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Waushara County Lakes Study Witters Lake

Final Report
to Waushara County and
Wisconsin Department of Natural Resources

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WITTERS LAKE STUDY RESULTS

WAUSHARA COUNTY LAKES STUDY BACKGROUND

Lakes and rivers contribute to the way of life in Waushara County. Local residents and visitors alike enjoy fishing, swimming, boating, wildlife viewing, and the peaceful nature of the lakes. Healthy lakes add value to our communities. They provide places to relax and recreate, and they can stimulate tourism. Like other infrastructure in our communities, lakes require attention and good management practices to remain healthy in our developing watersheds.

Thirty-three lakes in Waushara County were selected for this study. The study focused on learning about the lakes' water quality, aquatic plant communities, shoreland habitats, watersheds and histories in order to help people make informed lake management decisions. This report summarizes data collected for Witters Lake between fall 2010 and fall 2012.

ABOUT WITTERS LAKE

To understand a lake and its potential for water quality, fish and wildlife, and recreational opportunities, we need to understand its physical characteristics and setting within the surrounding landscape. Witters Lake is located in the township of Dakota, south of the Wautoma municipal airport, and west of Highway 22. There is one public boat launch located on the lake's eastern side. Witters Lake is a 43-acre seepage lake with surface runoff and groundwater contributing most of its water. Its maximum depth is 17 feet; the lakebed has a gradual to moderate slope resulting in an average depth of 4 feet in most of the lake (Figure 1). Its bottom sediments are mostly muck. Witters Lake has a water residence time of 18 months, which helps determine the potential effects of nutrients entering the lake and the length of time pollutants may stay in the lake.

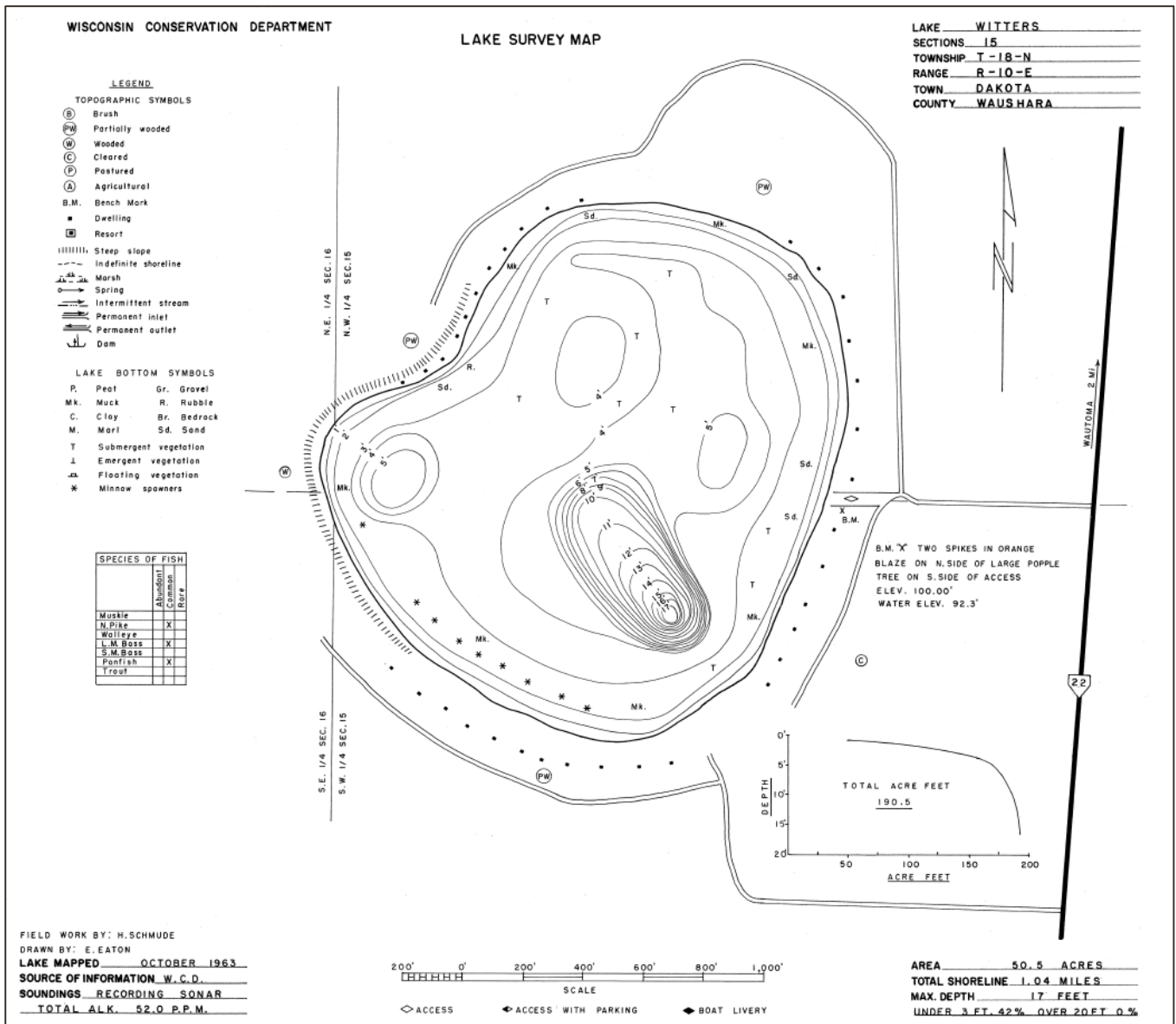


FIGURE 1. CONTOUR MAP OF THE WITTERS LAKE LAKEBED.

The water quality in Witters Lake is a reflection of the land that drains to it. The water quality, the amount of algae, aquatic plants, the fishery and other animals in the lake are all affected by natural and manmade characteristics. Natural characteristics that affect a lake include the amount of land that drains to the lake, the hilliness of the landscape, types of soil, extent of wetlands, and the type of lake. Within the lake's watershed, alterations to the landscape, the types of land use, and the land management practices are examples of how people may affect the lake.

It is important to understand where Witters Lake's water originates in order to understand the lake's health. During snowmelt or a rainstorm, water moves across the surface of the landscape (runoff) towards lower elevations such as lakes, streams, and wetlands. The land area that contributes runoff to Witters Lake is called a surface watershed. Groundwater also feeds Witters Lake; its land area may be slightly different than the surface watershed. The surface watershed is shown in Figure 2.

The capacity of the landscape to shed or hold water and contribute or filter particles determines the amount of erosion that may occur, the amount of groundwater feeding a lake, and ultimately, the lake's water quality and quantity. Essentially, landscapes with a greater capacity to hold water during rain events and snowmelt help to slow the delivery of the water to the lake. Minimizing excess runoff is desirable because it allows more water to recharge the groundwater, which feeds the lake year-round - even during dry periods or when the lake is covered with ice.

Land use and land management practices within a lake's watershed can affect both its water quantity and quality. While forests and grasslands allow a fair amount of precipitation to soak into the ground, resulting in more groundwater and better water quality, other types of land uses may result in increased runoff and less groundwater recharge, and may be sources of pollutants that can impact the lake and its inhabitants. Areas of land with exposed soil can produce soil erosion. Soil entering the lake can make the water cloudy and cover fish spawning beds. Soil also contains nutrients that increase the growth of algae and aquatic plants. Development on the land often results in changes to natural drainage patterns, alterations to vegetation on the landscape, and may be a source of pollutants. Impervious (hard) surfaces such as roads, rooftops, and compacted soil prevent rainfall from soaking into the groundwater, which may result in more runoff that carries pollutants to the lake. Wastewater, animal waste, and fertilizers used on lawns, gardens and crops can contribute nutrients that enhance the growth of algae and aquatic plants in our lakes.

