has been done elsewhere and what has been accomplished on Poskin Lake. A Lake Fair is much less formal than a lake meeting, and could provide activities for many different age groups and interests to get involved. The Wisconsin Lakes Partnership sponsors the annual Lakes Convention in March of every year. A smaller version of the Lakes

Convention is held each year in some location in northwest Wisconsin. Both of these events and many other resources could provide ideas and contacts for setting up a local lake fair event.

10.6.2 Objective 2: Increase public information and involvement

10.6.2.1 Action 1: Develop and provide multiple sources for public informational and educational materials related to management activities in the lake, including newsletters, a web page, individual mailings, open organization meetings, and social gatherings

Providing multiple sources to get informational and education materials is important for getting and keeping the general public involved. The PLA should offer newsletters both in print and digital format, and provide a web site for disseminating information about the lake and associated activities. Individual mailings to all lake residents could also be incorporated as a means to share information. The Association already offers open meetings and social events as a part of their operation.

10.6.2.2 Action 2: Develop and design signage for all public access points that promote a consistent message to aquatic invasive species, lake use and stewardship

Public access sites are another place to make sure the message of good lake stewardship is heard. All access points should be evaluated for the signage already in place and a plan developed and implemented addressing the need for updated and additional signage. A consistent message at all landings regarding AIS and other important lake functions can help accomplish the goals in this plan.

10.6.2.3 Action 3: Build and install signage at all public access points

10.6.3 Objective 3: Explore the formation of a Lake District in place of or in addition to the existing PLA

Membership in the PLA is voluntary and dues paid by members provide a funding source to support Lake Association activities. However, when management needs that affect all lake users begin to increase, it is often difficult to generate enough financial support through voluntary dues. In the 2009 Lake Property Owners Survey, respondents were asked if they would support the formation of a Lake District and 22% said yes or probably yes, 30% said no, and 48% were unsure. If a lake district is not formed, other methods for raising money to support implementation would have to be pursued. When provided with a list of options, the majority of respondents were in favor of soliciting cash donations, increasing the lake association dues, and participating in fundraisers. Donations can be sought, fundraising efforts can be made, and state lake grant funds can be utilized, but none of these activities provide a stable and consistent source of funding.

While there are management activities that can improve the condition of the lake over time with relatively low costs, these efforts are limited and will take many years to show an impact to the water quality of the lake, and it may be difficult to get lake users to participate freely. Many of the management activities that may be employed to help improve Poskin Lake will have substantial costs associated with them if implemented.

10.6.3.1 Action 1: Create a PLA committee to explore the formation of a Lake District

A Lake District is a special purpose unit of government with the purpose of maintaining, protecting, and improving the quality of a lake and its watershed for the mutual good of the members and the lake environment. The boundaries usually include the properties of all riparian owners and can include off-lake properties that benefit from the lake or that have affects on the lake and its watershed. The district may include all or part of a lake or more than one lake. A city or village must give its approval to be included in a district. Within a lake district, all property owners share in the cost of management activities undertaken by the district.

A lake district is a true example of participatory democracy. Eligible voters residing within and owners of property located in the district have a vote in the affairs of the district. This is accomplished at an annual meeting that must be held between May 22 and September 8 each year. Property owners living within the boundaries of a lake district can be required by law to pay fees. The amount of those fees is voted on by the members at the annual meeting. This fee is usually a part of your property tax bill and may come in the form of a mill levy (no more than 2.5 mill and often much less), a special assessment, or user charge. Some districts have no fees of any sort. Borrowing or grant programs can also be used to raise money if approved at the annual meeting.

Normally, a lake district's day-to-day activities are carried out by a board of from 5 to 7 commissioners. One is appointed by the county and one by the town. The remaining commissioners are elected by the membership. At least one elected commissioner must be a resident unless no resident is willing to serve, and the others must be either residents or property owners in the district. At all times, the powers of the commissioners are subject to the decisions of the membership at the annual meeting. The commissioners must meet quarterly and follow open meeting laws.

