Waushara County Lakes Study
Little Silver Lake (Springwater)

Final Report
to Waushara County and
Wisconsin Department of Natural Resources

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LITTLE SILVER 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 Little Silver Lake between fall 2010 and fall 2012.

ABOUT LITTLE SILVER 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. Little Silver Lake is located in the township of Springwater, east of Wild Rose, and south of County Highway A, with one public boat launch located on its southwestern side. Little Silver Lake is a 50-acre seepage lake with surface runoff and groundwater contributing most of its water. Its maximum depth is 56 feet; the lakebed has a moderate to steep slope (Figure 1). Its bottom sediments are mostly muck with a small amount of sand found along the perimeter of the lake.
Figure 1. Contour map of the Little Silver Lake lakebed.
The water quality in Little Silver 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 Little Silver 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 Little Silver Lake is called a surface watershed. Groundwater also feeds Little Silver 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. Less 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 ground, 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.
The surface watershed for Little Silver Lake is approximately 912 acres (Figure 2). The dominant types of land use in the watershed are forests (45%), developed lands (20%), and wetlands (20%). The land closest to the lake often has the greatest impact on water quality and habitat; Little Silver Lake’s shoreland is surrounded primarily by developed land, wetlands and forests.

**Figure 2. Land use in the Little Silver Lake surface watershed.**
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 Little Silver 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 Little Silver Lake from the northwest.

**Figure 3. Groundwater flow direction near Little Silver Lake.**
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 Silver 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. Little Silver Lake is classified as a seepage lake. Seepage lakes receive water primarily through groundwater, and to lesser extents 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 vulnerable to contamination moving towards the lake in the groundwater. Examples for Little Silver 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. As groundwater moves, some substances are filtered out, but some materials in the soil dissolve into the groundwater (Shaw et al., 2000). Minerals such as calcium and magnesium in the soil around Little Silver Lake are dissolved in the water. The average hardness for Little Silver Lake during the 2010-2012 sampling period was 151 mg/L, which is considered hard (Table 1). Hard water provides calcium necessary for building bones and shells for animals in the lake. The average alkalinity was 149 mg/L; higher alkalinity in inland lakes can support higher species productivity. Hardness and alkalinity also play roles in the types of aquatic plants that are found in a lake (Wetzel, 2001).

<table>
<thead>
<tr>
<th>Little Silver Lake</th>
<th>Alkalinity (mg/L)</th>
<th>Calcium (mg/L)</th>
<th>Magnesium (mg/L)</th>
<th>Hardness (mg/L as CaCO₃)</th>
<th>Color (SU)</th>
<th>Turbidity (NTU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Value</td>
<td>149</td>
<td>29.0</td>
<td>17.1</td>
<td>151</td>
<td>10.2</td>
<td>2.10</td>
</tr>
</tbody>
</table>
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. Potassium, chloride and sodium concentrations were slightly elevated in Little Silver Lake (Table 2). While these concentrations are not harmful to aquatic organisms, they indicate that pollutants are entering the lake. Chloride sources include animal waste, septic systems, fertilizer, and road-salting chemicals.

Atrazine, an herbicide commonly used on corn, was detected in one of the samples from Little Silver Lake (0.12 µg/L DACT). Some toxicity studies have indicated that reproductive system abnormalities can occur in frogs at this level (Hayes et al., 2001; Hayes et al., 2003). The presence of this chemical suggests that agricultural activities in the surrounding landscape may be impacting the lake.