A variety of land management practices can be put in place to help reduce impacts to our lakes. Some practices are designed to reduce runoff. These include protecting/restoring wetlands, installing rain gardens, swales, rain barrels, and routing drainage from pavement and roofs away from the lake. Some practices are used to help reduce nutrients from moving across the landscape towards the lake. Examples include manure management practices, eliminating/reducing the use of fertilizers, increasing the distance between the lake and a septic drainfield, protecting/restoring native vegetation in the shoreland, and using erosion control practices. Waushara County staff and other professionals can work with landowners to determine which practices are best suited to a particular property.

WITTERS LAKE SURFACE WATERSHED

The surface watershed for Witters Lake is approximately 521 acres (Figure 2). The dominant types of land use in the watershed are agriculture (30%) and developed land (29%). The land closest to the lake often has the greatest impact on water quality and habitat; Witters Lake's shoreland is surrounded primarily by wetlands, agriculture, developed land, and forests.

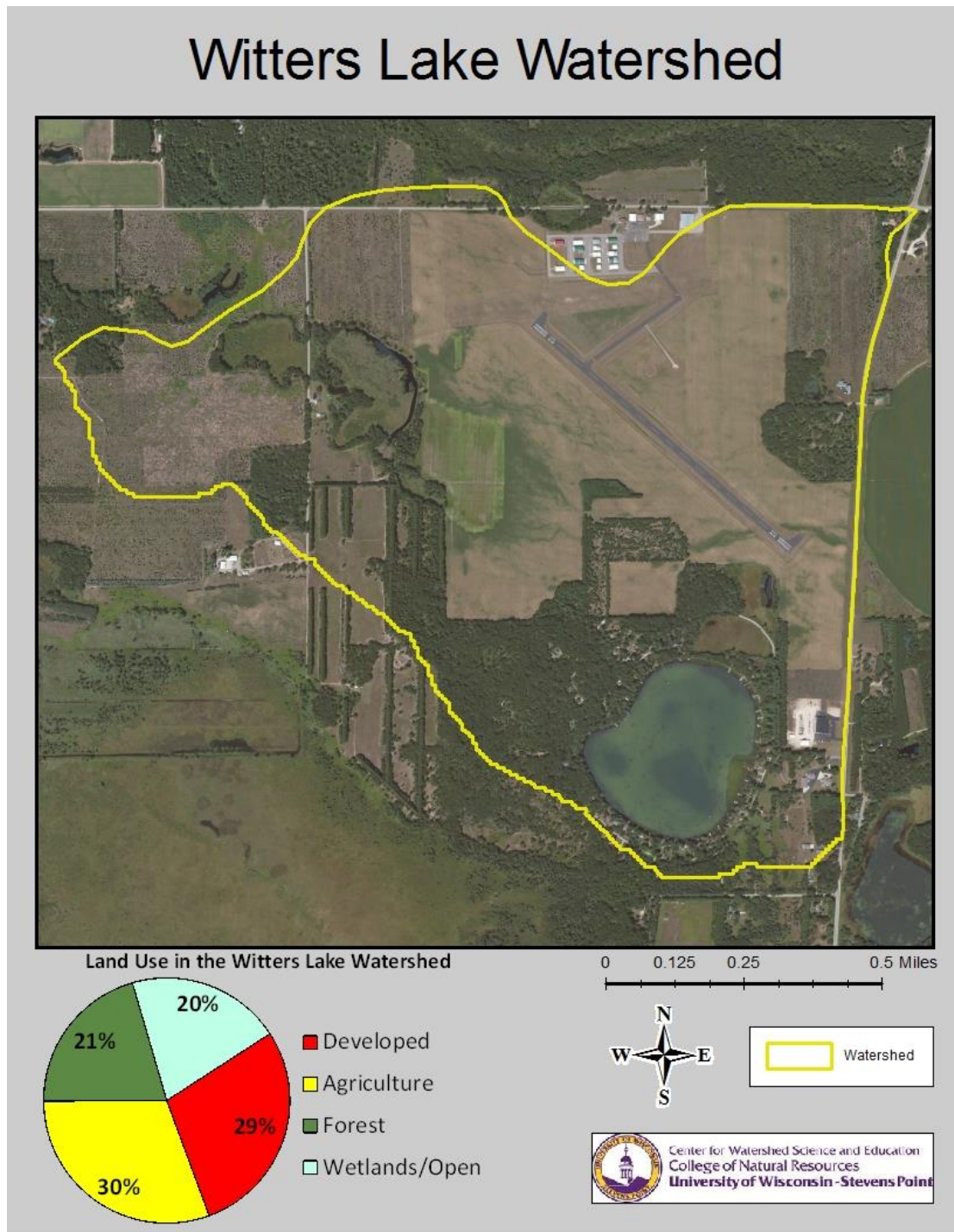


FIGURE 2. LAND USE IN THE WITTERS LAKE SURFACE WATERSHED.

WITTERS LAKE GROUNDWATER

The more the lake's water interacts with groundwater, the more influence the geology has on the lake. The length of time water remains below ground affects the temperature and chemistry of the groundwater. Groundwater temperature is near constant year round; during the summer, groundwater feeding Witters Lake will help keep the lake water cooler.

Groundwater flows below ground from higher to lower elevations, discharging into wetlands, streams, and lakes. The groundwater feeding the lakes in Waushara County originates nearby. The black arrows in Figure 3 indicate the general direction of groundwater flow. Much of the groundwater enters Witters Lake from the northwest.