10.6.3.2 Action 2: Form a Lake District

A lake district can be formed in one of four ways:

- By 51% of the landowners in the proposed district petitioning the county or town board;
- By owners of 51% of the land in the proposed district petitioning the county or town board;
- By resolution of a village board or city council; or
- By conversion of a town sanitary district.

An existing district may be dissolved by a 2/3 vote of the members at an annual meeting.

10.6.4 Objective 4: Identify the need for additional and (or) modified zoning and local ordinances

A township ordinance currently creates a no-wake period for Poskin Lake between the hours of 6:00 p.m. and 10:00 a.m. Barron County shoreland regulations are in place for protecting lakes and navigable waters. Under these regulations, Poskin Lake is classified as a Class 1 lake which is the least restrictive classification in Barron County. With two new real estate developments potentially amounting to a dozen or more new homes, the PLA should evaluate current zoning regulations to see if they will afford appropriate protections to the lake.

There has been much discussion about the Poskin Lake outlet dam, particularly pertaining to the current owner(s) and operators(s). Dams have a significant impact on water quality, wildlife, public safety, water rights issues, and land use in Wisconsin. The WDNR regulates the outlet dam and lists it as a low hazard potential dam. The dam was last inspected in 1969. The Poskin Lake outlet dam has a long history of owners and modifications. A report on the dam was completed as part of Phase 2 of this project and brief summary follows. The Surface Water Resources of Barron County (Sather and Threinen, 1964) indicates the dam was owned by one Stanley Kris. Currently, the Poskin Lake outlet dam is listed as being owned by the Barron County Property Committee. Although the current owner is listed as the Barron County Property Committee, Barron County does not currently operate the gate on the dam. Not all the operators of the gate are known at this time; however, the current owner of the Poskin Lake Resort stated he opens the gate when it is closed to reduce shoreland erosion. Currently, not all operators of the dam gate are known.

10.6.4.1 Action 1: Assign an entity with the responsibility of monitoring and operating the gate on the outlet dam

We recommend the top timbers and gate be removed from the dam for water quality reasons; however, until that occurs, some entity, be it the PLA or another group, should be assigned with the responsibility of monitoring the condition of the dam and operating the gate to control water levels.

10.6.4.2 Action 2: Create a PLA committee to analyze of the need for adoption of local ordinances for lake protection

A summary of current shoreline regulations and other ordinances that concern Poskin Lake was completed as part of Phase 2 of this project. This summary provides a good starting point for an evaluation of current rules. A description of the institutional framework affecting management of the lake including local government jurisdictional boundaries, plans, existing ordinances, statutes and regulations regarding dams, and an analysis of the need for adoption of local ordinances for lake protection should be completed before implementing any large-scale, or long-term management activities.

10.6.4.3 Action 3: Make recommendations for local ordinances for lake protection

11.0 Partnerships

The PLA should pursue partnerships with various governmental departments within Barron County including Soil and Water Conservation, Forestry, the Great Lakes Indian Fish and Wildlife Commission, the Poskin Community, including the Town of Clinton, local, state, and national fishing clubs, and others to help fund activities aimed at improving water quality conditions in the lake. All management activities should be well publicized and open for public debate. The Wisconsin Lakes Partnership which includes the WDNR, UW-Extension Lakes Program, and the Wisconsin Association of Lakes, should be considered operating partners in all lake management activities. Greater attempts to address the needs of all Poskin Lake property owners and lake users should be made.

We strongly recommend the PLA becomes a part of the Total Maximum Daily Load (TMDL) stakeholders group within the Red Cedar River Watershed, the larger basin in which Poskin Lake is located. A TMDL is essentially a pollution budget for a waterbody or watershed that establishes the pollutant reduction needed from point and nonpoint sources to meet water quality goals. The PLA should become active in the stakeholders group because decisions made for the Red Cedar River Watershed TMDL will likely affect Poskin Lake.