### Table 2. Average water chemistry in Little Silver Lake, 2010-2012.

<table>
<thead>
<tr>
<th>Silver Lake (Springwater)</th>
<th>Average Value</th>
<th>Reference Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Potassium (mg/L)</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>Chloride (mg/L)</td>
<td>4.1</td>
<td></td>
</tr>
<tr>
<td>Sodium (mg/L)</td>
<td>3.0</td>
<td></td>
</tr>
</tbody>
</table>

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 Little Silver Lake from the surface to the bottom at the time of sample collection. During the 2010-2012 study, late winter temperatures were fairly consistent with depth, with freezing temperatures at the surface and gradual warming with depth (Figure 5). Temperatures were uniform throughout the water column at the time of sampling in fall. In early May 2012, the lake water was beginning to stratify (layer); the lake remained stratified throughout the summer. The data illustrated the decreasing temperatures with depth in mid-summer: measured temperatures ranged from a high of 28°C (82 °F) at the surface to 8°C (46°F) near the bottom. In fall, concentrations of dissolved oxygen were also uniform throughout the water column (Figure 6). In summer, dissolved oxygen was stratified, with the upper 28 feet always having sufficient concentrations for the fishery. Measurements taken in February 2011 indicated that the upper 15 feet of water contained dissolved oxygen concentrations greater than 5 mg/L.
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 Little Silver Lake, color was low (Table 1), so the variability in transparency throughout the year is primarily due to fluctuating concentrations of algae and re-suspended sediment following storms and/or heavy boating activity.

The water clarity measured in Little Silver Lake was considered good during most of the year, but fair in late summer/early fall. A substantial dataset of water clarity exists for Little Silver Lake, with water clarity measurements reported by citizen monitors dating back to 1996. During the study, water clarity ranged from 3.25 feet to 26 feet (Figure 7). When compared with past data, the average water clarity measured during the study was better in May and November, about the same in June and July, and poorer in August and September. Most of the observations that indicated impaired water occurred in late summer/early fall.

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 Little Silver Lake ranged from a high of 21 ug/L in early September 2011 and May 2012, to a low of 3 ug/L in February 2011 and late August 2012 (Table 3). The summer median total phosphorus concentrations were 12 and 11 ug/L in 2011 and 2012, respectively. This is below Wisconsin’s phosphorus standard of 20 ug/L for deep seepage lakes.
During the study, inorganic nitrogen concentrations were elevated and considered high enough in the spring, winter and fall to enhance algal blooms throughout the summer (Shaw et al., 2000). In a lake like Little Silver Lake, this nitrogen is likely to be entering the lake via the groundwater. Typical sources of inorganic nitrogen are fertilizers, septic systems, and animal waste.

Chlorophyll $a$ is a measurement of algae in the water. Chlorophyll $a$ concentrations in Little Silver Lake varied throughout the monitoring period, ranging from a high of 7 ug/L in June 2011 to a low of 0.5 ug/L in August 2011, July 2012 and August 2012. The average over the monitoring period was 2.3 ug/L.

### Table 3. Seasonal Summary of Nutrient Concentrations in Little Silver Lake, 2010-2012.

<table>
<thead>
<tr>
<th>Little Silver Lake (Springwater)</th>
<th>Inorganic Nitrogen (mg/L)</th>
<th>Organic Nitrogen (mg/L)</th>
<th>Total Nitrogen (mg/L)</th>
<th>Soluble Reactive Phosphorus (ug/L)</th>
<th>Total Phosphorus (ug/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min Avg Max</td>
<td>Min Avg Max</td>
<td>Min Avg Max</td>
<td>Min Avg Max</td>
<td>Min Avg Max</td>
</tr>
<tr>
<td>Fall</td>
<td>0.32 0.32 0.32</td>
<td>0.57 0.57 0.57</td>
<td>1.40 1.40 1.40</td>
<td>5 5 5</td>
<td>11 11 11</td>
</tr>
<tr>
<td>Spring</td>
<td>0.50 0.61 0.71</td>
<td>0.40 0.41 0.41</td>
<td>1.14 1.47 1.79</td>
<td>3 4 5</td>
<td>13 17 21</td>
</tr>
<tr>
<td>Summer</td>
<td>0.47 0.47 0.47</td>
<td>0.52 0.52 0.52</td>
<td>1.60 1.60 1.60</td>
<td>17 17 17</td>
<td>3 3 3</td>
</tr>
<tr>
<td>Winter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Estimates of phosphorus from the landscape can help to understand the phosphorus sources to Little Silver 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. Based on modeling results, developed land and agriculture each accounted for one-third of the phosphorus contribution from the watershed to Little Silver Lake (Figure 8). The phosphorus contribution 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 Little Silver Lake watershed.

