LAKE REDSTONE

SAUK COUNTY

2022-32 9-KEY ELEMENT WATERSHED AND LAKE MANAGEMENT PLAN

WI-DNR WBIC: 1286400

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Developed by: Dave Blumer, Megan Mader, and Heather Wood
Lake Education and Planning Services, LLC
Cameron, WI 54822

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This management planning effort was a team-based project and could not have been completed without the input from many individuals and partners.

LEAPS Staff
Staff

Dave Blumer

Megan Mader

Heather Wood

LRPD Staff

Ken Keegstra

Mike Mittelstadt

Patrick Sullivan

Tom Walters

Brad Horner

Paul Burke

Al Baade

Sauk County

Serge Koenig

Melissa Schlupp

Juneau County Staff

Dustin Ladd

Sarah Fleck

Wisconsin DNR

Andrew Craig

Patrick Oldenburg

Susan Graham

United State Geological Survey

Matt Komiskey

Keegan Johnson

Executive Summary

Lake stewardship is a challenging and complex task that can reap long term rewards for future generations when performed with long term goals in mind. Today's lakes face many obstacles that include nutrient loading, sedimentation, invasive species, shoreline erosion, loss of habitat, and climate change. While presenting distinct challenges to lake groups, these obstacles can provide opportunities for improvement, community engagement and education, collaboration between a wide array of stakeholders, and the ability to shape future generations of lake stewards.

To protect and restore Lake Redstone, this 9-Key Element Plan was developed to tackle these major obstacles. Primarily, this plan will focus on reducing sediment and nutrient loading to the lake, improving riparian habitat, promoting appropriate lake stewardship, and engaging multiple partners to be invested in the future of the lake. Three areas of concern are focused on in this plan: the watershed of Lake Redstone, the riparian area around Lake Redstone, and Lake Redstone itself. These areas are specifically targeted because of their indirect and direct relationship to the degradation of Lake Redstone through contributions of sediments and nutrients. This plan will focus on best management practices that will assist in reducing loads of sediment and nutrients from these surrounding areas through the lens of the following objectives:

Overarching Goal: Improve the water quality and overall ecosystem of Lake Redstone by working with various stakeholders to implement best management practices to improve the watershed, riparian area, and the lake itself.

Objective 1: Implement best management practices throughout the watershed to reduce sediment and phosphorus loading into Lake Redstone.

Objective 2: Improve the riparian area by implementing BMPs to increase quality habitat for wildlife and mitigate the effects of development on Lake Redstone

Objective 3: Use BMPs within Lake Redstone to reduce negative impacts from pollution, aquatic invasive species, and shoreline erosion.

Objective 4: Build and maintain partnerships with outside resource, state, university, county, lake groups, and other local entities to guide the implementation of BMPs.

The implementation of this plan will connect individual BMPs to the larger goals of the LRPD, including people and funding aligned with the objectives; individual riparian owners and agricultural practitioners throughout the watershed; monitoring and data information systems; and milestones designed to meet the expectations of stakeholders throughout the period of this plan.

Execution of this plan depends on the collaboration of multiple stakeholders, including the LRPD, Juneau and Sauk Counties, Producers of the Lake Redstone Watershed, USGS, WI-DNR, and others. Within the Appendices included with this document, tables are provided that list the current goals and objectives, specific milestones to be met throughout implementation, timelines and methods of implementation, and expected outcomes for each area of concern – watershed (Appendix F), riparian area (Appendix G), and Lake Redstone (Appendix H).

Appendix I combines all Plan Actions into one table and adds Years 1-3, 4-6, and 7-10 milestones, estimated costs, and expected Resource Agencies that will either be responsible for completing the action or will provide technical assistance with implementation.

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LAKE REDSTONE

PREPARED FOR THE LAKE REDSTONE PROTECTION DISTRICT

1.0 Introduction

Lake Redstone is a 635 acre, artificially impounded drainage lake in northwest Sauk County (Figure 1). Lake Redstone has a maximum depth of 36.5 feet and a mean depth of 14 feet (WI-DNR). Although there are other intermittent streams and springs that make up the 28.83 sq. mile watershed, the east and west branches of Big Creek are the two biggest contributors to Lake Redstone. Water from the lake is released from a top draw dam that creates a cascading waterfall at the southernmost end of the lake and eventually drains into the Baraboo River (Figure 2). The southern end of the lake has scenic red sandstone cliffs which steeply slope into deep water with very little littoral habitat, while the many bays and the remainder of the lake has a gradual drop off and more littoral habitat.

Lake Redstone was created in the mid 1960's when a 38 foot high earthen dike was installed across Big Creek in northwestern Sauk County with the intent of creating >1500 lots for development. It has 17½ miles of shoreline and it is 4½ miles long. Lake Redstone is located in the Crossman Creek and Little Baraboo River watershed which lies in northwestern Sauk County, southern Juneau County, northeastern Richland County, and the southeast corner of Vernon County. It is part of the Driftless, or unglaciated, region of Wisconsin. This region is geologically unique with land areas that were by-passed by the last glaciers leaving steep terrain susceptible to flash runoff events and erosion that can increase the amount of sediment and nutrients lost from agricultural land and carried be into streams, rivers, and lakes.

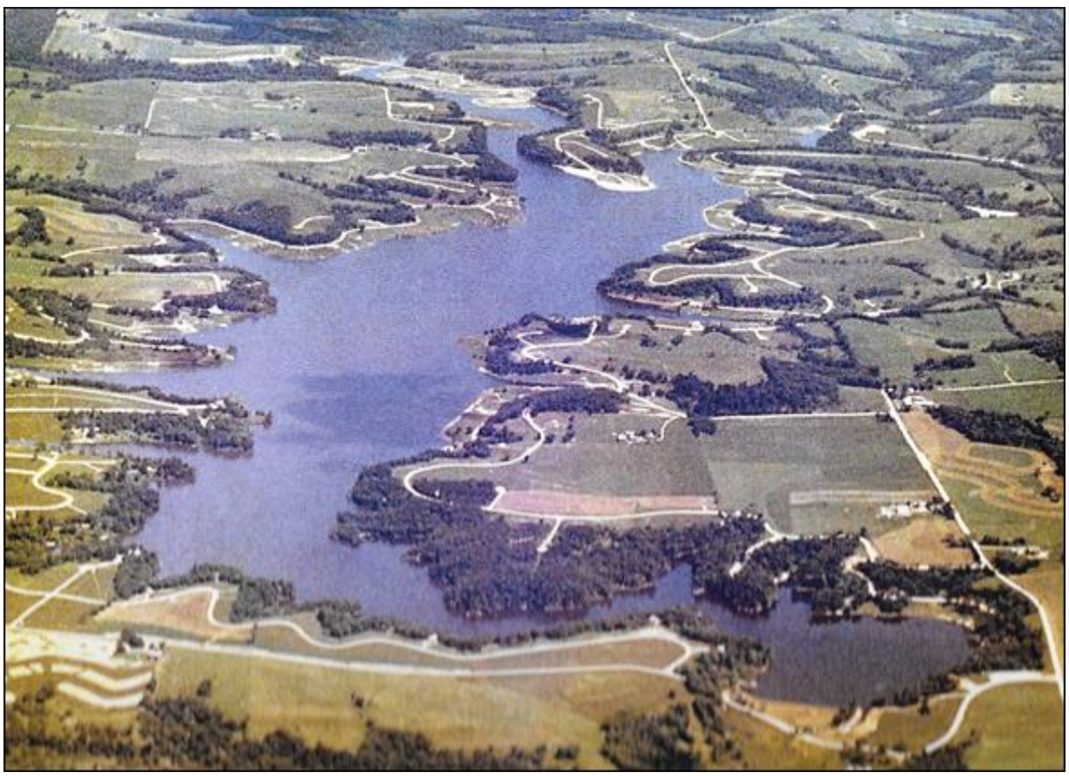


Figure 1: Lake Redstone shortly after filling. The two branches of Big Creek that flow into the lake are at the top of the picture. The dam is located at the lower right of the picture.

Figure 2: Cascading waterfall from the top draw spillway at the outlet of Lake Redstone (LRPD Facebook Page)

The topography of Lake Redstone includes many fjord-type bays around the lake. Each of these bays drains some portion of the watershed or riparian area of the lake. When discussing the lake and management actions, individual bays are often referred to by name. These names are generally determined by the road that travels around the bay or the name of the sub-division associated with it (Figure 3).

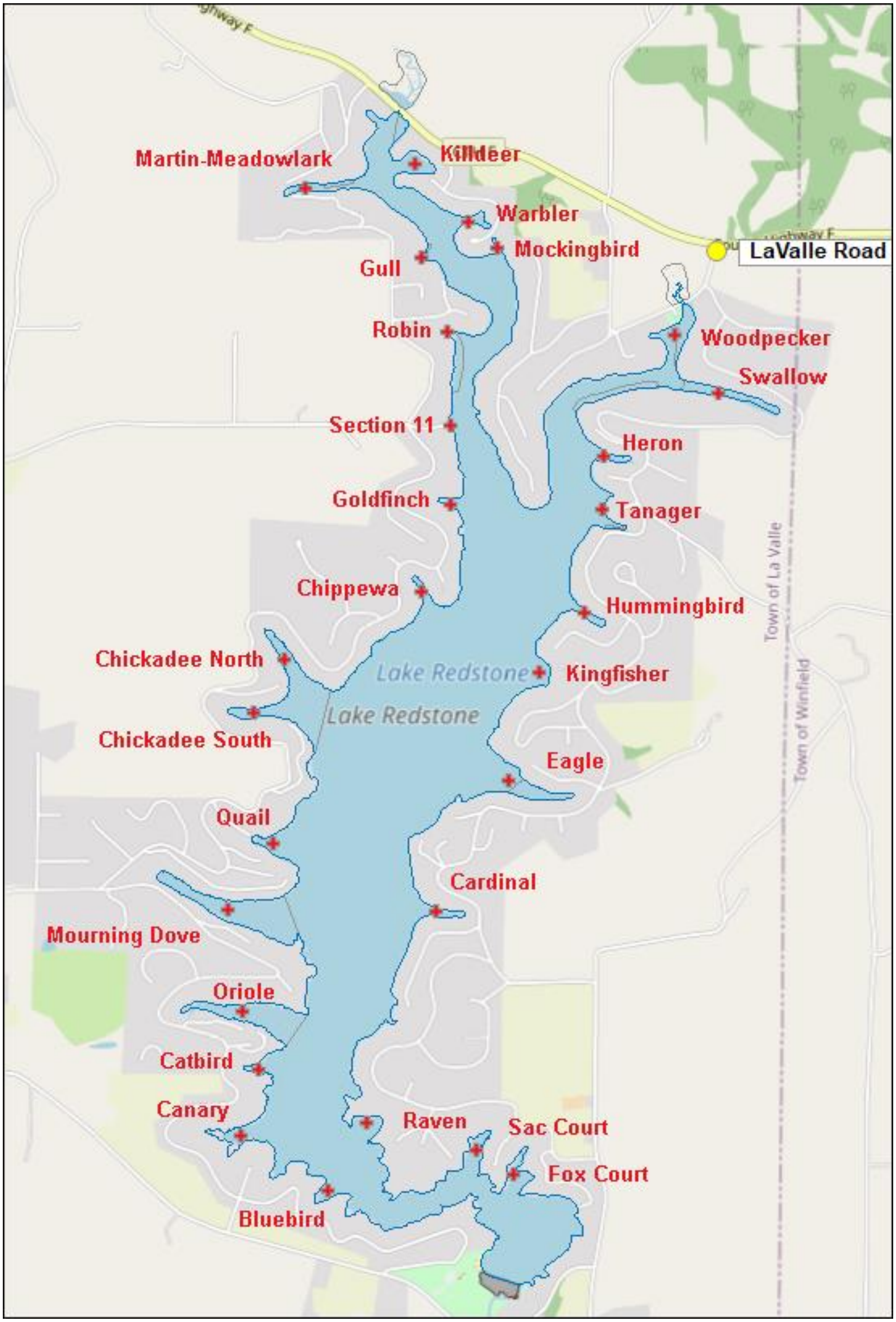


Figure 3: Individual bay names on Lake Redstone

1.1 Lake Redstone Protection District

Stewardship of Lake Redstone was first in the hands of the Lake Redstone Property Owners' Association (LRPOA), whose purpose when formed in 1969 featured "maintenance of the lake." In 1974, Wisconsin passed a set of laws that established local lake management districts to improve the quality of the lakes in the state. Under these guidelines, the Lake Redstone Management District was formed in 1976 and took over maintenance of the lake responsibilities. The LRPOA still remains but focuses more on social events and education. In 1987, the Lake Redstone Management District changed its name to the Lake Redstone Protection District (LRPD) to reflect an emphasis on protection and rehabilitation verses maintenance.

The LRPD is a government organization, funded through a small portion of taxes from property owners within the protection district. Other forms of support include grants from the Wisconsin Department of Natural Resources (WI-DNR), Sauk County, and other government entities. The LRPD is governed by a Board of Commissioners. Each commissioner is elected to a 3-yr term. Commissioners receive a small stipend for meetings and are reimbursed for expenses associated with LRPD work. Many volunteers contribute time during the year to support the actions of the LRPD.

The stated mission of the LRPD is to "protect and rehabilitate the water quality of Lake Redstone for its residences and the public." Powers granted to protection districts by the state are: to conduct studies for projects to improve and protect the lake, to adopt programs to improve water quality, and to control aquatic plants. The LRPD has the power to levy taxes and special assessments to improve water quality. Protection District powers are located in the Wisconsin Statutes, Chapter 33.

More information can be found on the LRPD webpage at: https://www.lakeredstonepd.org/.

1.2 Problem Statement and Purpose

The water quality of Lake Redstone has long been an issue – algal blooms, low oxygen, sedimentation, etc. – as a result of the land use in and topography of a watershed that contributes contaminants like nutrients and sediment. The lack of water clarity caused by the inflow of sediment and algal blooms (caused by the inflow of nutrients) limits the amount of aquatic plant growth by limiting the depth light can penetrate into the lake. However, the invasive aquatic plant, Eurasian watermilfoil (EWM), dominates the lake bed where native plant species cannot tolerate the degraded conditions. Additionally, at depths greater than 12-ft, oxygen is depleted beyond what is needed for fish and other biota to survive as a result of the decomposition of large amounts of organic material. These conditions placed Lake Redstone on the Wisconsin Impaired Waters List in 2014, where it remains to date.

The purpose of this project is to develop a lake and watershed management plan for Lake Redstone that will help reduce sediment and nutrient loading to the lake improving conditions consistent with the mission of the LRPD. Three areas of concern are focused on in this plan: the watershed of Lake Redstone, the riparian area around Lake Redstone, and Lake Redstone itself.

1.3 Impaired Waters Listing

Every two years, Sections 303(d) and 305(b) of the Federal Clean Water Act (CWA) require states to publish a list of all waters not meeting water quality standards and an overall report on the surface water quality status of all waters in the state. To assess surface water quality throughout the state, Wisconsin's Consolidated Assessment and Listing Methodology (WisCALM) is used. WisCALM uses available data to determine impairments based on two categories: natural (fish and aquatic life, FAL) and recreational (human/full body emersion activities, REC). A lake can exceed state standards in either or both of these categories, and designations are generally based on the concentration of total phosphorus (TP), the nutrient that supports aquatic life; and the concentration of chlorophyll-a (Chl-*a*), a measurement used to determine the biomass of algae in the water. Both are measured in micrograms per liter (µg/L). WisCALM provides guidance on the assessment of water quality data against surface water quality standards, and for required Clean Water Act reporting (WisCALM, 2021).

The Wisconsin acceptable standard for summer TP in the REC category for stratified reservoirs like Lake Redstone is a geometric mean concentration ≤30-µg/L (Figure 4). If the summer mean concentration of TP exceeds this level, the water is considered impaired. The Wisconsin assessment protocol for Chl-*a* is based on the number of days in a sampling season (July 15-September 15) that have moderate algal levels based on Chl-*a* concentrations that exceeds 20-µg/L. Once that level has been exceeded, the amount of algae in the surface water it represents discourages people from swimming (Figure 5). If the concentration of Chl-*a* exceeds 20-µg/L on more than 5% of the expected lake use days, then the water is considered impaired.

Figure 4: Wisconsin numeric water quality standards for phosphorus (WI-DNR, 2019)

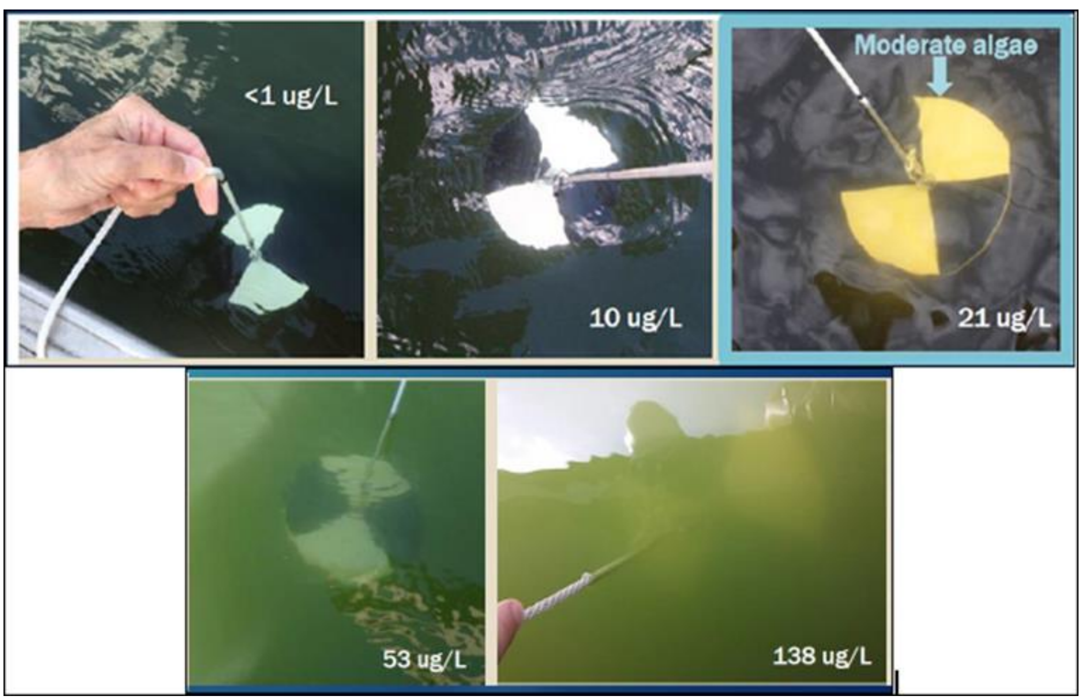


Figure 5: Chl-a concentrations and the corresponding water clarity as measured by a Secchi disk (WI-DNR, 2018)

Lake Redstone was first placed on the Impaired Waters List for TP in 2014, and for eutrophication with an unknown pollutant in 2016. In the most recent WisCALM assessment of Lake Redstone for the Impaired Waters List (for 2022), Chl-*a* values from 2016-2020 for REC indicated that the mean percent of lake use days where 20-µg/L of Chl-*a* was exceeded was 93% with a 78% to 98.5% high/low confidence interval, well above the 5% standard (Beranek, 2021). During the same assessment, the mean summer TP concentration was 57-µg/L, well above the 30-µg/L standard set for stratified reservoirs indicating that Lake Redstone will remain on the Impaired Waters List in 2022 (Beranek, 2021).

1.4 Total Maximum Daily Load (TMDL)

One of the underlying goals of the CWA is to restore all impaired waters so they meet applicable water quality standards. One of the key tools to meet this goal is the development of a TMDL. A TMDL establishes the amount of a pollutant (nutrients, sediment, manmade pollutants) a waterbody (lake, river, or stream) can receive and still meet stated water quality standards (WI-DNR, TMDL Overview).

Through a TMDL the current pollutant loads from point and nonpoint sources are quantified. Point source pollution is from easily identifiable locations including municipal, industrial, concentrated animal feed operations (CAFOs), and Municipal Separate Storm Sewer System (MS4) stormwater. Nonpoint source pollution comes from less definable locations like agricultural, residential, and urban landscapes and is often made worse by uncontrolled, natural storm events. Through the use of mathematical models, nonpoint source pollutant loads for specific waterbodies or collection of waterbodies are calculated with inputs related to weather, topography, soil types, and land use. With these and other data inputs, the model simulates physical processes associated with the flow of water, sediment movement, nutrient cycling, crop growth, etc. Models can also be used to predict impacts of changes in land use, climate, and management practices on water quality. Once targets are set for a given waterbody, the TMDL is established by allocating the allowable load between the point and nonpoint sources, with some amount of the total load set aside as a margin of safety (WI-DNR, TMDL Overview).

1.4.1 Wisconsin River Basin TMDL

The WI-DNR, together with many partners, is working to improve water quality in the Wisconsin River, its reservoirs, and tributaries through a TMDL (WI-DNR, Wisconsin River TMDL). The TMDL provides a strategic framework and prioritizes resources for water quality improvement in the Wisconsin River Basin (WRB). The WRB includes 9,156 square miles (15% of the state) spanning Wisconsin's central corridor from the headwaters of the river in Vilas County to Lake Wisconsin in Columbia County (Figure 6). Within this area, there are 110 stream/river segments and 38 lakes/reservoirs, including Lake Redstone, that are on the impaired waters list for phosphorus based on the 2016 303(d) Impaired Waters List.

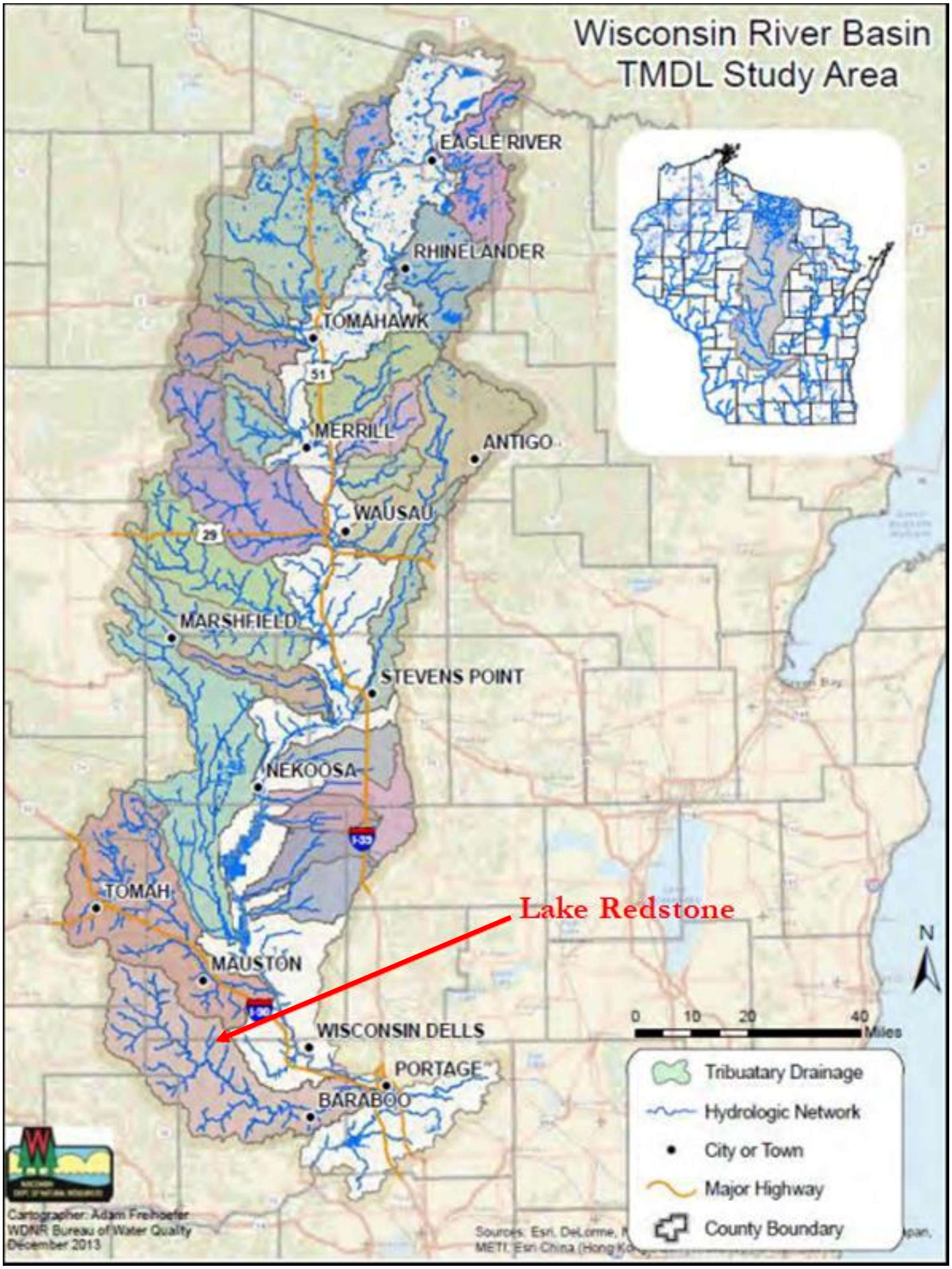


Figure 6: Wisconsin River Basin TMDL Study Area (WI-DNR, Wisconsin River TMDL)

For the purpose of assessing pollutant load generation and receiving water loading capacity, and for the development of load allocations in the WRB TMDL, the entire river basin was subdivided into 337 individual sub-basins. Each sub-basin represents a single "reach" which can be either a stream or an impoundment. The loads generated from each sub-basin are delivered to the reach and cumulate downstream through the drainage system. Lake Redstone and its watershed are delineated based on the lake itself and the east and west branches of Big Creek – sub-basins 13, 15, and 16 (Figure 7). These three sub-basins combined cover the entire Lake Redstone watershed.

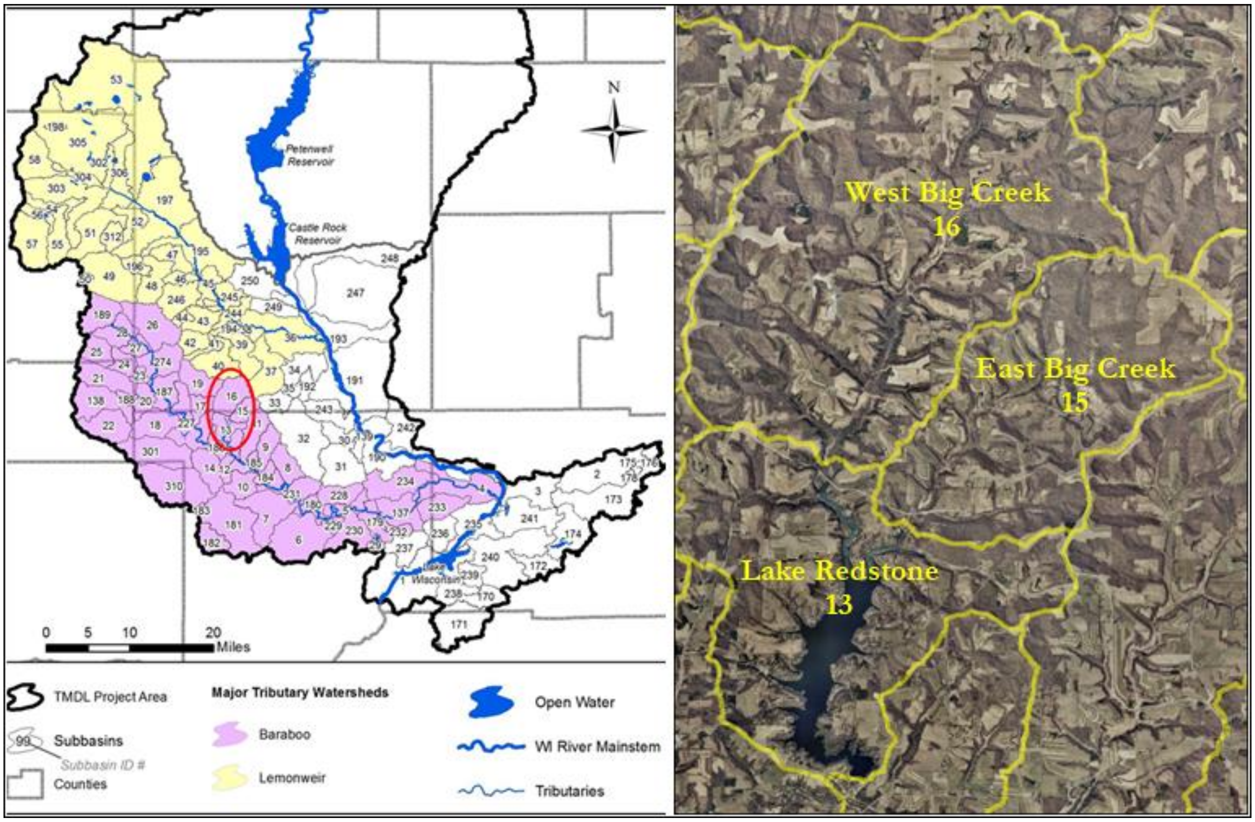


Figure 7: Wisconsin River TMDL sub-basins in the lower region. Lake Redstone and its watershed are circled in red, #'s13, 15&16 (left; WI-DNR, 2019) Sub-basins laid over Lake Redstone watershed (right).

The EPA approved the WRB TMDL on April 26, 2019. With that approval, allocations of point and nonpoint source load and margin of error were also approved based on both the statewide phosphorus criteria applicable at the time and newly approved site-specific criteria. These approved allocations are to be used for future point source permitting decisions and as the basis for locally-led nonpoint source reduction plans such as this Lake Redstone 9-Key Lake and Watershed Management Plan.

1.5 Watershed Planning and Implementation: 9-Key Elements Plan

In 2008, the EPA published a guide for developing and implementing watershed plans (EPA, 2008). The guide includes six steps to be included in a formal plan. Within the six steps are the nine key elements required by the EPA in order to make a watershed management plan and its implementation eligible for federal funds through the Clean Water Act, Section 319. The Clean Water Act Section 319 Grant Program awards grants to reduce and mitigate the effects of nonpoint source pollution – such as sediment, pesticides, and nutrients – to waters of the state.

The following 9-Key Elements are considered critical for achieving improvements in water quality following a watershed approach:

1) Identify causes and sources of pollution
2) Determine load reductions needed
3) Develop management actions to achieve goals
4) Identify technical and financial assistance needed to implement the plan
5) Develop an information/education component
6) Develop an implementation schedule
7) Develop the interim milestones to track implementation of management measures
8) Develop criteria to measure progress toward meeting watershed goals
9) Develop a monitoring component

More information about each of these steps is included in Appendix A.

2.0 Identification of Key Stakeholders

A stakeholder is any person, group, or organization that can place a claim on the organization's resources, attention, or output, or is affected by its output (Bryson, 1995). Over the past decade or more, the LRPD has worked at building partnerships with stakeholders who share a common goal of improving water quality in Lake Redstone. With that in mind, the LRPD identified the following key stakeholder groups that are important to management planning and implementation success:

2.1 Sauk County Land Resources and Environment Department

Even though the bulk of the Lake Redstone watershed is in Juneau County, the lake itself is in Sauk County. The Sauk County Land Resources and Environment (LRE) Department promotes many actions that protect Lake Redstone and others waters in the County. Their mission is to conserve natural, cultural, and community resources by promoting, planning, and implementing efficient and effective programs.

2.2 Juneau County Land and Water Resources Department

The largest portion of the Lake Redstone watershed lies in Juneau County. The mission of the Juneau County LWR Department is to aid the public in protecting, enhancing, and preserving natural resources through public information, education, and technical assistance within the guidelines of the Juneau County LWR Management Plan. Department staff has long been supporters of the LRPD and agricultural activities in the watershed to protect and improve the lake. Currently, they monitor the edge-of-field stations, lead stream monitoring activities in the two main branches of Big Creek entering Lake Redstone, and act as the main advisors to the PLRW.

2.3 Producers of the Lake Redstone Watershed (a Producer Led Cooperative)

The PLRW have the following vision statement – "The Producers of the Lake Redstone Watershed are working towards the goal of improving the water quality and soil health within the watershed," and their mission statement is as follows – "Our producer-led group is using on farm research and innovative practices to improve conservation in and out of the watershed." The group is collaborating with Juneau County and others to develop economically viable mechanisms to get cover crops seeded, develop a community manure application system, and use cover crops to provide nutrients late in the growing season. With additional funding from DATCP, the group continues to support farmer incentives to implement best management practices including cover crops, community manure sharing, establishing nutrient management plans, and for sponsoring community events, field days, and training.

2.4 Discovery Farms (a program of UW-Madison Division of Extension)

Discovery Farms, a program of UW-Madison Division of Extension, is a farmer-led research and outreach program focused on the relationship between agriculture and water quality. The program is unique in that it conducts research on privately-owned farms throughout Wisconsin, working with the USGS to gather credible and unbiased water quality information from monitored sites (UW-Extension Juneau County). In 2018, Discovery Farms established a partnership with the Juneau County Land and Water Resources Department and the Producers of the Lake Redstone Watershed. The partnership was established to understand what effects conservation practices in the area have on runoff and nutrient losses. Two edge-of-field monitoring stations were installed in the watershed to measure and collect runoff from monitoring basins.

2.5 Lake Redstone Property Owners' Association

The LRPOA focuses on the social side of the lake community and supports several clubs including the Garden Club, Nature Photography Club, In Stiches Sewing Club, and the Kayaking Club. Each of these clubs has an interest in maintaining or improving Lake Redstone for their own needs and in their own ways. Another organization, the Lake Redstone Fishing Club is concerned with promoting and protecting a healthy, abundant, and sustainable fishery.

2.6 Other Stakeholders

- Baraboo River Watershed Regional Conservation Partnership Program
- Natural Resource Conservation Service (NRCS) in Sauk and Juneau Counties
- United States Geological Survey (USGS)
- Town of LaValle
- Property owners on Lake Redstone
- General lake users
- Agricultural and animal operations in the watershed
- Dutch Hollow Lake Property Owners Association
- Wisconsin Department of Natural Resources
- UW-Stevens Point
- UW-Extension Services

Since 2014, the LRPD has organized an annual meeting of stakeholders known as the "Partners Meeting." Usually held in the fall at the Sauk County Building in Baraboo, WI, the meeting includes members of the LRPD board, member of the public interested in Lake Redstone, representatives from the WI-DNR, and from both Juneau and Sauk County Departments. In some years, farmers from the watershed have joined the meeting, and there have been representatives from other lake districts. In 2020, when the meeting was held virtually, representatives from the USGS participated. The topics on the agenda vary from year to year, but in the last two years, the major topic has been the preparation of the 9-Key Lake and Watershed Management Plan. Regardless of the topic, the meeting provides a chance for partners to exchange information, review activities from the previous year, and discuss plans for the coming year.

2.7 Public Outreach, Issues of Concern, and Preliminary Goals

In an effort to better understand issues of concern to property owners, the LRPD conducted several surveys of constituents seeking their input about the lake. In the first survey, completed in 1981, all 1270 property owners on Lake Redstone at that time were sent a survey, seeking their comment through a variety of questions. The survey had a 43% return rate and identified two important topics of concern to Lake Redstone residents: water quality perception and user conflict. Survey results indicated more people were concerned with user conflicts than water quality, and that more people were satisfied with water quality than were not. Most of those unsatisfied with water quality were occasional visitors to their lake property. Many responses from this survey had "no opinion" as it pertains to water quality, prompting researchers to suggest a greater emphasis on information and involvement efforts in the future to increase awareness.

In 2006, another survey, this time of approximately 1074 households in the LRPD boundaries was completed. The response rate to this survey was 32%. Based on the information from the survey and an internal LRPD board assessment, the following issues were determined to be of highest concern:

- How to better educate and communicate with users of Lake Redstone, both resident and day users;
- How to safely and effectively prevent and/or remove sediment build-up in Lake Redstone;
- How to better manage the number of exotic, invasive species found in and around Lake Redstone; and
- How to reduce the amount of nutrients entering Lake Redstone.

In response to this survey, the LRPD began strategic planning to guide future actions taken by the LRPD to improve the lake. Several broad goals were set to help focus planning and implementation efforts: 1) Identify, monitor, and address sediment erosion and nutrients entering the lake from the surrounding watershed; 2) Better manage/prevent the spread of exotic, invasive species in and around Lake Redstone; and 3) Make efforts to better involve and educate constituents of the LRPD (Erickson, 2006). Through this planning effort, potential actions that might lead to solutions to issues of concern were identified and in many cases, implemented.

In 2017, the LRPD created and distributed another constituent survey. Unlike the 1981 and 2006 surveys which were mailed out to over 1000 property owners, the 2017 survey was distributed online. There were 227 responses to the 2017 survey; the exact percentage of respondents is unknown.

The 2017 online survey presented a list of perceived issues on Lake Redstone and respondents were asked to rate them as serious, moderate, minor, or not a problem. The issues considered most serious in 2017 were:

- Water quality/water clarity;
- Accumulation of sediment;
- Farm runoff;
- Shoreline erosion;
- Excessive aquatic plants; and
- Excessive algae.

In the 2017 survey, a majority of respondents felt dredging was necessary to deal with the accumulation of sediment in the lake. Educating and informing lake users on a variety of topics from aquatic invasive species, boating rules and regulations, and lake and shoreland stewardship practices was not specifically addressed in the 2017 survey, but based on comments made, these issues were still important to many respondents.

In 2017, the LRPD completed a review of many of the studies related to Lake Redstone completed between 1981 and 2017. This 2017 review process culminated with a report summarizing the conclusions and recommended goals of each of these studies (Appendix B; (Blumer, 2017)). The report also identified apparent gaps in data collection and laid the groundwork for application and the subsequent award of WI-DNR surface water grant funding to develop this 9-Key Lake and Watershed Management Plan for Lake Redstone. The 2017 Report included the following, fairly specific recommendations:

- Complete a Shoreland Habitat Assessment of Lake Redstone;
- Complete a sediment pond feasibility study;
- Complete dredging of multiple bays;
- Evaluate methods for re-establishing native aquatic vegetation in the lake;
- Add nitrogen parameters to water quality monitoring; and
- Develop a Comprehensive Lake Management Plan.

Most of these recommendations have either been addressed, or are currently being addressed through this project.

3.0 Characterizing Lake Redstone and its Watershed

3.1 Lake Redstone

Depending on which source is used, Lake Redstone has a surface area of 612 to 635 acres. Based on a 2011 whole-lake, point-intercept survey, it has a maximum depth of 36.5-ft and a mean depth of 14.4-ft. Visitors have access to the lake from three public boat landings and a public beach. Fish include musky, panfish, largemouth bass, northern pike, and walleye. The lake's water clarity is low. Curly-leaf pondweed, Eurasian watermilfoil, purple loosestrife, and yellow iris are invasive plant species currently present in or along the shores of Lake Redstone; gizzard shad and common carp (an invasive fish species) are also present.