Management Activities need to based on three following principles if outcomes are expected to be positive: (1) sound lake science; (2) stakeholder involvement; and (3) compatibility with State of Wisconsin rules and guidelines. It is believed that this comprehensive lake management plan and the recommendations in it meet this expectation.

12.0 Bibliography

Allenby, K. G. 1981. Some analyses of aquatic plants and their waters. Hydrobiologia Vol. 7, pp. 177-189.

Berg, M. S., 2009. Curly-leaf pondweed P/I, bed mapping, and warm water point/intercept macrophyte surveys Poskin Lake (WBIC: 2098000) Barron County, Wisconsin. Report to the Poskin Lake Association and WDNR, 90 pp.

Beutel, Marc, 2002. Improving raw water quality with hypolimnetic oxygenation. AWWA 2002 Annual Conference Proceedings, pp. 1-16.

Booms, Travis, 1999. Vertebrates removed by mechanical weed harvesting in Lake Keesus, Wisconsin. Journal of Aquatic Plant Management, Vol. 37, pp. 34-36.

Danz, M. E., S. R. Corsi, D. J. Graczyk, and R. T. Bannerman, 2010. Characterization of suspended solids and total phosphorus loadings from small watersheds in Wisconsin. U.S. Geological Survey Scientific Investigations Report 2010-5039, 16 pp.

Farnsworth, R. K., E. S. Thompson, and E. L. Peck, 1982. Evaporation atlas for the contiguous 48 United States: National Oceanic and Atmospheric Administration Technical Report 33, 27 pp., 4 maps.

Freedman, Jan, Michael Grodowitz, Robin Swindle, and Julie Nachtrieb, 2007. Potential Use of native and Naturalized Insect Herbivores and Fungal Pathogens of Aquatic and Wetland Plants. Army Corp ERDC Environmental Laboratory, Vicksburg, Mississippi, pp. 1-64.

Garrison, P., 2010. Results of sediment core taken from Poskin Lake, Barron Couty, Wisconsin. Wisconsin Department of Natural Resources, September 2010, 7 pp.

Greenfield, Ben, Nicole David, Jennifer Hunt, Marion Wittmann, and Geoffrey Siemering, 2004. Aquatic Pesticide Monitoring Program - Review of Alternative Aquatic Pest Control Methods for California Waters. San Francisco Estuary Institute, Oakland, California, 109 pp.

Langlade County Land Records and Regulations Department. http://lrrd.co.langlade.wi.us/shoreland/bufferblocker.asp

Lillie, R. A., S. Graham, and P. Rasmussen, 1993. Trophic state index equations and regional predictive equations for Wisconsin Lakes. Wisconsin Department of Natural Resources Research Management Findings No. 35, 4 pp.

Madsen, John, 2000. Advantages and disadvantages of aquatic plant management techniques. Lakeline Vol. 20, No. 1, pp. 22-34.

Moss, Brian, Jane Madgwick, and Geoffrey Phillips, 1996. A Guide to the Restoration of Nutrient-enriched Shallow Lakes. WW Hawes, UK, pp. 180.

NRCS (U.S. Department of Agriculture Natural Resources Conservation Service), 2001. Wild rice establishment. Conservation Sheet 644b, available at ftp://ftp-fc.sc.egov.usda.gov/MI/AI/TechnicalAssistance/WildriceJobSheet.pdf

Nichols, Stanley A, 1999. Distribution and Habitat Description of Wisconsin Lake Plants. Wisconsin Geological and Natural History Survey. Bulletin 96. Madison, WI, 266 p.

Nurnberg, Gertrude 2007. Lake responses to long-term hypolimnetic withdrawal treatments. Lake and Reservoir Management, Vol. 23, Is. 4, pp. 388-409.

Roesler, Craig. 2008. Unpublished data. Wisconsin Department of Natural Resources, Hayward, WI.

Sather, L. M., and C. W. Threinen, 1964. Surface Water Resource of Barron County. Wisconsin Department of Natural Resources, Madison, WI, 135 pp.

Scheffer, Martin, 1998. Ecology of Shallow Lakes. Kluwer Academic Publishers. Norwell, MA, p. 357.