**Table 4.** Modeling data used to estimate phosphorus inputs from land uses in the Little Silver Lake watershed (low and most likely coefficients used to calculate range in pounds).

<table>
<thead>
<tr>
<th>Little Silver Lake Land Use</th>
<th>Phosphorus Export Coefficient (lbs/acre-yr)</th>
<th>Land Use Area Within the Watershed</th>
<th>Estimated Phosphorus Load</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Acres</td>
<td>Percent</td>
<td>Pounds</td>
</tr>
<tr>
<td>Water</td>
<td>0.1</td>
<td>66</td>
<td>7</td>
<td>4-13</td>
</tr>
<tr>
<td>Developed</td>
<td>0.27</td>
<td>169</td>
<td>19</td>
<td>45-90</td>
</tr>
<tr>
<td>Barren/Herbaceous/Wetland</td>
<td>0.09</td>
<td>166</td>
<td>18</td>
<td>15-44</td>
</tr>
<tr>
<td>Forest</td>
<td>0.04</td>
<td>384</td>
<td>42</td>
<td>17-31</td>
</tr>
<tr>
<td>Cultivated Agriculture</td>
<td>0.45</td>
<td>128</td>
<td>14</td>
<td>34-90</td>
</tr>
</tbody>
</table>

*Values are not exact due to rounding and conversion.
Aquatic plants play important roles in a lake’s ecosystem. They provide habitat for the fishery and other aquatic organisms, stabilize the sediment, reduce erosion, buffer temperature changes and waves, and infuse oxygen into the water. Aquatic plants near shore provide food, shelter and nesting material for shoreland mammals, shorebirds and waterfowl. It is not unusual for otters, beavers, muskrats and deer to be seen along a shoreline in their search for food or nesting material. The aquatic plants that attract the animals to these areas contribute to the beauty of the shoreland and lake.

The rapid and dominant growth of aquatic invasive plants, such as Eurasian watermilfoil (EWM), can reduce the recreational value of a lake. Aquatic invasive plants may also outcompete and cause a decline in native vegetation, which degrades habitat diversity and can alter the aquatic ecosystem.

An aquatic plant survey was conducted on Little Silver Lake in August 2013 by staff from Golden Sands Resource Conservation & Development Council, Inc. Seven species of aquatic plants were found in Little Silver Lake, with an additional two species observed visually (Table 5). This is below average compared with the other lakes in the Waushara County Lakes Study. The amount of aquatic plant diversity was somewhat uniform around Little Silver Lake (Figure 9). Eighty-five percent (117 of 137) of the sites visited had vegetative growth. The greatest depth at which aquatic plant growth was found was 34 feet.

<table>
<thead>
<tr>
<th>Scientific name</th>
<th>Common name</th>
<th>Sampled</th>
<th>Visuals</th>
<th>C-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chara spp.</td>
<td>muskgrass</td>
<td>x</td>
<td>x</td>
<td>7</td>
</tr>
<tr>
<td>Heteranthera dubia</td>
<td>water stargrass</td>
<td>x</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Lemna minor</td>
<td>small duckweed</td>
<td>x</td>
<td>x</td>
<td>4</td>
</tr>
<tr>
<td>Najas flexilis</td>
<td>slender naiad</td>
<td>x</td>
<td>x</td>
<td>6</td>
</tr>
<tr>
<td>Nymphaea odorata</td>
<td>white water lily</td>
<td></td>
<td>x</td>
<td>6</td>
</tr>
<tr>
<td>Potamogeton crispus</td>
<td>curly-leaf pondweed</td>
<td></td>
<td>x</td>
<td>0</td>
</tr>
<tr>
<td>Potamogeton friesii</td>
<td>Fries’ pondweed</td>
<td>x</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Potamogeton gramineus</td>
<td>variable pondweed</td>
<td></td>
<td>x</td>
<td>6</td>
</tr>
<tr>
<td>Sagittaria latifolia</td>
<td>broad-leaf arrowhead</td>
<td></td>
<td>x</td>
<td>3</td>
</tr>
<tr>
<td>Stuckenia pectinata</td>
<td>sago pondweed</td>
<td>x</td>
<td>x</td>
<td>3</td>
</tr>
<tr>
<td>filamentous algae</td>
<td></td>
<td>x</td>
<td></td>
<td>-</td>
</tr>
</tbody>
</table>