3.1.1 Water Quality

The quality of water in a lake is often assessed by collecting and comparing three measures or parameters – water clarity, total phosphorus, and chlorophyll-*a*.

Water clarity is a measurement of how deep sunlight can penetrate into the waters of a lake. It can be measured in a number of ways, the most common being an 8" disk divided into four sections, two black and two white, lowered into the lake water from the surface by a rope marked in measurable increments (Figure 8). The water clarity reading is the point at which the "Secchi" disk when lowered into the water can no longer be seen from the surface of the lake. Water color (like dark water stained by tannins from nearby bogs and wetlands), particles suspended in the water column (like sediment or algae), and weather conditions (clouds, wind, or sunlight) can impact how far a Secchi disk can be seen down in the water. Some lakes have Secchi disk readings of water clarity of just a few inches, while other lakes have conditions that allow the Secchi disk to be seen for dozens of feet before it disappears from view.

Phosphorus is essential to plant growth as a vital nutrient for converting sunlight into usable energy during photosynthesis. Under natural conditions, phosphorus is typically scarce in water. In the late 1960s, scientists discovered phosphorus contributed by human activity to be a major cause of excessive algal growth and degraded lake water quality. Phosphorus can be attached to sediment particles like clay and silt, and can then build up in the sediments of a lake. When it remains in the sediment, it is generally not available for use by algae; however, various chemical and biological processes can allow sediment phosphorus to be released back into the lake water.

Chlorophyll-*a* is the pigment that makes plants including algae, green. Measuring chlorophyll-*a* in a water sample can be used to determine algal biomass in the lake.

All three parameters are commonly used to determine the state of water quality in a lake. Individual values of each, when measured over time, can show whether or not water quality in a lake is getting better, not changing, or getting worse. All three are related to one another in that excess phosphorus can grow algae (measured by chlorophyll-*a*), which can in turn, impact water clarity. All three are used to determine the productivity or trophic status of a lake, and can be represented in relation to each other on a Trophic State Index (TSI) scale (Carlson, 1977). The TSI is a numeric index of lake trophic status on a scale of 1 to 100, with higher numbers indicating greater nutrient enrichment (Table 1).

Figure 8: Secchi disk

Table 1: Carlson's Trophic State Index values

TSI values	TrophicStatus	Attributes
< 30	Oligotrophic	Clear water, oxygen throughout the year in the hypolimnion
30-40	Oligotrophic	A lake will still exhibit oligotrophy, but some shallower lakes will become anoxic during the summer
40- 50	Mesotrophic	Water moderately clear, but increasing probability of anoxia during the summer
50-60	Eutrophic	Lower boundary of classical eutrophy: Decreased transparency, warm-water fisheries only
60-70	Eutrophic	Dominance of blue-green algae, algal scum probable, extensive macrophyte problems
70-80	Eutrophic	Heavy algal blooms possible throughout the summer, often hypereutrophic
>80	Eutrophic	Algal scum, summer fish kills, few macrophytes

Based on long-term trend data for Secchi depth, TP, and Chl-*a* retrieved from the WI-DNR SWIMS database, Lake Redstone is classified as a eutrophic, or nutrient-rich, system with TSI values ranging from the low 50's to high 60's (WI-DNR, Surface Water Integrated Monitoring System (SWIMS) Database). Figures 9-12 reflect the summer (July & August) mean TSI values for Secchi, TP, and Chl-*a* through 2020 at four monitoring sites in Lake Redstone (WI-DNR, Citizen Lake Monitoring Network).

Of note at all four sites is that TSI values for Chl-*a* and Secchi depth are generally the same, while TSI values for TP are generally lower than both Chl-*a* and Secchi depth. This is one of several familiar patterns that often emerge when comparing these three values (Carlson & Havens, 2005). This pattern suggests that algae biomass in a lake is limited by phosphorus and that algae dominate light attenuation. Under these conditions, algal bloom frequency may respond more quickly to phosphorus load reduction (Carlson & Havens, 2005).

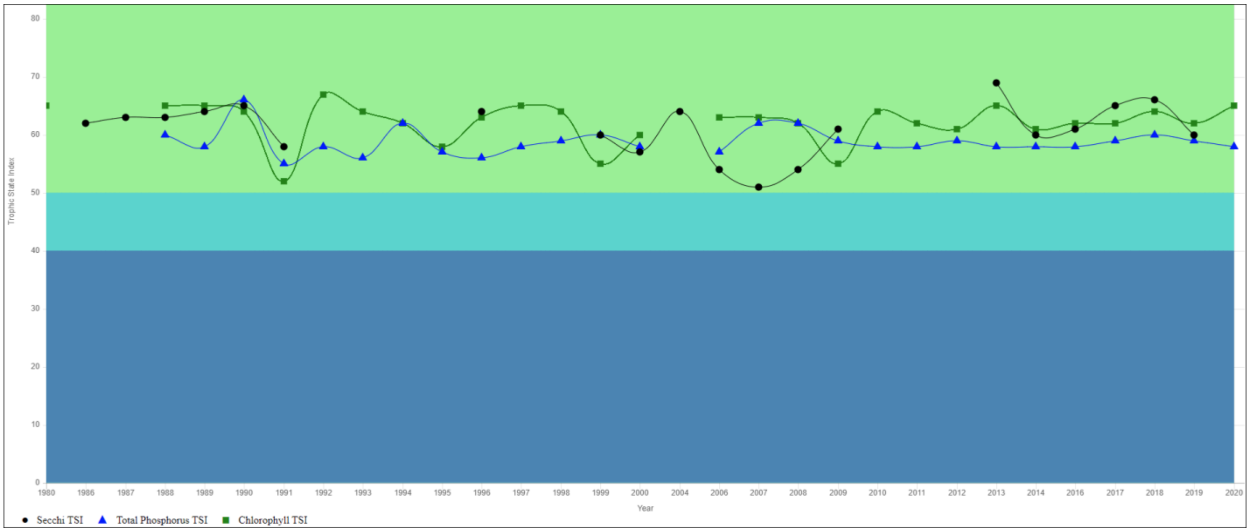


Figure 9: Deep Hole (SWIMS ID 573124) – Long Term Trend Monitoring

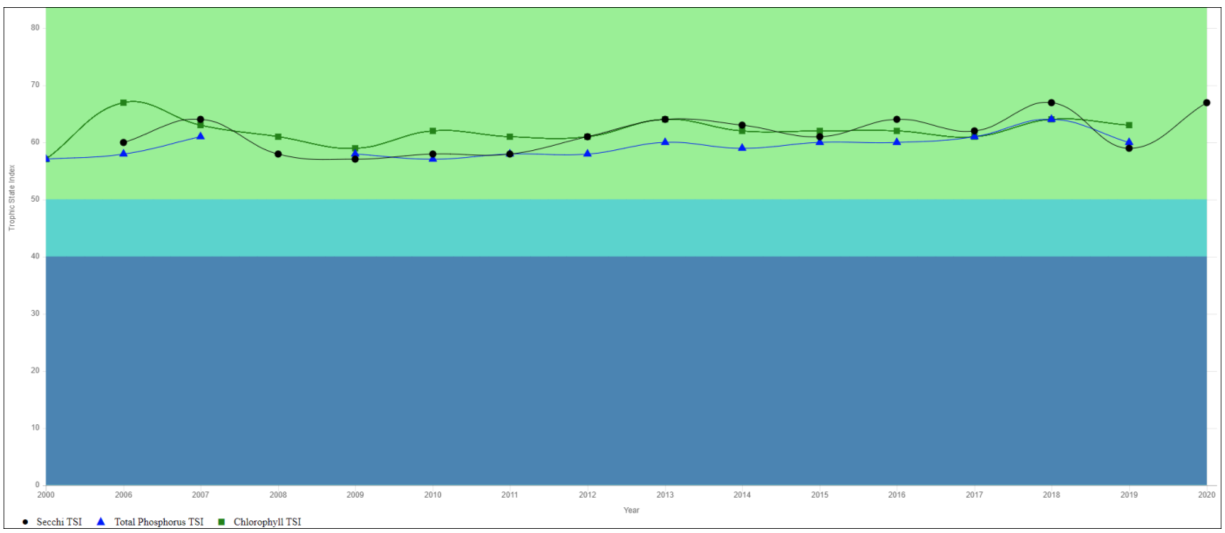


Figure 10: Lower Site (SWIMS ID 573129) – Navajo Court

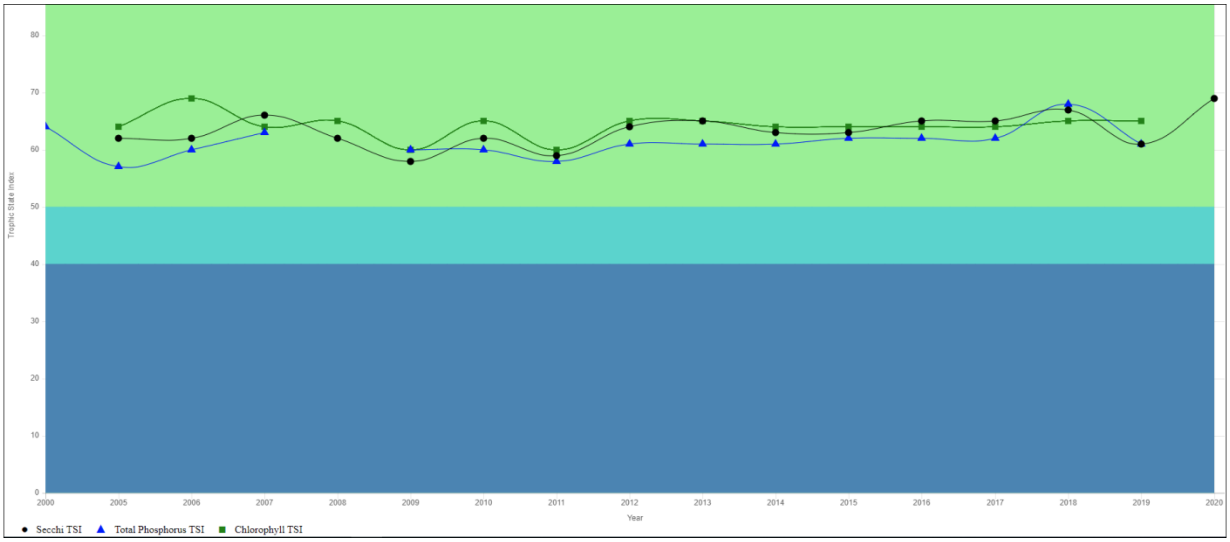


Figure 11: Middle Site (SWIMS ID 573131) – Mourning Dove

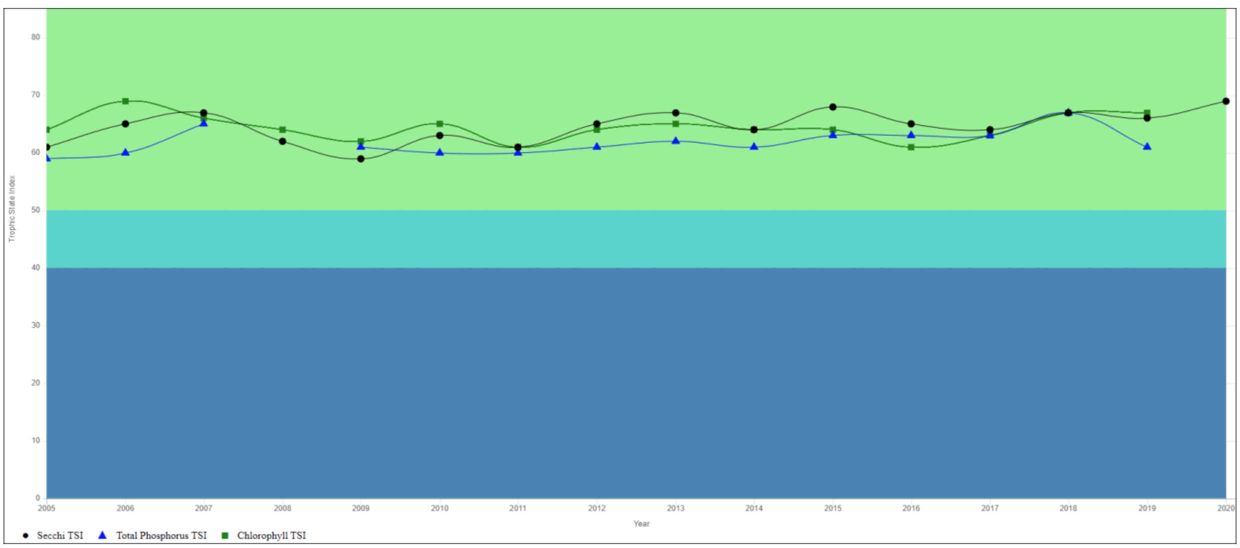


Figure 12: Upper Site (SWIMS ID 573205) – Winnebago Court

3.1.1.1 Statistical Analysis of Long-Term Water Quality Data from Lake Redstone (Oldenburg, 2021)

All four lake monitoring sites in the previous section have data sets supportive of long-term trend statistical analysis. Long-term trend analysis at the Deep Hole site, showed a significant increase in TP from 1988-2019. Given that the reservoir was initially built in 1966, this trend may be more indicative of reservoir ageing rather than an indication of increasing external TP loading. Looking at the data collected from 2006-2019, there was no significant trend in summer TP concentrations. Similarly, there was no significant trend in summer TP concentrations at the lower, middle, or upper sites.

When comparing each site to the other sites for TP, one-way analysis of variance (ANOVA) of TP data collected from 2006-2019 indicated that there was a significant difference between the four sites. Pairwise comparison of the sites indicated that the mean TP at the Deep Hole site was not significantly different than the mean TP at the Lower site, but was significantly different than mean TP at the Middle and Upper sites.

Pairwise comparison between mean TP at the Lower, Middle and Upper sites indicated that the means at these sites were not significantly different from one another (Table 2).

Based on these results, it may not be necessary to monitor all three supplementary sites in addition to the Deep Hole site to characterize the lake. When supplementary monitoring is conducted in the future, monitoring at the Deep Hole and Middle site should be sufficient to capture the longitudinal changes in TP that occur in the reservoir.

Table 2: Pairwise site comparisons of Lake Redstone TP data

Comparison	Absolute Difference in Mean log (TP)	Critical Range (α=0.05)	Critical Range Minus Absolute Difference	Result
Deep Hole-Lower	0.085	0.211	0.126	Not Different
Deep Hole-Middle	0.237	0.218	**-0.019**	Different
Deep Hole-Upper	0.291	0.216	**-0.075**	Different
Middle-Lower	0.152	0.211	0.059	Not Different
Upper-Lower	0.206	0.210	0.003	Not Different
Middle-Upper	0.054	0.216	0.162	Not Different

3.1.1.2 Lake Retention and Flushing Rate (Water Budget)

The average length of time that water spends in a lake (retention time) is the volume of the lake divided by the inflow of water from all sources. The flushing rate is the inverse of retention time, or the amount of time it takes to replace the volume of a lake (NALMS, 2017).

Lake response modeling was used in this plan to determine a retention time for Lake Redstone. Depending on which model is used, the retention time for water that comes into Lake Redstone is between 179 days (Bathtub Model) to 248 days (WiLMS)[1]. Thus, the total volume of water in Lake Redstone is replaced between 1.47 and 2.0 times per year (flushing rate). As a result, sediment and other pollutants entering the lake via surface water flow have plenty of time to settle and remain in the lake. Under normal conditions, a single flushing of Lake Redstone can take a long time, and the time required for multiple flushing events is even longer. But when things are not normal, like during large storm events like in 2018, the retention time may be only a few weeks, days, or hours and the flushing rate rapidly increases. Unfortunately, in these types of events, pollutant loading increases greatly as well.

3.1.1.3 WRB TMDL Lake Response Monitoring – Bathtub Modeling (Oldenburg, 2021)

As a part of the WRB TMDL, lake response modeling was done for Lake Redstone. The original modeling is described in Appendix I of the WRB TMDL report, and is included as Appendix C in this document. Steady-state modeling was conducted using Bathtub (Version 6.1, Walker 1996). Lake surface area and volume were based on values reported on WI-DNR lake survey maps (http://dnr.wi.gov/lakes/maps/). Mixed layer depth was based on model predictions. All model runs were based on long-term annual average loadings.

Long-term annual average water and nutrient loads to each lake were estimated using the SWAT model developed for the WRB TMDL (WI-DNR, 2019). Atmospheric loading rates were based on a precipitation rate of 0.8-m/yr. and a phosphorus load of 30-mg/m2/yr.

[1] For more information about water quality modeling tools and lake management tools go to https://dnr.wisconsin.gov/topic/SurfaceWater/Models.html or https://dnr.wi.gov/lakes/model/.

Epilimnetic (surface water) TP results for the modeling of Lake Redstone were acquired from the WI-DNR's comprehensive 2014 Lake Assessment data set developed for Wisconsin's 2014 Impaired Waters List. This data set encompassed the period from 2003 through 2012.

The Bathtub model and other lake response models are based on past research and studies. To assess whether modeling results make sense or not, the results are compared to these past studies, and the closest fit is used to make predictions. For Lake Redstone the Canfield-Bachman-Reservoirs TP sub-model was selected based on overall model fit. Model fit was adequate in all cases and no site-specific calibration was required.

To determine loading capacity for the lake, upstream tributary concentrations were sequentially lowered until modeled in-lake TP matched the goal for TP concentration in Lake Redstone of 30-μg/L (per NR 102.06 Wis. Admin. Code). Atmospheric TP loading rates were held constant as were hydraulic loading rates.

To provide some insight of potential lake response to reduced loadings, baseline TP loadings were reduced incrementally to evaluate resultant changes in in-lake TP concentrations (Figure 13). It is from this representation of the data that it is predicted that a 67% reduction in TP loading is necessary for the lake to meet state water quality standards. Note that these model outputs assume that the lake is in equilibrium with respect to any internal recycling (i.e. steady state condition). As watershed loads are reduced, there may be a lag in lake TP response as the system is adjusting to its new equilibrium. The length of this lag period is highly dependent on lake hydrology, morphometry, and sediment chemical characteristics. If substantial reduction in watershed loading is achieved and doesn't correspond to improvements in water quality; and if further investigation into the impact of and mechanisms controlling internal phosphorus recycling support them, then it may be appropriate at that time to implement practices like application of alum designed to control or minimize internal loading.

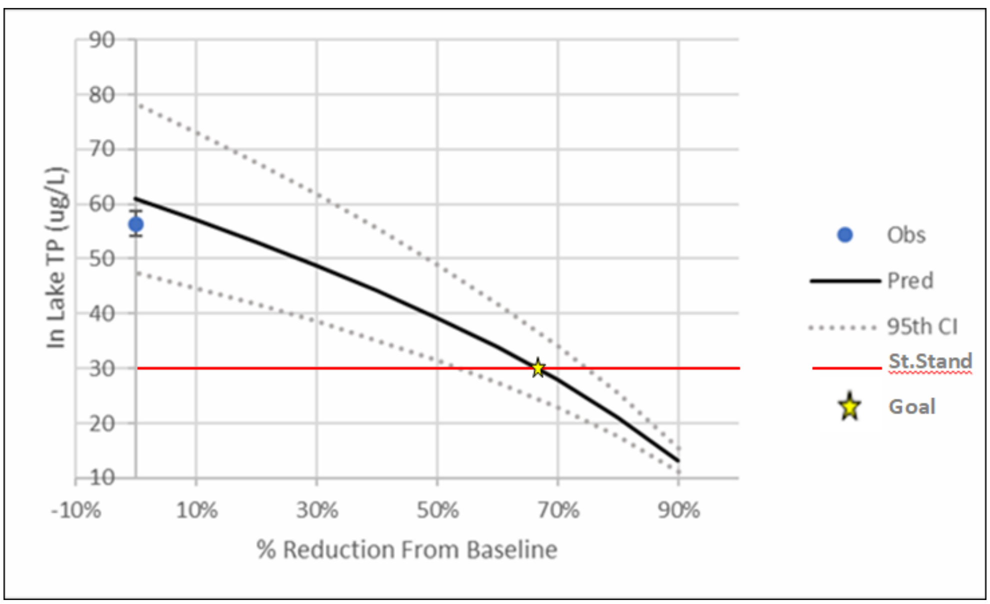


Figure 13: Bathtub predicted in-lake TP response to external TP load reductions. Error bars represent the 90th percentile confidence interval of observed values. The Star represents the goal for deep reservoirs like Lake Redstone set by the State of Wisconsin.

3.1.1.4 Chlorophyll as a Measure of Algae Biomass Response (Oldenburg, 2021)

While the TP criterion for Lake Redstone drove the TMDL goals, chlorophyll (algal) levels are a main driver impacting lake users and overall lake health. Bathtub modeling results were further evaluated to assess the impact of TP reductions on Chl-*a* levels. Several chlorophyll response models were evaluated in this process (Walker, 1984) (Hickman, 1980) (Jones & Bachman, 1976), with Jones & Bachman being selected based on best model fit. While the Jones & Bachman model was the best fit, based on measured Chl-*a* concentrations in the lake, it underestimates values. To account for this, and to provide a conservative estimate of the chlorophyll response, predictions from the model were adjusted upwards by 11%. Figure 14 reflects the expected change in Chl-*a* concentration with changes in TP concentration.

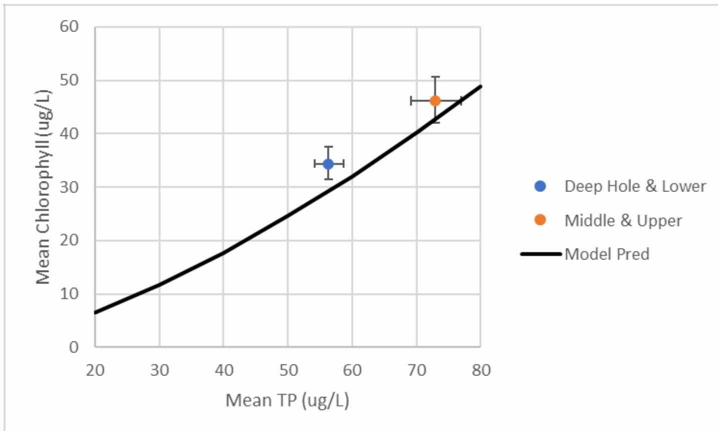


Figure 14: Jones & Bachman (1976) predicted mean Chl-*a* concentration. Error bars represent the 90th percentile confidence interval of observed values (Oldenburg, 2021).

Mean chlorophyll response is only a portion of the information that defines lake water quality. When measured in the water, Chl-*a* is used as a measure of the amount of algae in that water. Higher concentrations of Chl-*a* in the water are associated with more algae in the water. Increased levels of algae in the water are often associated with less enjoyment of that water. However, the amount of chlorophyll in the water does not always remain constant. Recreational lake users are oftentimes more impacted by periodic and often severe algal blooms (spikes in the concentration of chlorophyll) which can be much more intense than the seasonal averages that are predicted by Jones & Bachman model. How often an algae bloom is likely to occur in a body of water can be predicted through additional modeling. Once bloom frequencies are estimated they can be further related to the number of days an algae bloom of certain intensity may be expected between what is considered the period of heaviest lake use by the EPA and WisCALM between July 15 and September 15 (see Section 1.3).

How the intensity of an algae bloom impacts lake is perhaps best described through an analysis of a decade of Wisconsin user perception data from the Citizen Lake Monitoring Network (CLMN). This data indicates that at a chlorophyll concentration of 20-μg/L, half of Wisconsin lake users would consider their enjoyment of the lake somewhat impaired (WI-DNR, 2021). Other metrics include an analysis of user perception data from Lake Pepin by the Minnesota Pollution Control Agency. These data indicated a slightly higher tolerance by lake users for algal blooms with 40-μg/L considered a "nuisance" level (Walsey & Heiskary, 2009). The World Health Organization recommends a chlorophyll guideline of 50-μg/L to define a moderate health alert in recreational waters (World Health Organization, 2003).

Figure 15 estimates the frequency and intensity of algae blooms in Lake Redstone based on current summer conditions under all three of these metrics.

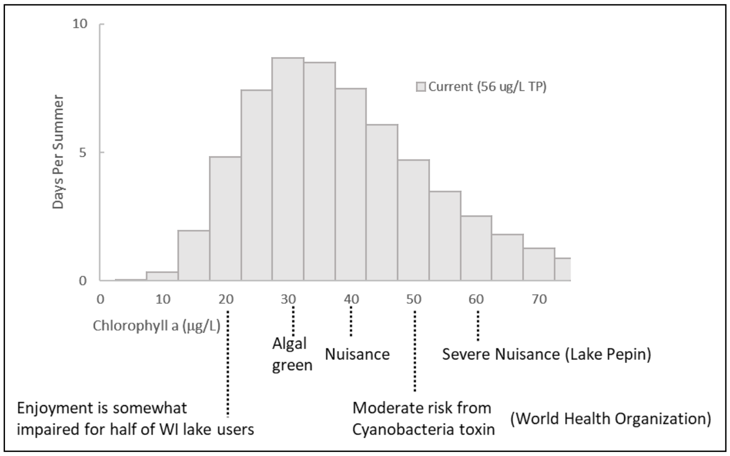


Figure 15: Estimated current distribution of chlorophyll bloom frequency for Lake Redstone in relation to user perception metrics (Oldenburg, 2021).

3.1.1.5 Internal Phosphorus Loading

Phosphorus entering the lake from external sources (watershed, riparian area, etc.) drives in-lake TP and productivity, and then that phosphorus is either exported out of the lake or deposited in its sediments (Robertson & Diebel, 2020). Not all phosphorus deposited in the sediments remains there, as some is released back into the water column, referred to as "internal phosphorus loading." From Robertson and Diebel 2020, internal phosphorus loading can be generically considered as all physical, chemical, and biological processes by which phosphorus is mobilized and translocated from the benthic (bottom of the lake) environment.

A study completed by the WI-DNR in 1997 determined that growing season TP loads to Lake Redstone came from the following sources: 66% from watershed runoff, 29% from internal phosphorus loading, and about 2% from groundwater (Leverance & Panuska, 1997). Although 29% of the phosphorus was predicted to be coming from internal loading of phosphorus, the study suggested that the 29% "may not be a significant part of the problem." The following factors led those who conducted the study to come to that conclusion. 1) Most of the phosphorus in the bottom water isn't available for algal use during the growing season but does become available in the fall when lake stratification is breaking down with cool weather. And 2) The frequency and duration of algal blooms during this period (fall) is low and not as noticeable as during the summer period. This latter observation was based on the flushing rate of Lake Redstone at the time that would exchange phosphorus laden water about two times per year suggesting that any phosphorus released from the sediment in early to mid-autumn would flow out of the lake by late autumn and winter (Panuska, 1997).

There is significant interest on the part of the LRPD to evaluate internal loading more completely in the first year or two of implementation.

3.1.1.6 Bottom Disturbances

Internal loading in shallow lakes can be exacerbated by the resuspension of bottom sediments. One study estimated that resuspension could enhance the phosphorus release rate by 20–30 times compared to undisturbed sediment (Sondergaard, Kristensen, & Jeppesen, 1992). About 90-95% of the phosphorus entering a lake is accumulated in the top layer of the sediment (Nedohin & Elefsiniotis, 1997). A significant portion of this is not readily available for uptake by algae, but the mixing of the sediment with the lake water above it releases a considerable amount of phosphorus which is then available for assimilation and utilization in the eutrophication process. Man-made mixing processes in a lake include swimming, motor boat activity, and other artificial mixing. These actions have greater impact on a lake when the lake has considerably high motor boat activity; it is considered shallow (<10 meters); and it has considerable resistance to wind and pressure changes (Nedohin & Elefsiniotis, 1997), all conditions that exist in Lake Redstone.

Re-suspended sediment can negatively impact water quality and aquatic plant growth. The current knowledge on effects of recreational boat traffic on the aquatic environment has been summarized in a number of reviews and government reports (Sagerman, Hansen, & Wickstrom, 2020). The resuspension of sediments can release sediment nutrients, stimulating phytoplankton growth that also results in shading of benthic vegetation The propellers of motorboats can directly cut or uproot the vegetation, and sensitive species can be damaged by wake and turbulence generated by propellers and boat movement. Water turbulence and wake also stir up sediment, resulting in shading of benthic vegetation due to increased water turbidity and in smothering when sediment settle on the shoots (Sagerman, Hansen, & Wickstrom, 2020). Figure 16 provides a simple illustration of the potential impacts of motorboat use.

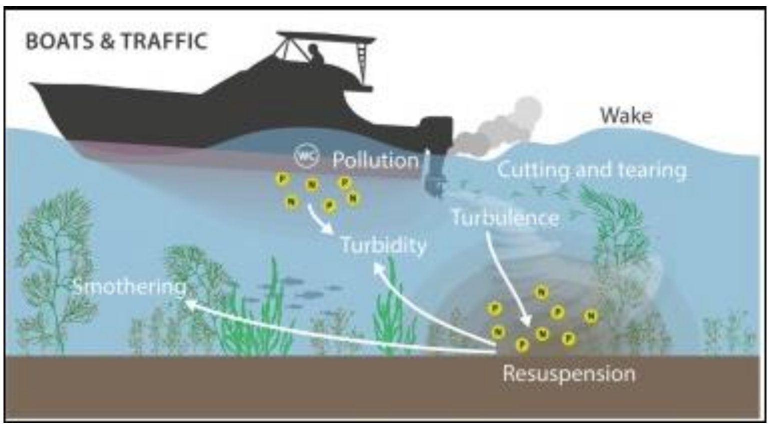


Figure 16: Illustration of mechanisms by which recreational boating activities affect submerged aquatic vegetation, separated into mechanisms generated by boats (Sagerman, Hansen, & Wickstrom, 2020)

3.1.2 Fisheries

Lake Redstone provides an excellent overall fishery, with a variety of quality fishing opportunities. Musky smallmouth bass, walleye, white crappie, and yellow perch are common. Yellow bullhead, channel catfish, bluegill, and largemouth bass are present. Because of the eutrophic nature of the lake, it has average to above average growth rates for all panfish and gamefish analyzed. According to the latest fisheries survey, management should focus on maintaining the current diverse fish community. Public access is good with three boat ramps maintained by the township and county (Rennicke, 2012).

Because depths over 12-ft have either low dissolved oxygen or are anoxic (no oxygen), the majority of the lake is not utilized by fish. For this reason, areas that are utilized by both fish and other organisms should be either enhanced or protected. Further remediation's to control, remove, and/or manage nutrients already in the lake and coming into the lake could potentially change the status of this area of the lake (Rennicke, 2012).

3.1.2.1 <u>Fish Stocking (Rennicke, 2012)</u>

With the exception of minimal stocking of walleye in 1967 and 1969, Lake Redstone did not receive stocked fish until 1982. Between 1969 and 1982 no stocking was done due to concerns related to annual and semi-annual die offs during both summer and winter months (Rennicke, 2012). Table 3 reflects stocking records since 1982 (WI-DNR, Fish Stocking Summary). Since 1982, walleye have been stocked almost annually. Since 1987, musky have been stocked in every other year. Northern pike were stocked once in 1982 and yellow perch once in 1983.

In 2018, the Lake Redstone Fishing Club (LRFC) began stocking larger walleye (6-8") in between the years when the WI-DNR stocked walleye fingerlings. In 2018 3,000 walleye were stocked by the LRFC, and in 2020, 5,500 were stocked (personal communication, Paul Burke 9/13/2021).

Channel catfish have been stocked twice, once in 1982 and once in 1993 (Rennicke, 2012). In 1997, the La Valle Hawg Hunters Club requested approval to stock smallmouth bass (which had previously not been present). The request was approved and for two years (1998 and 1999) smallmouth bass were stocked in the lake. There appears to be natural reproduction and the species is currently self-sustaining (Rennicke, 2012).

Currently the DNR quota requests for Lake Redstone are; walleyes at a rate of 18 small fingerlings per acre and musky at 1 large fingerling per acre each year. Walleye and musky will continue to be stocked to help maintain populations (Rennicke, 2012).

As of 2012, Lake Redstone follows the general inland fishing regulations with the exception of a 50 inch minimum for muskellunge (Rennicke, 2012).

3.1.2.2 Common Carp

Common carp were listed as "present" in Lake Redstone with WI-DNR survey results analyzed by Rennicke in 2012 documenting six carp ranging from 22.1-32.7 inches caught during the 2010 spring netting period. In the same year, spring electrofishing, where protocol is to observe and count carp, but not to measure them, found 29 carp per mile of shoreline surveyed. According to the current WI-DNR fisheries manager for Sauk County, this number is "not uncommon but not overly abundant either, relative to other area lakes" (personal communication Nathan Nye, October 7, 2021). Nye also stated that there is - not enough data on carp abundance, biomass, or population size structure to make any sort of educated statements about the carp population and how much it may be impacting Lake Redstone.

The effect of common carp domination on wetland and lake ecosystems is complex. Carp uproot aquatic macrophytes when spawning and feeding. These activities also suspend bottom sediments and nutrients, limiting light penetration needed for macrophyte growth. Carp also reduce zooplankton and macroinvertebrate populations by predation and by eliminating macrophytes that provide cover. Phytoplankton populations increase due to increased release of nutrients and reduced predation by zooplankton. Fish and wildlife are adversely affected by the loss of zooplankton and macroinvertebrate food sources, and loss of aquatic macrophytes that provide cover for larval and juvenile fish and substrate for eggs and invertebrates (Kahl, 1991).

Having a better understanding of the role of carp in nutrient cycling in the lake with an eye toward potential carp management activities is another important variable in determining just what is impacting the lake and how. According to Nye, it may be possible to "give carp some extra focus during the spring 2022 survey" and he sounds willing to do so (Personal communication Nathan Nye, 10/7/2021).

Regardless of not knowing for sure what role common carp play in internal nutrient loading in Lake Redstone, the Lake Redstone Fishing Club has sponsored carp "bow-fishing competitions" in years past. The last such event was held on June 20, 2020. It is a popular event on the lake and will likely continue at some level in the future.

Table 3: Fish stocking in Lake Redstone (WI-DNR, Fish Stocking Summary)

Year	StockedWaterbodyName	Location	Species	Age Class	NumberFishStocked	Avg FishLength (IN)
1983	LAKE REDSTONE	13N-3E-24	MINNOWS & CARPS UNSP.	ADULT	100,000	3
2018	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	612	12.3
2016	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	613	10.3
2015	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	609	11.8
2014	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	610	9.3
2013	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	612	11.35
2012	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	612	9.7
2011	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	612	10
2010	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	612	12.9
2008	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	1,224	10.7
2005	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	1,224	12.1
2003	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	1,224	11.4
2001	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	1,224	10.4
2000	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	612	12
2000	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	YEARLING	368	14.3
1999	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	337	11.8
1999	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	YEARLING	301	14.7
1998	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	275	11.9
1997	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	560	10.4
1995	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	FINGERLING	1,200	8.8
1993	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	FINGERLING	1,200	10.5
1991	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	FINGERLING	850	11
1987	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	FINGERLING	1,200	3
1982	LAKE REDSTONE	13N-3E-24	NORTHERN PIKE	FRY	310,000	
2019	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	21,054	2.06
2017	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	21,159	1.7
2015	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	21,159	1.8
2013	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	14,813	1.7
2012	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	10,600	1.7
2011	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	10,579	1.47
2010	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	11,736	1.73
2009	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	11,016	1.6
2008	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	11,016	1.3
2006	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	34,345	2.05
2005	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	33,019	1.91
2004	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	30,550	2.1
2003	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	30,660	2.1
2002	LAKE REDSTONE	13N-3E-24	WALLEYE	LARGE FINGERLING	621	7.9
2002	LAKE REDSTONE	13N-3E-24	WALLEYE	LARGE FINGERLING	5,626	7.8
2001	LAKE REDSTONE	13N-3E-24	WALLEYE	FRY	1,100,000	0.5
2000	LAKE REDSTONE	13N-3E-24	WALLEYE	FRY	1,100,000	0.5
2000	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	61,969	1.5
1999	LAKE REDSTONE	13N-3E-24	WALLEYE	FRY	1,101,000	0.4
1999	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	61,200	1.5
1998	LAKE REDSTONE	13N-3E-24	WALLEYE	FRY	1,050,000	0.4
1997	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	20,600	1.6
1995	LAKE REDSTONE	13N-3E-24	WALLEYE	YEARLING	6,854	5.1
1992	LAKE REDSTONE	13N-3E-24	WALLEYE	FINGERLING	18,837	3
1991	LAKE REDSTONE	13N-3E-24	WALLEYE	FINGERLING	13,992	3
1989	LAKE REDSTONE	13N-3E-24	WALLEYE	FINGERLING	15,136	2
1988	LAKE REDSTONE	13N-3E-24	WALLEYE	FINGERLING	2,100	8
1987	LAKE REDSTONE	13N-3E-24	WALLEYE	FINGERLING	12,000	4
1986	LAKE REDSTONE	13N-3E-24	WALLEYE	FINGERLING	9,135	3
1984	LAKE REDSTONE	13N-3E-24	WALLEYE	FINGERLING	6,540	5.25
1983	LAKE REDSTONE	13N-3E-24	WALLEYE	FINGERLING	1,500	5
1983	LAKE REDSTONE	13N-3E-24	WALLEYE	YEARLING	5	11
1983	LAKE REDSTONE	13N-3E-24	YELLOW PERCH	YEARLING	2,000	4

3.1.3 Critical Habitat Areas

Lake Redstone is considered an Area of Special Natural Resource Interest because portions of the lake contain critical habitat designated by the WI-DNR (Sefton & Graham, 2009). Every waterbody has critical habitat - those areas that are most important to the overall health of the aquatic plants and animals. Wisconsin law mandates special protections for these critical habitats assuming they have been identified in an official critical habitat designation. Areas are designated as Critical Habitat if they have Public Rights Features, Sensitive Areas, or both (WI-DNR, Critical Habitat Areas). The Critical Habitats (Public Rights Features) for Lake Redstone include:

- Fish and wildlife habitat, including specific sites necessary for breeding, nesting, nursery and feeding;
- Plant communities and physical features that help protect water quality; and
- Reaches of bank, shore or bed which are predominately natural in appearance or that screen man-made or artificial features.

There were 20 areas designated as Critical Habitat for Lake Redstone (Figure 17). Fourteen of these were classified as Sensitive Areas for their aquatic vegetation and six were classified as Other Public Rights Features for containing reaches of shore that are predominately natural in appearance or that screen man-made or artificial features, and/or fish and wildlife habitat values.