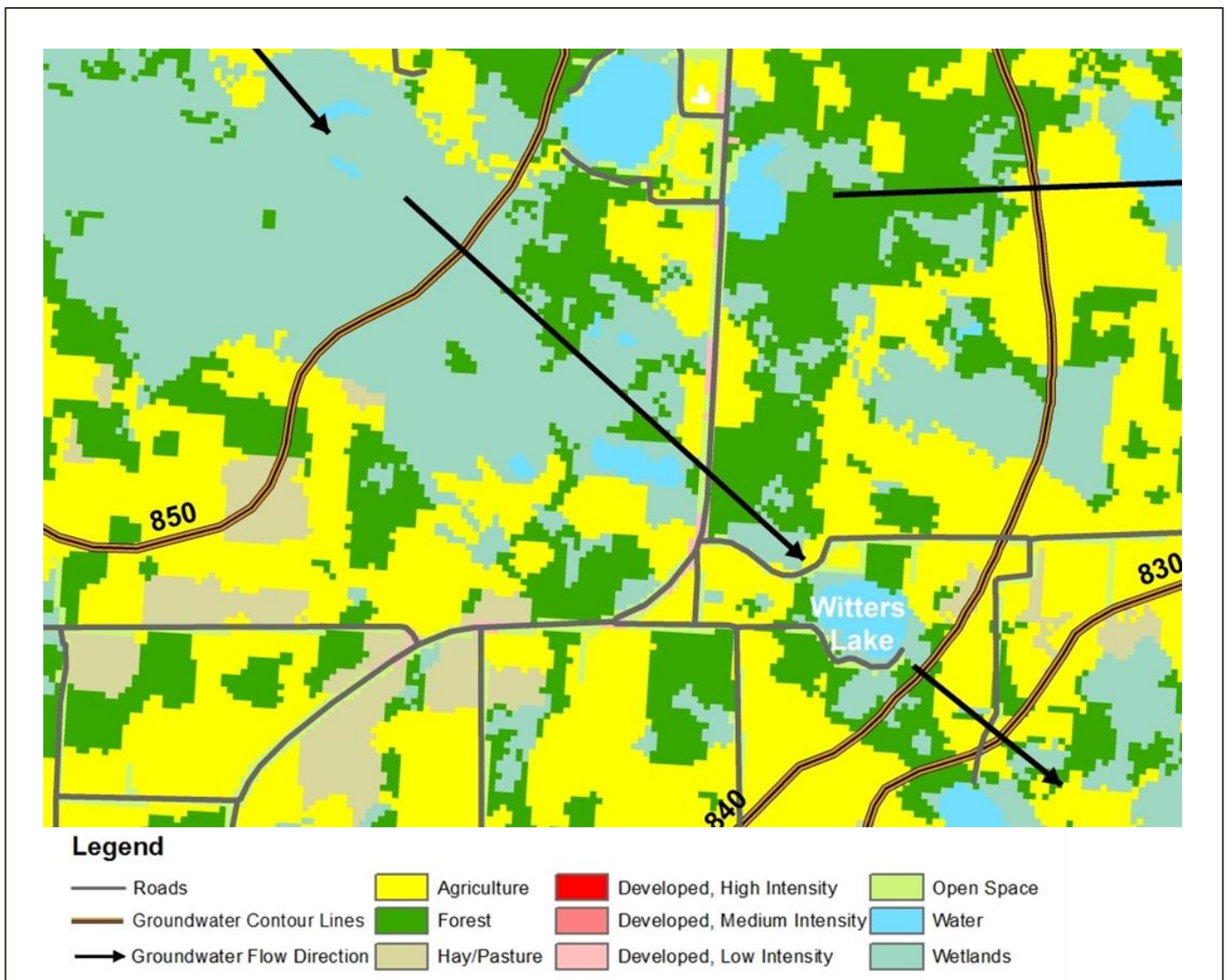
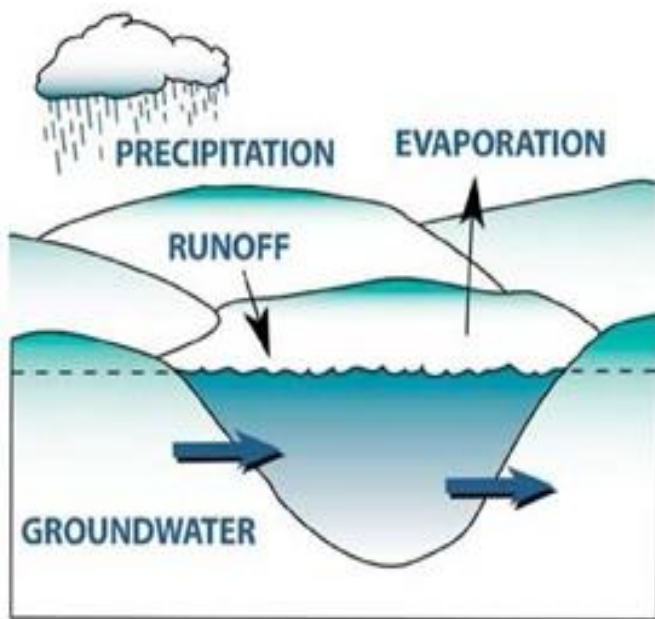


FIGURE 3. GROUNDWATER FLOW DIRECTION NEAR WITTERS LAKE.

WATER QUALITY

Lake water quality is a result of many factors including the underlying geology, the climate, and land management practices. Assessing lake water quality allows us to evaluate current lake health and changes from the past. We can then identify what is needed to achieve a more desirable state or preserve an existing state for aesthetics, recreation, wildlife and the fishery. During this study, water quality in Witters Lake was assessed by measuring different characteristics including temperature, dissolved oxygen, water clarity, water chemistry, and algae.

The source of a lake’s water supply is important in determining its water quality and choosing management practices to preserve or influence that quality. Witters Lake is classified as a seepage lake, or a lake that receives its water primarily through groundwater, and, to a lesser extent, direct runoff and precipitation (Figure 4). Seepage lakes have higher concentrations of minerals such as calcium and magnesium, which are picked up by groundwater moving through soil and rock. Seepage lakes generally have longer retention time (length of time water remains in the lake) which affects contact time with nutrients that feed the growth of algae and aquatic plants. Seepage lakes are also more vulnerable to contamination moving towards the lake in the groundwater. Examples for Witters Lake may include septic systems, agriculture, and road salt.



The geologic composition that lies beneath a lake has the ability to influence the temperature, pH, minerals, and other properties in a lake (Shaw et al., 2000). As groundwater moves, some substances are filtered out, but other materials in the soil dissolve into the groundwater. Minerals such as calcium and magnesium in the soil around Witters Lake are dissolved in the water. The average hardness for Witters Lake during the 2010-2012 sampling period was 102 mg/L, which is considered moderately hard (Table 1). Hard water provides calcium necessary for building bones and shells for animals in the lake. The average alkalinity was 100 mg/L; higher alkalinity in inland lakes can support higher species productivity. Hardness and alkalinity also play a role in the type of aquatic plants found in a lake (Wetzel, 2001).

FIGURE 4. CARTOON SHOWING INFLOW AND OUTFLOW OF WATER IN A SEEPAGE LAKE.

TABLE 1. MINERALS AND PHYSICAL MEASUREMENTS IN WITTERS LAKE, 2010-2012.

Witters Lake	Alkalinity (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Hardness (mg/L as CaCO ₃)	Color (SU)	Turbidity (NTU)
Average Value	100	20.6	11.6	102	12.9	1.63

Chloride concentrations, and to lesser degrees sodium and potassium concentrations, are commonly used as indicators of how a lake is being impacted by human activity. The presence of these compounds where they do not naturally occur indicates sources of water contaminants.

Witters Lake had low average concentrations of potassium, chloride, and sodium over the monitoring period (Table 2). Atrazine, an herbicide commonly used on corn, was below the detection limit (<0.01 ug/L DACT) in samples analyzed from Witters Lake.

TABLE 2. WITTERS LAKE AVERAGE WATER CHEMISTRY, 2010-2012.

Witters Lake	Average Value			Reference Value		
	Low	Medium	High	Low	Medium	High
Potassium (mg/L)	0.33			<.75	0.75-1.5	>1.5
Chloride (mg/L)	1.8			<3	3.0-10.0	>10
Sodium (mg/L)	1.3			<2	2.0-4.0	>4

Dissolved oxygen is an important measure in aquatic ecosystems because a majority of organisms in the water depend on oxygen to survive. Oxygen is dissolved into the water from contact with the air, which is increased by wind and wave action. Algae and aquatic plants also produce oxygen when sunlight enters the water, but the decomposition of dead plants and algae reduces oxygen in the lake. Some forms of iron and other metals carried by groundwater can also consume oxygen when the groundwater discharges to the lake.

In a lake, the water temperature changes throughout the year and may vary with depth. During winter and summer when lakes stratify (layer), the amount of dissolved oxygen is often lower towards the bottom of the lake. Dissolved oxygen concentrations below 5 mg/L can stress some species of cold water fish and over time can reduce the amount of available habitat for sensitive cold water species of fish and other aquatic organisms.

Water temperature and dissolved oxygen were measured in Witters Lake from the water surface down to 14 feet at the time of sample collection during the 2010-2012 study. During most of the year, temperatures in Witters Lake were consistent from top to bottom (Figure 5).

In October 2011 and December 2012, dissolved oxygen concentrations were uniform from the surface down to 14 feet; however, they were below 5 mg/L (Figure 6). In November 2010, dissolved oxygen concentrations were low in the water closer to the surface, but increased at depths of 6 feet, and again at 12 feet. In February 2011, only the upper two feet of water had dissolved oxygen concentrations above 5 mg/L. Throughout the growing season, dissolved oxygen concentrations were consistently above 5 mg/L. Although there was some variability in concentrations during the summer, the lake was never strongly stratified. Weakly stratified lakes can be prone to mixing throughout the summer which may cause a periodic increase in phosphorus in the water column.