The dominant plant species found in Little Silver Lake was muskgrass (Chara spp.), followed by slender naiad (Najas flexilis). Chara is a favorite waterfowl food and also offer cover for fish. Slender naiad is a food source for many species of waterfowl (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 value (C-value) that reflects its sensitivity to disturbance, and these numbers are used to calculate the FQI. C-values range from 0 to 10. The lower the number, the more tolerant the plant is of disturbance. Having more plants with low C-values than high C-values is an indicator of disturbance, as the lower C-value plants better tolerate stresses caused by...
disturbance. A C-value of 0 is assigned to exotic species. The FQI for Little Silver Lake was 15.5, which was below average for the lakes in the Waushara County Lakes Study.

In Little Silver Lake, C-values ranged from 3 to 8 (Table 5). One species, Fries' pondweed, had a C-value of 8, indicating good health in the aquatic plant community. The species with the highest frequency of occurrence within vegetated areas was Chara spp., with a C-value of 7. One invasive plant species was found, curly-leaf pondweed (CLP), which has a C-value of 0.

The potentially invasive plant curly-leaf pondweed (CLP) was found in several patches in Little Silver Lake during a survey conducted earlier in 2013. In some lakes, this species can grow as a part of the plant community, but it can also become aggressive. The life cycle of CLP is unique. CLP grows under the ice during late winter/early spring, begins growing in spring before native plants, and dies back in late June/early July, releasing phosphorus at a time when the water is warm. The timing of the release can enhance algal blooms for the balance of the summer.

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. The SDI uses a decimal scale from 0 to 1. Values closer to one represent higher amounts of biodiversity. The SDI of Little Silver Lake for the 2013 survey was 0.36. This represents a below average biodiversity when compared to all the lakes in the Waushara County Lakes Study.

Aquatic plants play another critical role in the lake’s ecosystem by using nutrients that would otherwise be available to algae. Any management activities should be planned to minimize the disturbance of native species in the water and on the shore in order to maintain the balance between aquatic plants and algae. In addition, care should be taken to minimize raking the lakebed and pulling plants, since disturbing these valuable open spaces may allow invasive plants to become established.
Figure 9. Number of aquatic plant species observed at each sample site in Little Silver Lake, August 2013.
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 healthier shorelines with good land management practices. These are areas where protection and/or conservation should be targeted. On the other hand, lower scores signify ecologically unhealthy shorelines. These are areas where management and/or mitigation practices may be desirable for improving water quality.

The summary of scores for shorelands around Little Silver 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 Little Silver Lake’s shorelands are in good shape, but many have challenges that should be addressed, including several segments that were 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 the Waushara County’s website [http://gis.co.waushara.wi.us/ShorelineViewer/](http://gis.co.waushara.wi.us/ShorelineViewer/).

### Table 6. Disturbances within 15 feet of shore around Little Silver Lake, 2011

<table>
<thead>
<tr>
<th>Disturbance</th>
<th>Length of Shoreline</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Feet</td>
<td>Percent</td>
</tr>
<tr>
<td>Artificial beach</td>
<td>4,250</td>
<td>60</td>
</tr>
<tr>
<td>Barren, bare dirt</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Boat landing</td>
<td>60</td>
<td>1</td>
</tr>
<tr>
<td>Dock/pier at water</td>
<td>5,826</td>
<td>83</td>
</tr>
<tr>
<td>Gully erosion</td>
<td>60</td>
<td>1</td>
</tr>
<tr>
<td>Undercut banks erosion</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mowed lawn</td>
<td>4,074</td>
<td>58</td>
</tr>
<tr>
<td>Rip-rap</td>
<td>2,907</td>
<td>41</td>
</tr>
<tr>
<td>Seawall</td>
<td>2,824</td>
<td>40</td>
</tr>
</tbody>
</table>
Figure 10. Overall shoreland health around Little Silver Lake (Springwater), 2011.
CONCLUSIONS & RECOMMENDATIONS