Designation as Critical Habitat may affect the decision process on Waterway and Wetlands Permits under Ch. 30, Wis. Statutes. These include activities such as grading on the banks, dredging, placement of pea gravel beds or sand blankets, boat ramps, or shoreline erosion control (subject to appropriate site-specific wave energy calculations). This does not mean these activities will be prohibited, but that they will undergo more careful review to ensure that the activity does not adversely affect the critical habitat in the area.

Designation as Critical Habitat may also affect decisions on permitting of aquatic plant management under NR107 and NR109 of the Wis. Adm. Code. All aquatic plant management activities in Lake Redstone undergo careful review to ensure that the activity does not adversely affect the sensitive ecosystem in the area.

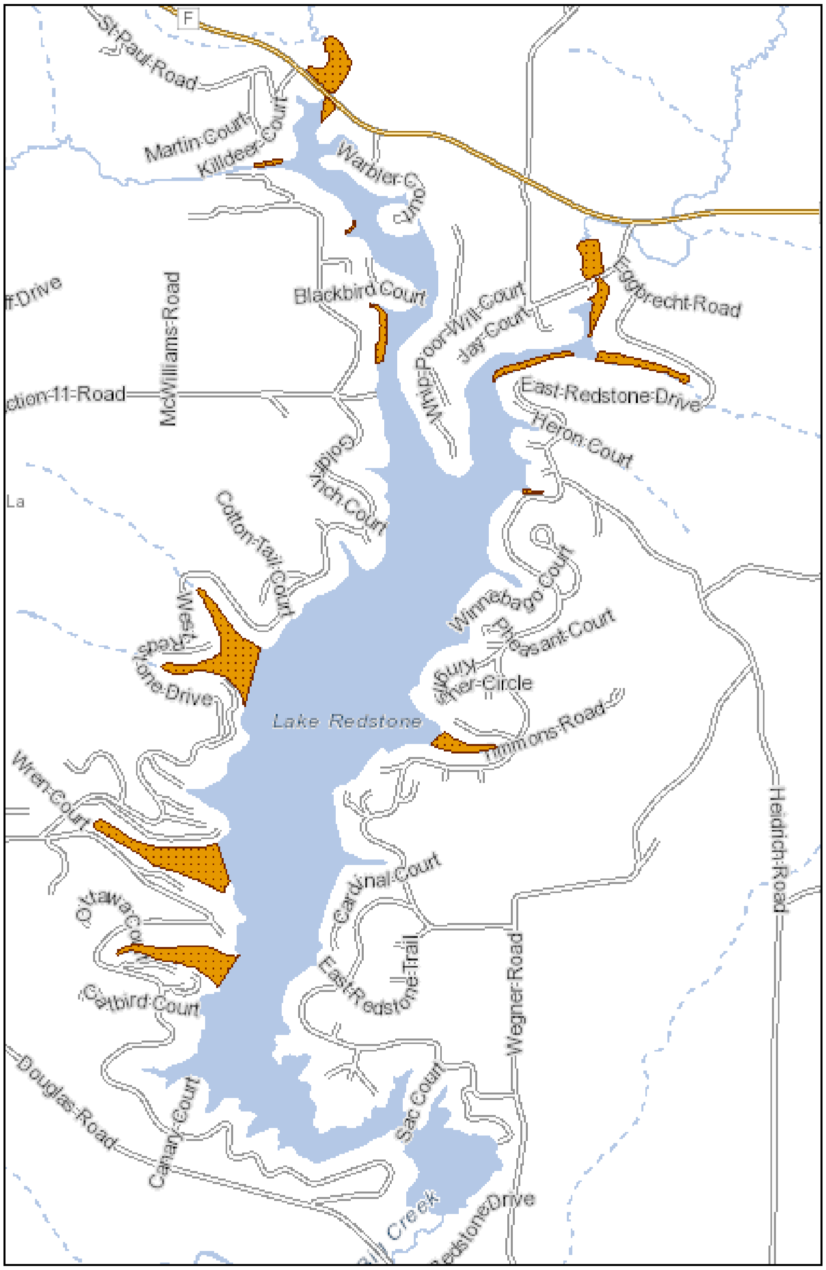


Figure 17: Critical habitat areas in Lake Redstone

3.1.4 Aquatic Plants

Aquatic plants form the foundation of healthy and flourishing lake ecosystems - both within lakes and rivers and on the shores around them. They not only protect water quality, but they also produce life-giving oxygen. Aquatic plants are a lake's own filtering system, helping to clarify the water by absorbing nutrients like phosphorus and nitrogen that could stimulate algal blooms. Plant beds stabilize soft lake and river bottoms and reduce shoreline erosion by reducing the effect of waves and current. Healthy native aquatic plant communities help prevent the establishment of invasive non-native plants like Eurasian watermilfoil, purple loosestrife or phragmites (WI-DNR, Aquatic Plants).

The best fishing spots are typically near aquatic plant beds. Aquatic plants provide important reproductive, food, and cover habitat for fish, invertebrates and wildlife. Aquatic plants fashion a nursery for all sorts of creatures ranging from birds to beaver to bass to bugs. In order to maintain healthy lakes and rivers, healthy native aquatic plant communities must be maintained (WI-DNR, Aquatic Plants).

Lake characteristics valued by so many are enhanced by the aquatic plant community. The visual appeal of a lakeshore often includes aquatic plants, which are a natural, critical part of a lake community. Plants such as water lilies, arrowhead, and pickerelweed have flowers or leaves that many people enjoy. Clear water is supported by the presence of aquatic plants. As a natural component of lakes, aquatic plants support the economic value of all lake activities.

3.1.4.1 Aquatic Plants in Lake Redstone

During the last whole-lake, point-intercept survey of the lake completed in July 2012, 85 out of 966 individual points surveyed had aquatic plants (Berg, 2012). Aquatic plants were patchy in distribution with just over 25% of the lake's available substrate being colonized. Species richness was low for such a large lake with only 11 species found in the lake. Including visuals and a boat survey, this number increased to 16 different plant species found growing in and immediately adjacent to the lake. Lake-wide, only 5 of the 85 points with vegetation had more than 3 native species present in the rake. The average number of plant species at points with vegetation was 1.4 when only counting native species and 1.74 when including exotic species. Plant density was low to moderate with a mean total rake fullness value at vegetative points of 1.54.

3.1.4.2 Measurements of Healthy Aquatic Plant Community

The Simpson's Diversity Index (SDI) allows the entire plant community at one location to be compared to the entire plant community at another location. It also allows the plant community at a single location to be compared over time thus allowing a measure of community degradation or restoration at that site. The SDI value represents the probability that two individuals (randomly selected) will be different species. The index values range from 0 -1 where 0 indicates that all the plants sampled are the same species to 1 where none of the plants sampled are the same species. The greater the index value, the higher the diversity in a given location. Although many natural variables like lake size, depth, dissolved minerals, water clarity, mean temperature, etc. can affect diversity, in general, a more diverse lake indicates a healthier ecosystem. Plant communities with high diversity also tend to be more resistant to invasion by exotic species (Berg, 2012). The SDI value for Lake Redstone in 2012 was 0.75 indicating low to moderate plant diversity (Berg, 2012).

The Floristic Quality Index (FQI) measures the impact of human development on an area's aquatic plants. The 124 species in the index are assigned a Coefficient of Conservatism (C) which ranges from 1-10. The higher the value assigned, the more likely the plant is to be negatively impacted by human activities relating to water quality or habitat modifications. Plants with low values are tolerant of human habitat modifications, and they often exploit these changes to the point where they may crowd out other species. The FQI is calculated by averaging the conservatism value for each native index species found in the lake during the point intercept survey, and multiplying it by the square root of the total number of plant species in the lake. Statistically speaking, the higher the index value, the healthier the lake's macrophyte community is assumed to be (Berg, 2012). (Nichols, 1999) identified four ecoregions in Wisconsin: Northern Lakes and Forests, Northern

Central Hardwood Forests, Driftless Area and Southeastern Wisconsin Till Plain. He recommended making comparisons of lakes within ecoregions to determine the target lake's relative diversity and health. Lake Redstone is in the Driftless Area Ecoregion.

During the 2012 survey, a total of 8 native index species were identified during rake sampling. They produced a mean Coefficient of Conservatism of 5.1 and a Floristic Quality Index of 14.5. Nichols reported an average mean C for the Driftless Area Ecoregion of 5.0 putting Lake Redstone slightly above average for this part of the state. The FQI was also slightly above the median FQI of 14.3 for the Driftless Area (Nichols 1999) (Berg, 2012).

Both the SDI and FQI indicate an aquatic plant community that is limited and that preserving what is currently present is important for the overall health of the lake.

3.1.4.3 Aquatic Plant Management

Aquatic plant management in Lake Redstone has been on-going since the early 1980's when the use of aquatic herbicides was first employed. In the years between the 1980s and 2002, EWM was chemically treated in small localized populations by LRPD volunteers who had obtained Category 5 commercial applicator certification. Large-scale algae treatments were completed in the 1980's. By 2002, the level of nuisance aquatic vegetation (EWM and certain native plants) in Lake Redstone reached a point where professional applicator services were required. From the early 2000s to the development of the last APM Plan in 2014, plant management permits applied for by the LRPD included 25-33 acres of possible treatment.

In 2009, the WI-DNR presented results from a critical habitat study (See Section 3.1.3) that was completed on Lake Redstone. This study identified areas of the lake sensitive to human development and use, and areas where the presence of valuable, native aquatic vegetation should have greater protection from nuisance aquatic plant management actions completed by the LRPD. The study raised a bit of controversy as it also impacted some of the regular aquatic plant management that had been occurring in the lake.

Lake Redstone property owners have many differing views related to the management of aquatic plants. Many did, and still do, express dissatisfaction with the aquatic plant management actions implemented by the LRPD. Many lake residents and users want improved water clarity in the lake and, at the same time, fewer plants, without realizing that these two statements are mutually exclusive. Aquatic plants in Lake Redstone are the basis of the ecosystem. Preserving them is critical to maintaining a healthy lake.

The main goal of the 2015 APM Plan was to seek a balance between management with the goal of protecting a healthy lake and management with the goal of protecting the rights of property owners to enjoy the lake. The 2015 APM Plan had the following ten aquatic plant management and lake protection goals. Each goal had several objectives to be met and identified management actions to help meet the objectives.

1) Protect, preserve and enhance native aquatic plant communities in Lake Redstone.
2) Complete annual monitoring and mapping of aquatic plants most affected by plant management actions.
3) Implement physical/manual removal actions to control aquatic invasive species and nuisance growth of native aquatic plants.
4) Implement herbicide application to control aquatic invasive species and nuisance growth of native aquatic plants.
5) Monitor and manage non-native, invasive plant species other than CLP and EWM identified in Lake Redstone.
6) Educate the lake populace so that they become well-acquainted with aquatic invasive species identification, prevention techniques, planning processes, and management actions.

7) Promote greater understanding in the lake populace of how their actions impact the aquatic plant and lake community.
8) Continue compilation and collection of lake related data to enhance and support current and future lake management planning and implementation.
9) Complete APM Plan implementation and maintenance for a period of five years following adaptive management practices.
10) Evaluate and summarize the results of the management actions implemented during the 5-year timeframe of this plan and repeat the whole-lake point-intercept aquatic plant survey implemented in 2012.

With the approval and implementation of the 2015 APM Plan, management of aquatic plants focused more on EWM in individual bays and less on native vegetation and EWM along the main shore of the lake – those areas not in a bay. It also included more increased aquatic plant surveying to determine the annual and long-term impacts of management. Chemical management of EWM has not been completed in any portion of Lake Redstone since 2018.

Repeating the 2012 whole-lake, point-intercept, aquatic plant survey work and updating of the 2015 APM Plan are short-term milestones in this plan.

3.1.4.4 Aquatic Invasive Species

Certain aquatic invasive species already in Lake Redstone can and likely are having an impact on water quality and overall health of the lake. These species include EWM, CLP, carp. Even native species such as coontail and gizzard shad, can rise to nuisance levels and impact the lake. There are several other aquatic invasive species that could be introduced into the lake and cause changes in water quality and lake health. Chief among these would be zebra mussels. Most existing and new AIS that could or are impacting the lake are discussed in the APM Plan. Guidelines are given in the APM Plan as to how to monitor and track AIS in the lake; how to prevent new introductions, and education and information resources to involve the constituency in protecting the lake from AIS.

3.2 Riparian Area

Riparian areas are the zones along all water bodies including lakes, ponds and some wetlands that serve as interfaces between terrestrial and aquatic ecosystems (Manci, 1989). Typical examples of riparian areas include floodplains, streambanks, and lakeshores. Riparian areas are important in mitigating or controlling nonpoint source pollution. Riparian vegetation can be effective in removing excess nutrients and sediment from surface runoff and shallow ground water and in shading waterbodies to optimize light and temperature conditions for aquatic plants and animals. Riparian vegetation, especially trees, is also effective in stabilizing streambanks and lakeshores and in slowing flood flows, resulting in reduced downstream flood peaks. Riparian areas are often important for their recreation and scenic values, such as hunting, fishing, boating, swimming, hiking, camping, picnicking and birdwatching (Montgomery, 1996).

Many riparian areas are heavily impacted by human activities, such as highway, bridge, and pipeline construction; water development; channel modifications for flood control; recreation; industrial and residential development; agriculture; irrigation; livestock grazing; logging; and mining (Manci, 1989).

3.2.1 Riparian Area of Lake Redstone

Two methods were combined to evaluate shoreland habitat and to determine the impact of development in the riparian area of the lake. The first was a Shoreland Habitat Assessment (SHA) following protocols found in the Lake Shoreland Habitat Monitoring Field Protocol developed by the WI-DNR in 2015 and updated in

November 2020.[2] This survey is intended to provide management recommendations to individual property owners based on the evaluation of their property. The protocol involves taking a photograph of each parcel/property from the lake and then assessing the land use in that parcel in an area from the high-water level back 35 feet. The information collected includes the amount of tree cover (canopy), ground cover (lawn, impervious surfaces, and native plants), human structures in the riparian area, and various other runoff concerns including steep slopes and the presence of erosion. Based on this information, each parcel is given an official "score" and a priority ranking. This assessment was completed in 2018.

The second part of this assessment involved mapping land use in a wider 300-ft strip of land around the lake. Aerial images of the lake and shoreland are digitized separating out impervious surfaces (rooftops, driveways, roads, and sidewalks), lawn, forest/undeveloped land, water, and wetlands. From these numbers, an estimate of the amount of nutrient loading from the riparian area can be made.

3.2.1.1 Shoreland Habitat Assessment

The priority rankings that accompany each parcel evaluation were developed by Lake Education and Planning Services (LEAPS) in order to determine the needs of each lake as it relates to projects that could realistically be completely on each parcel. The parameters used to determine the priority ranking were considered to be those that would have the biggest impact on rainwater runoff and habitat quality. This includes percentage of canopy cover, as well as the percentage of undisturbed vegetation and a summed percentage of ground covered by manicured lawn, impervious surfaces, and easily eroded surfaces such as exposed soil or shredded vegetation such as pine needles, loose leaves, small branches, etc. also known as duff. Additional consideration was given to the number of buildings present in the riparian area and the presence or absence of lawns that sloped directly to the lake. For each factor that was considered, there are value ranges assigned to each parameter which determine the color to be assigned (Table 4). Values that fall within the red range are worth 2 points, values in the yellow range are worth 1 point, and values in the white range are not given any points. The points are then summed and the properties prioritized based on the point range for the entire lake.

To establish priority rankings for the lake, it was important to consider the entire lake. The maximum possible score was 12 points, but the highest scoring parcel only scored 10 points. From here, four levels of concern were established: red, orange, yellow, and white. These colors correspond to properties that have the most potential to implement shoreland habitat and runoff reduction projects that will help improve the lake (Table 5, Figure 18).

[2] For more information about the Shoreland Habitat Assessment Protocol go to: https://www.google.com/search?q=2020+Shoreland+Habitat+Monitoring+Field+Protocol&rlz=1C1GGRV_enUS751US751&oq=2020+Shoreland+Habitat+Monitoring+Field+Protocol&aqs=chrome..69i57j33i160.20406j0j15&sourceid=chrome&ie=UTF-8

Table 4: Value ranges for color assignments of each SHA parameter of concern

Parameter	Red range (2 points)	Yellow Range (1 Point)	White (No points)
Percent canopy cover	0-33%	34-66%	>66%
Percent shrub and herbaceous (undisturbed)	0-33%	34-66%	>66%
Percent lawn, impervious, and other surfaces	>66%	34-66%	0-33%
Number of buildings and other human structures	>1	1	0
Presence/ Absence of lawn or soil sloping to lake	N/A	1 (Present)	0 (Absent)
Presence/Absence of bare soil	1 (Present)	N/A	0 (Absent)
Presence/Absence of sand deposits	N/A	1 (Present)	0 (Absent)

Table 5: Score ranges and priority rankings for the 784 parcels immediately adjacent to Lake Redstone

Color	Overall Score	Priority	Number of Parcels
Red	7-10 Points	High	214
Orange	4-6 Points	Moderate	209
Yellow	2-3 Points	Low	69
White	0-1 Points	No Concern	292

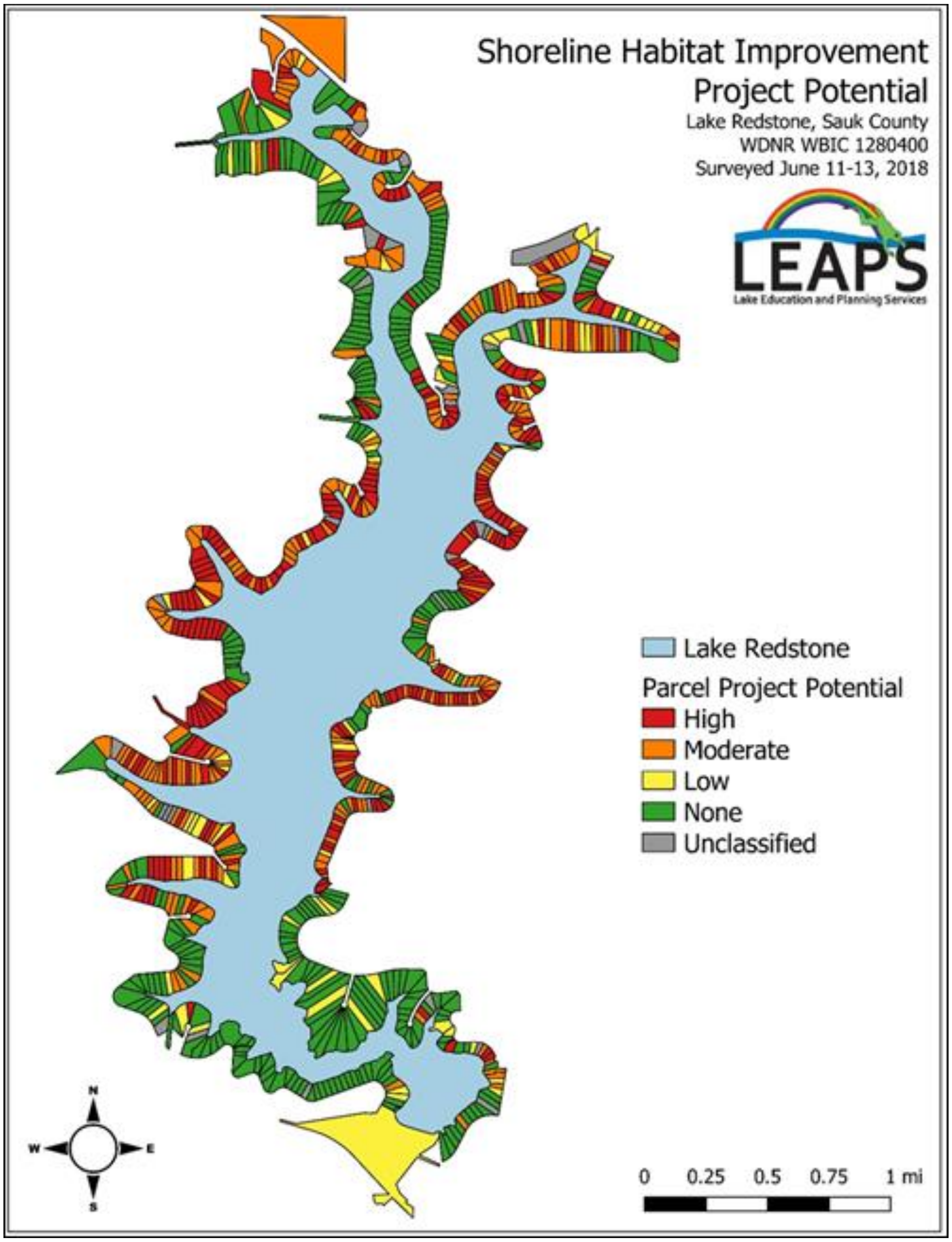


Figure 18: Lake-wide SHA results map

For each of the 784 parcels that were evaluated, an individual score and ranking was established based on the assessment. In addition to the assessment, surveyors took a photo of each parcel. Photos are intended to provide reference for individual property owners. It is important to note that when assessing each parcel, ONLY the 35-ft wide band along the shoreline was considered. The photos were not used to assess properties and can be misleading for certain parameters, particularly canopy cover. For example, some parcels appear mostly shaded, but only have 15% canopy cover. This is likely because the assessment only considered 35-ft back and the canopy cover started beyond that mark. Additionally, there are other considerations such as camera angle, time of day, etc. All evaluations were done in the field to prevent any misdirection that would have been caused by using photos to assess the properties. However, if it was determined that a photo of a given parcel was missing, aerial imagery was used instead of an actual photo.

3.2.1.2 Land Use Digitizing of the developed Area around the Lake

Land use digitizing in a 300-ft band around Lake Redstone was completed in 2019. The amount of impervious surface (rooftops, driveways, sidewalks, and roadway), lawn, natural/wooded, and wetland was determined by viewing aerial photos, and then creating geospatial files for each land use. In total approximately 600 acres in the developed area was digitized. This area includes both properties immediately adjacent to the lake and many of those "up on the bluff" or in some other way "off the lake". Table 6 shows how much of each land use was identified. Figure 19 shows the distribution of that land use.

Table 6: Riparian Area Land Use around Lake Redstone

Land Use	Acres	% of Total Land Use
Impervious Surface	95	15.8
Lawn	209	34.8
Forest/Natural	283	47.2
Wetland	13	2.2
	600	100

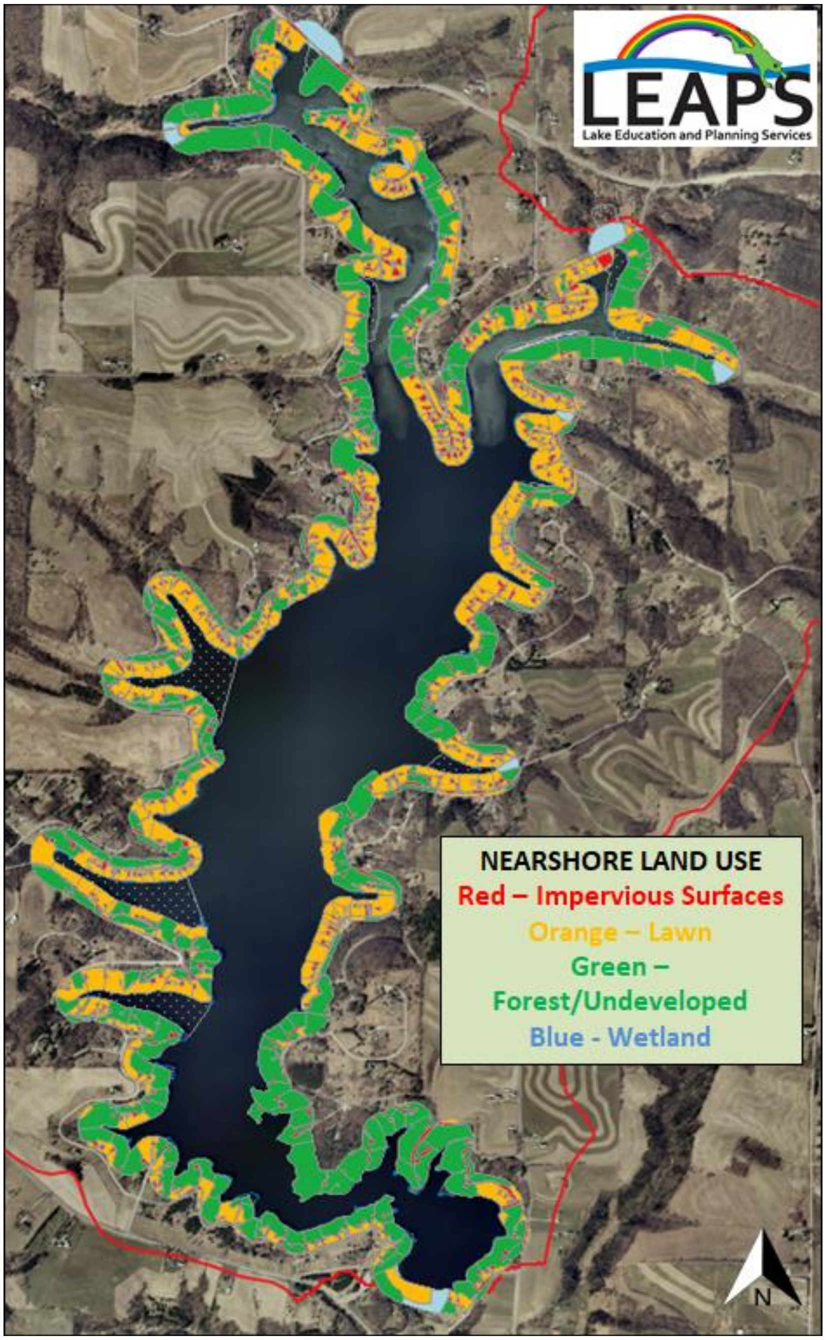


Figure 19: Land Use in a 300-ft band around Lake Redstone

More than 50% of the individual property parcels evaluated during the Shoreland Habitat Assessment were listed as having a moderate to high priority when considering the potential for implementing project that could improve habitat and reduce runoff. Similarly, results from the land use digitizing of the developed area around the lake showed more than 50% of the land in a 300-ft strip around the lake was either mowed grass or impervious surface (rooftops, driveways, roads, etc.).

Lake response modeling was used to estimate TP loading from the mowed lawn in the 300-ft riparian area around the lake and what would happen if the total acreage of mowed lawn increased or decreased (Table 7).

Table 7: Riparian land use TP loading (WiLMS)

Nearshore TP Loading (lbs/year)			
Condition	**Low**	**Likely**	**High**
50% less lawn	161.8	330.7	796.0
Current	161.8	331.6	802.5
20% more lawn	161.8	332.0	805.1

TP and sediment loading from the developed area of the riparian may be fairly insignificant when compared to loading from the larger watershed, but making improvements to this area is much easier and less expensive than what can be done across the entire watershed.

3.2.2 Gullies, Washes, and Streams

When Lake Redstone was first built, it flooded a large valley created by the two branches of Big Creek. Prior to the flooding, numerous gullies, washes, intermittent, and perennial smaller streams fed the two branches of the creek. Many of these same gullies, washes, intermittent and perennial streams now flow directly into Lake Redstone. There are 28 different bays around Lake Redstone proper, nearly all with some level of overland runoff via gullies, washes, or streams, particularly during storm events. After a large two-day rain event (August 27-28, 2018) that dropped 10 or more inches on Lake Redstone and its larger watershed, the LRPD solicited stories and photos of flooding and flood damage. Stories came in from around Lake Redstone, with Cardinal, Eagle, Mourning Dove, and Quail bays; and Sac Ct/Fox Ct having the most flood damage and soil erosion deposition (Figure 20).

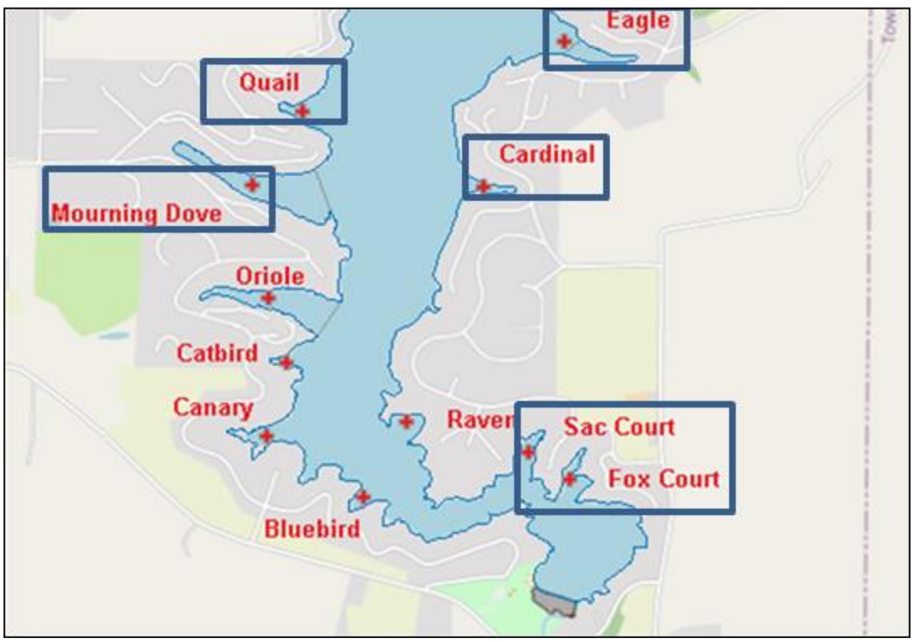


Figure 20: Locations of severe flooding during an August 2018 storm event

Several of the larger areas feeding certain intermittent and perennial streams have been delineated (See Section 3.2.2.1) and phosphorus loading estimated using models. However, none of the smaller gullies and washes has been delineated, nor has an attempt to determine sediment and phosphorus loading been made.

3.2.2.1 PRESTO Analysis of Phosphorous Loading from Intermittent or Perennial Streams in the Lower Lake Redstone Sub-basin

The Pollutant Load Ratio Estimation Tool (PRESTO) is a statewide GIS-based tool created by the WI-DNR that compares the average annual phosphorus loads originating from point and nonpoint sources within a watershed. PRESTO was designed to be easily modified, transparent to the end user, and to provide a consistent result based on readily available datasets. PRESTO performs three basic functions: watershed delineation, nonpoint source loading estimation, and point source loading aggregation. PRESTO outputs include a delineated watershed, watershed land cover composition, the estimated average annual nonpoint source and measured point source phosphorus loads (pounds per year), and the ratio of point to nonpoint phosphorus at a watershed outlet.

Chickadee North, Chickadee South, Martin-Meadowlark, Swallow, and Tanager (Heron) bays all have intermittent or perennial streams running into them and have all been delineated with PRESTO (Figure 21).

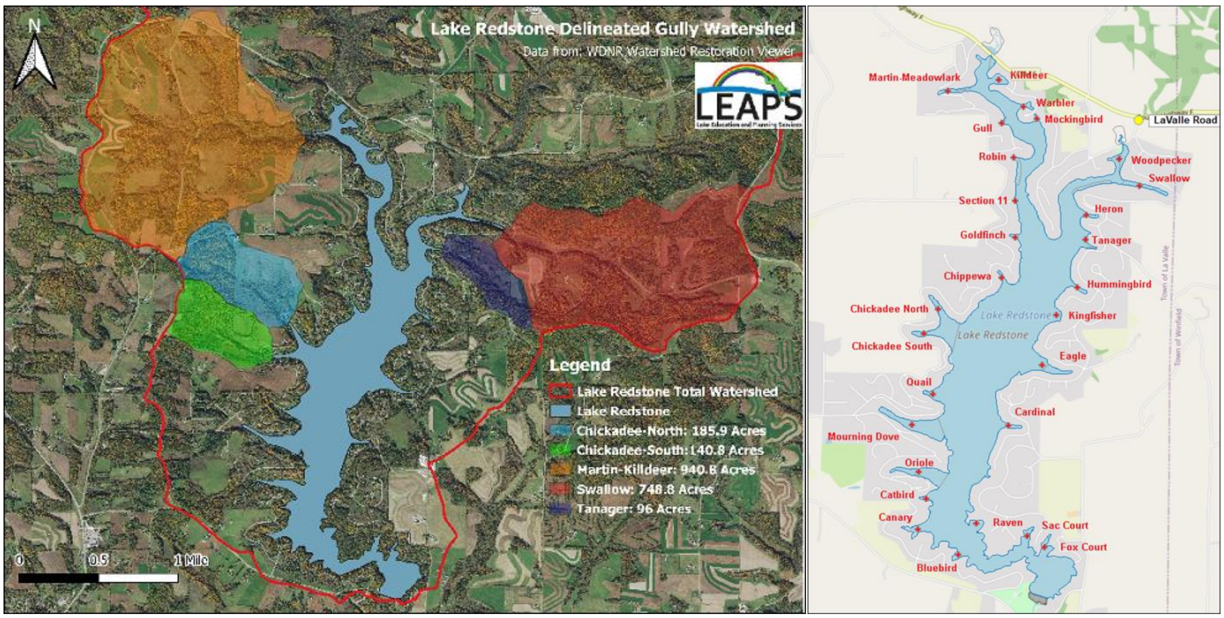


Figure 21: Land area delineation for intermittent and perennial streams flowing into Martin-Meadowlark (orange), Chickadee North (blue) and South (green), Swallow (red), and Heron (purple) bays

For each area delineated, a PRESTO report was generated to better define the contributing area to each bay (Figures 22-24). If the mean annual loading of phosphorus from each of these reaches is used and compared to the STEPL estimate of phosphorus loading from the entire Lower Lake Redstone sub-basin, they account for 26.8% of what is potentially entering Lake Redstone from this sub-basin.

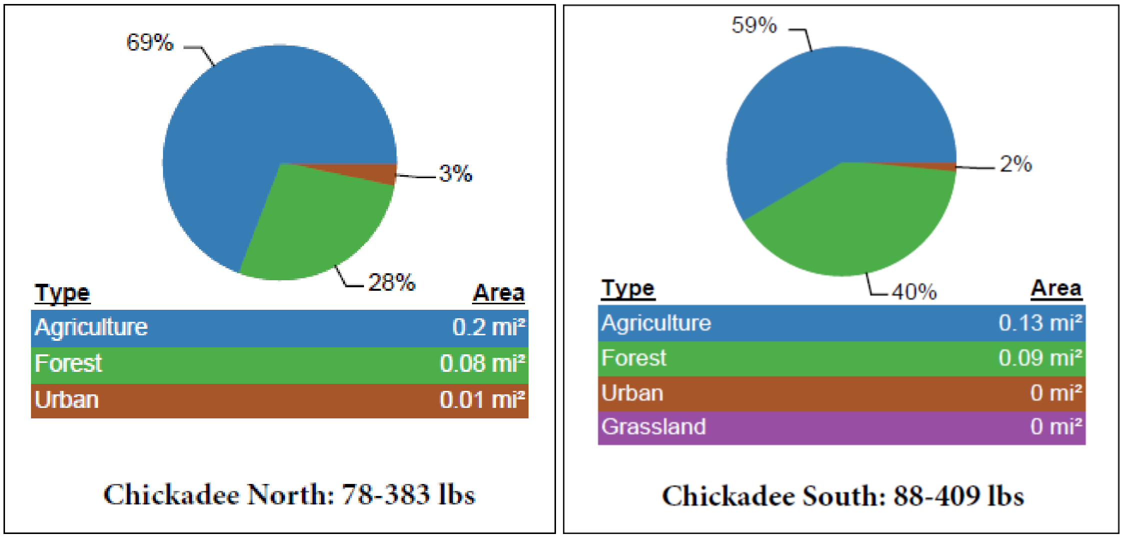


Figure 22: PRESTO outputs for land use and estimated annual phosphorus loading from Chickadee North and Chickadee South

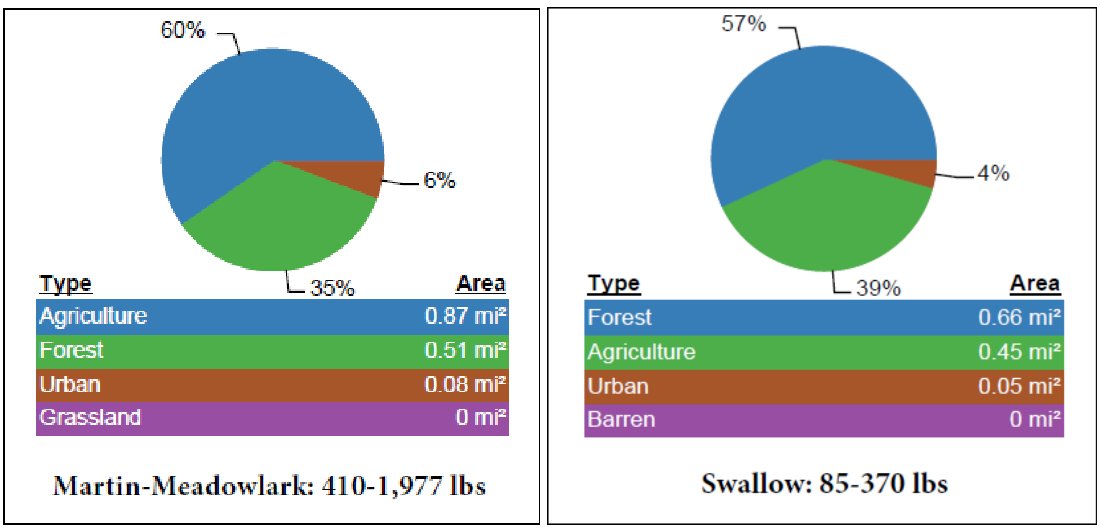


Figure 23: PRESTO outputs for land use and estimated annual phosphorus loading from Martin-Meadowlark and Swallow

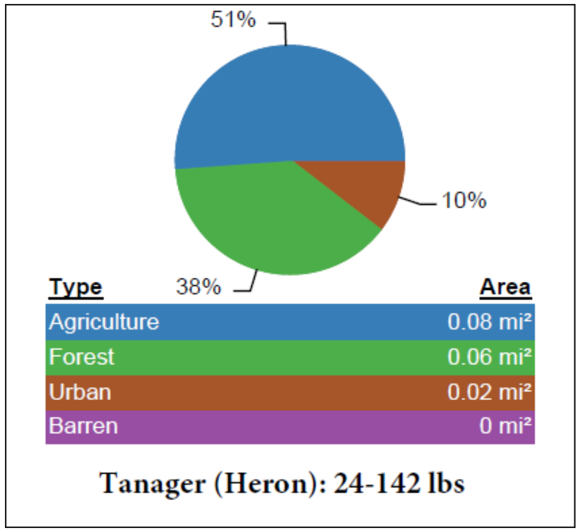


Figure 24: PRESTO outputs for land use and estimated annual phosphorus loading from Tanager

3.2.3 Private Onsite Wastewater Treatment (Septic) Systems

Private onsite wastewater treatment systems or POWTS, often referred to as septic systems, around Lake Redstone have not been inspected in any specific lakewide way since 2008. However, on record is a related program update that was given during a Sauk County Planning and Zoning meeting by Brian Cunningham.