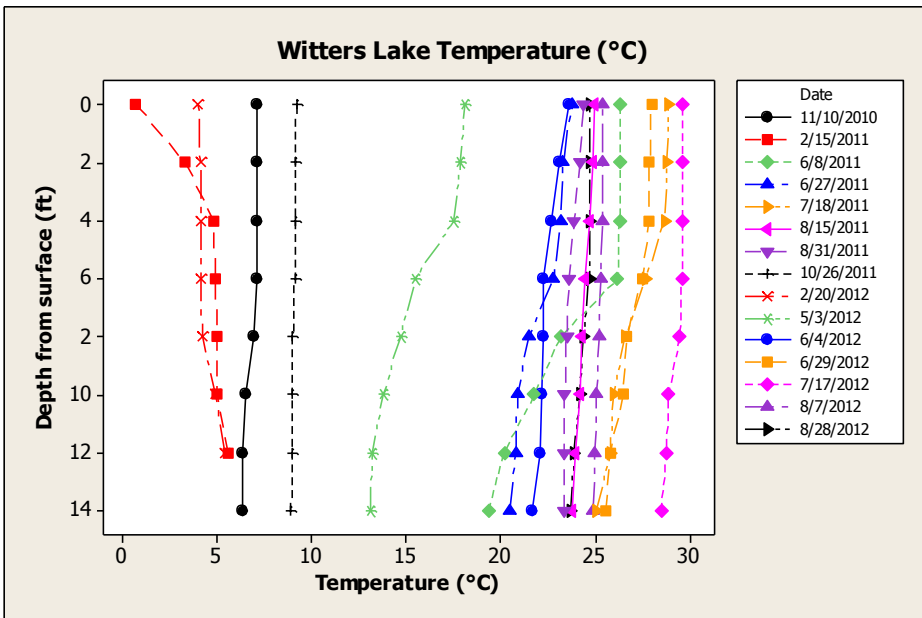


FIGURE 5. TEMPERATURE PROFILES IN WITTERS LAKE, 2010-2012.

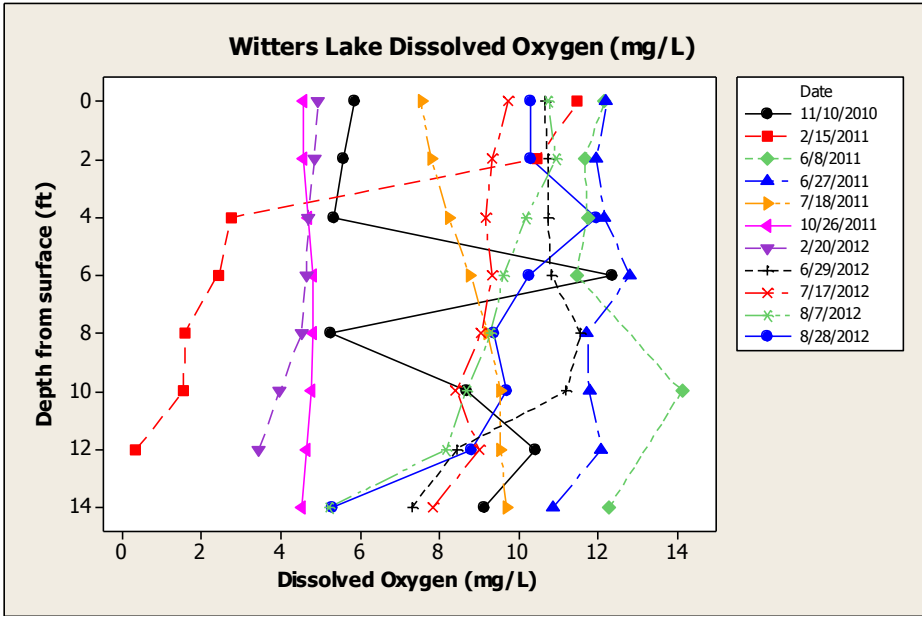


FIGURE 6. DISSOLVED OXYGEN PROFILES IN WITTERS LAKE, 2010-2012.

Water clarity is a measure of the depth that light can penetrate into the water. It is an aesthetic measure and is also related to the depth that rooted aquatic plants can grow. Water clarity is affected by water color, turbidity (suspended sediment), and algae, so it is normal for water clarity to change throughout the year and from year to year.

In Witters Lake, color was relatively low (Table 1), so the variability in transparency throughout the year is primarily due to fluctuating algae concentrations and suspended sediment. Water clarity in Witters Lake was considered good, ranging from 5.5 feet to 16.5 feet and averaging 11 feet over the monitoring period (Figure 7). When compared with historic data, the average water clarity measured during the study was slightly poorer for most months and quite a bit poorer in June and August. Water clarity in Witters Lake is typically poorest in late summer.

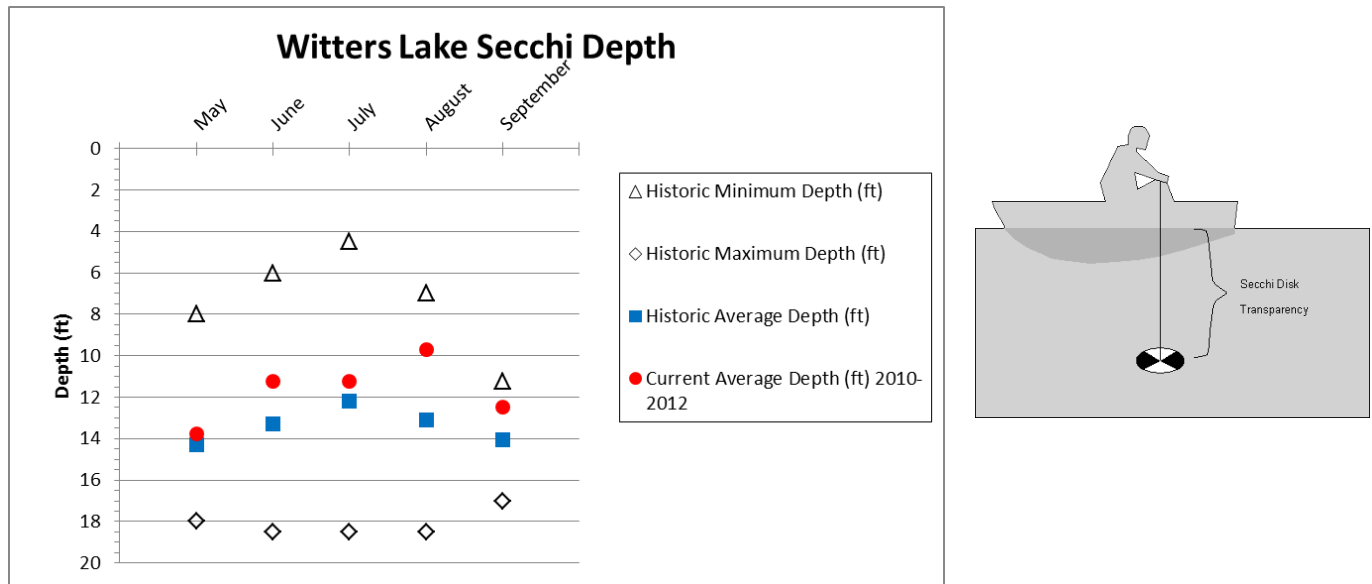


FIGURE 7. WATER CLARITY IN WITTERS LAKE, 2010-2012 AND HISTORIC.

Nutrients (phosphorus and nitrogen) are used by algae and aquatic plants for growth. Phosphorus is present naturally throughout the watershed in soil, plants, animals and wetlands. Common sources from human activities include soil erosion, animal waste, fertilizers and septic systems.

It is most common for phosphorus to move from the land to the water through surface runoff, but it can also travel to the lake in groundwater. Once in a lake, a portion of the phosphorus becomes part of the aquatic system in the form of plant and animal tissue, and sediment. The phosphorus continues to cycle within the lake for many years.

During the study, total phosphorus concentrations in Witters Lake ranged from a high of 27 ug/L in May 2012 to a low of 6 ug/L in February 2011 (Table 3). The summer median total phosphorus concentrations were 21 and 16 ug/L in 2011 and 2012, respectively. These are below Wisconsin’s phosphorus standard of 40 ug/L for shallow seepage lakes. Inorganic nitrogen concentrations in Witters Lake were low during the spring; however, they were very high in a sample collected in October 2011 and slightly elevated in a sample collected in February 2011.