Skogerboe, John and Kurt Getsinger, 2006. Selective control of Eurasian watermilfoil and curly-leaf pondweed using low doses of Endothall combined with 2,4-D. ERDC/TN APRCD-CC-05, 15 pp..

Smart, Michael, G. O. Dick, and R. D. Doyle, 1998. Techniques for establishing native aquatic plants. Journal of Aquatic Plant Management Vol. 36, pp. 44-49.

Smiley, Peter and Eric Dibble, 2006. Evaluating the feasibility of planting aquatic plants in shallow lakes in the Mississippi Delta. Journal of Aquatic Plant Management Vol. 44, pp. 73-80.

Waisel, Y, J. J. Oerteli, and A. Stahel, 1990. He role of macrophytes in phosphorous turnover: sources and sinks. Proceedings of the 8th Symposium on Aquatic Weeds. EWRS, pp. 243-248.

Wisconsin Department of Natural Resources, 2003. Alum Treatments to Control Phosphorous in Lakes. Fisheries and Habitat Program, March 2003.

Wisconsin Department of Natural Resources Wetlands Program. http://dnr.wi.gov/wetlands/

Wisconsin Natural Heritage Inventory Program. http://dnr.wi.gov/org/land/er/nhi

Zaporozec, A., 1987. Atlas of groundwater resources and geology of Barron County, Wisconsin. Wisconsin Geological and Natural History Survey Map 87-2e, scale 1:100,000.

Appendix A

WiLMS Lake Model

Wisconsin Lake Modeling Suite (WiLMS)
Poskin Lake Base Scenario

Lake Id: Poskin
Watershed Id: 0

Hydrologic and Morphometric Data

Tributary Drainage Area: 2125.0 acre
Total Unit Runoff: 9.00 in.
Annual Runoff Volume: 1593.8 acre-ft
Lake Surface Area <As>: 165.0 acre
Lake Volume <V>: 2348.2 acre-ft
Lake Mean Depth <z>: 14.2 ft
Precipitation - Evaporation: 4.5 in.
Hydraulic Loading: 4723.1 acre-ft/year
Areal Water Load <qs>: 28.6 ft/year
Lake Flushing Rate <p>: 2.01 1/year
Water Residence Time: 0.50 year
Observed spring overturn total phosphorus (SPO): 131.0 mg/m^3
Observed growing season mean phosphorus (GSM): 67.0 mg/m^3
% NPS Change: 0%
% PS Change: 0%

Hydrologic and Morphometric Data

Sources include WDNR (1968) Poskin Lake Map (morphometry); Barron County Soil & Water Conservation Department, WISCLAND, and orthophoto analysis (land use classification); and WiLMS default coefficients for Barron County, WI (loading and hydrologic data).

NON-POINT SOURCE DATA

Land Use	Acre (ac)	Low	Most Likely	High	Loading %	Low	Most Likely	High
		Loading (kg/ha-year)				Loading (kg/year)		
Row Crop AG	0.0	0.50	1.00	3.00	0.0	0	0	0
Mixed AG	1426.0	0.30	0.80	1.40	55.6	173	462	808
Pasture/Grass	84.0	0.10	0.30	0.50	1.2	3	10	17
HD Urban (1/8 Ac)	0.0	1.00	1.50	2.00	0.0	0	0	0
MD Urban (1/4 Ac)	0.0	0.30	0.50	0.80	0.0	0	0	0
Rural Res (>1 Ac)	68.0	0.05	0.10	0.25	0.3	1	3	7
Wetlands	131.0	0.10	0.10	0.10	0.6	5	5	5
Forest	355.0	0.05	0.09	0.18	1.6	7	13	26
Barrens	61.0	0.07	0.20	0.34	0.6	2	5	8
Lake Surface	165.0	0.10	0.30	1.00	2.4	7	20	67

POINT SOURCE DATA

Point Sources	Water Load (m^3/year)	Low (kg/year)	Most Likely (kg/year)	High (kg/year)	Loading %
Vermillion River	3783619.3	195.0	298.0	323.0	35.9
CLP	0.0	0.0	5.2	0.0	0.6

Point Sources

Vermillion River: 2009 monitoring year data.
Curly Leaf Pondweed (CLP): based of release rates from Roesler (2008).