"In the Fall of 2008, a total of 172 Lake Redstone homeowners were notified that they owned a steel tank or that they did not have a septic permit on file with Sauk County. Most of the required inspections as a result of notification were completed before the snow came. However, there is still a handful of owners who are in the process of completing the inspection form. I would like to thank all 172 home owners for their cooperation and response to this program.

Although the reports are still coming in, here are some of the preliminary results. So far only 8% of the steel septic tanks inspected have passed. As these tanks get replaced, many home owners are glad they replaced their tank when they see the condition of the tank. A much higher percentage, 64 % of the steel holding tanks have passed. It appears that a thicker gauge steel was used for holding tanks. Of the concrete tanks inspected 93% have passed.

Looking at the drain-fields, 26 % passed the inspection. The field inspections have revealed some interesting findings. For example, some drain-fields were actually installed below the lake level, causing direct discharge into our groundwater. Other drain-fields were found in or very near bedrock.

Homeowners who have a tank and/or a drain-field that did not pass inspection have until June 30, 2009 to have a completed septic permit application submitted to our office. They will then have two years from the issued date to install their septic system."

It is not known whether the "fixes" that were required as a result of this inspection were completed, but it has to be assumed that they were, given the time frame. It is also not known the current status of POWTS around Lake Redstone. Sauk County Ordinances, Chapter 25, Private Sewage System Ordinance currently guides building, management, and maintenance of POWTS around Lake Redstone and provides many resources on its webpage at https://www.co.sauk.wi.us/cpz/septic-systems.

The STEPL model used to estimate nutrient loading from the watershed has a portion of it directly related to septic system data from the watershed. Lake response modeling can be used to estimate nutrient loading from septic systems in the riparian area of the lake. However, to be more accurate, both of these septic system analyses require more current data that is not known at this time. As a result, only default data for watershed septic system loading was used in the STEPL model. For septic system loading from the riparian area of the lake, out-of-date data was used. This older data suggests that septic systems in the riparian area of the lake contributed between 2.73 and 73.02-lbs. of phosphorus per year. Further loading analysis could be done with more current conditions entered into STEPL and lake response models.

3.2.4 Beach Club Lots

There are a number of "beach club" lots around the lake. Beach club lots are parcels that have been put aside to provide access to the lake for out lots not directly on the lake. Figure 25 provides an example of these special parcels. Parcel 1115 on the lake is jointly owned by parcels 1979-1986 across W. Redstone Drive. Similarly, parcel 1098 on the lake is jointly owned by parcels 1120-1131 across W. Redstone Drive. These lots often have multiple docks on them, may be experiencing erosion, or be a place for invasive species to become established. There were at least 29 different beach club lots identified during the SHA for Lake Redstone. As these are jointly owned properties, if they present problems with erosion or other concerns, they will likely require extra effort to make changes, but could set great examples for other property owners. Furthermore, there are multiple lots owned by the LRPD or Town of LaValle and various easements that might also provide places to implement shoreland improvement projects.

Other than analysis associated with the Shoreland Habitat Assessment that was completed in 2018, no information has been collected regarding the state of Beach Club lots on Lake Redstone.

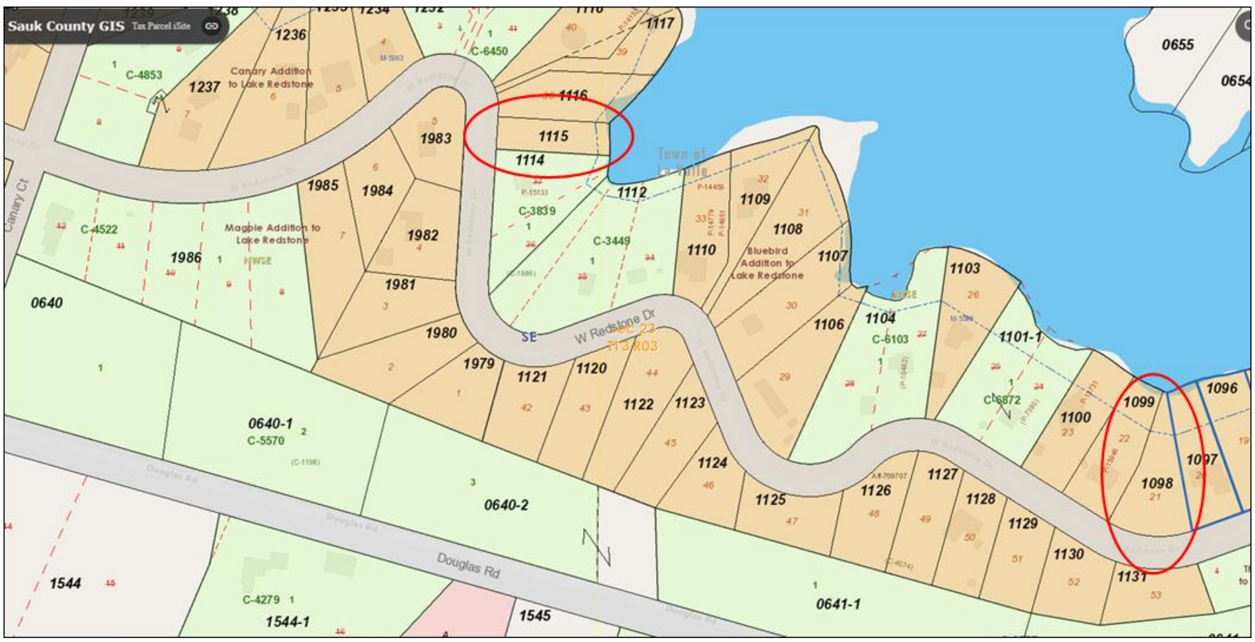


Figure 25: Example "beach club" parcels (1098 & 1115) and privately owned parcels (all others) on the south shore of Lake Redstone

3.3 Lake Redstone Watershed

The watershed of Lake Redstone covers approximately 18,500 acres, most of which is in Juneau County. The watershed consists mostly of forest (57.2%), with a combination of agricultural uses (cropland and pastureland) (35.4%) coming in second (Figure 26).

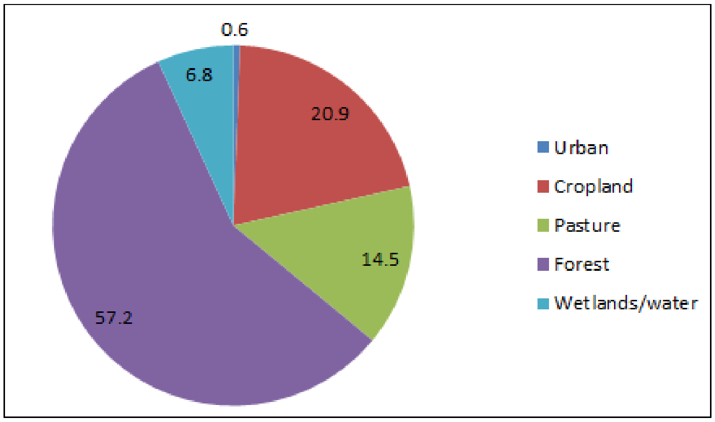


Figure 26: Percent of Land Use in the Lake Redstone Watershed

3.3.1 Lake Redstone Watershed Sub-Basins

In order to focus management planning efforts in this project, the watershed of Lake Redstone was further broken down from the reaches established by the WRB TMDL (see Section 1.4.1) to smaller reaches defined by stream order. Stream orders assign numerical designations to streams that indicate where in a watershed drainage system a certain stream segment lies. The smallest orders streams – first order – flow from upland, headwater areas like springs and seep sources that maintain defined stream beds throughout the year. Where two first-order streams combine, a second-order stream is designated; and two second-order streams join creating a third-order stream (Figure 27) (Strahler, 1957).

In the Lake Redstone watershed, both the east and west branches of Big Creek - sub-basins 15&16 in the WRB TMDL - are considered third-order streams. For this project, two areas of the Lake Redstone watershed are defined by third-order streams – Clark Road on the west branch of Big Creek, and LaValle Road on the east branch of Big Creek. The entire east branch of Big Creek is referred to as the LaValle Road sub-basin. The west branch of Big Creek is referred to as the Clark Road sub-basin. The west branch of Big Creek is further delineated into three additional sub-basins based on smaller tributaries feeding into it. These three sub-basins are referred to as the Daugs Road, Pfaff Road, and Lucht Road sub-basins. The final sub-basin, referred to as the Lower Lake Redstone sub-basin is made up of the part of the watershed that drains directly into Lake Redstone (Figure 28). This sub-basin contains all of the development in the riparian area of the lake and numerous gullies, washes, and intermittent or perennial streams.

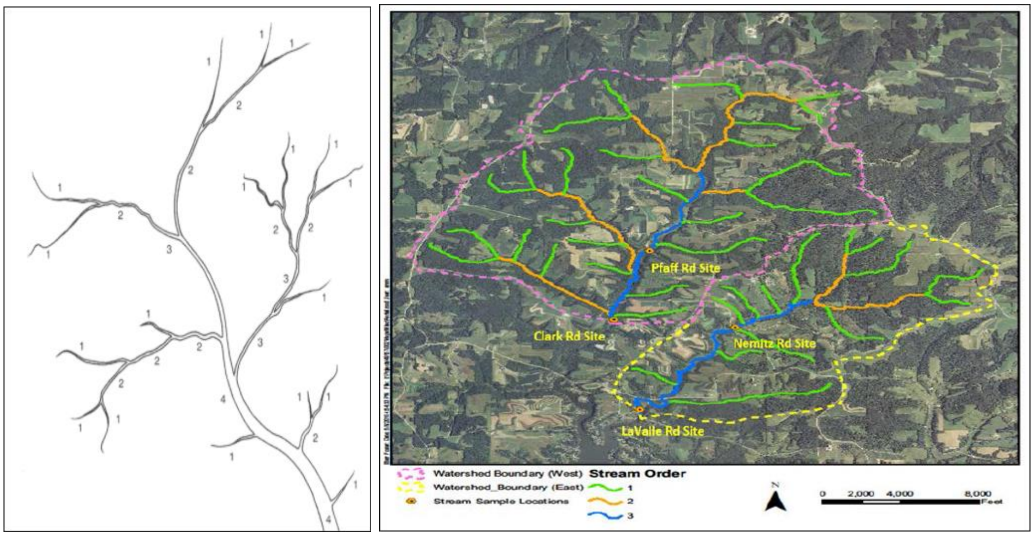


Figure 27: General stream order (left); Lake Redstone watershed stream order designations – blue streams represent the two branches of Big Creek (right)

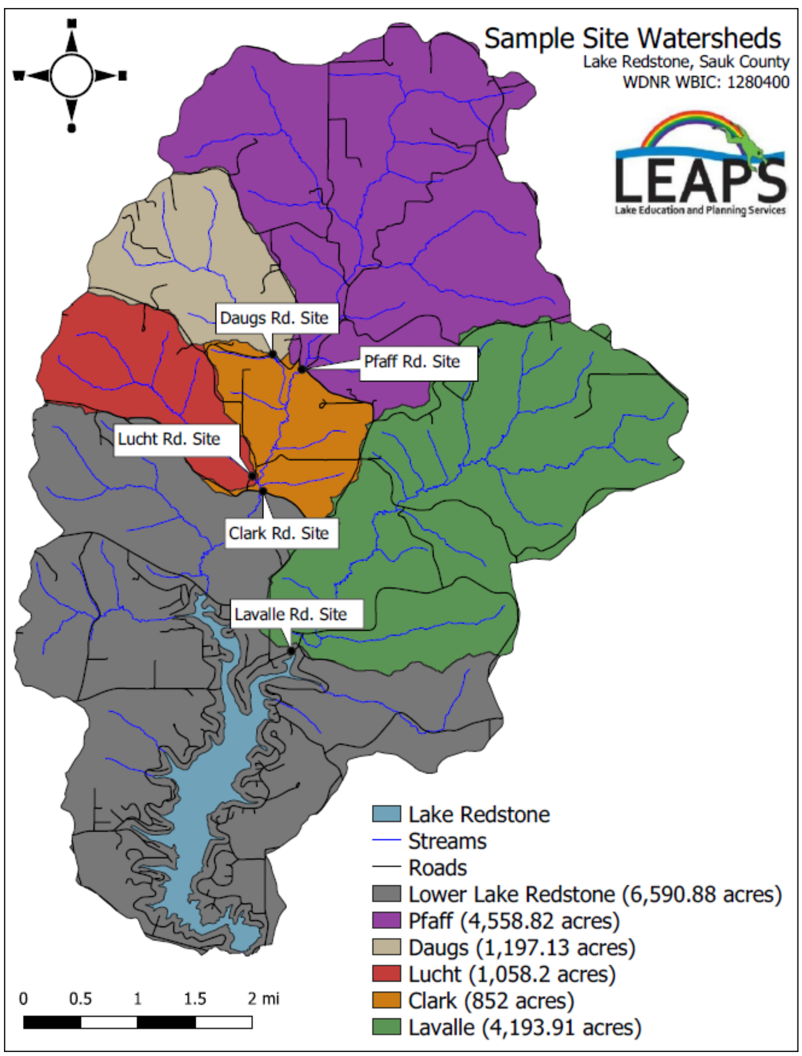


Figure 28: Lake Redstone watershed sub-basins (LEAPS, 2020)

3.3.1.1 Land Use in the Sub-basins

Land use in each of the sub-basins was determined by USGS 2016 National Land Cover Database (Table 8; USGS, 2016). It is these numbers that are used in calculating loads and load reductions across the watershed.

Table 8: Total acreage (land use) in each sub-basin of the Lake Redstone watershed

Land Use	W1-Pfaff	W2-LaValle	W3-LowRedstone	W4-Clark	W5-Lucht	W6-Daugs
Urban	0	0	113	0	0	0
Cropland	1076	909	1219	275	247	170
Pasture	434	583	1210	204	161	117
Forest	2713	2452	3623	321	574	810
Wetland	335	247	461	52	78	100
Feedlots	1.4	1.9	0.4	0.6	0	1
Total Acres	**4559**	**4193**	**6626**	**853**	**1060**	**1198**

3.3.2 Watershed Loading and Soil Erosion

Nutrient and sediment loading from a watershed into streams, rivers, and lakes is directly related to soil erosion. Dirt washed off a field, gravel along a road that is carried away, or material torn from a streambank has to go somewhere. Usually it goes with the water or wind that dislodged it to a place lower in the watershed. This process of erosion is natural and generally happens on long time scales, however, human activities like development and agriculture can greatly speed up these processes, resulting in unsustainable losses that natural mechanisms to replace the soil cannot keep up with. Soil erosion caused by water can be identified by small rills and channels on the soil surface, soil deposited at the base of slopes, sediment in streams, lakes, and reservoirs, and pedestals of soil supporting pebbles and plant material. Water-driven soil erosion can lead to sediment loading through the direct transport of sediment to a downstream location, like Lake Redstone. Wind erosion can be identified by dust clouds, soil accumulation along fence lines or snowbanks, and a drifted appearance of the soil surface (NRCS, 2012). Wind erosion can also contribute to sediment loading through atmospheric deposition when wind-blown particles get trapped in precipitation, like rain and snow, and then fall into the lake.

This loss of soil from where it belongs to places it doesn't belong has other consequences. Soil loss may also lead to nutrient loss. Phosphorus binds readily to soils, especially small particles like clay and silt that are easily eroded; thus, if an area has high soil loss from erosion, it may also be contributing large amounts of phosphorus that can be transported by wind and rain into water bodies where it can further degrade the quality of the water by contributing to algal blooms.

3.3.2.1 Soil Health

Soil erosion can be avoided by maintaining good soil health. Soil health, also referred to as soil quality, is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans (USDA). Healthy soils gives us clean air and water, bountiful crops and forests, productive grazing lands, diverse wildlife, and beautiful landscapes by performing five essential functions:

- Regulating water - Soil helps control where rain, snowmelt, and irrigation water goes. Water and dissolved solutes flow over the land or into and through the soil.
- Sustaining plant and animal life - The diversity and productivity of living things depends on soil.
- Filtering and buffering potential pollutants - The minerals and microbes in soil are responsible for filtering, buffering, degrading, immobilizing, and detoxifying organic and inorganic materials, including industrial and municipal by-products and atmospheric deposits.

- Cycling nutrients - Carbon, nitrogen, phosphorus, and many other nutrients are stored, transformed, and cycled in the soil.
- Physical stability and support - Soil structure provides a medium for plant roots. Soils also provide support for human structures and protection for archeological treasures (USDA).

When soil is disturbed by tillage, it becomes more vulnerable to erosion, waterlogging, and compaction. Because tillage also disturbs the habitat of soil organisms, their populations often decline and their positive effect on soil structure is reduced. No-till or minimal tilling practices usually promote the activity of soil engineering organisms and can improve the soil's physical characteristics (Earthfort, 2021). Additionally, practices such as adding manures or compost to soil, planting cover crops, and rotating crops are all aimed at rebuilding and maintaining soil organic matter, recycling and retaining nutrients, and potentially decreasing soil diseases. These practices are usually associated with increased microbial biomass and increased soil organism diversity – i.e. greater soil health (Earthfort, 2021).

3.3.2.2 Soils, Erodibility, Crop Rotations, and Practices in the Lake Redstone Watershed

The WI-DNR Bureau of Water Quality developed an Erosion Vulnerability Assessment for Agricultural Lands toolset (EVAAL) to assist watershed managers in establishing areas within a watershed that may be vulnerable to water erosion and increased nutrient export, which may contribute to downstream surface water quality problems. EVAAL evaluates the location of areas (fields) vulnerable to erosion using topography, soil, rainfall, and land cover data. The tool enables watershed managers to prioritize and focus field-scale data collection efforts, thus saving time and money while increasing the probability of locating fields with high sediment and nutrient export for implementation of best management practices.

EVAAL was used to prioritize areas or fields within the Lake Redstone watershed that may be vulnerable to soil erosion. A total of 140 fields in the Lake Redstone watershed were included in the EVAAL model run. From the 140 fields, the 20 fields with the highest vulnerability for erosion were documented. Following that, the remaining fields were evenly divided into 30 field groups in each ranking of low, mid-low, mid-high, and high vulnerability based on the average erosion vulnerability index (EVI) score of all the fields (Figure 29).

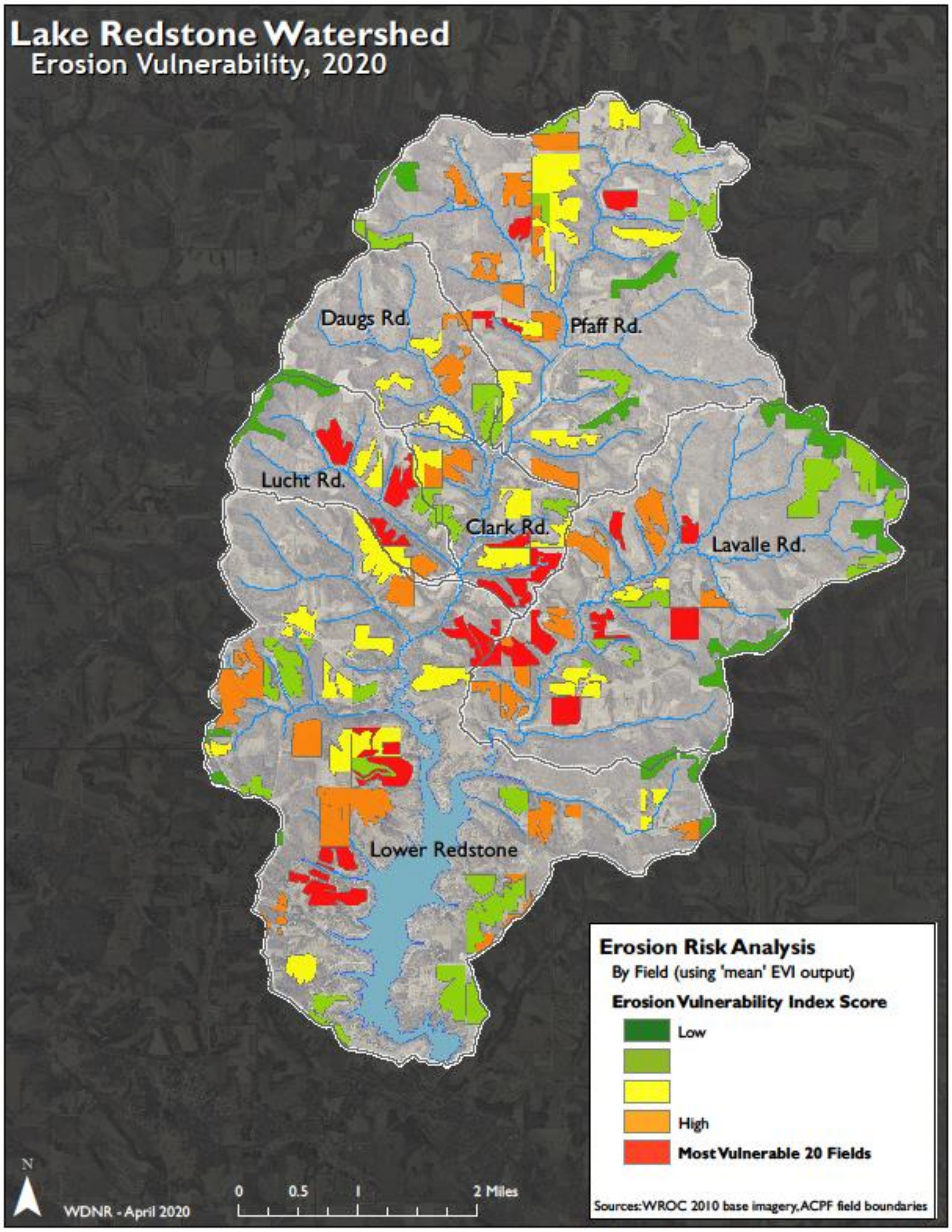


Figure 29: Erosion Risk Analysis for 140 fields in the Lake Redstone watershed (Beringer, 2021)

The number of field acres in each sub-basin that were either at high risk for erosion, or considered the most vulnerable fields for erosion are in Table 9. The Lower Lake Redstone sub-basin has the greatest amount of field acres considered at high risk for erosion, followed by the LaValle Road sub-basin. The Daugs Road sub-basin has the fewest number of acres considered at high risk for erosion (Figure 30).

Table 9: Individual sub-basin analysis of field acres highly vulnerable to soil erosion

Erosion Risk Analysis	Top20MVF (acres)	HighVF (acres)
W1-PfaffRoad	61.45	242.25
W2-LaValleRoad	188.39	201.55
W3-LowerRedstone	223.91	397.45
W4-ClarkRoad	82.89	50.26
W5-LuchtRoad	106.95	19.88
W6-DaugsRoad	0	39.97
Total	**663.59**	**951.36**

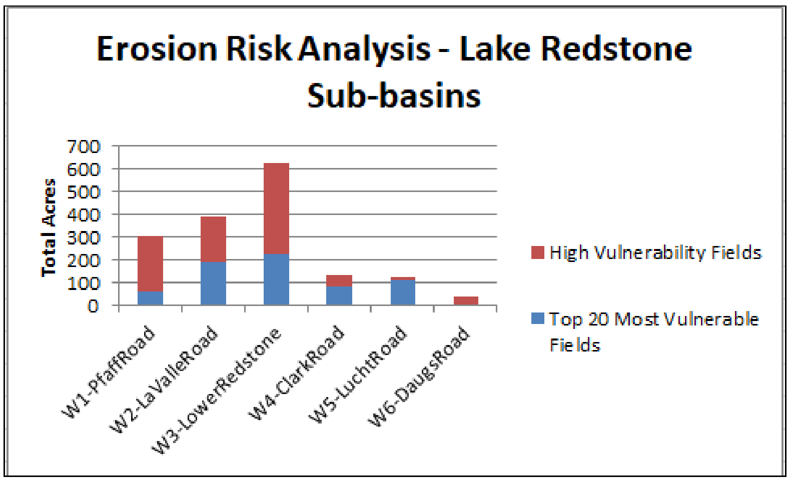


Figure 30: Individual sub-basin analysis of field acres highly vulnerable to soil erosion

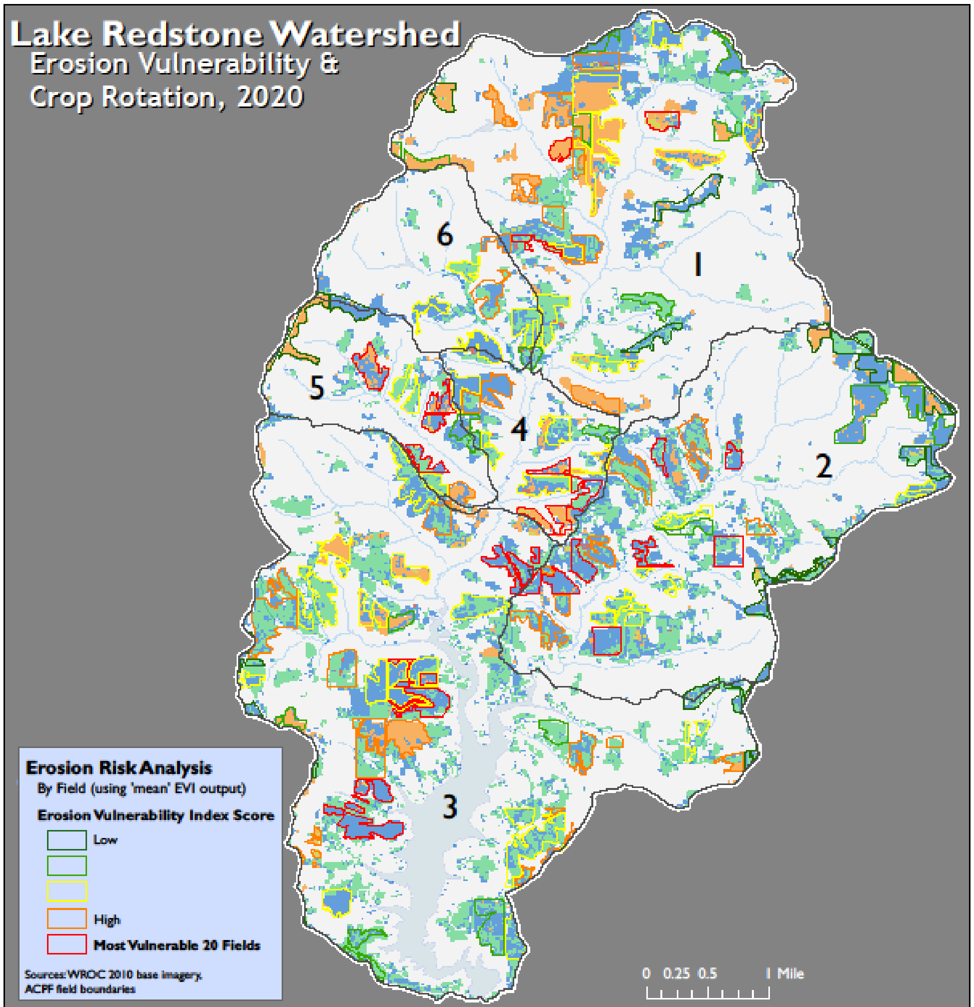
Using EVAAL, additional analyses were done to determine common crop rotations in the watershed over a five year period from 2015 to 2019 (Table 10). Other than no agriculture at all, dairy rotation (consisting of corn, corn silage, and then 3-yrs of alfalfa), pasture/hay/grassland, and cash grain are the most common crops. Continuous corn, corn planted in a dairy rotation, and cash grains generally would leave the most soil exposed during the planting, growing, and harvest season.

More than half of Lake Redstone's watershed agricultural land is in a continuous corn, cash grain, or dairy rotation (Figure 31). Many of the 20 most vulnerable fields and most of the fields with high vulnerability are either in a dairy rotation or cash grain.

Common cropping practices within the watershed over the last five years have been: contour farming with annual tillage during corn grain or corn silage years; average 30-59% crop residue levels maintained over crop rotation; grass pastures managed with 90% or greater vegetative cover (Juneau and Sauk County Land Conservation Departments, personal communication, 2020). These practices and their extent on agricultural cropland acres were incorporated into STEPL model inputs for the Lake Redstone watershed.

Table 10: Crop rotation within 6,451 agricultural acres of the nearly 18,500 acre watershed of Lake Redstone

Rotation Type	W1-Pfaff	W2-LaValle	W3-LowRedstone	W4-Clark	W5-Lucht	W6-Daugs	TOTAL (acres)
Potato/grain/vegie	8	5	5	5	1	2	**26**
Continuous corn	37	22	20	7	6	1	**93**
Cash grain	429	78	204	59	79	9	**858**
Pasture/hay/grassland	434	583	1210	105	106	117	**2555**
Dairy rotation	602	804	990	204	161	158	**2919**
Total Agriculture Acreage	1510	1492	2429	380	353	287	**6451**
No agriculture	3049	2701	4197	473	707	911	**12038**
TOTAL Sub-basin Acreage	**4559**	**4193**	**6626**	**853**	**1060**	**1198**	**18489**



Crop Rotation Acreage 2015 - 2019

	(1) Pfaff Rd.	(2) Lavalle Rd.	(3) Lower Redstone	(4) Clark Rd.	(5) Lucht Rd.	(6) Daugs Rd.
Potato/Grain/Veggie	8	5	5	5	1	2
Continuous Corn	37	22	20	7	6	1
Cash Grain	429	78	204	59	79	9
Pasture/Hay/Grassland	434	583	1,210	105	106	117
Dairy Rotation	602	804	953	204	161	158
No Agriculture	3,049	2,701	4,197	473	707	911
TOT. BASIN ACREAGE	4,559	4,193	6,626	853	1,060	1,198

Figure 31: Erosion Risk Analysis combined with Crop Rotation Acreage (Beringer, 2021)

3.3.2.3 Streambank Erosion (Iowa Department of Natural Resources, 2006)

Erosion of streams in agricultural areas normally occurs as a result of one of three factors: change in stream flow, water flowing over or through the streambank, and the discharge of concentrated runoff from other sources. Streams in the Midwest are subject to wide fluctuations in both flow depth and velocity over a period of years, due to normal seasonal changes in rainfall and large single-storm events. As flow depths and velocities increase, the force of the water flowing against the streambank removes soil particles from the banks, and in many cases erosion causes banks to slump and fall into the flowing water. Rain falling on streambanks or runoff from adjacent fields that enter a stream by flowing over the streambanks can also erode soil from streambanks, particularly if banks are inadequately protected. Water discharged into a stream from tributary drainage systems (such as waterways and tile lines) can also erode streambanks, particularly if the water is discharged in an area where the bank is unstable or highly erodible.

A document prepared by the Iowa Department of Natural Resource entitled "How to Control Streambank Erosion" provides many examples of actions that can be implemented to reduce streambank erosion.[3]

Another function of EVAAL is developing a Stream Power Index for the watershed in question. The Stream Power Index (SPI) is a measure of the erosive power of flowing water. SPI is calculated based upon slope and contributing area. Within a watershed, the SPI approximates locations where gullies might be more likely to form on the landscape. While this was done for the watershed of Lake Redstone, the results are not available. SPI will again be calculated for the watershed of Lake Redstone in the first year of implementation with results being used to identify potential problem areas within each sub-basin.

3.3.3 Watershed STEPL Modeling

The Spreadsheet Tool for Estimating Pollutant Load (STEPL) is a customized spreadsheet-based model in Microsoft Excel that is used to calculate nutrient and sediment loads in watershed surface runoff from different land uses and the load reductions that would result from the implementation of various BMPs (EPA, 2021).

STEPL can be used to evaluate watershed loading and load reductions at a variety of scales. The user defines the size and characteristics of each area being evaluated, based on the total acreage of each land use entered into STEPL. In the case of the Lake Redstone watershed, data from each of the six sub-basins was entered into the STEPL model. Annual nutrient loading from each sub-basin was calculated based on the runoff volume and the pollutant concentrations in the runoff water, as influenced by factors such as the land use distribution and management practices (Table 11)

Table 11: Designated land uses (acres) by sub-basin in the Lake Redstone watershed

Sub-basin	Urban	Cropland	Pasture land	Forest	Wetland, Open Water, Scrub	Feedlots	Total Sub-basin Acreage
W1 - Pfaff	0	1076	434	2713	335	1.4	4559
W2 - Lavalle	0	909	583	2403	247	1.9	4144
W3 - Lower Red	113	1219	1210	3693	461	0.4	6696
W4 - Clark	0	275	204	420	52	0.4	951
W5 - Lucht	0	247	161	629	78	0.0	1115
W6 - Daugs	0	170	117	810	100	1.0	1198
Total Land Use	113	3896	2709	10668	1273	5.1	

STEPL modeling is used to calculate an estimate of total loading and is based on the different land uses, dominant hydrologic soil group, annual rainfall, agricultural practices and BMPs. Table 12 shows the STEPL total nutrient loading for the entire watershed of Lake Redstone. Table 13 shows the STEPL nutrient loading from each sub-basin.

[3] To view the Iowa DNR document about how to reduce streambank erosion go to: https://www.iowadnr.gov/portals/idnr/uploads/water/stormwater/streambankmanual.pdf

Table 12: Nitrogen (N), phosphorus (P), and sediment loading from the entire Lake Redstone watershed

Land Use Sources	N Load (lb/yr)	P Load (lb/yr)	Sediment Load (t/yr)
Urban	427	72	11
Cropland	31245	13435	3982
Pastureland	15537	1771	257
Forest	3025	1765	252
Feedlots	9050	1810	0
Wetland, Open Water, Scrub	96	78	30
Septic	78	30	0
Total	**59458**	**18961**	**4532**

Table 13: Nitrogen (N), phosphorus (P), and sediment loading from each sub-basin included in the Lake Redstone watershed

Sub-basin	N Load (lb/year)	P Load (lb/year)	Sediment Load (t/year)
W1 - Pfaff	15466	5571	1381
W2 - Lavalle	14019	4194	919
W3 - Lower Red	18652	5550	1342
W4 - Clark	4237	1370	355
W5 - Lucht	3037	1088	308
W6 - Daugs	4047	1188	227
Total	**59458**	**18961**	**4532**

STEPL modeling suggests that the three highest contributing sub-basins to nutrient and sediment loading are Pfaff, Lower Redstone, and LaValle in that order. These three sub-basins also have 84% of the total agriculture in the entire watershed; 65% of the most vulnerable fields for erosion; and 83% of the fields considered to be highly vulnerable to erosion based on the mean erosion vulnerability index calculated using EVAAL.

In the first years of implementation of this plan, BMPs to improve soil health will primarily be focused on these three sub-basins.

3.3.4 Tributary Monitoring

Starting in 2018, Juneau and Sauk Counties partnered with the LRPD and their consultant to try and determine nutrient and sediment loading from the two major tributaries (east and west branches of Big Creek) flowing directly into the lake, and three tributaries flowing out of the Daugs, Lucht, and Pfaff sub-basins into the west branch of Big Creek (Figure 32). Basic stream flow and volume determination using pressure transducers, stream gauges, and volunteer data collection following guidelines in the Water Action Volunteer Stream Monitoring Program[4] along with collection of water samples to test for an array of water quality parameters (Table 14) were to be conducted manually by LRPD volunteers. Loading calculations were to be completed by Juneau and Sauk County personnel.

[4] For more information about the Water Action Volunteer program go to: https://wateractionvolunteers.org/

In the fall of 2018, the watershed was impacted by heavy rainfall and severe flooding. During this period, it was apparent that the available equipment to monitor stage and measure discharge (flow and volume) was inadequate, making it nearly impossible to compute loads as intended. As a result, changes were made to the tributary monitoring program in 2019 and 2020.

In 2019, the LRPD, their consultant, and the counties partnered with the USGS to explore a different method of collecting site discharge data – camera image stage-interpretation. This technology involved the installation of cameras to provide continuous monitoring of stream stage, while volunteers continued to collect monthly baseline water samples (Figure 33).

Monitoring results in 2019 were better, but still not completely representative of what was actually happening in the streams, particularly during storm events. Preliminary analysis of the data collected in both years revealed that the majority of the sediment and nutrients enters the lake during storm events, which are difficult to monitor with conventional means. USGS staff suggested that more detailed analysis of storm events would provide more reliable data regarding the total load of nutrients and sediment entering the lake during each year.

In 2020, in cooperation with the USGS automated sampling equipment was installed at the monitoring stations on the east branch (LaValle Road) and west branch (Clark Road) of Big Creek (Figure 33). The automated sampling equipment mechanically collects 6-8 water samples during a given storm event. Following the storm, LRPD volunteers collect the water samples from the sampling stations and ship them to USGS labs for analysis of TP and TSS. Based on the data provided by this analysis along with stream flow provided by the monitoring equipment, the total load of phosphorus and suspended solids entering the lake can be more accurately calculated by USGS staff. The automated sampling stations will remain in place as long as there is funding to support it.