Chlorophyll *a* is a measurement of algae in the water. Chlorophyll *a* concentrations in samples collected from Witters Lake varied only slightly throughout the study, ranging from a high of 3 ug/L to a low of 1 ug/L. The average for the monitoring period was 1.8 ug/L.

TABLE 3. SEASONAL SUMMARY OF NUTRIENT CONCENTRATIONS IN WITTERS LAKE, 2010-2012.

Witters Lake	Inorganic Nitrogen (mg/L)			Soluble Reactive Phosphorus (ug/L)			Total Phosphorus (ug/L)		
	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
Fall	0.03	2.65	5.27	4	4	4	21	21	21
Spring	0.09	0.11	0.13	1	2	2	12	20	27
Summer							9	17	26
Winter	0.32	0.32	0.32	0	1	1	6	10	14

Estimates of phosphorus from the landscape can help to understand the phosphorus sources to Witters Lake. Land use in the surface watershed was evaluated and used to populate the Wisconsin Lakes Modeling Suite (WILMS) model. In general, each type of land use contributes different amounts of phosphorus in runoff and through groundwater. The types of land management practices that are used and their distances from the lake also affect the contributions to the lake from a parcel of land. Modeling results indicated agriculture and developed land had the greatest percentages of phosphorus contributions from the watershed to Witters Lake (Figure 8). The phosphorus contributions by land use category, called phosphorus export coefficients, are shown in Table 4. The phosphorus export coefficients have been obtained from studies throughout Wisconsin (Panuska and Lillie, 1995).

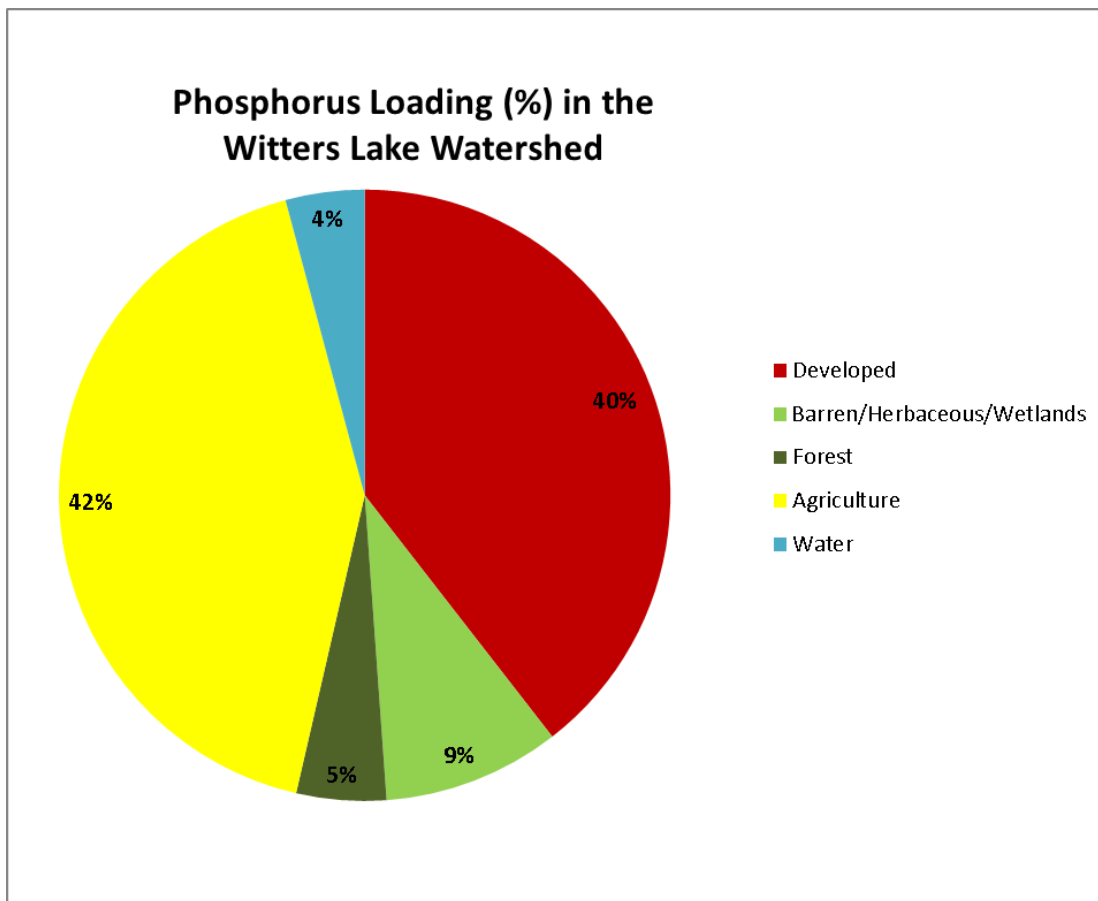


FIGURE 8. ESTIMATED PHOSPHORUS LOADS FROM LAND USES IN THE WITTERS LAKE WATERSHED.

TABLE 4. MODELING DATA USED TO ESTIMATE PHOSPHORUS INPUTS FROM LAND USES IN THE WITTERS LAKE WATERSHED (LOW AND MOST LIKELY COEFFICIENTS USED TO CALCULATE RANGE IN POUNDS).

Witters Lake Land Use	Phosphorus Export Coefficient (lbs/acre-yr)	Land Use Area Within the Watershed		Phosphorus Load	
		Acres	Percent	Pounds	Percent
Water	0.1	44	8	4-11	4
Developed	0.27	136	26	36-73	40
Barren/Herbaceous/Wetland	0.09	97	19	9-26	9
Forest	0.04	98	19	4-9	5
Cultivated Agriculture	0.45	146	28	39-104	42

*Values are not exact due to rounding and conversion.

AQUATIC PLANTS

Aquatic plants are the forested landscape within a lake. They provide food and habitat for a wide range of species including fish, waterfowl, turtles, amphibians, as well as invertebrates and other aquatic animals. They improve water quality by releasing oxygen into the water and utilizing nutrients that would otherwise be used by algae. A healthy lake typically has a variety of aquatic plant species, creating diversity that makes the aquatic plant community more resilient and helps to prevent the establishment of non-native aquatic species.

During the 2011 aquatic plant survey of Witters Lake, eight species of aquatic plants were found (Table 5). The greatest plant diversity was found in the southern shallows of the lake (Figure 9). Ninety-nine percent (147 of 149) of the sampled sites had vegetative growth. Of the sampled sites within Witters Lake, the average depth was six feet and the maximum depth with rooted vegetation was 22 feet.

TABLE 5. AQUATIC PLANTS IDENTIFIED IN THE AQUATIC PLANT SURVEY OF WITTERS LAKE, 2011.

Scientific Name	Common Name	Coefficient of Conservatism Value	% Frequency of Occurrence
Submergent Species			
<i>Chara</i> , spp.	muskgrass	7	81.6
<i>Elodea canadensis</i>	common waterweed	3	36.7
<i>Potamogeton foliosus</i>	leafy pondweed	6	2.7
<i>Potamogeton gramineus</i>	variable pondweed	7	1.4
<i>Potamogeton illinoensis</i>	Illinois pondweed	6	64
<i>Potamogeton zosteriformis</i>	flat-stem pondweed	6	2
<i>Stuckenia pectinata</i>	sago pondweed	6	6.1
<i>Vallisneria americana</i>	wild celery	3	21.8

The dominant plant species in the survey was muskgrass (*Chara* spp.), followed by Illinois pondweed (*Potamogeton illinoensis*) and common waterweed (*Elodea canadensis*). Muskgrass is a favorite food source for a wide variety of waterfowl, and muskgrass beds offer cover and food to fish, especially young trout, largemouth bass, and smallmouth bass. Illinois pondweed is an important food source for a variety of waterfowl, and common waterweed is a potential food source for muskrat. Both submerged species also offer shade and cover to fish, and habitat to invertebrates (Borman et al., 2001).