Little Silver Lake has many good attributes; however, numerous measurements indicated impairment of water quality and habitat. Efforts to improve conditions are likely to have good results. Little Silver Lake has hard water. This calcium-rich water can help to reduce the response of algae to additions of phosphorus, but this protection is limited. At the start of the summer, the water clarity in Little Silver Lake was good, but it progressed to poor by summer’s end. This was due to algal growth, which could be reduced by reductions of phosphorus to the lake. Other measurements of water chemistry indicated pollutants are entering Little Silver Lake from shoreland and watershed land management practices.

- Little Silver Lake had elevated nitrate (NO$_2$+NO$_3$-N) concentrations. Sources of nitrate include fertilizers, septic systems, and animal waste. The nitrate is likely moving to the lake in groundwater.
  - In a lake, nitrate can be readily used by aquatic plants and some types of algae, increasing their growth.
  - Water users around and upgradient of the lake should have the water from their private wells tested to determine if they exceed health standards for drinking water.
- Potassium, chloride and sodium concentrations were slightly elevated. While these concentrations are not harmful to aquatic organisms, they indicated that pollutants are entering the lake. Chloride sources include animal waste, septic systems, fertilizer, and road-salting chemicals.
- Atrazine, an herbicide commonly used on corn, was detected in one of the samples from Little Silver Lake.
  - Some toxicity studies have indicated that reproductive system abnormalities can occur in frogs at this level.
  - The presence of this chemical suggested that agricultural activities in the surrounding landscape may be impacting the lake.
  - Water users around and upgradient of the lake should have the water from their private wells tested to determine if they exceed health standards for drinking water.
- During the study, total phosphorus concentrations for Little Silver Lake ranged from 3 to 21 ug/L. The summer median total phosphorus concentrations were 12 and 11 ug/L in 2011 and 2012, respectively. This is below Wisconsin’s phosphorus standard of 20 ug/L for deep seepage lakes.
- Routine monitoring of water quality can help to track changes in Little Silver Lake. A monitoring plan should be designed and carried out. Nutrient and chlorophyll a (algae) monitoring should be focused on late summer to better understand the reduced water clarity during this time.

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.

- Identifying and taking steps to maintain or improve water quality in Little Silver Lake depends upon understanding the sources of nutrients to the lake and identifying those that are manageable. Based on modeling results, agriculture and developed land provided major phosphorus contributions from the watershed to Little Silver 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. Little Silver 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 Little Silver Lake’s shorelands are in good shape, but many have challenges that should be addressed, including several segments that were ranked as poor.
  - Structures such as seawalls, rip-rap (rocked shoreline), and artificial beach can result in habitat loss.
  - Erosion can contribute sediment to the lake, which can alter spawning habitat and carry nutrients into the lake.
  - 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 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 help 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. Nine species of aquatic plants were found in Little Silver Lake, which is low compared with other lakes in the Waushara County Lakes Study.
- One high quality plant species (C-value of 8), Fries' pondweed, was found in Little Silver Lake.
- One invasive species, curly-leaf pondweed (CLP), was found in several patches in Little Silver Lake during a survey conducted in 2013. This species was first confirmed in Little Silver Lake in 2009.
  - In some lakes, CLP can grow as a part of the plant community, but it can also become aggressive.
The life cycle of CLP is unique. CLP grows under the ice during late winter/early spring, begins growing in spring before native plants, and dies back in late June/early July, releasing phosphorus at a time when the water is warm. The timing of the release can enhance algal blooms for the balance of the summer.

Citizens should learn to identify this plant and map the beds to verify if populations of CLP are increasing. If they are, authorities should be notified and a plan for control should be developed.

- 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 establish.
- 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.
REFERENCES


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 mediums 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”.

**Overturin:** 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.”