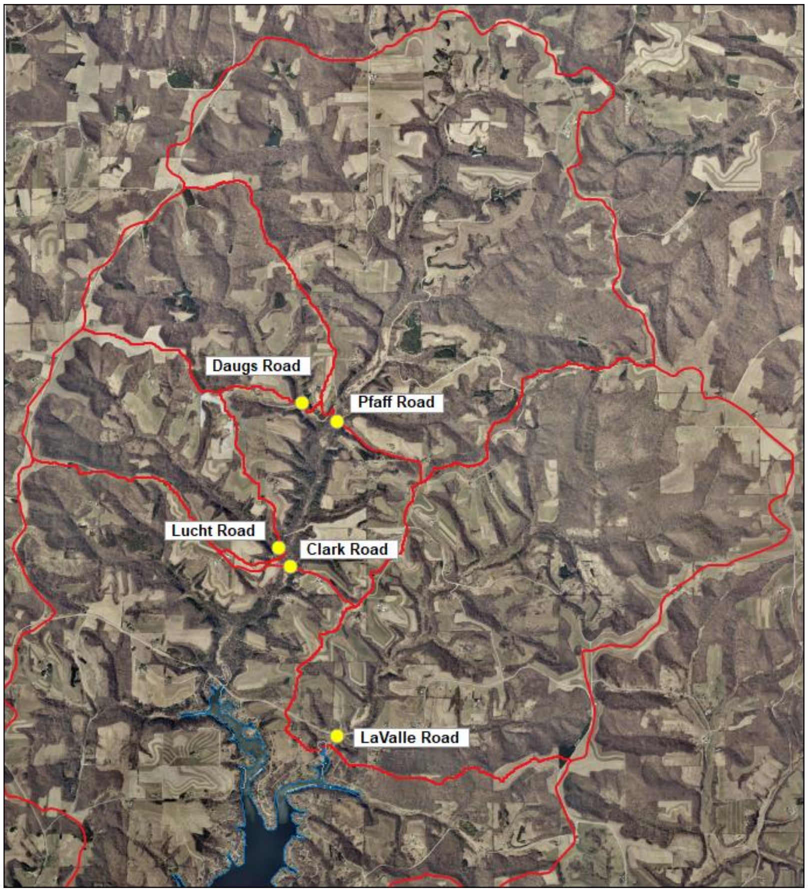


Figure 32: 2018-2020 Tributary Sampling Sites

Table 14: Tributary Monitoring Parameters 2018-2020

Nutrients and Suspended Solids (mg/L)		Flow (f/s) and Volume (cf/s)
Residue Total NFLT (Total Suspended Solids) (TSS)		WAV/floating orange
Phosphorus Total (TP)		Flow Meter
Phosphate Ortho Diss (Ortho)		Transducers and Staff Gage
Nitrogen NH3 - N Diss (NH3)		Video Camera
Nitrogen Kjeldahl Total (TKN)		USGS Monitoring Station
Nitrogen NO3+NO2 Diss (as N) (NO3-NO2)		

Figure 33: Camera installation for "camera image stage-interpretation" (left) (K. Keegstra, 2019); Typical USGS recording streamflow-gaging station with automatic water sampler for load determinations (middle & right) (K. Keegstra, 2021)

With the installation of the automated sampling equipment, sampling of the smaller streams coming from the Daugs, Lucht, and Pfaff sub-basins was suspended in 2020. However, two other sites were added where perennial streams enter Martin-Meadowlark and Swallow Bays. Monitoring of these two sites was added to begin to try and determine nutrient and sediment loading from smaller stream reaches within the watershed that form gullies that drain directly into Lake Redstone in the Lower Redstone sub-basin.

3.3.4.1 Tributary Monitoring Results

The Daugs, Lucht, and Pfaff road sub-basins drain into the west branch of Big Creek and make up some of what is measured at the Clark Road site. There currently is only one tributary monitoring site on the east branch of Big Creek at the LaValle Road site. Baseline water samples were collected by LRPD volunteers, once monthly between April and November in 2018 and 2019 at each of the sub-basin locations. Storm event samples were collected on four different dates at the same sites during the same time frame. Baseline and storm event loading from each individual sub-basin cannot be reliably calculated or compared due to incomplete or inaccurate flow and volume data, but comparisons of the nutrient and sediment concentrations in the samples from each sub-basin can be made giving a glimpse into those sub-basins that may be contributing more or less phosphorus and sediment into the two branches of Big Creek or into Lake Redstone.

Comparisons were made between water sampling results from the east branch (LaValle Road) and the west branch (Clark Road) of Big Creek. There is more sediment in the east branch during normal flow, but there is more sediment in the storm water from the west branch. There is more total phosphorus in both the normal flow and the storm water from the west branch (Figure 34). The east branch of Big Creek at the LaValle Road site drains 4,194 acres of the watershed. The west branch of Big Creek at the Clark Road site drains 7,666 acres of the watershed. Both have substantial agriculture.

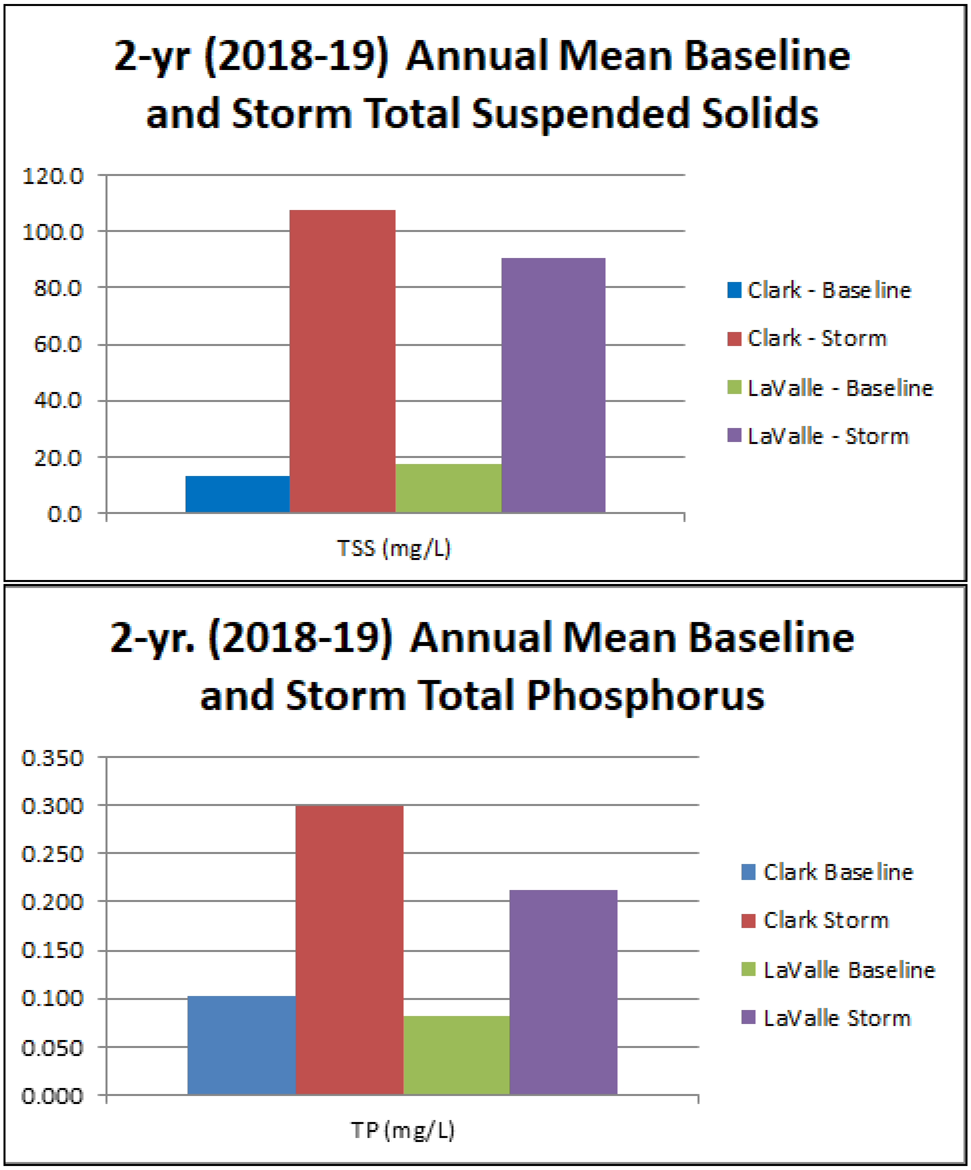


Figure 34: Comparisons of TSS (top) and TP (bottom) concentrations in water samples collected from Clark Road (west branch of Big Creek) and LaValle Road (east branch of Big Creek)

Tributaries from the Daugs, Pfaff, and Lucht road sub-basins drain into the west branch of Big Creek above the Clark Road monitoring site. Each covers a portion of the larger watershed draining through the Clark Road site: Daugs Road (1,197 acres), Pfaff Road (4,559 acres), and Lucht Road (1,058 acres). The remaining 852 acres are specific to the Clark Road sub-basin. Despite having the largest land area of the four sub-basins, water flowing from the Pfaff Road sub-basin had the lowest concentration of sediment and total phosphorus per sample in both its normal flow and storm water. Water from the Daugs Road sub-basin has the highest concentration of sediment and total phosphorus per sample in both its normal flow and storm water (Figure 35). A close second is the concentration of sediment and total phosphorus in samples from the Lucht Road sub-basin (Figure 35). These conclusions are drawn from preliminary observations made over two years. The patterns of sediment and phosphorus entry into the lake will be re-evaluated following the three years of more intensive analysis that will be performed during implementation of this plan (see Section 9.1.2.1 and items in Appendix I.) Section 3.3.4.2 discusses current and past conditions in the watershed in more detail.

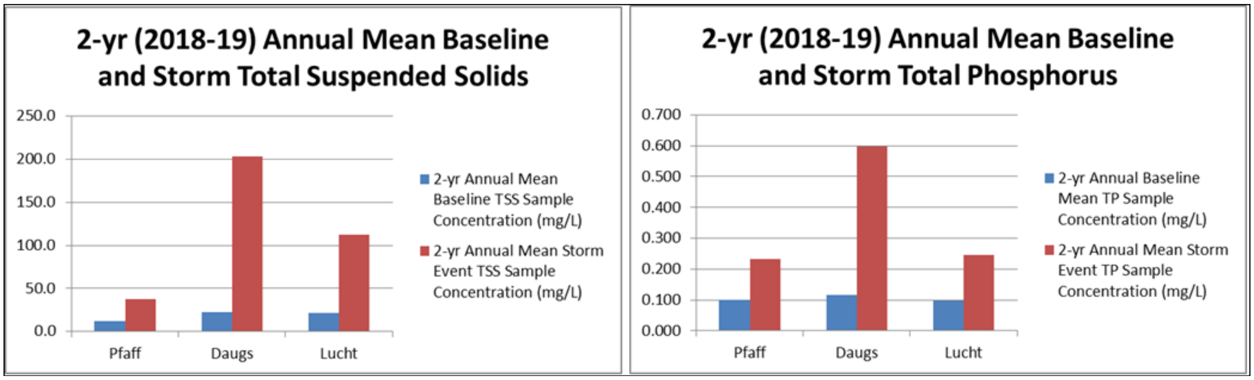


Figure 35: Comparisons of TSS and TP concentrations in water samples collected from Pfaff, Daugs, and Lucht sub-basins

3.3.4.2 Current versus Past Conditions in the Watershed of Lake Redstone

Two studies have been completed since the early 2000's that reflect conditions of erosion in the watershed at that time. In 2002, MSA completed a "field verification of sediment delivery" study as a follow-up to an earlier study of the watershed to determine the location of farming operations and land use (MSA, 1998; MSA, 2002). During the 2002 study it was determined that several of the farm tracts from the 1998 study that were expected to have excessive field soil loss were not experiencing that loss due to actions already taken by the property owner.

In 2007, MSA completed a watershed stream assessment project surveying nearly the entire waterway of both branches of Big Creek upstream of Lake Redstone (MSA, 2007). This survey found that the bulk of the main branches of Big Creek and its adjacent shoreland were "relatively untouched and in good condition"; and that they were "buffered by high quality wetlands with a high diversity of vegetation". They also noted that "minor tributaries in the headwaters of the watershed were in steeper valleys with forested slopes and more prone to sediment delivery to the streams"

Since 2007, there have been at least two major storm and flooding events, one in 2008, and again in 2018. It is quite possible that the "good conditions" surveyed by MSA in 2002 and 2007 may have changed. In the first years of implementation of this plan, the Daugs and Lucht sub-basins will be evaluated for gully/ravine erosion. Gully/ravine evaluations in the other sub-basins will occur in later years of implementation.

3.3.5 Silviculture (Forestry) and Mining

More than 57% of the land in the watershed of Lake Redstone is covered in forests, most of which is on the steep forested side slopes of the many intermittent and perennial stream, gullies, and washes that are characteristic of the Driftless Area. Several natural forest community types are represented including oak forests, mesic maple-basswood forests, floodplain forests, and hemlock and pine "relicts" (WI-DNR, 2015). Timber harvests and other forest related management actions are limited in the watershed, but do occur. There is no county-owned forest land in the watershed other than the Lake Redstone County Park at the lowest end of the watershed. As such, there are no forestry management practices occurring on public lands. Timber harvests on private land do occur. Silviculture is the art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet the diverse needs and values of landowners and society such as wildlife habitat, timber, water resources, restoration, and recreation on a sustainable basis[5].

[5] For more information on silviculture go to:
https://www.fs.fed.us/forestmanagement/vegetation-management/silviculture/index.shtml

3.3.5.1 Managed Forest Land

The Managed Forest Law (MFL), administered by the WI-DNR, is a landowner incentive program which encourages sustainable forestry on private woodlands in Wisconsin. Together with landowner objectives, the law incorporates timber harvesting, wildlife management, water quality and recreation to maintain a healthy and productive forest. Sustainable forest management benefits Wisconsin's economy, hunting, fishing, wildlife, recreation, soils, waterways, and air quality, and renews our beautiful forests for everyone to enjoy. In exchange for following sound forest management, the landowner pays reduced property taxes. MFL is the only forest tax law that is open to enrollment by private land owners. Land enrolled in the MFL program must be managed according to a plan agreed to by the landowner.

Over the next ten years, there are approximately 21 harvests scheduled totaling roughly 900 acres on MFL properties within the Lake Redstone watershed. These numbers may fluctuate as harvest schedules can be adjusted earlier or later if needed. All harvests on MFL properties are required to be completed sustainably and according to sound silvicultural practices. This includes following best management practices for water quality to limit the impact these activities will have on water resources (Personal communication Robert Anderson, WI-DNR Forester – Juneau County August 27, 2021).

On Non-MFL private lands within the watershed there has been a minimal level of harvest activity. The Wisconsin DNR Division of Forestry is currently emphasizing outreach to this demographic of landowners to try and encourage sustainable forest management so this level could increase in the future (Personal communication Robert Anderson, WI-DNR Forester – Juneau County August 27, 2021).

3.3.5.2 Non-metallic Mining

Non-metallic mining in Sauk County (and Juneau County) is regulated by the Planning and Zoning Department and, depending on activities, the Department of Natural Resources.

Non-metallic mining is defined as operations or activities at a nonmetallic mining site for the extraction from the earth of mineral aggregates or nonmetallic minerals (i.e. crushed or broken stone/gravel) for sale or use by the operator. Nonmetallic mining includes use of mining equipment or techniques to remove materials from the in-place nonmetallic mineral deposit, including drilling and blasting, as well as associated activities such as excavation, grading and dredging. Nonmetallic mining does not include the removal of materials such as commercial sod, agricultural crops, ornamental or garden plants, forest products, or plant nursery stock (Sauk County).

Nonmetallic mining also includes processes carried out at nonmetallic mining sites that are related to the preparation or processing of the mineral aggregates or nonmetallic minerals obtained from the site. These processes include, but are not limited to stockpiling of materials, blending mineral aggregates or nonmetallic minerals with other mineral aggregates or nonmetallic minerals, blasting, grading, crushing, screening, scalping and dewatering (Sauk County).

There is a low level of mining, primarily for aggregates (crushed or broken stone) currently going on in the watershed of Lake Redstone. There are many resources within the industry to do aggregate mining in a way that protects water resources. One such document is entitled Water Quality BMPs for the Aggregate Mining Industry[6].

[6] Water Quality BMPs for the Aggregate Minong Industry. Atlanta, Georgia, USA. Highland Engineering, Inc. (2009, May 21). Retrieved from: https://epd.georgia.gov/sites/epd.georgia.gov/files/related_files/site_page/Aggregate%20Mining%20Industry%20Water%20Quality%20Best%20Management%20Practices%202009.pdf

4.0 Sources of Pollution and Load Reduction (Key Elements 1&2)

The emphasis of this planning project is to identify sources of pollutants, primarily excess phosphorus and sediment to Lake Redstone, and then determine what level of reduction in the loading of those pollutants needs to be achieved to help the lake meet state standards for recreation and fish and wildlife. The sources of pollutants are fairly clear, coming from the larger watershed, the riparian area of the lake, and from the lake itself.

4.1 Phosphorus in Lake Redstone

Based on 2018 in-lake, water column, total phosphorus sampling set up by a consultant and completed by LRPD volunteers, it was estimated that there was nearly 3,400-lbs of phosphorus in the lake water at any one time during the 2018 summer months (Table 15). Baseline water sampling data from the outlet of Lake Redstone during the summer of 2018 (collected by LRPD volunteers and analyzed by LEAPS) indicated a TP concentration of 0.17-mg/L. The amount of water leaving the lake through the outlet during that timeframe is estimated at 4,110-acft carrying an estimated 1,899-lbs of phosphorus. From Table 16, 3,527-lbs of phosphorus is entering the lake with 1,899-lbs leaving the lake during the same time frame, suggesting that 1,628-lbs or about 46% of the phosphorus entering the lake under normal flow conditions stays in the lake to be used up by plants and algae, or stored in the sediment.

Table 15: An estimate of the total phosphorus in the waters of Lake Redstone at any given time during the summer of 2018 based on water column sampling for total phosphorus (TP)

Depth (ft)	Volume (acft)	TP (mg/L)	Total TP (lbs)
0 to 6	2,544.47	0.08	576.15
6 to 15	3,924.10	0.10	1,088.02
15 to 24	1,760.07	0.21	1,004.72
24 to 35	499.74	0.53	725.41
TOTAL	**8,728.38**		**3,394.31**

The sources of phosphorus to Lake Redstone are fairly clear, consisting most prominently of the east and west branches of Big Creek; the immediate drainage area of the lake including the gullies and washes, developed area of the shoreland, and septic system contributions; some level of internal loading; and natural sources including ground water and atmospheric deposition. By combining data from various sources over the last 25 years some estimates can be made and a phosphorus budget for the lake created.

Under baseline conditions, not accounting for storm events, the east and west branches of Big Creek represented by the Clark and LaValle Road sub-basins contribute 34% of the TP load. The riparian area, gullies, and septic system represented by the Lower Redstone sub-basin, contribute an estimated 34% of the TP load to the lake. Internal loading is the next largest amount at 27%. Groundwater and atmospheric deposition contributes another 5% of the TP load (Table 16).

Table 16: Estimated lbs. of phosphorus contributed by each source and where the data used came from

Jun-Sept	Total TP (lbs)	% of Load	Source of Data
Clark - West Branch	693.68	20.00%	calculated
LaValle - East Branch	480.25	14.00%	calculated
Internal	984.35	27.00%	From 1996 Study
Groundwater	67.89	2.00%	From 1996 Study
Nearshore	165.80	5.00%	WiLMS
Measured Gullies	1014.75	28.00%	PRESTO
Septic	18.94	1.00%	WiLMS
Atmospheric	101.83	3.00%	From 1996 Study
	3527.49	100.00%	

In many TMDLs, internal phosphorus loading is assumed to be negligible or it is estimated based on sediment release rates and dissolved oxygen conditions in the lake (Robertson & Diebel, 2020). This was the case in 1997 when researchers concluded that internal phosphorus loading, in terms of how it likely impacted water quality in the lake, may not be a significant part of the problem (Leverance & Panuska, 1997). Robertson and Diebel 2020 further state that "Accurately quantifying net internal P loading and using this information in lake models are important in evaluating how large shallow lakes should respond to P reduction strategies, setting realistic expectations from watershed P reductions, and guiding TMDL efforts."

The LRPD has never been quite satisfied with the conclusion of the 1997 study and given the Robertson and Diebel statement, feel the impact of internal loading should be revisited. Once new data from an internal loading study, and other studies looking at tributary loading, septic systems, and gullies and washes has been gathered the phosphorus budget for Lake Redstone will be recalculated.

4.1.1 Phosphorus Reduction in Lake Redstone

The WRB TMDL set goals for nonpoint source phosphorus loading reductions across the entire Wisconsin River watershed. The goals vary for different parts of the larger watershed, but for Lake Redstone and the east and west branches of Big Creek (Sub-basins 13, 15, & 16, Figure 7) it was set at an 67% reduction. Taking out what is considered background or natural phosphorus loading, a total phosphorus reduction goal of 86% for urban and agricultural nonpoint sources (Table J-5 WRB TMDL) was determined to be necessary in order for Lake Redstone and its watershed to meet the WisCALM goal of 30-µg/L (see Figure 13 in Section 3.1.13). If the amount of phosphorus entering Lake Redstone is reduced by 67%, the WisCALM goal for chlorophyll-a (<5% of days in sampling season with algal levels >20µg/L) also gets closer.

4.1.2 Chlorophyll Reduction in Lake Redstone

Once the phosphorus level in Lake Redstone reaches the water quality criterion of 30-µg/L, the predicted mean chlorophyll would be 13-µg/L (Oldenburg, 2021). This indicates that the lake may have some difficulty completely meeting the WisCALM chlorophyll goal mentioned above. However, revisiting lake response modeling results in Section 3.1.1.4, a substantial reduction in bloom frequencies in Lake Redstone is predicted at the 30-µg/L criterion, including the effective elimination of algae blooms over 50-µg/L (Figure 36).

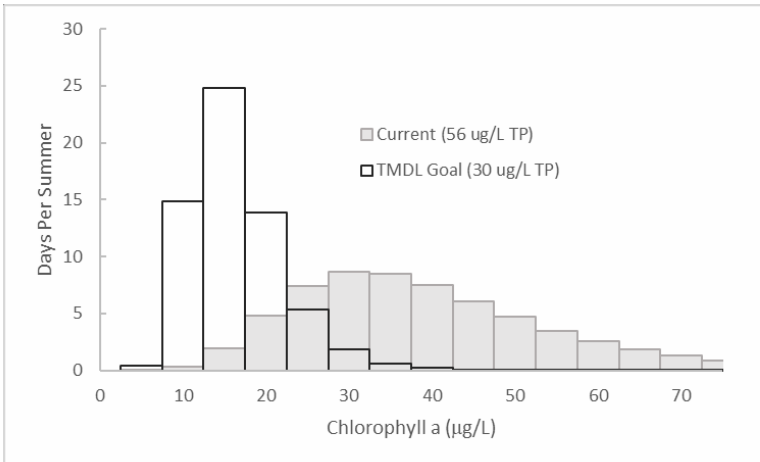


Figure 36: Estimated algae bloom frequency (days per summer) at current in-lake TP levels (grey bars), and bloom frequency if TP levels reach the TMDL goal of 30-µg/L (clear bars)

Given the uncertainty associated with predicting algal levels given major changes in lake nutrient levels, TP-Chl-*a* relationships and bloom frequencies through lake response modeling should be revaluated periodically during this plans ten year schedule and/or as lake improvements take place.

4.2 Sediment in Lake Redstone

Since the construction of Lake Redstone in the late 1960's, severe flooding events have been documented in 1978, 1992, 2008, and 2018. Each of these events included rainfall of 10 inches or more in as little as 24-48 hours. These events wreak havoc on the watershed, lake, and riparian area, and bring in untold amounts of sediment to be deposited on the bottom of the lake. Additionally, many smaller-scale flooding events have occurred, each contributing to the daily sediment load carried into the lake from the watershed.

Sediment carried into Lake Redstone from the two branches of Big Creek and from the many smaller gullies and washes has continually been an issue. Two large-scale dredging projects have been completed since the lake was constructed circa 1967. The first occurred in the late 1980's with 10 bays being dredged to improve boater access, deepen bays, and restore the lakebed closer to what it was in 1967. There is no easily attained record of how much sediment was removed at that time. The second, completed in 2019, removed an estimated 104,000 cubic yards of sediment combined from nearly all of the bays of the lake, enough to have been as tall as a six-story building if stacked on a football field (Mittelstadt, 2020). The 2019 dredging project carried a hefty price tag of $3.5 million.

Under baseline conditions, not accounting for extreme storm events, STEPL modeling referenced in Section 3.3.3 estimated the load of sediment into the two branches of Big Creek at more than 4,500 tons/year. The gullies, washes, streams, and developed area of the riparian zone were included in this modeling via estimates from the Lower Lake Redstone sub-basin.

In 2015, a sediment survey completed by Ayres Associates documented nearly 100,000 cubic yards of sediment averaging 3-ft deep in 29 different bays. Surveying after the August 2018 storm event concluded that another 67,000 cubic yards had been added on top of what was already there. Based on an estimate of the mass of lake/stream sediment (0.65-g/cm3) determined by a USGS study completed for Lake Linganore, Maryland in 2012 (Sekellick, Banks, & Myers, 2013), the mass of sediment in Lake Redstone before the 2019 dredging was nearly 94,000 tons. At 4,500 tons/year of baseline loading of sediment from the watershed, it would have taken about 21 years to put that much sediment into the lake.

The 2019 dredging project removed an estimated 56,972 tons of sediment from the lake, or 12.7 years of accumulation if baseline sediment loading was the only concern.

The additional sediment brought in between 2015 and 2018 has an estimated mass of 38,500 tons. Calculations after the August 2018 storm event estimated that 14,900 tons of sediment was brought into Lake Redstone just by the east and west branches of Big Creek. If 14,900 tons came in from the two branches of Big Creek in one event, and three years of base-level loading at 4,500 tons/year is added, it means about 10,200 tons of sediment came into Lake Redstone in between 2015 and 2018 from other sources - likely all of the gullies and washes that drain directly into the lake. With this calculation, the sediment removed by the 2019 dredging project would only equate to 4 years of baseline sediment loading and one year's (2018) worth of storm event loading.

The sediment surveys in 2015 and after the August 2018 storm event only included the bays, they did not take into account the sediment in the deeper portions of the main body of the lake, so the actual amount of sediment in Lake Redstone is likely far greater than is depicted here. These calculations, though likely not wholly indicative of the actual sediment load, provides some insights into how large storm events may be impacting Lake Redstone.

There has been some discussion related to documenting the amount of sediment in the main basins of the lake but how to do this has not been determined but is milestone in this project. It has also been discussed that keeping better records of changes in sediment deposition in the bays would be beneficial. To date, sediment deposition in the bays has only been documented two times, once in 2015 when developing the dredging plan for 2019, and again in 2018 after the large storm event in August of that year. Another milestone in this project is to document sediment deposition in multiple bays early in implementation and again in the last of 10-yrs of implementation.

4.2.1 Sediment Modeling

Between the first dredging and the 2019 dredging, dozens of projects were implemented in the watershed and riparian area of Lake Redstone to reduce sediment loading. Whether these actions can be tied directly to the extended time between dredging projects (from 20 to 30 years) is unknown, but it is hoped that continued management efforts will extend the period until the next large-scale dredging project is needed even longer. Over the next few years, it is expected that many more projects will be implemented to reduce sediment loading further. Given this, it would be useful to be able to model sediment loading from various sources to estimate the reductions that could be expected from projects implemented particularly in the riparian area of the lake.

Two models supported by the WI-DNR (and there may be others) potentially could be used, with modifications, to model sediment loading in the riparian area of the lake. WinSLAMM (Source Loading and Management Model for Windows) was developed to evaluate nonpoint source pollutant loadings in urban areas using small storm hydrology. The model determines the runoff from a series of normal rainfall events and calculates the pollutant loading created by these rainfall events. The user is also able to apply a series of control devices, such as infiltration/bio-filtration, street sweeping, wet detention ponds, grass swales, porous pavement or catch-basins to determine how effectively these devices remove pollutants (WI-DNR, SLAMM and P-8 Models). The P-8 (Program for Predicting Polluting Particle Passage through Pits, Puddles, and Ponds) Urban Catchment Model is a model for predicting the generation and transport of storm water runoff pollutants in urban watersheds. The model has been developed for use by engineers and planners in designing and evaluating runoff treatment schemes for existing or proposed urban developments. Predicted water quality components include suspended solids, total phosphorus, total Kjeldahl nitrogen, copper, lead, zinc, and total hydrocarbons (WI-DNR, SLAMM and P-8 Models).

The process of developing a sediment delivery and deposition model may benefit from collection of additional information related to the amount of sediment already in the lake and bays as discussed in Section 4.2.

4.2.2 Sediment Reductions

Unlike phosphorus and chlorophyll, there is no State standard for an appropriate amount of sediment loading to lakes, rivers, and streams. In the absence of a recognized and accepted goal to meet when considering sediment reductions in a lake, and until a separate goal is set based on modeling results proposed in Section 3.5.2.1, this plan defers to whatever reduction in sediment loading occurs in tandem with reductions in total phosphorus that occur with recommended management actions. More specifically, management actions implemented to help meet a 67% reduction in phosphorus loading to Lake Redstone will also create a reduction in sediment loading.

The STEPL model will be used to estimate sediment load reductions after adoption of various practices in the watershed. Once a new model has been created, STEPL model results will be used in tandem with other sediment reduction methods/calculations to determine baseline sediment loading into Lake Redstone.

4.3 Nitrogen

Nitrogen is second only to phosphorus as an important nutrient for plant and algae growth. Sources of nitrogen include: wastewater treatment plants, runoff from fertilized lawns and croplands, failing septic systems, runoff from animal manure and storage areas, and industrial discharges that contain corrosion inhibitors. There are three forms of nitrogen that are commonly measured in waterbodies: ammonia (NH_3), nitrates (NO_3^-), and nitrites (NO_2^-). Total kjeldahl nitrogen (TKN) is a combined measurement of ammonia, organic and reduced nitrogen. Total nitrogen is the combined sum of TKN and NO_3+NO_2 (EPA, 2013). Nitrites, nitrates, and ammonia – the dissolved forms of nitrogen – can be used by most plants and algae. Nitrate is usually the most prevalent form of nitrogen in lakes (UMass - Amherst, 2016).

An acceptable range of total nitrogen in lakes is 2-mg/L to 6-mg/L (EPA, 2013). The Deep Hole water quality monitoring site near the dam has the most existing nitrogen data for Lake Redstone, and has a combination of surface and bottom water samples collected between 1989 and 2019. During this time, total nitrogen values ranged from 0.436-mg/L to 5.64-mg/L with a mean of 1.22-mg/L. Total nitrogen data collected from the east and west branches of Big Creek between 2018 and 2020 show a concentration of nitrogen in the water carried into Lake Redstone between 1.09 and 2.47-mg/L. All Lake Redstone sampling data indicates that phosphorus, not nitrogen, is the limiting nutrient in Lake Redstone at this time. As phosphorus levels in the lake are reduced, this situation may change.

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4.3.1 Hypolimnetic Withdrawal

There is one scenario where the amount of nitrogen as pollution, in the form of ammonia (NH_3) has implications in Lake Redstone. The outlet of Lake Redstone is most recognizable as a small waterfall that is formed when surface water flows out of the lake through a spillway over the top of the dam. There is another outlet or gate near the bottom of the dam that can be opened to draw water out from the bottom of the lake. Because of this gate, hypolimnetic withdrawal is possible. Hypolimnetic withdrawal is simply removing water from the bottom of the lake instead of letting it flow out from the surface of the lake.

Hypolimnetic withdrawal was listed along with numerous other potential management alternatives for Lake Redstone in an earlier study (UW-Madison, 1981). In the 1990's, the LRPD proposed hypolimnetic withdrawal in an effort to reduce internal phosphorus source and complement ongoing efforts to reduce watershed nutrient loads.

In 2002, the WI-DNR in cooperation with the LRPD and Sauk County completed a hypolimnetic (bottom water) withdrawal study of the lake. The following is taken from the final report accompanying that study (Marshall, Jaeger, Panuska, Lathrop, Unmuth, & Decker, 2002).

Hypolimnetic withdrawal has been used to reduce internal phosphorus loading in European lakes since 1961 and North American lakes since 1983 (Cooke 1986, Nurnberg 1987). Both of these sources reported some successes when thermal stratification was maintained. Nurnberg (1987) reported that optimum effectiveness can occur when the withdrawal pipe is located near the bottom in the deepest location of a lake and high discharge rates are sustained without destratifying or lowering the lake levels. Other factors that will influence the success of a hypolimnetic withdrawal include the lake morphometry and balance of phosphorus inputs versus outputs (Cooke, 1986).

Numerous sources have identified the threats and impacts of anoxic hypolimnetic discharges to downstream fisheries and water quality, whether the release is designed to reduce sediment phosphorus pools or to maintain a desired temperature regime. Due to low dissolved oxygen levels in the hypolimnion of eutrophic lakes, special precautions are needed to protect downstream fisheries (Cooke, 1986). Nurnberg (1987) reported that wastewater treatment is required in some cases to prevent adverse effects downstream. Below several North American impoundments, including Twin Valley Lake in Wisconsin, hypolimnetic discharges significantly reduced macroinvertebrate (Young, et al. 1976, Hilsenhoff 1971, Lehmkulm 1972) and fish populations (Edwards 1978).

Tailwater discharges from reservoir hypolimnions often contain toxic levels of hydrogen sulfide and ammonia and can adversely affect downstream ecology, while epilimnetic discharges are generally less disruptive to tailwater biota (Walburg et al. 1981). Minute hydrogen sulfide concentrations can generate nuisance odors, of particular concern in populated areas. Efforts to reduce the "rotten egg" odors have included construction of baffles and fountains to dissipate hydrogen sulfide or enclosures to dilute hypolimnetic water with epilimnetic water (Nurnberg, 1987).

Hydrogen sulfide (H2S) is a toxic, colorless gas that can form in sediments when bacteria feed on organic debris in areas that are low or depleted of oxygen, giving off a rotten egg smell when the sediments are stirred up. When dissolved in water, H2S can undergo two chemical steps, which go back and forth depending on the pH. At pH less than 6, most of the hydrogen sulfide will be in the toxic H2S form, whereas at higher pH (8-12), most of the hydrogen sulfide will be in the less toxic HS- form (Sallenave, 2012).

Ammonia is a form of nitrogen found in organic materials and many fertilizers. It is the first form of nitrogen released when organic matter decays and is the main nitrogenous waste excreted by most fish and freshwater invertebrates. High concentrations of ammonia (greater than 0.02 ppm) are considered sub-lethal and fish exposed may experience reduced growth and increased susceptibility to disease (Sallenave, 2012).

The 2002 WI-DNR study concluded the following:

- Lake Redstone behaves as two contiguous lakes; the upper lake is mixed and lower lake is thermally stratified.
- Internal phosphorus loading is a significant water quality factor within the mixed upper lake and poor water quality resulted. Due to a combination of weak thermal stratification, close proximity to external phosphorus sources and the remote location from the dam, hypolimnetic withdrawal would not improve the water quality in this part of the lake.
- Pronounced thermal stratification in the smaller basin near the dam allows for sediment phosphorus reduction if outputs exceed inputs. However, this part of the lake displays the best water quality and indicates that internal phosphorus sources are not affecting surface water quality.
- Big Creek supports diverse fisheries and aquatic life. A hypolimnetic discharge could pose a serious threat to the stream based on high levels of ammonia and hydrogen sulfide and low dissolved oxygen.

- The two test releases showed that the existing valve could be manually set to accurately control the low flow rates needed for a bottom discharge, but the submerged dam makes the existing structure ineffective at removing high phosphorus concentrations from the lake. Some aeration occurred at the discharge valve and pipe. Downstream dissolved oxygen remained high in Big Creek during both tests. Elevated ammonia concentrations were found in Big Creek and to a lesser extent in the Baraboo River.
- Whether or not structural changes are made to avoid effects of the submerged dam, a Chapter 30 and/or WPDES permit will be required for any proposed hypolimnetic discharge in an effort to protect downstream fisheries, the public interest and water quality standards. As part of the permitting process, effluent calculations will limit hypolimnetic discharge rates based on a number of factors including stream classification, stream dilution and effluent quality. Maximum hypolimnetic discharge rates to Big Creek and directly to the Baraboo River are 0.123 and 3.1 cfs respectively.
- Strong hydrogen sulfide (rotten egg) odors would be produced during a hypolimnetic withdrawal and create nuisance conditions during heavy park use periods.
- Results of the Lake Planning Grant-Baraboo River Restoration and Research Study have largely confirmed the predictions and support recommendations of the 1997 Lake Redstone Water Quality Model Study that suggests controlling internal loading is less important than controlling significant external phosphorus sources.
- From a statewide perspective on water quality management, a thorough analysis of lake response and downstream impacts is recommended for all proposed hypolimnetic withdrawal projects, whether the goal is internal phosphorus loading reduction or sustaining a desired downstream temperature regime.

A more recent bottom withdrawal of water was implemented by Sauk County between 7/22/16 and 8/11/16 in response to the need for an emergency repair/examination of the dam. The release was started slowly so the anoxic water didn't have a profound and immediate effect on the aquatics within the stream that it was discharged into. Before increasing the release of water, as many fish as possible were removed from the stream between the dam and the Baraboo River with the help of a local WI-DNR fisheries biologist. After, the release of bottom water was subsequently increased, but at no time was the gate even opened halfway. There was no additional testing, other than Sauk County Park staff watching for any fish die off where the stream met the Baraboo River, and no die off was observed.

Because the bottom withdrawal was a directive from the DNR to drawdown the lake immediately, there was not a lot of time to prepare or plan for reducing the impacts the discharge could ultimately cause. Sauk County Park personnel were pleasantly surprised to see very little impact on the stream and no impact at the confluence of the Baraboo River (personal communication Matt Stieve, Sauk County, September 14, 2021).

It is recommended that a study similar in scope for to the one completed in 2002 be completed to reevaluate the feasibility of hypolimnetic withdrawal.

5.0 Management Measures (Element 3)

Best management practices (BMPs) are methods or actions that have been determined to be the most effective and practical means of preventing or reducing non-point source pollution to help achieve water quality goals. They include both measures to prevent pollution via source control and measures to mitigate pollution via treatment/filtering methods. For the purpose of this plan, BMPs will be recommended in each of the three main areas of concern: watershed/agriculture, riparian area, and within the lake. Many of the management actions or measures to reduce sediment and phosphorus loading and improve water quality in Lake Redstone over the next 10 years or more are dependent on successful implementation of BMPs.

For more information on BMPs and examples of those that may be specific to one or more of these areas of concern see Appendix D.

5.1 Watershed/Agricultural BMPs

Agricultural BMPs focus on reducing non-point sources of pollution from cropland and farm animals Runoff from these areas may contain nutrients, sediment, animal wastes, salts, and pesticides. Many agricultural BMPs have already been implemented in the Lake Redstone watershed. Juneau and Sauk County land conservationists estimate that more than 3,000 acres of contour strip farming already exist in the watershed. More than 350 acres incorporate the use of cover crops. A few acres are included in nutrient management plans (Table 17). No-till farming has become a more common practice in the watershed in the last several years with about 20% of the cropland implementing it.