The Floristic Quality Index (FQI) evaluates how close a plant community is to undisturbed conditions. Each plant is assigned a coefficient of conservatism (C-value) that reflects its sensitivity to disturbance. These numbers are used to calculate the FQI. C-values range from 0 to 10. The higher the number, the more intolerant the plant is of disturbance. A C-value of zero is assigned to non-native species. The C-values for aquatic plants in Witters Lake ranged from 3 to 7, with an average C-value of 5.5 (Table 5).

The FQI for Witters Lake was 15.6, which is low when compared with other lakes in the Waushara County Lakes Study. No species of special concern in Wisconsin were observed.

The Simpson Diversity Index (SDI) quantifies biodiversity based on a formula that uses the number of species surveyed and the number of individuals per site. Witters Lake had an SDI value of 0.73. This represents below average biodiversity when compared with other lakes in the Waushara County Lakes Study.

The absence of non-native aquatic plant species in Witters Lake is a good indicator of overall aquatic health within the lake, and it demonstrates diligence by lake users in cleaning watercraft before entering the lake in order to prevent non-native species transfer.

Witters Lake Aquatic Plant Survey 2011: Species Richness

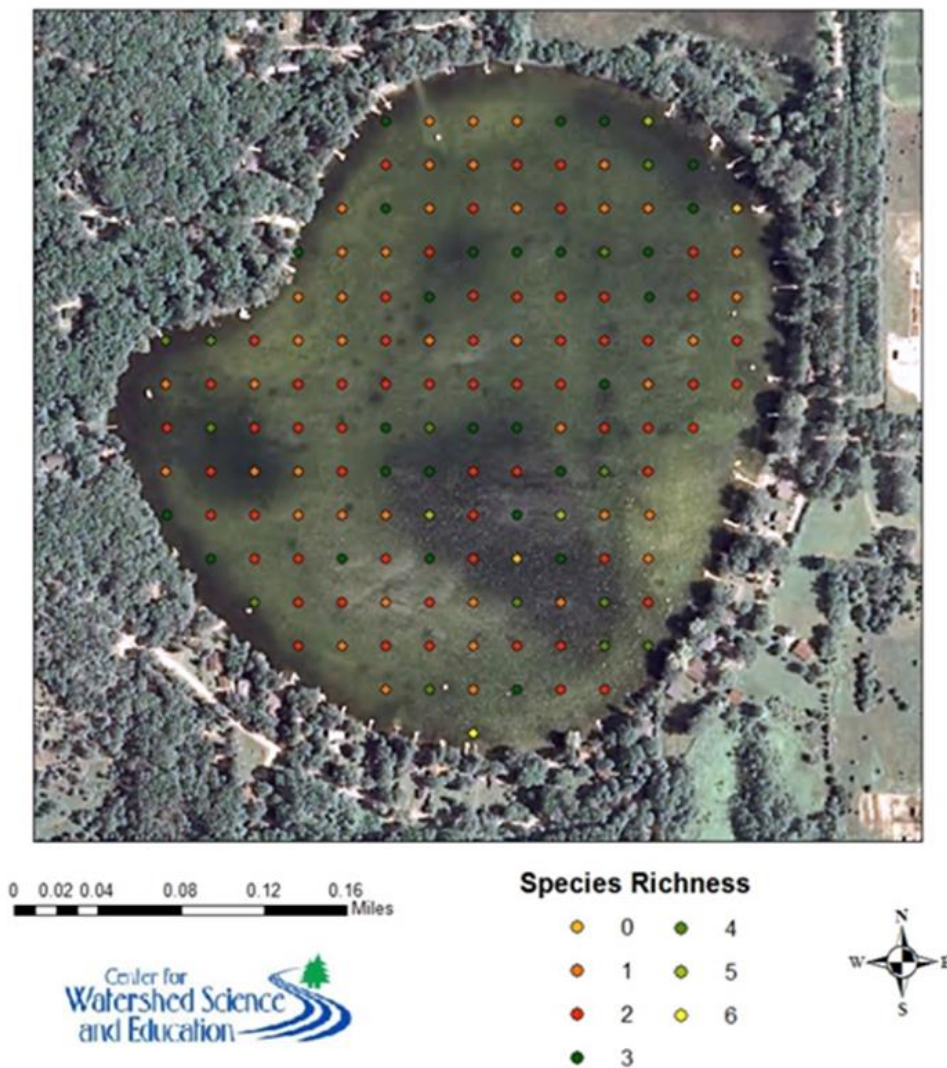


FIGURE 9. NUMBER OF AQUATIC PLANT SPECIES OBSERVED AT EACH SAMPLE SITE IN WITTERS LAKE, 2011.

SHORELAND

Shoreland vegetation is critical to a healthy lake’s ecosystem. It provides habitat for many aquatic and terrestrial animals including birds, frogs, turtles, and many small and large mammals. It also helps to improve the quality of the runoff that is flowing across the landscape towards the lake. Healthy shoreland vegetation includes a mix of tall grasses/flowers, shrubs and trees which extend at least 35 feet landward from the water’s edge.

To better understand the health of the Waushara County lakes, shorelands were evaluated by professionals from the Center for Land Use Education and Waushara County as a part of the Waushara County Lakes Study. The survey inventoried the type and extent of shoreland vegetation. Areas with erosion, rip-rap, barren ground, seawalls, structures and docks were also inventoried.

A scoring system was developed for the collected data to provide a more holistic assessment. Areas that are healthy will need strategies to keep them healthy, and areas with potential problem areas and where management and conservation may be warranted may need a different set of strategies for improvement. The scoring system is based on the presence/absence and abundance of shoreline features, as well as their proximity to the water’s edge. Values were tallied for each shoreline category and then summed to produce an overall score. Higher scores denote a healthier shoreline with good land management practices. These are areas where protection and/or conservation should be targeted. On the other hand, lower scores signify an ecologically unhealthy shoreline. These are areas where management and/or mitigation practices may be desirable for improving water quality.

The summary of scores for shorelands around Witters Lake is displayed in Figure 10. The shorelands were color-coded to show their overall health based on natural and physical characteristics. Blue shorelands identify healthy shorelands with sufficient vegetation and few human disturbances. Red shorelands indicate locations where changes in management or mitigation may be warranted. A few segments of Witters Lake’s shorelands are in good shape, but large segments with challenges exist and should be addressed. One stretch of the southeastern shore of Witters Lake ranked as poor. A summary of shoreland disturbances within 15 feet of the water is displayed in Table 6. For a more complete understanding of the ranking, an interactive map showing results of the shoreland surveys can be found on Waushara County’s website at <http://gis.co.waushara.wi.us/ShorelineViewer/>.