SEPTIC TANK DATA

Description		Low	Most Likely	High	Loading %
Septic Tank Output (kg/capita-year)		0.30	0.50	0.80	
# capita-years	80.0				
% Phosphorus Retained by Soil		98.0	76.0	80.0	
Septic Tank Loading (kg/year)		0.48	9.60	12.80	1.2

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	869.2	1831.2	2808.6	100.0
Total Loading (kg)	394.3	830.6	1274.0	100.0
Areal Loading (lb/ac-year)	5.27	11.10	17.02	
Areal Loading (mg/m^2-year)	590.47	1243.96	1907.88	
Total PS Loading (lb)	429.9	668.4	712.1	36.5
Total PS Loading (kg)	195.0	303.2	323.0	36.5
Total NPS Loading (lb)	423.5	1097.5	1921.0	62.3
Total NPS Loading (kg)	192.1	497.8	871.4	62.3

Septic Tank Output

Capita-years: estimate based off Lake User Survey conducted as part of Phase I of this project.

Capita-years = (average # of residents per household) x (average fraction of year inhabited) x (households),

where the number of households was estimated from analysis of orthophotos – approximately 70 households – and groundwater flow map (Zaporozec, 1987) – 5 households with groundwater flow away from lake.

80 capita-years = 2.8 persons x 0.44 year (160.8 days) x 65 households

Phosphorus Retained by Soil lowered to 76 to reflect moderately-high soil fertility.

Phosphorus Prediction and Uncertainty Analysis Module

Date: 12/6/2010 Scenario: 2
Observed spring overturn total phosphorus (SPO): 131.0 mg/m^3
Observed growing season mean phosphorus (GSM): 67.0 mg/m^3
Back calculation for SPO total phosphorus: 131 mg/m^3
Back calculation GSM phosphorus: 67 mg/m^3
% Confidence Range: 70%
Nurenberg Model Input - Est. Gross Int. Loading: 0 kg

Highlight indicates observed 2009 growing season mean total phosphorus and best-fit model (Canfield and Bachman 1981 natural-lake).

Lake Phosphorus Model	Low Total P (mg/m^3)	Most Likely Total P (mg/m^3)	High Total P (mg/m^3)	Predicted -Observed (mg/m^3)	% Dif.
Walker, 1987 Reservoir	25	52	80	-15	-22
Canfield-Bachmann, 1981 Natural Lake	38	69	95	2	3
Canfield-Bachmann, 1981 Artificial Lake	33	55	72	-12	-18
Rechow, 1979 General	27	56	86	-11	-16
Rechow, 1977 Anoxic	56	117	180	50	75
Rechow, 1977 water load<50m/year	38	80	122	13	19
Rechow, 1977 water load>50m/year	N/A	N/A	N/A	N/A	N/A
Walker, 1977 General	42	89	137	-42	-32
Vollenweider, 1982 Combined OECD	32	58	83	-41	-41
Dillon-Rigler-Kirchner	23	47	73	-84	-64
Vollenweider, 1982 Shallow Lake/Res.	26	50	73	-49	-49
Larsen-Mercier, 1976	40	84	128	-47	-36
Nurnberg, 1984 Oxic	30	63	96	-4	-6