Table 17: Specific BMPs (cover crops, contour strip farming, no-till farming, and nutrient management planning) estimated acres within each sub-basin

Sub-basin	Conventional Farming	Contour Farming	No Till Farming	Estimated Total Crop Land	Pasture	Cover Crops	Nutrient Management Planning	% Conventional Farming	% Contour Farming*	% No Till Farming	% Cover Crops	% Nut Man Plan
W1-PfaffRoad	211	650	215	1076	434	55	0	19.6	60.4	20.0	5.1	0
W2-LaValleRoad	83	644	182	909	583	185	87	9.1	70.8	20.0	20.4	9.6
W3-LowerRedstone	330	645	244	1219	1210	50	200	27.1	52.9	20.0	4.1	16.4
W4-ClarkRoad	0	220	55	275	204	20	0	0.0	80.0	20.0	7.3	0
W5-LuchtRoad	0	198	49	247	161	45	0	0.0	80.2	19.8	18.2	0
W6-DaugsRoad	0	136	34	170	117	0	0	0.0	80.0	20.0	0.0	0
TOTALS	624	2493	779	3896	2709	355	287					
Mean % of Ag Land in practice								7.2	72.8	20.0	10.0	4.3
*updated with July 2021 Cropping Practices from Sauk and Juneau Counties 7/30/2021 DLB												

5.1.1 Loading Reductions In the Watershed

STEPL modeling results demonstrate one way to reach 67% reduction in nutrient and sediment loading from the watershed to the tributaries and Lake Redstone by implementing additional BMPs (Table 18). Nearly 19,000-lbs of phosphorus is estimated to be coming from the watershed annually. Not all of the phosphorus and sediment moving from the land in the watershed ends up in Lake Redstone. Much of it stays in the creeks and smaller tributaries, particularly under normal or baseline conditions. Table 16 in Section 4.1 estimated annual phosphorus loading to the lake itself at a little more than 3,500-lbs.

Table 18: Current pollutant loading: nitrogen (N), phosphorus (P), and sediment based on total land use in the six sub-basins

Sources	N Load (lb/yr)	P Load (lb/yr)	Sediment Load (t/yr)
Urban	427.13	71.84	10.59
Cropland	31244.51	13434.68	3982.12
Pastureland	15537.32	1771.00	256.65
Forest	3024.98	1764.68	252.19
Feedlots	9049.98	1810.00	0.00
User Defined	96.35	78.29	30.11
Septic	77.72	30.44	0.00
Gully	0.00	0.00	0.00
Streambank	0.00	0.00	0.00
Groundwater	0.00	0.00	0.00
Total	59457.99	18960.93	4531.66

5.1.1.1 Feedlots

One of the most obvious changes in land use that has a direct impact on nutrient loading is reducing the number of acres in the watershed impacted by feedlots. In Table 18, feedlots contribute over 1,800 lbs of phosphorus. Table 8 in Section 3.3.1.1 identifies 5.3 acres across the six sub-basins with active feedlots. If 100% of the acres impacted by feedlots are addressed over the 10 yrs of this plan, just shy of 10% of loading can be eliminated.

5.1.1.2 Changing Land Use

Both Sauk and Juneau County conservationists feel a reasonable land use goal for the first five years is to reduce cropland by 779-acres, and replace it with pastureland while also transitioning 75% of remaining cropland acres in the watershed to soil health practices (no-tillage/conservation tillage and/or cover crop BMPs). With these changes, STEPL modeling results confirm 43% of the target goal of a 67% reduction in phosphorus can be achieved (Tables 19, 20, 21). At the same time, sediment loading is reduced by 53% and nitrogen loading by 25% (Table 21).

Table 19: Current land use in the six sub-basins of the Lake Redstone watershed (left); and land use after 20% of the crop land is converted to rotational grazing/pastureland (right)

Watershed	Cropland	Pastureland	Cropland	Pastureland
W1 - Pfaff	1076	434	860.8	649
W2 - Lavalle	909	583	727.2	765
W3 - Lower R	1219	1210	975.2	1454
W4 - Clark	275	204	220	259
W5 - Lucht	247	161	197.6	210
W6 - Daugs	170	117	136	151
Total Acres	**3896**	**2709**	**3116.8**	**3488**

Table 20: Pollutant loading after a 20% change in land use (cropland converted to rotational grazing/pastureland) and soil health practices on 75% of remaining cropland acres

Sources	N Load (lb/yr)	P Load (lb/yr)	Sediment Load (t/yr)
Urban	427.13	71.84	10.59
Cropland	13901.16	4990.69	1534.05
Pastureland	18193.99	2145.17	306.32
Forest	3024.98	1764.68	252.19
Feedlots	8851.23	1765.28	0.00
User Defined	96.35	78.29	30.11
Septic	46.63	18.26	0.00
Gully	0.00	0.00	0.00
Streambank	0.00	0.00	0.00
Groundwater	0.00	0.00	0.00
Total	44541.47	10834.21	2133.26

Table 21: Changes in loading after a 20% change in land use and how they relate to the WRB TMDL goal of a 67% reduction

Sources	N Load (lb/yr)	P Load (lb/yr)	Sediment Load (t/yr)
Urban	0.00	0.00	0.00
Cropland	17343.35	8443.99	2448.06
Pastureland	-2656.66	-374.16	-49.67
Forest	0.00	0.00	0.00
Feedlots	198.74	44.72	0.00
User Defined	0.00	0.00	0.00
Septic	31.09	12.18	0.00
Gully	0.00	0.00	0.00
Streambank	0.00	0.00	0.00
Groundwater	0.00	0.00	0.00
Total	**14916.52**	**8126.72**	**2398.40**
% Reduction	**25%**	**43%**	**53%**

Using the STEPL model, if the goal of the first five years is to convert 20% of cropland in the watershed to rotational grazing/pastureland, and adopt soil health practices on 75% of cropland acres and that gets 43% of the 67% reduction desired, changes in years six to ten can have an additional impact. By converting another 20% of cropland to rotational grazing/pastureland, retirement of 300 acres (10%) of existing cropland acres to prairie vegetation, and transitioning 85% of remaining cropland acres in the watershed to soil health practices (no-tillage/conservation tillage and/or cover crop BMPs) (Table 22), an additional reduction in phosphorus loading of 29% is predicted, totaling a 72% reduction, more than the goal of 67% (Table 23). These scenarios also reduce the amount of sediment entering the lake by another 26% and nitrogen by another 23% after ten years.

Table 22: Current land use in the six sub-basins of the Lake Redstone watershed (left); and land use after 40% of the crop land is converted to rotational grazing/pastureland (right)

Watershed	Cropland	Pastureland	Cropland	Pastureland
W1 - Pfaff	1076	434	645.6	865
W2 - Lavalle	909	583	545.4	947
W3 - Lower R	1219	1210	731.4	1698
W4 - Clark	275	204	165	314
W5 - Lucht	247	161	148.2	260
W6 - Daugs	170	117	102	185
Total Acres	**3896**	**2709**	**2337.6**	**4269**

Table 23: Changes in loading after a 40% change in land use and adopting soil health practices on 85% of remaining cropland acres (left) - and how they relate to the WRB TMDL 67% reduction goal (right)

Sources	N Load (lb/yr)	P Load (lb/yr)	Sediment Load (t/yr)
Urban	427.13	71.84	10.59
Cropland	6847.38	2172.44	650.07
Pastureland	20514.22	2233.17	245.52
Forest	2773.04	1559.98	173.46
Feedlots	1756.76	342.04	0.00
User Defined	81.87	66.52	25.59
Septic	38.86	15.22	0.00
Gully	0.00	0.00	0.00
Streambank	0.00	0.00	0.00
Groundwater	0.00	0.00	0.00
Total	32439.27	6461.21	1105.22
AG NPS Total	29118.37	4747.65	895.58

Sources	N Load (lb/yr)	P Load (lb/yr)	Sediment Load (t/yr)
Urban	0.00	0.00	0.00
Cropland	24397.13	11262.24	3332.05
Pastureland	-4976.90	-462.17	11.14
Forest	251.94	204.70	78.73
Feedlots	7293.22	1467.96	0.00
User Definec	14.48	11.77	4.53
Septic	38.86	15.22	0.00
Gully	0.00	0.00	0.00
Streambank	0.00	0.00	0.00
Groundwater	0.00	0.00	0.00
Total	**27018.73**	**12499.72**	**3426.44**
AG NPS Tota	**26713**	**12268**	**3343**
% Reduction	**48%**	**72%**	**79%**

5.1.2 Producer-Led Cooperative Predicted Reductions in Watershed Loading of Phosphorus and Sediment

On a more local level, the Producers of the Lake Redstone Watershed (PLRW) have been exploring the use of several BMPs and how they would reduce sediment and phosphorus leaving the fields and entering the waterways. They explored the use of cover crops, cover crops with the intent of incorporating them as "green manure", vertical tillage, no-till, and zero tillage (pasture/rotational grazing). Green manure is a term used to describe specific plant or crop varieties that are grown and turned into the soil to improve its overall quality. A green manure crop can be cut and then plowed into the soil or simply left in the ground for an extended period prior to and/or during planting. They also compared changes as a result of these practices on different sloping gradients; steeper gradients benefitted more from these practices than did less steep gradients.

In 2019-20, the DATCP worked closely with the PLRW members to identify prevalent crop rotations and the types/extent of existing agricultural BMP in the watershed and then modeled those conditions within SnapPlus model. DATCP found that if all 3000 acres of corn crops were planted using no-till methods instead of conventional tillage, an 8.9-lbs/ac/yr. (69%) reduction in phosphorus could be achieved. In another example, using a vertical tillage farming implement instead of a chisel plow to prep soil for planting could reduce phosphorus loss by 5.3-lbs/ac/yr. (40%). By adding a green manure cover crop and planting into living field cover, phosphorus loss could be reduced by an additional 4.7-lbs/ac/yr. (35%) for a total reduction of 75% in these areas. Finally, converting annual tilled cropland to rotational grazing for beef or dairy is another option for reducing phosphorus and sediment loading from cropland because it reduces nearly all sediment and particulate phosphorus loss from a field. A DATCP 2019 Producers of Lake Redstone Conservation Benefit report further explains these findings (Appendix J).

In 2021, 15 different farmers used cost-share incentives provided by PLRW to plant cover crops and implement other conservation practices. PLRW members farm over 3,000 acres in the watershed combined. When the different scenarios explored by the PLRW are modeled for the total acreage covered by these farmers, loading reductions are substantial and align with reductions predicted in the STEPL model. It is expected that member farmers of the PLRW will increase in the next five years, as will the total acreage covered by these producers, and will the number of BMPs put in place. Any amount of cropland where conventional farming practices are modified in favor of more friendly soil health and practices bodes well for water quality in Lake Redstone.

5.1.2.1 Financial Incentive Programs

Where appropriate and based on need, additional financial incentive programs will be developed that will increase the number of producers who can participate, beef up existing programs, and/or provide incentives where there currently aren't any.

5.1.2.2 Nutrient Management Planning

The number of acres in the watershed that are covered under nutrient management plans is limited, only 7%. Nutrient management planning accounts for all nutrient inputs to a field, ensuring that there are sufficient nutrients available for crop needs while preventing excessive nutrient loading (application of manure or fertilizer), which may result in leaching of the excess nutrients to the ground water, or contained in surface water runoff from the land into local lakes and waterways. Discussions with Juneau and Sauk County put increasing the number of acres covered by nutrient management plans as a low priority activity but one that is still worth doing. The Producers of Lake Redstone are the most logical to promote this activity in the watershed.

5.2 Riparian BMPs

Many BMPs exist for the improving the riparian area along a waterbody and minimizing the impact of development. Rain gardens, native plantings, different water runoff diversion techniques, and buffer strips along the lake are a few examples. There are many more pertaining to construction, homeowner access to the lake, patios and decks, use of fertilizers, pesticides and other chemicals, leaves and grass clippings, firepits, etc. The extent to which these and other BMPs are currently implemented or followed by property owners and others in the riparian area was not determined, but a continuous effort to remind property owners about them will help reduce pollution carried by runoff or added to the lake inadvertently.

5.2.1 Loading Reductions in the Riparian Area

The riparian area of Lake Redstone offers many opportunities to implement reduction projects that will benefit the lake. The results of individual projects may be difficult to measure, but the cumulative impact may be significant. For example, repairing damage caused by recent storm events to existing infrastructure in place to help control runoff; maintaining existing retention basins, berms, and other BMPs will reduce both phosphorus and sediment loading. Converting mowed lawns to more native vegetation; installing storm water diversions and infiltration trenches to reduce runoff into the lake from driveways, rooftops and other impervious surfaces; planting rain gardens to store more of the runoff allowing it to soak into the ground; repairing and preventing areas of active erosion, and eliminating unnecessary fertilization of lawns and gardens; will reduce phosphorus and sediment loading into the lake.

5.2.1.1 Shoreland Habitat Improvement Projects

Through the 2018 SHA (see Section 3.2.1.1), management recommendations were made for evaluated parcels based on Wisconsin's Healthy Lakes and Rivers Initiative. Recommended BMPs include the installation of raingardens, native plantings, runoff diversions, and runoff infiltration trenches. Most of these activities can be funded in part through WI-DNR grants.

A specific goal set by the LRPD regarding the SHA is to decrease the percentage of properties with a moderate to high priority ranking and increase the percentage of properties with a low or no priority ranking through the implementation of these small-scale BMPs (Brad Horner, personal communication).

5.2.1.2 Gullies, Washes, and Streams

Many of the bays around the lake have had runoff-reducing BMPs installed on them in the past including rock chutes, energy stilling basins, and retention basins (Figure 37). One example is a single dirt berm at the head of Mourning Dove Bay that was replaced in 2020 with three rows of gabion baskets filled with rock after having been washed out and repaired after flooding in 2008, and again in 2018 (Figure 38). Currently, the LRPD is seeking bids for another repair project at the head of Swallow Bay where a spillway was damaged during the 2018 flooding.

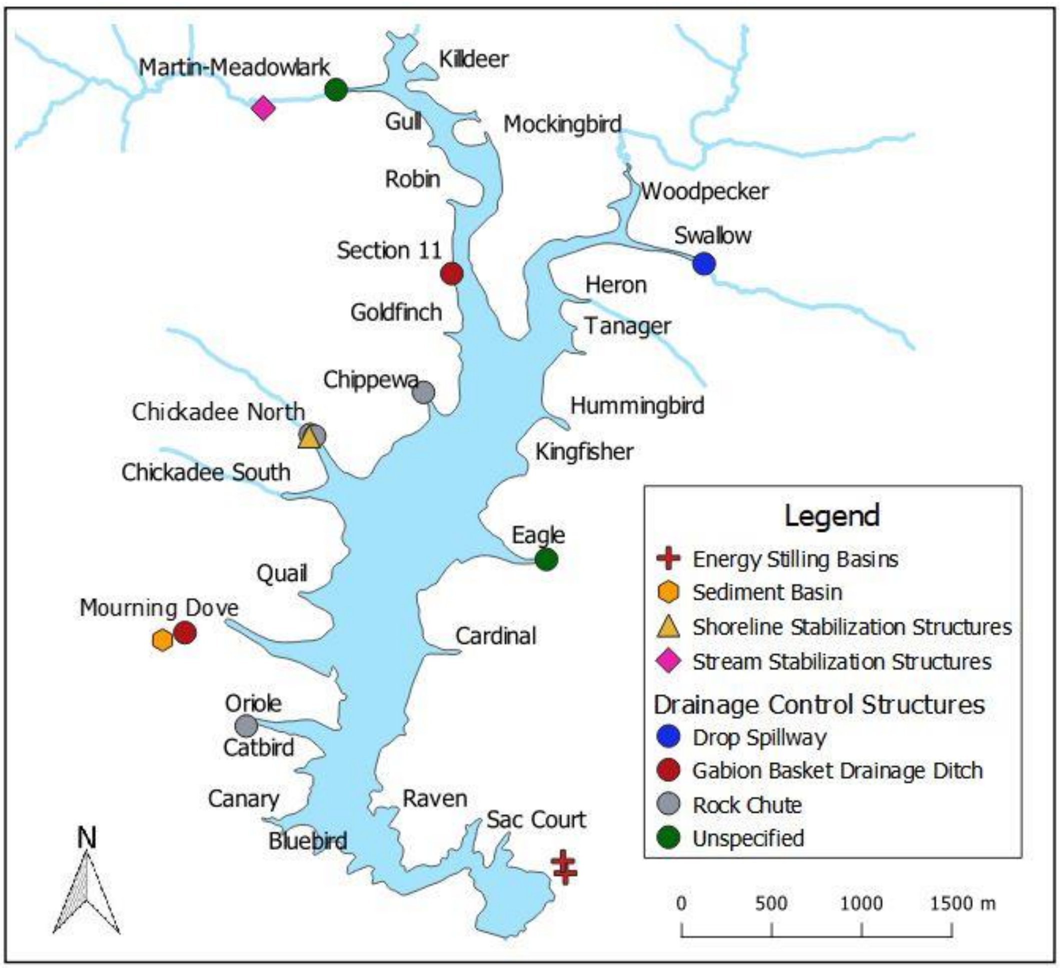

Figure 37: Existing sediment and runoff reduction BMPs in place around Lake Redstone (Al Baade, personal communication 9/29/2021, LEAPS)

Figure 38: Stone-filled gabion baskets placed at the head of Mourning Dove Bay (LRPD Website)

5.2.1.3 Beach Club Lots

Beach club lots around Lake Redstone provide a special challenge when it comes to implementing BMPs that will reduce runoff and improve habitat. Because they are collaboratively owned by multiple properties, it is not sufficient to convince a single property owner to implement a project. Individually owned parcels on Lake Redstone will receive initial priority for implementing BMPs, but once the number of individual parcels begins to lag, the LRPD will move to evaluating individual beach club lots and then meeting with the owners of each lot to prioritize issues and develop management plans.

5.2.1.4 POWTS

Private onsite wastewater treatment systems (septic systems) are used to treat and dispose of small volumes of wastewater onsite, usually from houses and businesses located in suburban and rural locations not served by a centralized public sewer system. Septic systems treat wastewater from household plumbing fixtures (toilet, shower, laundry, etc.) through both natural and technological processes (US EPA, 2020). There are several steps homeowners can take to prevent their home's septic system from impacting nearby water sources. Some are simple while others can be more involved and expensive[7].

To ensure that septic systems within the larger watershed of Lake Redstone and in the developed area (riparian zone) around the lake are functioning properly and not negatively impacting water quality, survey work will be completed to determine the number of septic systems, their age, and maintenance schedule for the last five years. Once completed, survey results will be used to: determine the potential extent of septic system failure (direct discharge into Lake Redstone or its receiving waters); prioritize POWTS for repair/maintenance; inform property owners; and share information with/connect them to the programs offered by the counties and supported by the State that are designed to reduce the number of faulty or failing systems.

5.3 BMPs in Lake Redstone

Like agriculture and riparian areas, in-lake BMPs also exist. Some focus on invasive species, others on protecting the littoral area of the lake, and still others on minimizing disturbances of the bottom sediment and keeping the water free of pollutants and garbage. The LRPD is responsible for aquatic plant management and in mindful of how those management actions impact the lake. No wake zones exist and are marked with

[7] For more information about how homeowners can prevent their septic systems from impacting the lake and groundwater go to: https://www.epa.gov/septic/septic-system-improvements-protect-nearby-water-sources

buoys essentially wherever the distance from shore to shore is 400-ft or less (Figure 39). In addition, the Town of LaValle has an ordinance (Section 11.01.05 Controlled Areas), that establishes an Emergency Slow No-Wake designation for all of Lake Redstone during high water conditions. Aquatic invasive species education, planning, and prevention activities/BMPs including Clean Boats, Clean Waters and AIS monitoring are implemented on a regular basis by the LRPD and supported by the Town of LaValle and LRPOA.

How well users of Lake Redstone comply with fishing and boating regulations and other general lake stewardship activities has not been determined and no effort in this plan will be done to do so. However, the LRPD and its partners will continue to promote these activities to their constituency and other lake users.

Figure 39: Approximate location of buoys designating "no-wake" areas on Lake Redstone (Town of LaValle)

5.3.1 Mitigating Internal Loading

If additional study of the role of internal loading completed in the first year or two of implementing this plan determines that internal loading does play a significant role in the loading of phosphorus into Lake Redstone and reducing phosphorus loading from the watershed does not have a more immediate positive impact on the lake, additional actions including more dredging and/or the application of phosphorus binding agents could be evaluated. Internal loading can be exacerbated by the resuspension of bottom sediments caused by man-made disturbances like boating or by natural disturbances like wave action, particularly in areas where limited or no aquatic plants exist to buffer or attenuate wave energy.

If the levels of phosphorus entering the lake from the watershed can be controlled and if internal loading is found to be a significant factor in maintaining phosphorus levels in the lake, then the LRPD may examine other treatments, such as alum treatments to reduce the levels phosphorus in the water. But this is likely a long-term strategy that may happen after the 10 years covered by this plan.

5.3.1.1 Considering P Removal Technologies for Use at Smaller Scales

The LRPD is interested in evaluating the use of phosphorus removal technologies at smaller scales, i.e. at intermittently flowing inlets in the riparian area around the lake. One possibility is the use of absorptive filter media. From Bunce et al. (2018), P is removed by filter media through the process of sorption or by direct precipitation. Briefly, this involves the movement of inorganic P from the wastewater to the surface or body of reactive components (e.g., calcium or iron) contained in the media, where is accumulates. The P removal capacity is dependent on the mineral content of the media. Early work on P removal by sorptive media focused on the use of locally sourced sands and gravel. More recently, the development of a wide variety of natural or man-made materials has advanced the potential for the application of this technology at small-scale Bunce et al. (2018)

The applicability of this technology has not been fully developed with several obstacles still to be overcome. It is likely that a small-scale system like this would be remotely located without major civil infrastructure. As such, to sustain operational efficiency, it would be critical that any technology implemented in rural and remote locations requires minimal maintenance. This can only be made a reality if the system is rapid to stabilize and simple in terms of construction and operation. The use of absorptive filter media within the context of a constructed wetland or as a standalone system is a promising solution on these bases. However, significant capital outlay, space considerations, and long-term sustainability may limit these options Bunce et al. (2018).

Small-scale application of this P management technique is in its infancy, with only a few companies offering solutions. Further research is needed to determine the long-term effectiveness of such systems for smaller scale treatment applications and the performance of absorptive media under rapid fluctuations in flow and nutrient loadings.

5.3.2 Dredging to Remove Sediment and Phosphorus

Not listed as a BMP, but effective at reducing the amount of sediment and phosphorus in Lake Redstone regardless, is dredging. Based on analytics done on multiple core samples of sediment collected from the bottom of bays around Lake Redstone in 2015/16, the mean phosphorus content of the sediment was 232.8-ug/kg (Ayres Associates, 2015). The 2019 dredging project removed an estimated 51,684,129 kg of sediment – meaning approximately 12,032-kg or 26,526-lbs of phosphorus was removed from the lake with the sediment. At an estimated seasonal loading of phosphorus in the lake of 1,628-lbs, and assuming that all that phosphorus settled out into the sediment at the bottom of the lake (which it didn't), that would be a little more than 16 years' worth of phosphorus build-up.

These calculations are only for baseline loading conditions and do not represent what is brought into the lake during storm events or spring snowmelt. Improved monitoring techniques are already being implemented that will improve data associated with tributary loading during storm events.

6.0 Implementation Schedule (Key Element 6) and Milestones (Key Element 7)

The main goal of all of the efforts past, present, and future put forth by the LRPD and supporting entities is encompassed in its mission statement: "… to protect and rehabilitate the water quality of Lake Redstone for its residents and the public". For Lake Redstone, this means reducing loads of sediment and phosphorus from multiple sources in the larger watershed, the riparian area around the lake, and in the lake itself.

Sections 6.1 – 6.3 lay out actions to be implemented by the LRPD and its partners over the course of the next 10 years. The actions for each area of concern (watershed, riparian area, and lake) are listed under two categories - "Reducing Phosphorus and Sediment" and "Gathering Data". More detail about each action is included in the Implementation and Milestones Matrix for each area of concern presented in Appendices E, F, and G.

6.1 Watershed Objectives and Actions

Reducing sediment and phosphorus loading in the watershed is focused primarily on changing agricultural land use by implementing recognized BMPs. Additional focus is on addressing existing animal feedlots in the watershed, identifying and addressing issues where gully and ravine erosion exists (fields, streams, washes, etc.), and increasing the amount of agricultural land covered under nutrient management plans. Where appropriate, implementation is divided by each of the six sub-basins.

Actions to gather additional information to improve management include evaluating each individual sub-basin via the Stream Power Index, physical follow-up to confirm or document gully and ravine erosion, improving tributary monitoring to better document actual sediment and phosphorus loading in the two main branches of Big Creek.

6.1.1 Reducing Sediment and Phosphorus Loading - Watershed

- Convert 40% of existing cropland acres to grazing/pasture (1,558 acres)
- Apply a wide range of BMPs (no-till, cover crops, etc.) to 85% of all remaining cropland (1,988 acres)
- Increase the amount of acres covered by nutrient management plans by 10% (390 acres)
- Convert 10% of all remaining cropland to prairie through restoration (234 acres)
- Reduce the number of improperly managed animal feedlots by 100%
- Reduce verified field gully/ravine erosion areas
    - Implement grassed waterways, grade stabilization structures, contour farming, etc.
- Repair faulty or failing POWTS so they comply with current regulations
- Work with others to make sure appropriate forestry and mining BMPs are being utilized in the watershed

6.1.2 Gathering Additional Data - Watershed

- Complete streambank and lateral recession rate monitoring in at least two sub-basins
- Complete a Stream Power Index and gully/ravine inventory outside of the Lake Redstone sub-basin
- Monitor land use changes via satellite imagery and "cropland data layer" annually
- Complete cropland roadside transect surveys with in the entire watershed annually
- Complete an inventory of active POWTS outside of the Lake Redstone sub-basin
    - Prioritize POWTS for repair and maintenance

6.2 Riparian Area Objectives and Actions

Reducing sediment and phosphorus loading in the riparian area is focused primarily on encouraging property owners around the lake to modify their properties in ways that will improve and/or protect wildlife habitat and reduce surface water runoff across properties. Associated with this is identifying and addressing issues of gully, ravine, and wash erosion within the riparian area but not necessarily tied to individual parcels. Additional focus is on repairing and/or providing maintenance for existing runoff control structures in place to reduce direct drainage into Lake Redstone; and to identify new ones that could be put in place. Identifying and bringing faulty septic systems into compliance and reducing runoff from multi-owner parcels around the lake are also included.

Actions to gather additional information to improve management include repeating the Shoreland Habitat Assessment, documenting sediment loading in individual bays and developing a sediment model to be used to predict future loading, collecting time-at-the-lake people data for use in lake response modeling, determining potential loading from septic systems, and evaluating multi-owner parcels around the lake.

6.2.1 Reducing Sediment and Phosphorus Loading – Riparian Area

- Reduce the number of moderate and high priority property parcels by 20%
  - Annual Shoreland Improvement Workshops
  - Project assistance through application grant programs
- Reduce the number of beach club and other cooperatively owned parcels contributing to sediment and phosphorus loading
- Repair faulty or failing POWTS so they comply with current regulations
- Evaluate and repair existing sediment and stormwater control BMPs
- Reduce verified field gully/ravine and stream erosion areas
  - Implement grassed waterways, grade stabilization structures, contour farming, etc.

6.2.2 Gathering Additional Data – Riparian Area

- Repeat the SHA in five years
- Complete a Stream Power Index and gully/ravine inventory within the Lake Redstone sub-basin
- Complete an inventory of active POWTS outside of the Lake Redstone sub-basin
  - Prioritize POWTS for repair and maintenance
- Evaluate streams, gullies and washes entering directly into Lake Redstone for stormwater runoff and erosion issues
  - Prioritize for further documentation through monitoring and collection of water samples
- Document the level of sediment entering the individual bays of Lake Redstone during storm events
- Develop a sediment model

6.3 Lake Redstone Objectives and Actions

Reducing sediment and phosphorus loading within Lake Redstone is focused on actions that can reduce resuspension of sediment and availability of phosphorus to support plant and algae growth. Aquatic plant management, disturbance of bottom sediment by boats, waves, and carp are addressed either directly in this plan or in the Lake Redstone Aquatic Plant Management Plan. Actions are included that would remove sediment and phosphorus from the lake including hypolimnetic withdrawal, binding of phosphorus, and additional dredging. Of these three, adding agents that would bind phosphorus and dredging are low in priority and highly dependent on new data collected during the implementation of this plan.

Actions to gather additional information to improve management include updating the APM Plan, reevaluating the role of internal loading of phosphorus (and possible alum treatment), and the feasibility of hypolimnetic withdrawal. Efforts to better quantify the amount of sediment already in the lake and that which is added (or removed) over the next 10 years of implementation.

6.3.1 Reducing Sediment and Phosphorus Loading – Lake Redstone

- Aquatic plant management planning, survey, permitting and treatment
- Encourage carp removal by working with the Lake Redstone Fishing Club to continue the carp removal programs held in 2021 and earlier years.
- Use of alum or other phosphorus binding agents
  - After external phosphorus sources in watershed are substantially controlled and internal loading is determined to remain a significant factor in maintaining lake phosphorus levels
- Hypolimnetic withdrawal from the dam
  - If it is determined that such withdrawals can be performed without significant negative impacts downstream in the Baraboo River
- Adapt/adopt new boating ordinances that will help minimize bottom disturbances

6.3.2 Gathering Additional Data – Lake Redstone

- Update the Aquatic Plant Management Plan
- Update existing lake response modeling
- Complete an internal phosphorus loading study
- Reevaluate hypolimnetic withdrawal from the lake
- Review and evaluate existing boating ordinances
- Recalculate sediment and phosphorus loading to Lake Redstone from all sources based on new data
- Survey sediment in the main basin of Lake Redstone to quantify deposition

7.0 Education and Outreach (Key Element 5)

To be effective, an education and outreach plan must include increased and better communication with the many stakeholders across the three main areas of concern for Lake Redstone – the watershed, riparian area, and lake. The main goal for Education and Outreach for Lake Redstone is to create public awareness of water quality issues in the watershed, increase public involvement in watershed stewardship, and increase communication and coordination among stakeholders and partners.

7.1 Objectives

The following is a list of objectives related to the Education and Outreach goal.

- Develop targeted educational and information materials to appropriate audiences in the watershed and distribute through newsletters, brochures, website and Facebook posts, etc.
- Support, plan, and promote agriculturally-based field days, demonstrations, and project tours.
- Partner with other 9-Key Element Watershed Organizations to plan and present a Watershed Conference on a regular basis (how regular would be determined in the planning process)
- Promote goodwill and partnership between lake property owners and the agricultural community with tours of non-agricultural conservation practices put in place.
- Work with and support efforts by the Producers of the Lake Redstone watershed to successfully implement actions supported by DATCP grants
- Plan and promote at least two meetings a year to discuss implementation and evaluation of this plan with stakeholders and partners
- Host at least one annual meeting meant to update and involve the LRPD constituency in plan implementation

For more information about these objectives and the estimated cost to implement consult Appendix I.

7.2 Target Audience

Multiple audiences will be targeted through this education and outreach plan. Target audiences include but are not limited to property owners on and adjacent to Lake Redstone, agricultural operators and producers, local clubs and organizations, local businesses and schools, local government officials, and other watershed groups.

The following sections provide more information about specific education and outreach activities in each area of concern.

7.3 Watershed

The main stakeholders representing the larger watershed of Lake Redstone include the local agricultural producers, Sauk County, Juneau County, the United State Geological Survey (USGS), University of Wisconsin Discovery Farms, and the Producers of the Lake Redstone Watershed, a producer-led initiative.

7.3.1 Discovery Farms – Edge-of-Field Monitoring Stations

Two edge-of-field monitoring stations were installed in the watershed to measure and collect runoff from monitoring basins (Figure 40). Located in the Driftless area of the state, this region is geologically unique with land areas that were by-passed by the glaciers leaving steep terrain susceptible to flash runoff events and erosion that can increase the amount of sediment and nutrients lost from agricultural land and carried into streams, rivers, and lakes. Samples are collected with remote technical assistance from the USGS, and are analyzed for nitrogen, phosphorus and sediment. The Juneau County LWR Department performs sample collection and site maintenance at edge-of-field monitoring stations.

Results and data analysis from the monitoring stations are shared with interested partners during local field days and other events open to the public. It is during these events that the LRPD gets involved; bringing what is learned to its constituency. It is expected that these two monitoring stations and the partnerships will remain in place for several more years.

Figure 40: Example edge-of-field surface water monitoring station/system (left); actual Lake Redstone watershed edge-of-field monitoring station

7.3.2 Producers of the Lake Redstone Watershed

The purpose of a producer led watershed group is for participating farmers to reach out to other farmers to join the group and to help them adopt similar conservation practices. With additional funding from DATCP, the group will continue to support farmer incentives to implement best management practices including cover crops, community manure sharing, establishing nutrient management plans, and for sponsoring community events, field days, and training.

7.3.3 Juneau County

The following education and outreach components are part of the Juneau County LWR Management Plan and also are of benefit to Lake Redstone: planned on-farm visits to producers in selected watersheds to review resource concerns and potential ways to address them; summer/fall field events in each watershed to talk about practice implementations; winter meetings with watershed participants to review results and next steps; annual programs discussing soil health and innovative conservation strategies; tours on non-agricultural conservation practices like stream bank, shoreline, rain gardens, etc.; and as nutrient management plans are developed, meetings will be conducted with producers to expand and develop agricultural enterprise areas.

7.3.4 Sauk County

One of the goals of the Sauk County Land and Water Resource Management Plan is to deliver information and education programs focusing on agricultural and environmental issues affecting the county. Some of the current programs that can be associated with protecting and improving Lake Redstone include: classes and workshops – cover crop/soil health field days, small acreage landowner workshops, pasture walks, and nutrient management farmer education classes; publication of the Conservation Chronicle newsletter & news releases; maintaining a County website & Facebook page; sponsoring an Agricultural Plastics Recycling Program; sponsoring special events – Earth Day, lake fair, county fair, dairy breakfast;, supporting citizen water monitoring; and sponsoring partnership projects with environmental, sporting, and service groups.

In the past, Sauk County has been successful in obtaining funding to support the Baraboo River Watershed Regional Conservation Partnership Program (RCPP). Lake Redstone and its watershed are part of this partnership. RCPP promoted coordination between USDA, NRCS and its partners to deliver conservation technical and financial assistance to agricultural producers and forest landowners to help implement conservation practices that improve soil health, water quality, restore wildlife habitat, and improve agricultural productivity.

Both Sauk and Juneau County provide education and informational materials to the public via brochures, demonstrations, displays, notices, and other publications.

7.4 Riparian Area

The main stakeholders representing the riparian area of Lake Redstone include the LRPD, the LRPOA, group-owned beach club sites, individual property owners, and local businesses and real estate agencies. The riparian area of Lake Redstone is typical of most developed lakes in southern WI – far too much impervious surface and mowed lawn to the edge of the lake. Changing the public perception of what a healthy riparian area around Lake Redstone should be has long been a topic of discussion within the LRPD.

7.4.1 Riparian Ditch and Gully Erosion

Minimizing ditch and gully erosion during large storm events is a high priority for the LRPD. The LRPD Board recently created a Sediment Control Committee that will be focusing on ditches and gullies closer to the lake that periodically become streams following rain storms. This committee will try to identify problem areas and come up with ideas/plans to help reduce sediment carried into the lake from these areas. Included in this is analyzing culverts under the myriad of roads around Lake Redstone and documenting unimpeded runoff to the lake during storm events. Individual gullies draining directly to the lake will be prioritized based on the level of concern and potential for the implementation of "fixes". Existing BMPs in place to reduce runoff and sediment loading will be evaluated and maintenance planned and implemented if needed. Ideas for new or additional BMPs will be discussed, ultimately leading to plans and implementation. To do this, the LRPD will work closely with local and county resources, property owners around the lake, and owners of land upstream of any identified problem area.

7.4.2 Shoreland Improvement Project

In 2020, the LRPD began organizing a shoreland improvement education and implementation program based on the results of the 2018 SHA. The goal of the program is to help property owners understand how their property values benefit relative to better water quality through runoff reduction; healthier and more diverse habitat for fish and wildlife; and potentially improved natural aesthetics around the lake. This project has four phases to it. All four phases are expected to occur in each year of implementation.

The first phase of the project is to share with individual property owners the results of their evaluation during the 2018 SHA. Postings on the LRPD webpage and Facebook page, articles in LRPD newsletters, and one on one conversation with property owners, will encourage them to ask about their evaluation, review it with the LRPD, and ask questions about it.

During the second phase of the project, interested property owners will be invited to workshops to better understand their assessment results, learn more about possible improvement opportunities, and what resources exist to help them implement projects that will reduce runoff and improve habitat. These workshops would also include information on shoreline preservation methods (e.g. bio-logs, rip-rap, etc.) to prevent shoreland erosion.

The third phase is sponsoring actual workshops. The content of each year's workshop could vary but would be focused on why the LRPD sponsored this SHA of properties around the lake; review/explanation of the parameters used to score properties during the SHA; a review/explanation of individual property management recommendations made during the SHA; an introduction to the WI-DNR Healthy Lakes and

Rivers Initiative and how it provides reimbursement for projects implemented to reduce runoff and improve shoreland habitat; options for reducing sediment runoff and habitat improvement that go beyond the management recommendations in the SHA; introduction to the Sauk County water quality improvement and lake protection program, eligible projects, and opportunities for reimbursement of expenditures for completed projects; and introduction of landscaper(s) and other businesses who could help assess properties for methods to reduce runoff and preserve shoreline and then possibly contract with property owners to perform the work.

The final phase of this activity is organizing property owners and projects and applying for grant funds on their behalf, and then providing support to complete identified projects.

It is expected that these activities will be carried out annually as long as there are still interested property owners. After five years, the SHA will be redone to determine the level of changes that have occurred.

7.4.3 Septic System Education

Sauk County has several information brochures related to septic systems, permitting, and erosion control that were prepared by the county with the intent to distribute to property owners, not just on Lake Redstone, but throughout the County. Gaining access to these existing publications and resending them to property owners around the lake is an activity that could be done and would be beneficial for making current and future improvements to the lake. Sauk County has a grant program – Wisconsin Fund-Private Sewage System Replacement or Rehabilitation – that exists to help property owner's deal with faulty or failing septic systems. More information about this grant is available through Sauk County.

7.4.4 Beach Clubs

Although the shorelines of some beach clubs are problematic, the complexity associated with working with multiple owners makes it difficult to make improvements on these shorelines. (Beach clubs on Lake Redstone can have fewer than 10 owners or more than 100 different owners.) Thus, initial efforts at shoreline improvement will focus on lots with a single owner. But in the latter years of this plan, it may become necessary to address the shoreline of some of the beach clubs.

7.4.5 Real Estate

When ownership of a property changes due to sale, foreclosure, or by some other means, this is a good opportunity to approach the new owners with information about what they can do to make their new property more lake friendly. Being part of a lake district, each new property owner automatically pays extra taxes to support a healthy lake. Providing information to these new property owners about what their extra taxes are being used for may increase support for what the LRPD does. Ultimately, taxes will be less and home/property values more when a lake is considered generally healthy with only minor issues. While mowed and manicured properties may sell better, a fact often noted by real estate agents, they are less healthy to the lake overall.