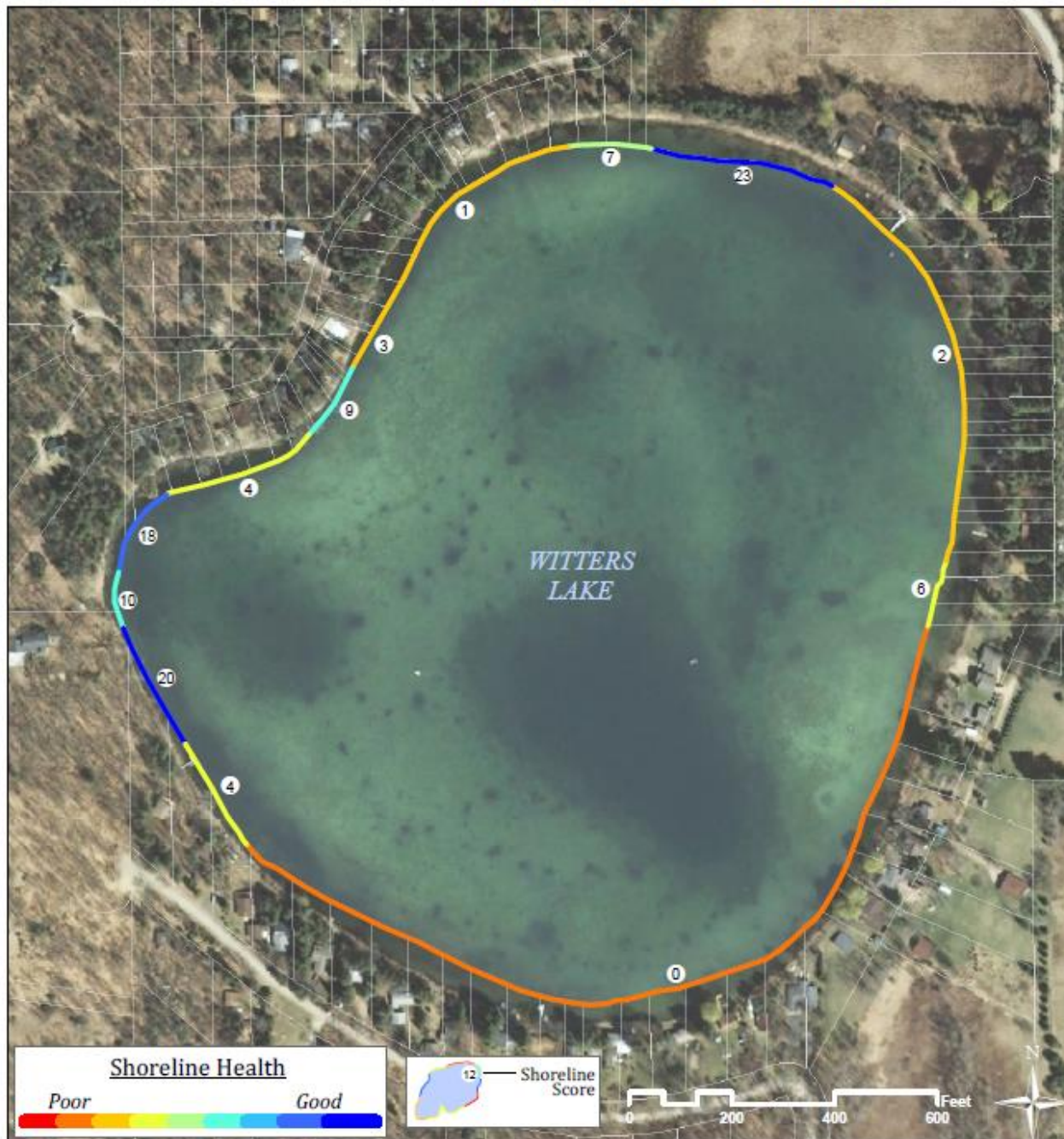
TABLE 6. DISTURBANCES WITHIN 15 FEET OF SHORE AROUND WITTERS LAKE, 2011.

Disturbance	Length of Shoreline	
	Feet	Percent
Artificial beach	1,461	28
Barren, bare dirt	0	0
Boat landing	134	3
Dock/pier at water	4,273	82
Gully erosion	0	0
Undercut banks erosion	0	0
Mowed lawn	3,953	76
Rip-rap	2,341	45
Seawall	3,168	61

Waushara County Shoreline Assessment

Map Date -- July, 2011
Aerial Date -- April, 2010

WITTERS LAKE



Summary

Shorelines are color-coded to show their overall health based on natural and physical characteristics. For example, shorelines shown in red indicate locations where management or mitigation may be warranted. Blue shorelines mark healthy riparian areas with natural vegetation and few human influences.

Calculating Shoreline Scores

Scores are based on the presence/absence of:

- + Natural vegetation
- + Human influences (docks, boathouses, etc)
- + Erosion
- + Structures



Map created by Dan McFarlane
Center for Land Use Education

FIGURE 10. OVERALL SHORELAND HEALTH AROUND WITTERS LAKE, 2011.

CONCLUSIONS & RECOMMENDATIONS

Many of the water quality measurements indicated good overall water quality in Witters Lake. Witters Lake has moderately hard water, which provides calcium for the formation of bones and shells of aquatic organisms and can help to reduce in-lake impacts of phosphorus.

- Witters Lake had low average concentrations of potassium, chloride, and sodium, which are indicators of human impacts from septic systems, fertilizers, and road salt. Atrazine, an herbicide commonly used on corn, was below the detection limit.
- Dissolved oxygen concentrations were low in Witters Lake during the fall and winter. These periodic low concentrations limit the type of fish that can survive and flourish in the lake.

In general, each type of land use contributes different amounts of phosphorus, nitrogen, and pollutants in runoff and through groundwater. The types of land management practices that are used and their distances from the lake affect the contributions to the lake from a parcel of land.

- During the study, the summer median total phosphorus concentrations were 21 and 16 ug/L in 2011 and 2012, respectively. This is below Wisconsin's phosphorus standard of 40 ug/L for shallow seepage lakes.
- Overall, water clarity was good in Witters Lake. Reduced clarity was observed in late summer, likely a result of algal blooms.
- Measurements of algae were low in samples collected from the upper six feet of water.
- Inorganic nitrogen concentrations in Witters Lake were low during the spring; however, they were very high in a sample collected in October 2011 and slightly elevated in a sample collected in February 2011.
 - Sources of nitrate include fertilizers, septic systems, and animal waste.
 - The nitrate is likely moving to the lake in groundwater.
 - Water users around and upgradient of the lake should have the water from their private wells tested to determine if nitrate levels exceed the health standards for drinking water.
 - In a lake, nitrate can be readily used by aquatic plants and some types of algae, increasing their growth.
- Routine monitoring of water quality can help to track changes in Witters Lake. A monitoring plan should be designed and implemented.

Identifying and taking steps to maintain or improve water quality in Witters Lake depends upon understanding the sources of nutrients to the lake and identifying those that are manageable. Modeling results indicated that development and agriculture had the greatest percentages of phosphorus contribution from the watershed to Witters Lake.

- Over-application of chemicals and nutrients should be avoided. Landowners in the watershed should be made aware of their connection to the lake and should work to reduce their impacts through the implementation of water quality-based best management practices.
- Shoreland health is critical to a healthy lake's ecosystem. Witters Lake's shoreland was assessed for the extent of vegetation and disturbances. Shoreland vegetation provides habitat for many aquatic and terrestrial animals, including birds, frogs, turtles, and many small and large mammals. Vegetation also helps to improve the quality of the runoff that is flowing across the landscape towards the lake. Healthy shoreland vegetation includes a mix of tall grasses/flowers, shrubs and

trees extending at least 35 feet inland from the water's edge. Alone, each manmade disturbance may not pose a problem for a lake, but on developed lakes, the collective impact of these disturbances can be a problem for lake habitat and water quality.

- A few segments of Witters Lake's shorelands are in good shape, but large segments with challenges exist and should be addressed. One stretch on the southeastern shore of Witters Lake ranked as poor.
 - Structures such as seawalls, rip-rap (rocked shoreline), and artificial beach can result in habitat loss.
 - Unmanaged runoff from rooftops of structures located near shore can also contribute sediment to the lake.
 - Docks and artificial beaches can result in altered in-lake habitat. Denuded lakebeds provide opportunities for invasive species to become established and reduce habitat that is important to fish and other lake inhabitants.
 - Strategies should be developed to ensure that healthy shorelands remain intact and efforts should be made to improve shorelands that have disturbance. Depending upon the source of the disturbances, erosion should be controlled, vegetation should be restored, and/or excess runoff should be minimized.
 - Dissemination of relevant information to property owners is the recommended first step towards maintaining healthy shorelands.
- The Waushara County Land Conservation Department and USDA Natural Resources Conservation Service (NRCS) have professional staff available to assist landowners interested in learning how they can improve water quality through changes in land management practices.