Lake Phosphorus Model	Confidence Lower Bound	Confidence Upper Bound	Parameter Fit?	Back Calculation (kg/year)	Model Type
Walker, 1987 Reservoir	30	77	FIT	1070	GSM
Canfield-Bachmann, 1981 Natural Lake	21	199	FIT	790	GSM
Canfield-Bachmann, 1981 Artificial Lake	17	158	FIT	1110	GSM
Rechow, 1979 General	31	86	FIT	987	GSM
Rechow, 1977 Anoxic	69	172	FIT	474	GSM
Rechow, 1977 water load<50m/year	45	121	P	699	GSM
Rechow, 1977 water load>50m/year	N/A	N/A	N/A	N/A	N/A
Walker, 1977 General	44	149	FIT	1221	SPO
Vollenweider, 1982 Combined OECD	28	100	FIT	1583	ANN
Dillon-Rigler-Kirchner	28	70	P	2293	SPO
Vollenweider, 1982 Shallow Lake/Res.	24	85	FIT	1829	ANN
Larsen-Mercier, 1976	51	120	P Pin	1301	SPO
Nurnberg, 1984 Oxic	32	101	P	890	ANN

Appendix B

Comprehensive Lake Management Plan Implementation Schedule

Timeline of Recommended Activities in the Poskin Lake Comprehensive Management Plan									
Goal	**Objective**	**Action**	**Facilitator**	**Grant Eligible**	**Year One**	**Year Two**	**Year Three**	**Year Four**	**Year Five**
Reduce nuisance algal blooms	Reduce external phosphorus loading	Identify and promote watershed BMPs	PLA/WDNR/County	yes	x	x	x	x	x
		Identify and promote riparian BMPs	PLA/WDNR/County	yes	x	x	x	x	x
		Planning and implementation	PLA/WDNR/County/Consultant	yes	x	x			
	Reduce internal phosphorus loading	Increase the flushing rate by dam modification	PLA/WDNR/County	no	x	x			
		Evaluate zooplankton and algal communities	PLA/Consultant	yes		x	?		
Better understanding of hydrology	Citizen-based water quality monitoring	Expanded Citizen Lake Monitoring Network (CLMN)	PLA/UWEx	yes	x	x	x	x	x
and water quality		Citizen-based Stream Monitoring (CBSM) program	PLA/UWEx	yes	x	x	x	x	x
	More knowledge of water quantity and quality	Develop a hydrologic understanding of the watershed	PLA/Consultant/WDNR	yes	x	x	?	?	?
		Develop an understanding water quality in the watershed	PLA/Consultant/WDNR	yes	x	x	?	?	?
AIS and native plant management	Implement APM Plan	Review APM plan at least annually and update as necessary	PLA/Consultant	yes	x	x	x	x	x
AIS Prevention	Watercraft inspection	Clean Boats Clean Waters (CBCW) program	PLA/UWEx	yes	x	x	x	x	x
	AIS monitoring	CLMN AIS monitoring program	PLA/UWEx	yes	x	x	x	x	x
	AIS identification training	Train interested parties	PLA	no	?	x	x	x	x
Maintain fishery	Minimize management activity impacts	Identify Sensitive Areas and Critical Habitat	PLA/WDNR	yes					
Education and involvement	Promote good lake stewardship	Showcase existing good lake stewardship activities	PLA	no	x	x	x	x	x
		Sponsor an annual Lake Fair	PLA	no	x	x	x	x	x
	Increase public information and involvement	Develop and provide public educational materials	PLA/WDNR/County	yes	x	x			
		Develop and design signage	PLA	yes	x	?			
		Build and install signage	PLA	yes	x	?			
	Formation of a Lake District	PLA committee to explore the formation of a Lake District	PLA	no	x				
		Form a Lake District	PLA	no		?	x		
	Zoning and local ordinance reviews	Assign a temporary dam monitor and operator	PLA/County	no	x				
		PLA committee to analyze local ordinances	PLA	yes	x				
		Make recommendations for local ordinances to protect lake	PLA	--		x			
Assessment and Evaluation	Annual activity and assessment reports	Revise and update annual plans	Consultant/PLA	yes	x	x	x	x	x
	End of Project summary reports	Review of successes and failures	Consultant/PLA	yes					x
		Revise comprehensive plan	Consultant/PLA	yes					x

Abbreviations: PLA, Poskin Lake Association
County, Barron County governmental offices
WDNR, WI Department of Natural Resources
UWEx, University of Wisconsin - Extension