This plan recommends that the LRPD be actively engaged in property sales around the lake. When a property exchanges hands, representatives of the LRPD should be at the door immediately welcoming the new owner and passing on materials about how and what that property owner can do to maintain or improve the lake into the future.

7.5 Lake Redstone

Like the watershed and the riparian area, there are many things that are done that directly impact the water quality in the lake. The main stakeholders representing the lake are the property owners around the lake, users of the lake, fishing clubs and other community organizations, the LRPD, and the many resource agencies managing the lake.

7.5.1 LRPD

The LRPD will continue to work on identifying, obtaining, and/or developing their own publications on topics of concern for distribution to the watershed, riparian area, and lake stakeholders. Both the LRPD and the LRPOA have active web and Facebook pages to help keep stakeholders involved. The LRPD will continue to assist in planning and participate in watershed level activities and continue to promote riparian area workshops and training sessions. The LRPD will continue to hold annual "Partners" meetings whereby many stakeholders are brought together to discuss the status of Lake Redstone and share accomplishments and plans.

7.5.2 Property Owners

How property owners view and treat the lake, often called lake stewardship, is vital to maintaining the health of the lake. Lake stewardship can encompass many things including but not limited to how a property adjacent to the shore is managed, proper septic system maintenance, lighting along the shore, noise, being a good neighbor, responsible boat use, following fishing rules and regulations, and doing what is necessary to avoid spreading aquatic invasive species.

Lake stewardship will be promoted through lake organization meetings and publications. Many organizations create specific awards, brochures, or other materials promoting and/or recognizing good stewardship practices and the people who are practicing them.

People use lakes in different ways, and may have different goals for enjoyment of the lake. Discussing these goals in an open forum can help people understand each other's view points and vision for the lake. Additionally, gaining an understanding of general lake processes and ecology can help people understand what is happening in their lake. Determining the current condition of the lake can then provide a knowledge base that can be used to protect and restore the lake.

7.5.3 Lake Users

Lake users can be anybody with property on the lake or who comes to the lake for some purpose. Lake Redstone is a popular recreation lake for fishing, power boating, water skiing and tubing, and use of personal watercraft. Lake Redstone has several "no wake" areas where the lake is too narrow to accommodate fast moving boats safely. A continued effort toward providing education and information regarding safe and legal use of watercraft in Lake Redstone not only protects the people of the lake, but also helps protect the health of the lake. Fishing is another popular activity on Lake Redstone, practiced by both property owners and outside lake users. Like other good lake stewardship practices, following fishing rules and regulations related to size and bag limits, proper handling of catch and release fish, draining livewells, and proper disposal of live bait will also help protect the health of the lake.

7.5.4 Others

The various other clubs and organizations that focus on Lake Redstone and the surrounding area will continue to support and promote good lake stewardship through their members and the activities they support. Real estate agencies, local marinas and bait stores, businesses that do lake work (dock installers, landscapers, etc.), lake-related clubs and organizations, and local governments should also promote good lake stewardship and may need reminders every now and then from the LRPD to do so.

8.0 Authorities, Funding Sources, and Technical Assistance (Key Element 4)

Identifying practices that are expected to make improvements to the lake, riparian area, or watershed is only one step in developing and implementing a plan. It is necessary to know under what authority, what guidelines the practices are to be implemented. Then it is necessary to determine the cost of implementation and how that cost is going to be covered. Finally, knowing what expertise is needed to successfully implement a plan and where that expertise is coming from is imperative.

8.1 Authorities

Natural resources in the United States are protected to some extent under federal, state, and local law. The Clean Water Act is the strongest regulating tool at the national level. In Wisconsin, the WI-DNR has the authority to administer the provisions of the Clean Water Act. The U.S. Fish and Wildlife Service and U.S. Army Corps of Engineers work with the WI-DNR to protect natural areas, wetlands, and threatened and endangered species. The Safe Drinking Water Act also protects surface and groundwater resources.

Both Juneau and Sauk Counties have established zoning ordinances regulating land development and protecting surface waters. A majority of the Lake Redstone watershed is in Juneau County. The entirety of Lake Redstone is in Sauk County.

8.1.1 Juneau County

The following ordinances in both counties will help guide implementation of this plan.

8.1.1.1 Chapter 4, Article V – Animal Waste Management

The purpose of this article is to regulate the design, location, construction, installation, alteration and use of animal waste storage facilities and application of waste from these facilities; to prevent water pollution and thereby protect the health of county residents; to prevent the spread of disease; and to promote the health, prosperity and welfare of the residents of the county. It is also intended to provide for the administration and enforcement of this article and to provide penalties for its violation.

8.1.1.2 Chapter 16 – Floods

The purpose of this chapter is to regulate floodplain development to: 1) Protect life, health and property; 2) Minimize expenditures of public funds for flood control projects; 3) Minimize rescue and relief efforts undertaken at the expense of the taxpayers; 4) Minimize business interruptions and other economic disruptions; 5) Minimize damage to public facilities in the floodplain; 6) Minimize the occurrence of future flood blight areas in the floodplain; 7) Discourage the victimization of unwary land and homebuyers; 8) Prevent increases in flood heights that could increase flood damage and result in conflicts between property owners; and 9) Discourage development in a floodplain if there is any practicable alternative to locate the activity, use or structure outside of the floodplain.

8.1.1.3 Chapter 15 – Private Onsite Wastewater Treatment

The purpose of this chapter is to promote and protect public health and safety by assuring proper siting, design, installation, inspection and management of private sewage systems and non-plumbing sanitation systems.

8.1.1.4 Chapter 21 – Ag Waste and Performance Standards

The purpose of this chapter is to provide for proper and safe storage, handling, and land application of agricultural waste and to reduce the delivery of manure, other waste materials, fertilizers, and sediment to surface waters and groundwater through the use of conservation practices and implementation of state performance standards and prohibitions for agriculture. This chapter is also intended to provide for administration and enforcement, and to provide penalties for violation of the chapter.

8.1.1.5 Chapter 22, Article II – Non-metallic Mining Reclamation

The purpose of this article is to establish a local program to ensure the effective reclamation of non-metallic mining sites on which non-metallic mining takes place in the county.

8.1.1.6 Chapter 36 - Waterways and Boating, Appendix A: Shoreland-Wetland Zoning

For the purpose of promoting the public health, safety, convenience and welfare, this appendix has been established to:

1) Further the maintenance of safe and healthful conditions and prevent and control water pollution through:
   a) Limiting structures to those areas where soil and geological conditions will provide a safe foundation.
   b) Establishing minimum lot sizes to provide adequate area for private sewage disposal facilities.
   c) Controlling filling and grading to prevent serious soil erosion problems.
2) Protect spawning grounds, fish and aquatic life through:
   a) Preserving wetlands and other fish and aquatic habitat.
   b) Regulating pollution sources.
   c) Controlling shoreline alterations, dredging and lagooning.
3) Control building sites, placement of structures and land uses through:
   a) Separating conflicting land uses.
   b) Prohibiting certain uses detrimental to the shoreland area.
   c) Setting minimum lot sizes and widths.
   d) Regulating side yards and building setbacks from roadways and waterways.
4) Preserve shore cover and natural beauty through:
   a) Restricting the removal of natural shoreland cover.
   b) Preventing shoreline encroachment by structures.
   c) Controlling shoreland excavation and other earth moving activities.
   d) Regulating the use and placement of boathouses and other structures.
   e) Controlling the use and placement of signs.

8.1.2 Sauk County

8.1.2.1 Chapter 7, Subchapter III – Zoning Districts

The purpose of this subchapter is to outline the land management goals and general land uses allowed in each zoning district.

8.1.2.2 Chapter 8, Subchapter I – Shoreland Protection General Provisions

This Chapter/subchapter is nearly the same as Chapter 36 Appendix A in Juneau County ordinances.

8.1.2.3 Chapter 8, Subchapter IV - Shoreland-Wetland Zoning District

The purpose of the shoreland-wetland district is to maintain safe and healthy conditions, to prevent water pollution, to protect fish spawning grounds and wildlife habitat, to preserve shore cover and natural beauty, and to control building and development in wetlands whenever possible. When development is permitted in a wetland, the development should occur in a manner that minimizes adverse impacts on the wetland.

8.1.2.4 Chapter 9 – Floodplain Zoning

This Chapter is similar to Chapter 16 in Juneau County ordinances.

8.1.2.5 Chapter 24 – Non-metallic Mining Reclamation

This Chapter is similar to Chapter 22 in Juneau County ordinances.

8.1.2.6 Chapter 25 – Private Onsite Wastewater Treatment Systems

The underlying principles of this ordinance are to promote and protect the public health, safety, general welfare and natural resources and to:

1) Further the maintenance of safe and healthful conditions by regulating POWTS use, location, design installation, operation, management, inspection and repair.
2) Prevent and control surface water and groundwater pollution through:
   a) Requiring setbacks between POWTS components and water courses.
   b) Regulating the use of POWTS to protect the public health, safety, general welfare and natural resources.
   c) Requiring in-situ soils to be the preferred system.

8.1.2.7 Chapter 26 – Ag Performance and Manure Management

This Chapter is similar to Chapter 21 in Juneau County ordinances.

8.1.3 NR 151

In addition to using local ordinances and educating landowners in the watershed on programs and funding available to them to improve water quality and meet current state and local agricultural regulations, Juneau and Sauk County LCDs will collaborate with WI-DNR to verify and document NR151 compliance via the following actions:

1) Annually meet with WI-DNR Nonpoint Source and TMDL staff to review and discuss NR151 implementation efforts in the watershed, including:
   a) Review existing cropland acres and animal operations in the watershed
   b) Determine what number/percent of agricultural cropland acres and farms are complying with NR151 and how many are not.
   c) Confirm how many cropland acres or farms in watershed have been documented in compliance with NR151 Standards & Prohibitions via a letter.
   d) Review selected copies of NR151 compliance letters with WI-DNR staff.
   e) Do plan implementation efforts for agricultural cropland/operations reflect the following priorities?
      i) Priority 1: Achieving compliance with current NR151 performance standards on a majority (>70%) of agricultural acres/operations in the watershed
      ii) Priority 2: Promoting additional practices on agricultural acres/operations already in compliance with NR151 - to further reduce ag pollutant loads in the watershed.
   f) Incorporate NR 151 compliance information within selected 9-key element plan tracking reports.

8.1.4 WI Dept. of Safety and Professional Services (DSPS)

The DSPS – Private Onsite Wastewater Treatments Systems (POWTS) Program protects public health and the waters of the state by regulating onsite wastewater treatment and recycling systems. The program works with counties (including Juneau and Sauk) to promote the use of the best available technology to provide onsite sewage treatment system solutions for property owners. It provides required plan review for new system installations and/or replacements or additions to existing POWTS treatment, holding, or dispersal components. The program also provides oversight for the Wisconsin Fund (see 8.2.1).

8.1.5 Town of LaValle

The following Town of LaValle ordinances pertain directly or indirectly to Lake Redstone.

8.1.5.1 Chapter 4.02 – Boat Landing Entrance Fees

- Boat landing hours (4.02.04), piers and swimming (4.20.05), and signs (4.02.06)

8.1.5.2 Chapter 11.01 – Lake Redstone and Water Traffic

- 11.01.05 - Boat exclusion areas (public and marked swimming areas)
- 11.01.06 - Controlled areas (slow-no wake and emergency slow-no wake)
- 11.01.07 - Other water traffic rules (water skiing)
- 11.01.08 – Water exhibition

8.1.5.3 Chapter 11.03 – Aircraft landing

8.1.6 Lake Redstone Protection District

Lake districts can work cooperatively with other government bodies and private organizations to carry out authorized activities. Wisconsin local governments (including lake districts) have broad powers to undertake cooperative efforts with other government bodies and Indian tribes. For example, some lake districts work cooperatively with counties or other government bodies on boating law enforcement, erosion control, and other programs important to the lake or its watershed. Lake districts can also work cooperatively with nonprofit organizations on conservation projects beneficial to the lake and the district's mission.

8.1.6.1 Recreational Boating Regulations

All lake districts have the authority to establish water safety patrols and contract with certified law enforcement officers to enforce state boating laws and any local boating ordinances that affect the lake. Like on many lakes, the use of wake boats and other craft that create large wakes are a source of concern on Lake Redstone. At present, only state boating regulations and those in effect via the Town of LaValle ordinance related to high water are in place and can be enforced. At some point in the future, there may be some level of interest in creating additional ordinances to guide the use of wake boats or similar craft.

Wisconsin law generally gives towns, villages and cities the authority to enact local boating regulations. This power can be delegated to a lake district. For a lake district to enact a boating ordinance, it must be authorized by resolutions adopted by at least one-half of the cities, villages and towns having frontage on the lake, the approving units of government must include at least 60% of the lake's frontage, and the entire lake must be within the district's boundaries.

Whether a boating ordinance is adopted by a lake district, city, village or town, various statutory requirements must be met. The adopting local government (including a lake district) must take into account local conditions in developing boating ordinances, including the lake's size and shape, environmental features and the extent of congestion and conflict among boaters. There are also detailed procedural requirements, including published notices, public hearings, WI-DNR advisory review and other steps. The Legislature has expressly authorized boating regulations that restrict speed or establish time or location standards for different types of boating activities. Boating ordinances may not be inconsistent with state boating law, but may generally be more restrictive than state laws. If a lake district enacts boating ordinance provisions that conflict with town, village or city boating ordinances, the lake district provisions supersede the local conflicting provisions. Local boating ordinances may be enforced by citations, similar to "traffic tickets."

8.1.7 Producers of Lake Redstone

The Producers of Lake Redstone are required to follow guidelines established through DATCP, specifically those that apply to producer-led watershed protection grants – Wisconsin Statute 93.59 and Chapter ATCP 52. Permitted uses for grant funds include the following:

1) Development of work plan, mission development, goal setting, and learning days to have experts discuss related topics or development of incentive program.

2) Incentive payments for conservation practices such as soil testing and cover crop seed.
3) Field days, workshops and conferences including facility rentals, meals, and expenses directly related to hosting the event.
4) Personnel for coordinator role including expenses for salaries and wages, contract and consulting services, and mileage at allowable state rates. The maximum amount for any type of labor expense is $25 per hour.
5) Mailings, creation of marketing and outreach brochures, handouts, newsletters, or factsheets.
6) Materials and supplies directly associated with the project.
7) Incentive payments for equipment rentals of innovative technologies used or shared by all farmers within the producer led group, for example covering costs for renting a low-disturbance manure injector or no-till drill.
8) Rental costs for equipment directly associated with research projects, if pre-approved by project manager.
9) Cost-effective edge-of-field and water quality monitoring.
10) Farm assessments to identify and evaluate potential or existing resource concerns, nutrient management implementation and other water quality practices.
11) Other costs deemed by the department as consistent with the purpose of s. 93.59, Stats.

https://library.municode.com/wi/juneau_county/codes/code_of_ordinances
https://www.co.sauk.wi.us/general/county-ordinances
http://townoflavalle.us/towncodeofordinances.html
https://www.uwsp.edu/cnr-ap/UWEXLakes/Documents/organizations/Lake%20Districts/Lake_Org_Guide2018.pdf
https://datcp.wi.gov/Pages/Programs_Services/ProducerLedProjects.aspx

8.2 Cost to Implement

Table 24 below and Appendix I attempt to estimate the cost to implement the actions in this plan. Table 24 provides a quick view of expenses, while Appendix I provides more detail about each item in Table 24.

Table 24: 10-year Implementation Cost Estimate

Plan Action	Total Cost Estimate - 10 years
Surface Water Monitoring	$263,784
Lake Monitoring	$14,040
Reduce Sediment and P loading – Watershed	$2,179,499
Reduce Sediment and P loading - Riparian	$534,000
Reduce Sediment and P loading - Lake Redstone	$81,000
Gathering Additional Data – Lake Redstone	$151,000
Gathering Additional Data - Riparian	$108,116
Gathering Additional Data - Lake Redstone	$11,500
Staff Costs	$790,000
Plan Implementation Tracking	$125,000
Education and Outreach	$207,500
TOTAL COST	**$4,465,439**

Cost estimates for WQ monitoring activities in Appendix I (described in sections 2, 3 and 9 of plan) were obtained from the LRPD, who previously provided the majority of funding for much of the existing WQ monitoring activities in the watershed. Other sources include the SLOH, USGS, WI-DNR, and County Land Conservation Departments/UW Discovery Farms (who has completed edge of field monitoring in the watershed.

Cost estimates for agricultural-based practices in Appendix I were obtained after consulting with Sauk and Juneau County Land Conservation Departments with additional information from the PLRW, who have been offering cost-share incentives to plant cover crops and implement other conservation practices in the watershed. Costs for interim milestones reflect plan content (modeling), information from existing 9-Key element plans, or professional judgment.

Cost estimates for shoreland improvements in the riparian area were based on the existing Sauk County Lakeshore Assistance Program and WI-DNR Healthy Lakes and Rivers Initiative (Section 8.2.7.2). These programs can be used to help implement BMPs for high priority shoreline parcels/properties identified in the plan. After implementation, cost estimates for redoing the SHA are based on the cost of past assessments.

Cost estimates for Education and Outreach efforts in the watershed were obtained from Land Conservation Departments, LRPD, and past educational efforts.

Cost estimates, or milestones for determining cost, to complete certain actions are missing from Appendix I. These are actions where either cost estimates are much harder to generate without additional data, or the action is included, but may not be implemented based on results of future data gathering. Individual lines in Appendix I marked with an asterisk indicates the cost estimate may change as new or additional cost information is determined during the 10-year plan implementation schedule. Individual lines marked with TBD (to be determined) indicate that the action is being considered, but actual implementation and the timing of that implementation will depend on future information.

8.2.1 Federal & State Funding Sources

Most of the federal funding is available for agricultural lands through the Natural Resource Conservation Service (NRCS) or the Farm Service Agency (FSA). State funding comes largely from the Surface Water grants program.

The Wisconsin Fund is a program that provides grants to homeowners and small commercial businesses to help offset a portion of the cost for the repair, rehabilitation, or replacement of existing failing Private Onsite Wastewater Treatment Systems (POWTS). Eligibility is based upon several criteria, including household income and age of the structure. In Wisconsin, 67 counties out of 72 counties, the City of Franklin, and the Oneida Tribe of Wisconsin participate in the program. County government officials assist interested individuals in determining eligibility and in preparation of grant applications.

8.2.2 EPA 319 Grant Programs for States and Territories

The 1987 amendments to the Clean Water Act (CWA) established the Section 319 Nonpoint Source Management Program. Section 319 addresses the need for greater federal leadership to help focus state and local nonpoint source efforts. Clean Water Act Section 319(h) funds are provided only to designated state and tribal agencies to implement their approved nonpoint source management programs. State and tribal nonpoint source programs include a variety of components, including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and regulatory programs. Each year, EPA awards Section 319(h) funds to states in accordance with a state-by-state allocation formula that EPA has developed in consultation with the states. Section 319(h) funding decisions are made by the states. States submit their proposed funding plans to EPA. If a state's funding plan is consistent with grant eligibility requirements and procedures, EPA then awards the funds to the state. In 2020, over $172 million dollars was awarded to the states for nonpoint source management.

8.2.3 Agriculture

The following are brief descriptions of current agricultural funding programs that may be applicable to the implementation of this plan, and their acronyms. In most cases these programs are supported by the WI-DNR or Natural Resource Conservation Service (NRCS). A majority of these programs would be administered by the Sauk and Juneau County Land Conservation Departments.

- **Targeted Runoff Management Grant Program (TRM)** – WI-DNR program offers competitive grants for local governments for controlling nonpoint source pollution. Grants reimburse costs for agriculture or urban runoff management practices in critical areas with surface or groundwater quality concerns. The cost-share rate for TRM projects is up to 70% of eligible costs.
- **Environmental Quality Incentives Program (EQIP) –** NRCS program provides financial and technical assistance to implement conservation practices that address resource concerns. Farmers receive flat rate payments for installing and implementing runoff management practices.
- **Conservation Partners Program (CPP)** – A collaborative effort between U.S. Department of Agriculture's Natural Resource's Conservation Service (NRCS) and the National Fish and Wildlife Foundation (NFWF) to provide grants on a competitive basis to increase technical assistance capacity to advance the implementation of NRCS/NFWF initiatives and Farm Bill conservation programs.
- **Conservation Reserve Program (CRP)** - A land conservation program administered by the Farm Service Agency. Farmers enrolled in the program receive a yearly rental payment for environmentally sensitive land that they agree to remove from production. Contracts are 10-15 years in length. Eligible practices include buffers for wildlife habitat, wetlands buffer, riparian buffer, wetland restoration, filter strips, grass waterways, shelter belts, living snow fences, contour grass strips, and shallow water areas for wildlife.
- **Conservation Reserve Enhancement Program (CREP) –** NRCS program provides funding for the installation, rental payments, and an installation incentive. A 15-year contract or perpetual contract conservation easement can be entered into. Eligible practices include filter strips, buffer strips, wetland restoration, tall grass prairie and oak savanna restoration, grassed waterway, and permanent native grasses.
- **Agricultural Conservation Easement Program (ACEP)** - New program that consolidates three former programs (Wetlands Reserve Program, Grassland Reserve Program, and Farm and Ranchlands Protection Program). Under this program, NRCS provides financial assistance to eligible partners for purchasing Agricultural Land Easements that protect the agriculture use and conservation values of eligible land.
- **Conservation Stewardship Program (CSP) –** NRCS program offers funding for participants that take additional steps to improve resource condition. Program provides two types of funding through 5-year contracts; annual payments for installing new practices and maintaining existing practices as well as supplemental payments for adopting a resource conserving crop rotation.
- **Farmable Wetlands Program (FWP) -** Program designed to restore previously farmed wetlands and wetland buffer to improve both vegetation and water flow. The Farm Service Agency runs the program through the Conservation Reserve Program with assistance from other government agencies and local conservation groups.

8.2.4 Preserving Land/Land Trusts

Landowners also have the option of working with a land trust to preserve land. Land trusts preserve private land through conservation easements, purchase land from owners, and accept donated land.

- Knowles-Nelson Stewardship Program

- Nature Conservancy

8.2.5 WI-DNR Surface Water Grants[8]

The surface water grant program provides cost-sharing grants for surface water protection and restoration. Funding is available for education, ecological assessments, planning, implementation, and aquatic invasive species prevention and control. With many different projects eligible for grant funding, you can support surface water management at any stage: from organization capacity development to project implementation.

- Education
- Planning
- Comprehensive Management Planning
- County Lake Grants
- Healthy Lakes and Rivers
- Surface Water Restoration
- Management Plan Implementation
- Clean Boats, Clean Waters
- AIS Supplemental Prevention
- AIS Early Detection and Response
- AIS Large- or small-scale Population Management
- AIS Research and Demonstration
- Land Acquisition
- Early Detection and Response Projects
- Established Population Control Projects
- Maintenance and Containment Projects
- Research and Demonstration Projects

8.2.6 Producer-Led Watershed Protection Grants

Funded through DATCP, these grants go to projects that address ways to prevent/reduce agricultural field runoff and to increase farmer participation in voluntary efforts to do so. This grant requires a minimum of at least 5 agricultural producers in the same watershed who, with a memorandum of understanding with at least one of a list of collaborators, want to assist agricultural producers in the watershed to conduct soil and water quality improvement efforts.

8.2.7 Sauk County Grants

8.2.7.1 Lake Management Grant Program

The Sauk County Land Resources and Environment (LRE) Department offers grants up to $50,000.00 to eligible applicants including lake districts, associations, or other organization that has been established for the protection of a lake that is located in Sauk County.

Funding can be used to offset costs associated with developing a lake management plan. Applicants are encouraged to integrate the US Environmental Protection Agency's 9 Key Element Plan into a Lake Management Plan, when appropriate. At a minimum, the lake management plan must be consistent with plan standards in ss. NR 191.45(20). Funding can be used to offset costs associated with updating an existing 9 Key Element plan or lake management plan previously approved by DNR. Funding can be used to offset costs associated with implementing lake protection and restoration projects identified in a DNR-approved

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[8] For more information on WI-DNR Surface Water Grants go to: https://dnr.wisconsin.gov/aid/SurfaceWater.html

lake management plan that is less than 5 years old. Funding can be used to implement lake protection and restoration projects that reduce soil erosion, urban or agricultural runoff, or improve wildlife habitat within a lake or contributing watershed.

8.2.7.2 Lakeshore Assistance Program

The Sauk County LRE Department provides cost share assistance to lake shore owners to address erosion and runoff concerns on their property. Cost share funding is limited to 50% of the project cost up to $2,500 per applicant.

Eligible projects will be practices that reduce sediment loads that cause degradation of habitat and water quality of lakes in Sauk County. These projects may include but are not limited to: vegetated buffers, bioengineering with natural fiber products (e.g. natural fiber rolls and logs, blocks, and mats), wave-reducing natural timbers (e.g. log and root wad revetment, fish sticks and tree drops), and rock riprap with bioengineering techniques (e.g. Rock riprap with native plantings, geotextile bags, geogrid lifts, and synthetic engineered matting).

WI-DNR Healthy Lakes and Rivers grants also provide cost-share assistance to lake shore owners to address runoff and habitat improvement concerns on their property. Cost share funding is limited to 75% of the project costs up to $1,000 per project implemented. Eligible projects include native plantings, rain gardens, runoff diversions, infiltration trenches, and fishsticks fisheries habitat. Grants are sponsored by the lake organization on behalf of properties owners.

8.3 Technical Assistance

Technical expertise needed to successfully implement this plan includes the WI-DNR, Juneau and Sauk Counties, the USGS and NRCS, Producers of Lake Redstone, and consultants that specialize in relevant areas including aquatic plant management, water quality, shoreland planning and improvement. These entities have been discussed in previous sections.

It is expected that between Juneau and Sauk Counties, at least one full-time staff position will be needed to support implementation of this Plan. In addition, it is likely that the LRPD will have to hire outside private contractors to support plan implementation. In addition, there are several University of Wisconsin System Programs that could support actions recommended in this plan.

8.3.1 Center for Land Use Education

The Center for Land Use Education (CLUE) is a joint venture of the College of Natural Resources at the UW-Stevens Point and the UW-Madison Division of Extension. It is a focal point for land-use planning and management education. Through applied research, teaching and outreach, CLUE specialists and faculty support students, local government officials, communities and K-12 audiences on a variety of land and water topics including planning and zoning, land divisions, fragmentation, sustainability, bio- and renewable energy, food systems, shorelands and wetlands. By providing up-to-date and comprehensive training on planning and zoning tailored to address specific local needs, CLUE specialists are able to assist towns, villages, cities and counties in making sound land use decisions.

https://erc.cals.wisc.edu/programs/center-for-land-use-education/

8.3.2 Center for Watershed Science and Education

The Center for Watershed Science and Education (CWSE) at UW-Stevens Point supports watershed understanding and stewardship across and beyond the state of Wisconsin. The center includes specialists with expertise in groundwater, lakes, streams, water chemistry and analysis, and data science. The center helps individuals, organizations and private and public water resources professionals understand water quality and quantity in private wells, groundwater, lakes and rivers. Through their programming, center staff provides guidance on sampling and data collection, education on water quantity and quality, and interpretation and evaluation of monitoring results. The center also performs applied research and creates data visualization tools to improve watershed understanding.

Current research explores the movement of nitrate-nitrogen in soil and groundwater, the quantity and chemistry of groundwater, changes in lake water quality and the occurrence of pharmaceuticals and new pesticides in the water.

https://erc.cals.wisc.edu/programs/center-for-watershed-science-and-education/

8.3.3 Center for Limnological Research and Rehabilitation

The Center for Limnological Research and Rehabilitation (CLRR) at UW-STOUT focuses on eutrophication issues and management solutions for freshwater systems. They provide limnological research services to the surrounding community, including: diagnosing eutrophication-related problems in lakes and reservoirs; conducting comprehensive hydrologic and limnological monitoring programs; identifying and quantifying important phosphorus sources that drive cyanobacterial blooms; and developing and implementing management plans to sustainably rehabilitate degraded aquatic systems.

Their laboratory facilities provide an array of analytical capabilities for the examination of nutrients (primarily phosphorus species) and algae in water and sediment. They have a variety of field monitoring equipment for quantifying tributary flow and phosphorus loads discharging into lakes, boats and sampling equipment for monitoring lake chemistry and biology, and coring capabilities for the examination of aquatic sediment. In particular, they have unique expertise for determining important mobile phosphorus fractions in aquatic sediments and nutrient exchanges between sediments and the overlying water.

https://www.uwstout.edu/directory/center-limnological-research-and-rehabilitation

8.3.4 Natural Resources Education Program

NRE Water Programming - Leading and facilitating water quality projects across the state

Natural Resource Educators (NRE) are providing leadership on nutrient reduction and water quality projects across the state. Key efforts include outreach to increase local capacity to reduce nonpoint source pollution in the Lower Fox, Wisconsin, St. Croix, Red Cedar and Rock River watersheds and the Lower Fox River Demo Farm Network initiative. Projects are carried out in collaboration with federal, state and local partners as well as producer-led watershed initiatives. The Demo Farm initiative works with farmers and their advisers to conduct on-farm demonstrations that measure and share the effectiveness of conservation practices to reduce erosion and sediment runoff, control phosphorus runoff and address other nonpoint sources of pollution.

NRE Forestry Programming - Engaging private woodland owners to encourage sustainable forest management.

ERC-based Natural Resources Educators and key partners are leading classes (Learn About Your Land and Your Land, Your Legacy) and other efforts to engage landowners in the sustainable management of Wisconsin's privately-owned forests. NREs create content for landowners on a variety of topics in publication, video, and website formats.

https://erc.cals.wisc.edu/programs/regional-natural-resources-education-program/

8.3.5 Aquatic Invasive Species Outreach

Wisconsin's aquatic invasive species (AIS) program focuses on preventing the introduction of new invasive species to Wisconsin, containing the spread of invasives that are already in the state, and managing established populations when possible. In close cooperation with the Wisconsin Department of Natural

Resources and Extension Lakes program, UW– Madison Division of Extension education efforts focus on working with resource professionals and citizens statewide to teach boaters, anglers and other water users the steps they should take to prevent transporting aquatic invasives to new waters. Efforts also address other potential mechanisms of introduction, including aquarium pet release and water gardening.

https://erc.cals.wisc.edu/programs/aquatic-invasive-species-outreach/

8.3.6 UW-Extension Lakes Program

Based at UW-Stevens Point, the Extension Lakes Program seeks to preserve Wisconsin's legacy of lakes through education, communication and collaboration. The program works with over 800 local lake associations and lake districts in Wisconsin, assisting them through education and capacity building. Lakes also partners with the Wisconsin DNR to coordinate a number of programs and projects to assist those concerned with the future of our lakes, including the Citizen Lake Monitoring Network, the Clean Boats, Clean Waters program and the Lake Leaders Institute. The *Lake Tides* newsletter reaches thousands of readers throughout the region.

https://erc.cals.wisc.edu/programs/extension-lakes-program/

8.3.7 Ecological Restoration

There are many "Resource Professionals" that specialize in the restoration of native prairie, streambank, forest, wetland, and other natural areas in Wisconsin. The WI-DNR maintains of list of companies that do these types of work across the state.[9]

More on the project guiding authorities, individual cost estimates for actions in this plan, and the amount of technical assistance needed can be found in Appendix I.

[9] For more information about Resource Professionals specializing in various types of ecological restoration go to https://dnr.wi.gov/files/pdf/pubs/er/er0698.pdf. This list, put out by the WI-DNR, was last updated in January 2021.

9.0 Monitoring (Key Element 9)

Watershed restorations and adoption of agricultural best management practices for conservation purposes has become commonplace in recent decades (WI-DNR, 2020), and is the main avenue for attempting to make positive changes in Lake Redstone. However, for many projects like this, success in determining whether or not the practices actually have the desired effect has been mixed, partially due to inadequate monitoring and lack of appropriate experimental designs to evaluate the restorations. A typical watershed restoration project will include implementation of practices at multiple locations to reduce excess soil and nutrient runoff to a local or downstream waterbody, as in Lake Redstone. It is however, often difficult to document water quality improvements through standard monitoring procedures in only a 1-2 years within a HUC 12 size watershed. Monitoring three or more years in specific areas of the watershed where BMPs are adopted may be necessary to measure changes in stream water quality with confidence. Special thought should be given to a monitoring program to make sure it will help answer questions and to temper expectations of what monitoring can demonstrate.

The following defines the level of monitoring included in this plan. Monitoring recommendations are made for each area of concern – the watershed, the riparian area, and the lake itself. In addition a Monitoring Matrix is included as Appendix H.

9.1 Watershed and Riparian Area

For monitoring purposes, the watershed and riparian area are being combined as many monitoring recommendations made in this plan pertain to both.

9.1.1 Monitoring Land Use Changes

As human and natural forces modify the landscape, resource agencies find it increasingly important to monitor and assess these alterations. For the Lake Redstone project, changes in land use and land cover (LULC) in the watershed are most interesting as they have a direct impact on the water quality in local streams and the lake. This management plan focuses primarily on changing land uses through the implementation of BMPs designed to reduce surface water runoff. LULC changes are very dynamic in nature and have to be monitored at regular intervals for sustainable environment development.

There are several common methods for monitoring changes in LULC. On a nation-wide scale, the National Land Cover Database (NLCD) from the USGS is used to identify basic categories of land cover from agriculture to forests to urban. Initial land cover designations for the Lake Redstone watershed were derived from the 2016 NLCD. This database is satellite-based and updated every five years. Another tool that is updated annually is the USDA cropland data layer (https://nassgeodata.gmu.edu/CropScape/). This may be used to monitor changes in land use in the Lake Redstone watershed. The NLCD does not identify more specific LULC like no-till planting and residual cover, pasture verses forage crops, etc. in smaller, more local areas like the different sub-basins included in the Lake Redstone watershed.

Recently, remote sensing satellite imagery has been used as a tool for identifying changes in LULC. Small changes in the spectral response in these images related to tone, texture, shape, size, and pattern can be interpreted and associated with different land uses, and even down to the amount of crop residue that is present on a particular field (USGS).

Both Juneau and Sauk Counties have completed "boots-on-the-ground" surveys of points in the watershed with the intent to gather information on tillage and crop residue management systems. Referred to as "cropland roadside transect surveys", the purpose of these surveys is three-fold: (1) to provide information that can be used in establishing priorities for educational or other programs, (2) to evaluate progress achieved in reaching local, county, or statewide goals, and (3) to provide accurate data on the adoption of conservation tillage systems by crop for other national databases (Purdue Univesity, 2002).

While these surveys provide a high degree of confidence in the accuracy of the results, they are labor intensive and time consuming, often involving multiple staff and days to complete, so often are not implemented on an annual basis. Case in point, Juneau County has not completed a boots-on-the-ground transect survey in the last five years. Sauk County still completes an annual survey, but has limited points in the watershed of Lake Redstone (Figure 41). With this project, a survey route and points will be established within the entire watershed of Lake Redstone. County personnel will train LRPD volunteers how to complete the survey, which will then be done at least annually during the timeframe of this project. Alternatively, it may be possible to have the Producers of the Lake Redstone Watershed take the lead on completing these transects annually. This data, when combined with other land use data, can be used to track the BMPs put in place each year, to compare changes in implementation of BMPs, track overall changes in LULC, and be used as an indicator of the success of this management plan.

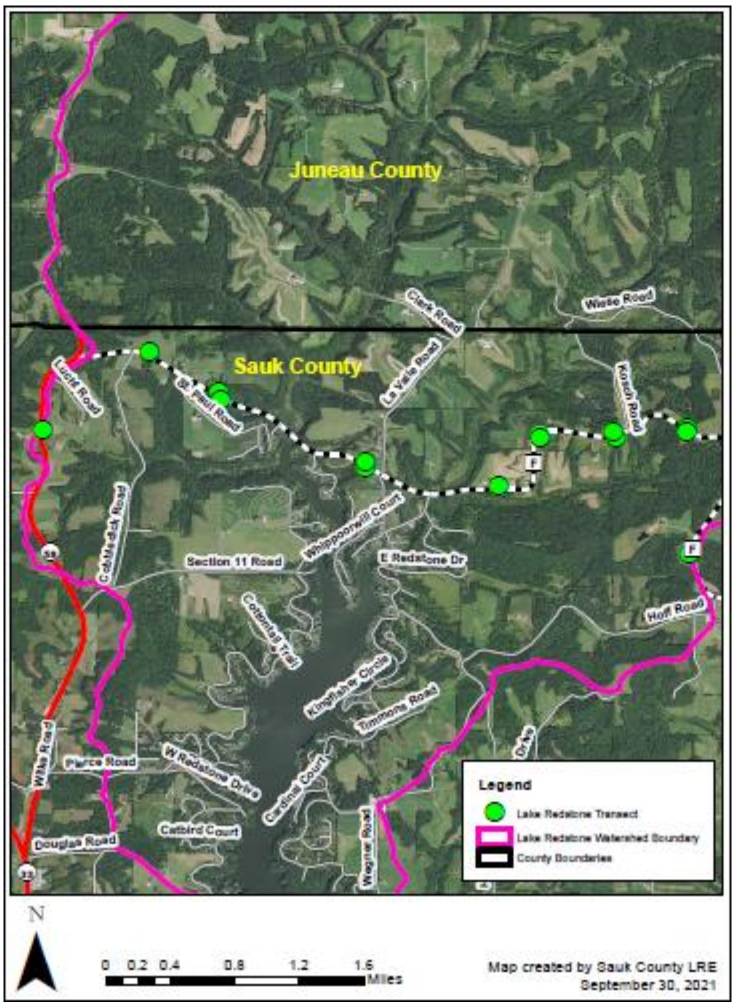

Figure 41: Lake Redstone Transect Survey Points – Sauk County

9.1.2 Monitoring Water Quality

The water quality parameters of most concern in the watershed and riparian area are sediment and total phosphorus. Of slightly less concern are nitrogen parameters including ammonia (NH_3), nitrates (NO_3^-), and nitrites (NO_2^-) and total kjeldahl nitrogen (TKN). The most commonly measured parameter for sediment is total suspended solids (TSS). TSS are particles larger than 2 microns found in the water, anything smaller than 2 microns (average filter size) is considered a dissolved solid (Figure 42). Most suspended solids are made up of inorganic materials, though bacteria and algae can also contribute to the total solids concentration. These solids include anything drifting or floating in the water, from sediment, silt, and sand to plankton and algae. Most of these parameters are measured in water samples analyzed by a lab.