Aquatic plants are the forested landscape within a lake. They provide food and habitat for a wide range of species including fish, waterfowl, turtles, and amphibians, as well as invertebrates and other aquatic animals. They improve water quality by releasing oxygen into the water and utilizing nutrients that would otherwise be used by algae. A healthy lake typically has a variety of aquatic plant species that creates the diversity needed to make the aquatic plant community more resilient and helps prevent the establishment of non-native aquatic species.

- The diversity of an aquatic plant community is defined by the type and number of species present throughout the lake. Eight species of aquatic plants were found in Witters Lake, which is low compared with other lakes in the Waushara County Lakes Study.
- Ninety-nine percent of the sites sampled had aquatic plants present.
- No aquatic invasive species (AIS) have been found in Witters Lake. It is important to take the following steps to prevent AIS from becoming established in the lake:
 - The amount of disturbed lakebed from raking or pulling plants should be minimized, since these open spaces are "open real estate" for aquatic invasive plants to become established.
 - Early detection of aquatic invasive species (AIS) can help to prevent their establishment should they be introduced into the lake. Boats and trailers that have visited other lakes can be a primary vector for the transport of AIS.
 - Programs are available to help volunteers learn to monitor for AIS and to educate lake users at the boat launch about how they can prevent the spread of AIS.

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GLOSSARY OF TERMS

Algae: One-celled (phytoplankton) or multicellular plants either suspended in water (plankton) or attached to rocks and other substrates (periphyton). Their abundance, as measured by the amount of chlorophyll a (green pigment) in an open water sample, is commonly used to classify the trophic status of a lake. Numerous species occur. Algae are an essential part of the lake ecosystem and provide the food base for most lake organisms, including fish. Phytoplankton populations vary widely from day to day, as life cycles are short.

Atrazine: A commonly used herbicide. Transports to lakes and rivers by groundwater or runoff. Has been shown to have toxic effects on amphibians.

Blue-Green Algae: Algae that are often associated with problem blooms in lakes. Some produce chemicals toxic to other organisms, including humans. They often form floating scum as they die. Many can fix nitrogen (N₂) from the air to provide their own nutrient.

Calcium (Ca⁺⁺): The most abundant cation found in Wisconsin lakes. Its abundance is related to the presence of calcium-bearing minerals in the lake watershed. Reported as milligrams per liter (mg/l) as calcium carbonate (CaCO₃), or milligrams per liter as calcium ion (Ca⁺⁺).

Chloride (Cl⁻): The chloride ion (Cl⁻) in lake water is commonly considered an indicator of human activity. Agricultural chemicals, human and animal wastes, and road salt are the major sources of chloride in lake water.

Chlorophyll a: Green pigment present in all plant life and necessary for photosynthesis. The amount present in lake water depends on the amount of algae, and is therefore used as a common indicator of algae and water quality.

Clarity: See “Secchi disk.”

Color: Color affects light penetration and therefore the depth at which plants can grow. A yellow-brown natural color is associated with lakes or rivers receiving wetland drainage. Measured in color units that relate to a standard. The average color value for Wisconsin lakes is 39 units, with the color of state lakes ranging from zero to 320 units.

Concentration units: Express the amount of a chemical dissolved in water. The most common ways chemical data is expressed is in milligrams per liter (mg/l) and micrograms per liter (ug/l). One milligram per liter is equal to one part per million (ppm). To convert micrograms per liter (ug/l) to milligrams per liter (mg/l), divide by 1000 (e.g. 30 ug/l = 0.03 mg/l). To convert milligrams per liter (mg/l) to micrograms per liter (ug/l), multiply by 1000 (e.g. 0.5 mg/l = 500 ug/l).

Cyanobacteria: See “Blue-Green Algae.”

Dissolved oxygen: The amount of oxygen dissolved or carried in the water. Essential for a healthy aquatic ecosystem in Wisconsin lakes.

Drainage basin: The total land area that drains runoff towards a lake.

Drainage lakes: Lakes fed primarily by streams and with outlets into streams or rivers. They are more subject to surface runoff problems, but generally have shorter residence times than seepage lakes.

Emergent: A plant rooted in shallow water and having most of its vegetative growth above water.

Eutrophication: The process by which lakes and streams are enriched by nutrients, and the resulting increase in plant and algae. The extent to which this process has occurred is reflected in a lake's trophic classification: oligotrophic (nutrient poor), mesotrophic (moderately productive), and eutrophic (very productive and fertile).

Groundwater drainage lake: Often referred to as a spring-fed lake, it has large amounts of groundwater as its source and a surface outlet. Areas of high groundwater inflow may be visible as springs or sand boils. Groundwater drainage lakes often have intermediate retention times with water quality dependent on groundwater quality.

Hardness: The quantity of multivalent cations (cations with more than one +), primarily calcium (Ca⁺⁺) and magnesium (Mg⁺⁺) in the water expressed as milligrams per liter of CaCO₃. Amount of hardness relates to the presence of soluble minerals, especially limestone or dolomite, in the lake watershed.

Intermittent: Coming and going at intervals, not continuous.

Macrophytes: See “Rooted aquatic plants.”

Marl: White to gray accumulation on lake bottoms caused by precipitation of calcium carbonate (CaCO₃) in hard water lakes. Marl may contain many snail and clam shells. While it gradually fills in lakes, marl also precipitates phosphorus, resulting in low algae populations and good water clarity. In the past, marl was recovered and used to lime agricultural fields.

Mesotrophic: A lake with an intermediate level of productivity. Commonly clear water lakes and ponds with beds of submerged aquatic plants and medium levels of nutrients. See also “eutrophication”.

Nitrate (NO₃-): An inorganic form of nitrogen important for plant growth. Nitrate often contaminates groundwater when water originates from manure, fertilized fields, lawns or septic systems. In drinking water, high levels (over 10 mg/L) are dangerous to infants and expectant mothers. A concentration of nitrate-nitrogen (NO₃-N) plus ammonium-nitrogen (NH₄-N) of 0.3 mg/L in spring will support summer algae blooms if enough phosphorus is present.

Oligotrophic: Lakes with low productivity, the result of low nutrients. Often these lakes have very clear waters with lots of oxygen and little vegetative growth. See also “eutrophication”.

Overturn: Fall cooling and spring warming of surface water increases density, and gradually makes lake temperatures and density uniform from top to bottom. This allows wind and wave action to mix the entire lake. Mixing allows bottom waters to contact the atmosphere, raising the water's oxygen content. Common in many lakes in Wisconsin.

Phosphorus: Key nutrient influencing plant growth in more than 80% of Wisconsin lakes. Soluble reactive phosphorus is the amount of phosphorus in solution that is available to plants. Total phosphorus includes the amount of phosphorus in solution (reactive) and in particulate form.

Rooted aquatic plants (macrophytes): Refers to higher (multi-celled) plants growing in or near water. Macrophytes are beneficial to lakes because they produce oxygen and provide substrate for fish habitat and aquatic insects and provide food for many aquatic and terrestrial animals. Overabundance of such plants, especially problem species, is related to shallow water depth and high nutrient levels.

Secchi disk: An 8-inch diameter plate with alternating quadrants painted black and white that is used to measure water clarity (light penetration).

Sedimentation: Materials that are deposited after settling out of the water.

Stratification: The layering of water due to differences in density. As water warms during the summer, it remains near the surface while colder water remains near the bottom. Wind mixing determines the thickness of the warm surface water layer (epilimnion), which usually extends to a depth of about 20 feet. The narrow transition zone between the epilimnion and cold bottom water (hypolimnion) is called the metalimnion. Common in many deeper lakes in Wisconsin.

Watershed: See “Drainage basin.”