Another measurement of sediment is settle-able solids or how much settles out of runoff once it enters a place where continuous flow no longer keeps it moving or suspended. Settle-able solids can be measured by collecting samples of runoff from gullies, ravines, streams, and washes entering a lake or other waterbody and then using Imhoff cones in a lab or home setting to quantify the amount (Figure 42). Measurements are un-complicated, only requiring a reading of how much material settles out after a set amount of time. The data collected might be indicative of the worst areas of runoff to focus on and help to determine a sediment budget for the lake.

Both total suspended solids and settle-able solids can impact a lake, so both measurements are recommended at least when monitoring the smaller, individual intermittent inlets to the lake.

In each of the following areas, one or more of the parameters just discussed will be monitored. Greater detail is also provided for when and where monitoring should take place.

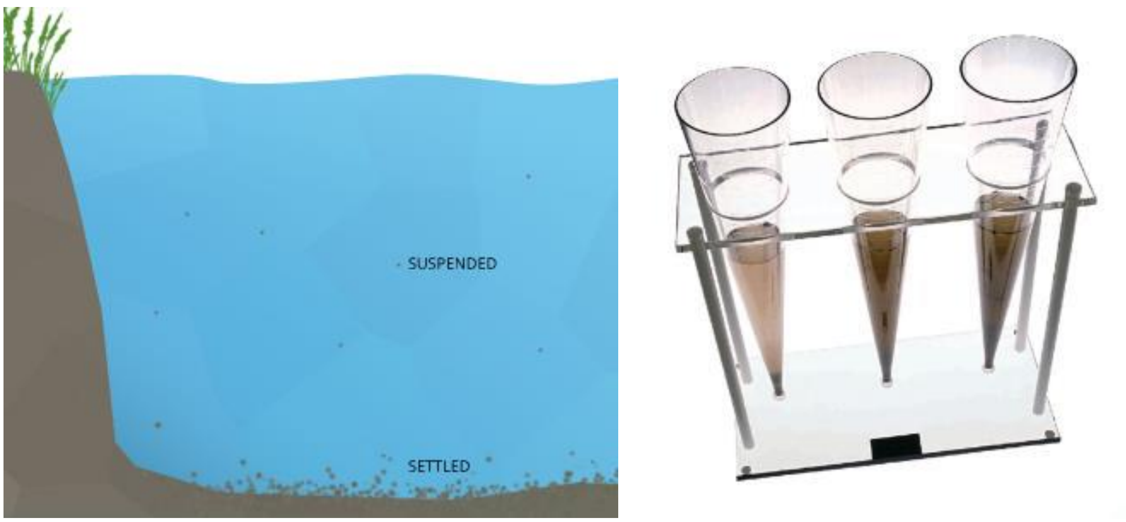

Figure 42: Settled versus suspended solids in a lake (Fondriest Environmental, Inc, 2014); Imhoff cones for measuring settle-able solids (Wards Science, 2021)

9.1.2.1 Tributary Monitoring

The following plan for monitoring is based on guidelines in the WI-DNR document *Guidelines for Monitoring for Watershed Restoration Effectiveness* (WI-DNR, 2020). Because this project is expected to show restoration results over a long period of time, an observational, continuous monitoring plan will be incorporated in an attempt to detect subtle changes over time. In this kind of study, a smaller number of stream sites are monitored before, during, and after a period when BMPs are implemented. How many BMPs will be implemented, what BMPs will be implemented, and where they are implemented is likely unknown before the monitoring begins (WI-DNR, 2020).

The two main inlets to Lake Redstone, the east branch of Big Creek at LaValle Road and the west branch of Big Creek at Clark Road, were sampled in 2006-07, 2011, and 2018-2020. These locations are the last road crossings over the creeks before they entered Lake Redstone. The sampling sites correspond to the Clark Road and LaValle Road sub-basins. Due to issues with earlier attempts to sample discharge, automated sampling systems were set up in 2020 with support from the USGS, Juneau and Sauk Counties, and LRPD volunteers. These systems are designed to collect discharge data regardless of the size of a storm event, and to collect water samples that can be analyzed for TSS, TP, and other parameters. Automated sampling at these two sites is expected to continue for at least 2-3 more years, longer if funding can be obtained to keep the stations operating. These two sites will provide continuous monitoring for much of this project implementation. Companion outlet monitoring is also being completed and will continue until funding runs out.

Stream monitoring at the outlets of three sub-basins that drain into the west branch of Big Creek (Daugs Road, Lucht Road, and Pfaff Road sub-basins) was completed in 2018 and 2019 by a combination of LRPD volunteers and County staff. Multiple parameters were collected (see Section 2.3.2). Discharge was also collected but difficulties in sampling and short-comings in the equipment used may necessitate changes in how this data is collected in the future. These three sites will be sampled again for three years starting in 2023, then again for three years starting in 2028 collecting similar parameters. At least one additional site, Nemitz Road on the East Branch of Big Creek about midway from the outlet to its headwaters (sampled in 2011), could be added if it is determined that it would be relevant to BMPs implemented through this project.

Tributary sampling would follow WI-DNR WisCALM guidelines where samples are collected once a month from May to October. Parameters to be analyzed include but are not limited to TSS and TP.

9.1.2.2 Gullies, Ravines, and Washes

Once a new SPI study (Section 3.3.2.3) has been completed it is expected that a number of gullies/ravines/washes will be identified across the watershed, including in the Lower Lake Redstone sub-basin which also represents what is considered the riparian area of concern. While addressing ways to reduce runoff from these areas in the larger watershed is important, it is likely more important to address those that empty directly into Lake Redstone.

An unnamed tributary feeding into Martin-Meadowlark Bay was sampled in 2020 and a similar site upstream of Swallow Bay was sampled in 2006, 2007, and 2020. Data from these sampling events represent early attempts to monitor nutrient and sediment loading directly into Lake Redstone from gullies and washes. There are several other sites with intermittent gully flow into the lake including Chickadee North and South, Eagle, Heron, and Fox Court bays. Collecting water samples for analysis of sediment (suspended and settle-able) and phosphorus concentration, along with some attempt to quantify flow and discharge will help identify the severity of the problem in identified areas. Once that is done, and potential BMPs are identified and implemented, additional monitoring will be done at these sites to see if changes occur. That monitoring will involve similar parameters and procedures used in watershed tributary monitoring.

9.1.3 Streambank Erosion

In both the watershed and riparian area, once areas with potential erosion issues have been identified (based on the SPI and boots-on-the-ground surveys), the amount of physical erosion (lateral recession rate) can be tracked by using erosion pins. Erosion pins are metal rods that are inserted into the bank perpendicular to the flat surface of the streambed and either flush with the soil surface or with a measured section of the pin sticking out when installed. Figure 43 shows a follow up inspection that indicates 8” of soil has eroded from the bank since installing it flush. An initial survey of the streambank of selected sites should also be conducted to serve as benchmark. A minimum of 3 sites should be surveyed in each sub-watershed. Pins should be measured at least 3 times a year and after significant storm events to determine trends in erosion. There are several references for the proper installation and data interpretation when using erosion pins (Kearny, Fonte, Garcia, & Smukler, 2018) (Rathbun, 2009). Appropriate installation practices will be followed.

Long-term tracking of streambank erosion rates will help refine phosphorus and sediment loss estimates from streambank erosion and help to determine if source control practices implemented in the headwaters of the watershed are having an impact on streambank erosion rates downstream. Drone and aerial imagery may also be used as a tool to assess bank erosion rates over this plan’s 10-yr implementation period. A sustained decrease in observed lateral recession rate over a specified time period will demonstrate plan progress. If lateral recession rates are observed to be increasing or remaining the same after several years of implementation, it may indicate that the BMPs implemented in the watershed may need to be reevaluated for effectiveness. However, annual weather conditions will need to be taken into account as extreme storm events will likely impact the observations.

Figure 43: Erosion pin inserted into a streambank showing 8" of soil eroded after inspection in Kankapot Creek, Calumet County, Wisconsin.

9.2 Lake Redstone

There are currently two state-sponsored surface water monitoring programs going on in Lake Redstone. The first is through the Citizen Lake Monitoring Network (CLMN) sponsored by the WI-DNR and UW-Extension Lakes. As a part of this program, volunteers collect water quality data including Secchi disk readings of water clarity, total phosphorus, chlorophyll-*a*, and temperature and dissolved oxygen profiles. Regular Level volunteers collect Secchi data 2-3 times a month during the open water season and comment on other parameters including water color, lake level, ice-on and ice-out dates, and general perception of the lake for usability. Expanded Level volunteers add to this, collection of water samples to analyze total phosphorus and chlorophyll-*a*, collect temperature profiles, and in some cases collect dissolved oxygen profiles at least four times during the open water season.[10] Data presented in Section 3.3.1 is from Lake Redstone CLMN expanded monitoring at four different sites in the lake – Deep Hole, and the Lower, Middle and Upper Sites (Figure 44) since about the year 2000.

In addition, the Deep Hole site is part of the WI-DNR Long-Term Trend (LTT) lake monitoring program. In this program, water quality monitoring is conducted by the state every year on 62 lakes statewide to monitor trends over time. Water quality parameters collected on LTT lakes include total phosphorus and Secchi depth during spring overturn and collection of additional parameters 3 times during a summer index period (15 July - 15 September). These parameters include components of the Trophic Status Index or TSI (total phosphorus, Secchi disk, and chlorophyll-*a*), and field profiles for dissolved oxygen, temperature, and conductance. This should be done once every 2 to 3 weeks. Other water quality parameters collected once

[10] For more information about the Citizen Lake Monitoring Network go to: https://www.uwsp.edu/cnr-ap/UWEXLakes/Pages/programs/clmn/default.aspx or https://dnr.wisconsin.gov/topic/lakes/clmn

each summer include pH, conductivity, alkalinity, color, nitrate/nitrite, and total Kjeldahl-N. Calcium and magnesium are sampled once every 5 years.

Additional water quality data, beyond what is collected through the CLMN and LTT programs has been collected and paid for by the LRPD, mainly in an attempt to have as complete a water quality dataset as possible. That said analysis of available data completed by the WI-DNR (Oldenburg, 2021) determined that there were not significant differences in the data from each of the four sites as compared to all of the sites. It did show that data from two of the sites were different. As such, future in-lake monitoring is recommended at only two of the four sites. With only half the sites, it is possible for the LRPD to collect more data from the two sites at the same or less cost than it was to sample all four sites. Future monitoring will be completed at the Deep Hole and Middle sites, and should be sufficient to capture longitudinal changes in TP that occur in the reservoir due to management implementation.

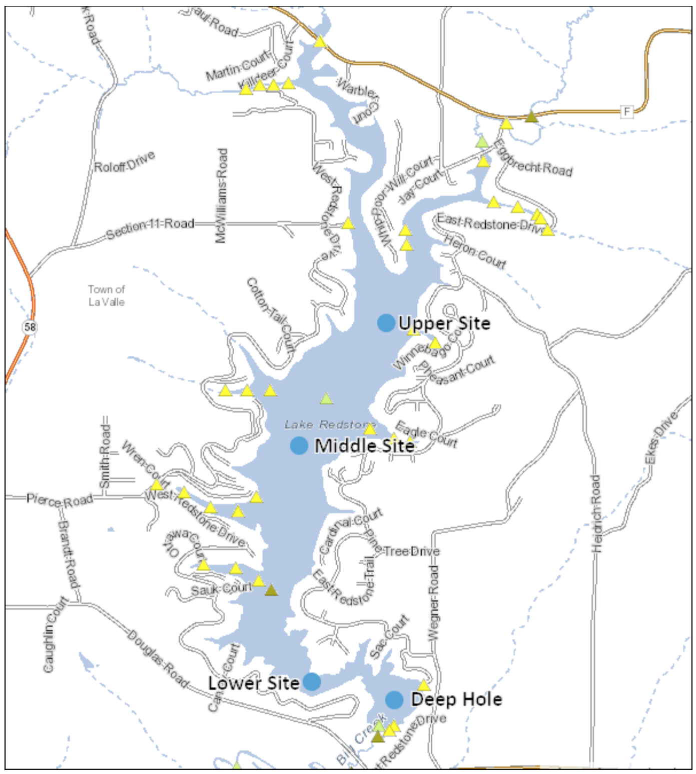

Figure 44: Citizen Lake Monitoring Network water quality monitoring sites

9.2.1 Surface Water Monitoring

The water quality parameters of most concern in Lake Redstone are sediment (both suspended and settle-able), TP, dissolved phosphorus, Chl-a, water clarity, temperature and dissolved oxygen. Of slightly less concern are nitrogen parameters including ammonia (NH3), nitrates (NO3-), and nitrites (NO2-) and total kjeldahl nitrogen (TKN). Additional parameters of value are conductivity and pH.

TP, Chl-*a*, and water clarity as measured by the Secchi disk remain the most important parameters to monitor in Lake Redstone as they are the basis for all long-term trend analysis to date, and will be used to determine success or failure in the implementation of this plan.

More frequent collection/documentation of temperature and dissolved oxygen profiles in Lake Redstone will be important to understanding current and changing conditions in the lake. More frequent profiling will help determine when and for how long the lake stratifies with waters in the hypolimnion (bottom waters) becoming anoxic (devoid of oxygen). More frequent sampling for TP in the hypolimnion over several years will also help estimate the contribution of internal loading to the enrichment of the lake.

Specific conductance or conductivity is a commonly measured water quality parameter. In addition to being the basis of most salinity and total dissolved solids calculations, conductivity is an early indicator of change in a water system. Most bodies of water maintain a fairly constant conductivity that can be used as a baseline for comparison to future measurements. Significant change, whether it is due to natural flooding, evaporation, or man-made pollution can be very detrimental to water quality (Fondriest Environmental, Inc, 2014).

A measurement of how acidic or basic water is, is called pH. It ranges from 0 (acidic) to 14 (basic), with 7 being neutral. The pH of water determines the solubility (amount that can be dissolved in the water) and biological availability (amount that can be utilized by aquatic life) of chemical constituents such as nutrients (phosphorus, nitrogen, and carbon) and heavy metals (lead, copper, cadmium, etc.). It directly impacts how much and what form of phosphorus is most abundant in the water and determines whether or not aquatic life can use it.

Both conductivity and pH can be measured by field equipment or in water samples analyzed by a lab.

9.2.2 Recommended Lake Monitoring

Participation in the two existing surface water monitoring programs already active (CLMN and LTT) is highly recommended, however, it is likely only necessary at the Deep Hole and Middle sites in the lake. Secchi disk readings of water clarity should be collected at least two to three times per month but no more than once a week during the open water season from ice out to ice in, with particular focus put on the summer months between July and September. As a guide, Secchi disk readings could be taken approximately every 10 days following remote sensing satellite dates each year. TP sampling is completed approximately 2 weeks after ice out and then once a month June-August. Chlorophyll-*a* samples are collected once a month June – August.

Additional water sampling described below should be added in accordance with WisCALM guidelines. WisCALM guidelines for TP sampling frequency and seasonal range for stratified lakes include: one sample per month between May and mid-September with samples collected near the middle of the month and at least 15 days apart; with only surface samples taken from the top 2 meters of the lake. For chlorophyll-*a*, water samples should be collected once each in the months of July, August, and September with only surface samples taken from the top 2 meters of the lake. For Lake Redstone, this means adding both TP and chlorophyll-*a* sampling to the month of September, in addition to what is done via the CLMN program.

Long-Term Trend monitoring by the WI-DNR should continue at the Deep Hole site.

Because there is interest in learning more about how much internal loading contributes to the phosphorus load in Lake Redstone, it is recommended that water column sampling for TP (and perhaps orthophosphates) be completed up to two times per month from July through September or October for a period of at least 2 years, and maybe 3 at both the Deep Hole and Middle sites. Collecting temperature and dissolved oxygen profiles more frequently (at least once a week) during the same time period would better help quantify when the hypolimnion of the lake presents anoxic conditions and for how long. Coupled with a sediment release study at the same two sites, the role of internal loading could be much more clearly defined.

9.2.3 Aquatic Plant and Aquatic Invasive Species (AIS) Monitoring

Although aquatic plant and AIS monitoring will be covered in an update of the existing Aquatic Plant Management Plan for Lake Redstone, a brief description of both is included here. Under an active plant management scenario, documentation of changes in the aquatic plant community is usually accomplished through whole-lake, point-intercept (PI), aquatic plant survey work to be completed every five years. In between, aquatic plant monitoring will likely include pre- and post-treatment PI survey work possibly on an annual basis, and some level of late season AIS reconnaissance or bed-mapping survey work. AIS monitoring will also be completed during the entire open water season following CLMN AIS Monitoring Guidelines.[11]

For more information on the monitoring components of this plan and the estimated costs associated, refer to Appendix I.

[11] For more information about the CLMN AIS Monitoring Program go to: https://www.uwsp.edu/cnr-ap/UWEXLakes/Pages/programs/clmn/AIS.aspx

10.0 Tracking, Assessment, and Depreciation (Key Element 8)

Tracking and assessment is a critical component to meeting interim and long term goals of this plan. Plan progress and success will be assessed by tracking the implementation of conservation practices, information and education activities, and water quality monitoring. Beyond implementation, ensuring that the expected value of implementation is reached and/or maintained will be accomplished by following recommendations made by the EPA to identify causes of and then minimize depreciation of the BMPs implemented.

For more information on these actions and the estimated costs associated, refer to Appendix I.

10.1 Tracking Conservation Best Management Practices

Annual updates related to the implementation of conservation practices and their corresponding pollutant load reductions in the three areas of concern will be completed and may include but are not limited to the following:

- Number or extent of conservation practices implemented
- Modeled or measured pollutant load reductions from completed BMPs
    - STEPL, In-lake Modeling (WiLMS, Bathtub), Producer Led Reports, Sediment modeling (as developed), etc.
- Number of NR 151 implementation compliance checks and plan reviews performed.
- Costs associated with implementation of conservation practices.
    - Cost share funding under contract and spent;
    - Expenditures by landowners and/or partners;
    - Staff time (salary + fringe) and expenses allocated to project within the watershed;
    - Estimate of future expense needs.

10.1.1 BMP Depreciation

The causes and sources of water resource impairment have been assessed in this watershed plan. Existing and new BMPs to address the identified problems, the best locations for these BMPs, and the pollutant load reductions likely to be achieved by implementing these BMPs have been determined. Whether or not these BMPs will actually do what they are supposed to for the expected amount of time depends on accurate information on their performance levels.

All too often, watershed managers and agency staff have assumed that, once certified as installed or adopted according to specifications, a BMP continues to perform its pollutant reduction function at the same efficiency (percent pollutant reduction) throughout its design or contract life, sometimes longer. An important corollary to this assumption is that BMPs already in place during project planning are performing as originally intended. Experience in NPS watershed projects across the nation, however, shows that, without diligent operation and maintenance, BMPs and their effects probably will depreciate over time, resulting in less efficient pollution reduction – BMP Depreciation. Recognition of this fact is important at the project planning phase, for both existing and planned BMPs.

BMPs credited during the planning and implementation phases of a watershed project will be expected to achieve specific load reductions or other water quality benefits as part of the overall plan to protect or restore a water body. Verification that BMPs are still performing their functions at anticipated levels is essential to keeping a project on track through implementation to achieve its overall goals.

Once verified, through adaptive management, verification results can be used to inform decisions about needs for additional BMPs or maintenance or repair of existing BMPs. In a watershed project that includes short-term (3–5 years) monitoring, subtle changes in BMP performance level might not be detectable or critical, but planning must account for catastrophic failures, BMP removal or discontinuation, and major maintenance shortcomings. Over the longer term, however, gradual changes in BMP performance level can be significant in terms of BMP-specific pollutant control or the role of single BMPs within a BMP system or train.

The methods outlined in the US EPA technical memo (Meals & Dressing, 2015), "Adjusting for Depreciation of Land Treatment When Planning Watershed Projects" will be used when evaluating BMP effectiveness and identifying factors that may affect BMP performance levels and implementation.[12]

10.2 Tracking Information and Education Efforts

Annual updates related to efforts made related to education and outreach may include but are not limited to the following:

- Number of one-on-one contacts made with operators, landowners, and riparian property owners in the watershed.
- Number of information pieces create and updated annually.
- Number of communication pieces distributed, including handouts, mailing, emails sent, and social media metrics.
- Number of educational events held or advertised, including number of attendees.
- Assessment of current education program and future educational needs.

10.3 Future Conservation Practices and Technologies

As part of the annual update process, progress towards finding and implementing new or changing solutions to issues across the three areas of concern will be reported as follows:

- Proposed and ongoing research projects and grant opportunities.
- Final reports of data gathering efforts in each of the areas of concern.
- Review of innovative practices and improvements in pollutant load reductions advancing in other watersheds.
- Updating the Lake Redstone 9-Key Plan to incorporate emerging practices into the implementation strategy and model pollutant load reductions.

10.4 Water Quality Improvements in Lake Redstone

The purpose of this entire document is to make improvements in water quality in Lake Redstone. Several monitoring components are built into this plan to track changes or the lack of changes in water quality. Assessments of this data will occur annually and be presented in summary reports shared with all involved stakeholders.

Consultation with the WI-DNR Biologists will be critical when evaluating water quality monitoring results. Water quality changes may not occur immediately following implementation of BMPs. Several factors may contribute to shortfalls in meeting water quality goals, and should be evaluated along with water quality monitoring to determine reasons for shortfalls. Remodeling is already included in this plan in order to incorporate additional factors and new information. Some factors that perhaps are not entirely within the control of anyone involved in the implementation of this plan include but are not limited to:

- Changes in operator and/or management resulting in a reversal of phosphorus loading reductions that were gained.

[12] For more information go to:
https://www.epa.gov/sites/default/files/2015-10/documents/tech_memo_1_oct15.pdf

- Changes in growing season, soil conditions and water quality resulting from changes in climate, weather patterns, and precipitation events.
- Frequency and timing of monitoring.
- Legacy phosphorus in sediment (i.e. cropland, shoreland buffers, wetlands and benthic).
- Modeling estimates that exceed realistic reductions.

In general, measuring the success of actions implemented in this plan will require:

- Patience and a long-term outlook (make incremental progress over time).
- Focusing existing resources where it is determined they are needed most.
- Increased adoption/compliance with existing standards and programs.
- Coordination between agricultural producers, riparian owners, lake users, and county, state and local stakeholders for a long period of time.
- Setting interim reduction goals with realistic times frames.
- Keeping up with the changes that occur to accurately represent their impacts.

10.5 Grants and Other Funding Sources

Throughout the implementation of this 10-yr Plan various state grant and other funds will be utilized. One important measure of the success of this project will be how well the LRPD and its partners meet the requirements for these funding sources, complete funded projects, and receive reimbursements. The progress reports, study reports, and other documents generated during the implementation of this plan will also support funding mechanisms.

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Lake Redstone, Sauk County
2022-32 9-Key Element Watershed and Lake Management Plan
Appendices
January 2022

Appendix A:“9 Key Elements” for Watershed-Based Plans EPA Nonpoint Source (Section 319) Program

1. An identification of the **causes and sources** or groups of similar sources that will need to be controlled to achieve the load reductions estimated in the watershed-based plan (and to achieve any other watershed goals identified in the watershed-based plan), as discussed in item (2) immediately below. Sources that need to be controlled should be identified at the significant subcategory level with estimates of the extent to which they are present in the watershed (e.g., X number of dairy cattle feedlots needing upgrading, including a rough estimate of the number of cattle per facility; Y acres of row crops needing improved nutrient management or sediment control; or Z linear miles of eroded streambank needing remediation).

2. An estimate of the **load reductions expected for the management measures** described under paragraph (3) below (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time). Estimates should be provided at the same level as in item (1) above (e.g., the total load reduction expected for dairy cattle feedlots; row crops; or eroded streambanks).

3. A description of the **NPS management measures** that will need to be implemented to achieve the load reductions estimated under paragraph (2) above (as well as to achieve other watershed goals identified in the watershed-based plan), and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement the plan.

4. An estimate of the amounts of **technical and financial assistance** needed, associated **costs**, and/or the sources and **authorities** that will be relied upon, to implement the plan.

5. An **information/education** component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.

6. A **schedule** for implementing the NPS management measures identified in the plan that is reasonably expeditious.

7. A description of interim, **measurable milestones** for determining whether NPS management measures or other control actions are being implemented.

8. A set of **criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards** and, if not, the criteria for determining whether the plan needs to be revised or, if a NPS TMDL has been established, whether the NPS TMDL needs to be revised.

9. A **monitoring** component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (8) immediately above.

Appendix B
Strategic Lake Management Planning Review

Lake Redstone

Sauk County, Wisconsin

WBIC. 1280400
DNR No. SPL-362-16

November 13, 2017

SPL-362-16 Final Report

Strategic Lake Management Planning Review
Lake Redstone
Sauk County, Wisconsin

Prepared for:
Lake Redstone Protection District
La Valle, WI 53941

Prepared by:

Dave Blumer - Lake Educator

Lake Education and Planning Services, LLC
302 21-1/4 Street
Chetek, WI 54728
715-642-0635

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Introduction

Every two years, the Wisconsin Department of Natural Resources (WDNR) is required by the Environmental Protection Agency (EPA) through the Clean Water Act to create a list of impaired waters in the state. The EPA further requires that a TMDL eventually be prepared for waters on the list. TMDL means Total Maximum Daily Load and is a document that calculates the maximum amount of a given pollutant that can occur in a waterbody before there is a potential for negative consequences. It also allocates reductions to given pollutant sources that are necessary to either maintain or restore the waterbody. Some of the most common pollutants are total phosphorus and chlorophyll. Phosphorus is an essential nutrient of plant, animal and human. In water, it exists primarily as orthophosphate (PO_4^{3-}) or in organic compounds. Total phosphorus (TP) defines the sum of all phosphorus compounds that occur in various forms. Chlorophyll is the green pigment in most aquatic plants including algae in the water. As such it is used as a measurement of the amount of algae in the water. A TMDL serves as a planning tool and potential starting point for restoration or protection activities with the ultimate goal of attaining or maintaining water quality standards set for a given body of water like Lake Redstone.

Lake Redstone is a 612 acre reservoir created in the mid 1960's when a 38-foot high earthen dike was installed across Big Creek in northwestern Sauk County with the intent of creating >1500 lots for development. The lake reached full pool in 1966 and water quality issues including algae blooms, low dissolved oxygen, and sedimentation, emerged almost immediately. The lake reflects the extensive agricultural watershed it drains (>19,000 acres) with heavy, late summer algal blooms. Aquatic vegetation in the lake is sparse due to poor light penetration and few shallow areas and Eurasian water milfoil is found in the lake. Organic decomposition depletes the oxygen below 12 feet during the summer. Because of these conditions, Lake Redstone was placed on the Wisconsin "impaired waters" list in 2014.

An impaired water is a waterbody that does not meet water quality criteria that support its designated use. A designated use is a legally recognized description set by a regulatory entity like the WDNR, of a desired use for a given waterbody such as aquatic life support, body contact recreation, fish consumption, or public drinking water supply. It is these designated uses that help determine water quality expectations and/or water quality goals. Lake Redstone, as a deep lowland drainage lake, was officially listed in 2014 for total phosphorus concentrations that exceeded designated thresholds for recreational use (≥30 µg/L) for at least 3 monthly values between June 1 and September 15 from data collected within the last five years. Total phosphorus values did not exceed thresholds for fish and aquatic life (≥30 µg/L). Further assessments in 2016 showed total phosphorus data continued to exceed thresholds for recreational use and in addition, chlorophyll data exceeded thresholds for both recreational (> 5% of days in sampling season have "nuisance algal blooms" (> 20 µg/L)) and fish and aquatic life (≥27 µg/L (≥63 TSI)). High levels of algae prompted a "high" priority ranking by the WDNR and recommended the development of a TMDL within 10 years.

Purpose

The purpose of this project is to begin the process of developing a Comprehensive Lake Management Plan to address water quality in Lake Redstone. While not exactly a TMDL, a Comprehensive Lake Management Plan addresses as many of the sources of lake degradation as possible including nutrient loading (natural and human derived sources), non-native invasive species, land use near the lake and within the larger watershed, aquatic plants and algae, and lake use. Addressing water quality in a lake essentially means addressing the entire watershed of the lake, so a comprehensive plan equates to a watershed plan. A watershed is an area of land that drains all the streams and rainfall to a common outlet such as the outflow of a reservoir, mouth of a bay, or any point along a stream channel. The word watershed is sometimes used interchangeably with drainage basin, basin, or catchment. The watershed consists of surface water--lakes, streams, reservoirs, and wetlands--and all the underlying ground water. Larger watersheds contain many smaller watersheds. It all depends on the outflow point; all of the land that drains water to a given outflow point is the watershed for that outflow location. Watersheds are important because the water quality within that watershed is affected by things, human-induced or not, happening in the land area "above" the identified outflow point (U.S. Geological Survey, 2016).

Watershed plans are a means to resolve and prevent water quality problems that result from both point source and nonpoint source problems. Point source pollution means any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged (EPA Clean Water Act Section 502 General Definitions). Nonpoint source (NPS) pollution, also known as polluted runoff, is a leading cause of water quality problems in Wisconsin. Polluted runoff is caused by rainfall or snowmelt moving over and through the ground picking up natural and human–made pollutants, depositing them into rivers, lakes, wetlands and groundwater. Pollutants include fertilizers, nutrients (like phosphorus and nitrogen), oil, grease, sediment and bacteria from agricultural, urban and residential areas (Wisconsin Department of Natural Resources, 2014). Watershed plans are intended to provide an analytic framework to restore water quality in impaired waters, and to protect water quality in other waters adversely affected or threatened by point source and nonpoint source pollution (United States Environmental Protection Agency, 2008).

Due to the complex and diffuse nature of nonpoint source pollution, the substantial costs to address it, and frequent reliance on voluntary action by individual landowners, successfully addressing nonpoint source pollution to achieve water quality standards often requires years of support from a coalition of stakeholders, programs, and funding sources. Watershed planning helps address water quality problems in a holistic manner by fully assessing the potential contributing causes and sources of pollution, then prioritizing restoration and protection strategies to address these problems.

Watershed Planning and Implementation: 9-Key Elements Plan

In 2008, the EPA published a guide for developing watershed plans (United States Environmental Protection Agency, 2008). The process outlined in this document is fully supported by the WDNR. There are six steps for watershed planning and implementation included in this document (Figure 1). Each step has several tasks associated with it. Within the six steps and their associated tasks are nine key elements that are critical for achieving improvements in water quality. These 9-Key Elements are required in watershed plans that are federally funded with Clean Water Act Section 319 funds, but also strongly recommended for all other plans to address water quality impairments.

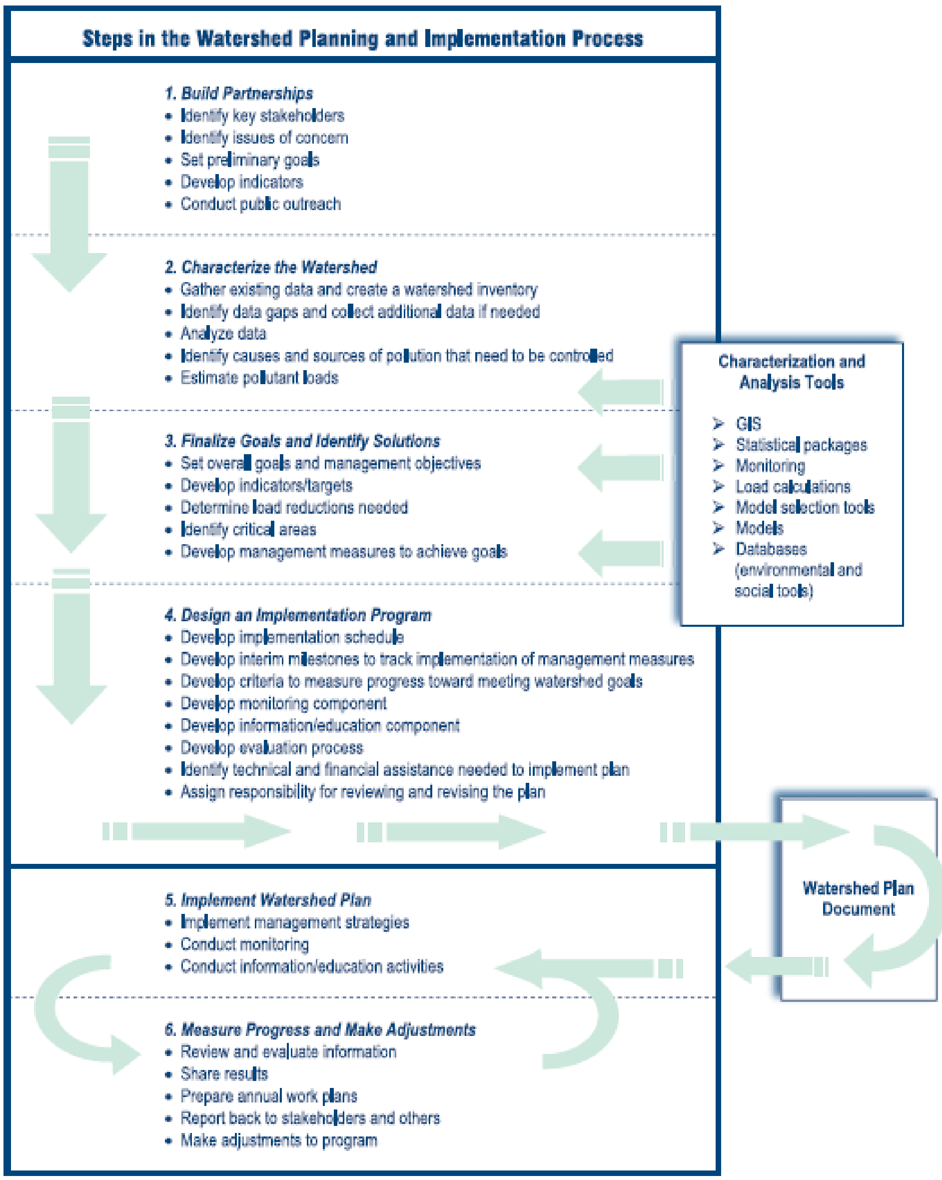


Figure 1 – Steps in Watershed Planning and Implementation (United States Environmental Protection Agency, 2008)

More specifically, the 9 Key Elements are as follows:

a. Identify causes and sources of pollution
b. Estimate pollutant loading into the watershed and the expected load reductions
c. Describe management measures that will achieve load reductions and targeted critical areas
d. Estimate amounts of technical and financial assistance and the relevant authorities needed to implement the plan
e. Develop an information/education component
f. Develop a project schedule
g. Describe the interim, measurable milestones
h. Identify indicators to measure progress
i. Develop a monitoring component

These nine elements are embodied within the six steps of the watershed planning and implementation process (Figure 2).

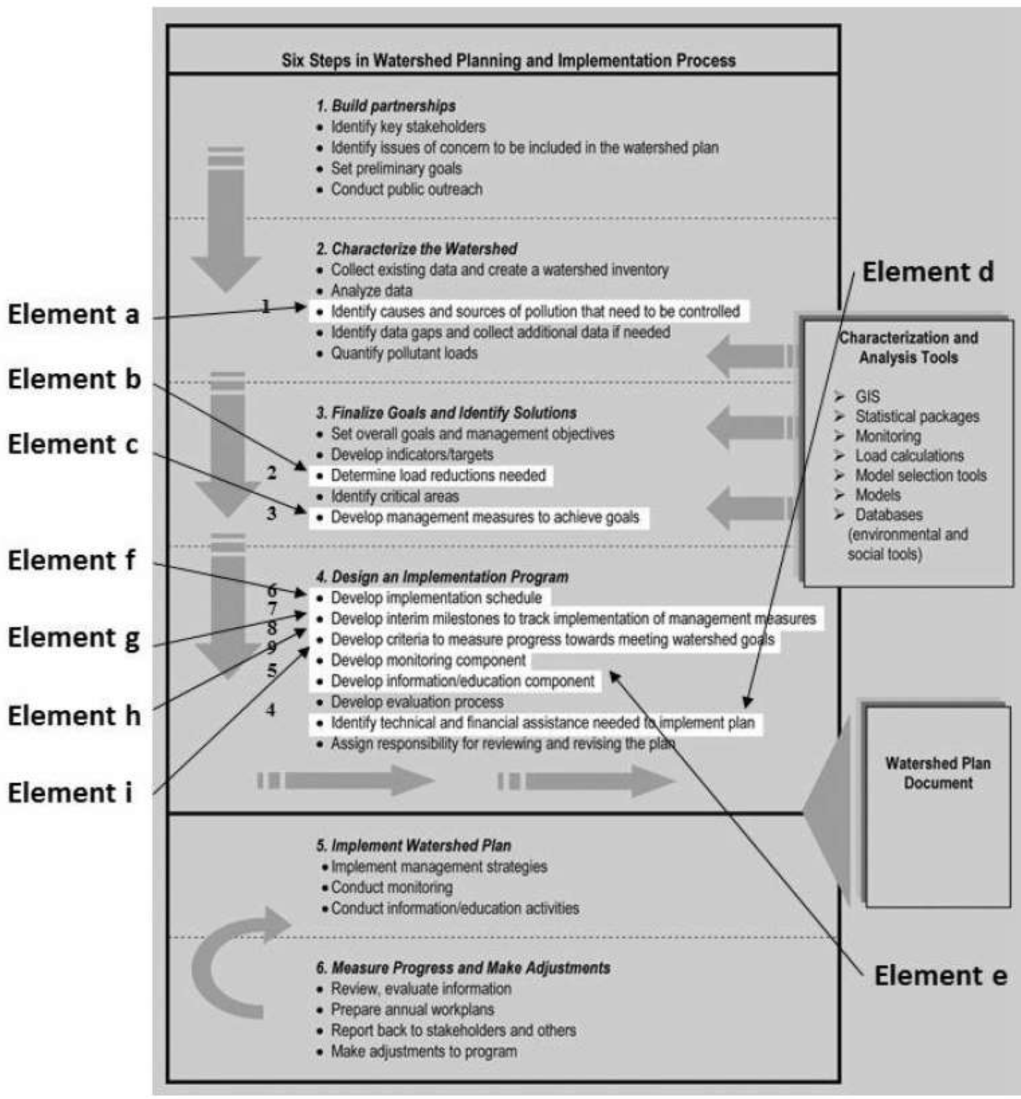


Figure 2 - Crosswalk between the six steps of watershed planning and the section 319 nine minimum elements (EPA, 2013)

Through a WDNR small-scale lake management planning grant awarded in 2016, the Lake Redstone Protection District (LRPD) began the process of assembling a Comprehensive Lake Management/Watershed Plan for the lake. The LRPD has identified key stakeholders and issues of concern to be included in a Comprehensive Plan from Step 1; and collected existing data, created a watershed inventory, and identified data gaps to be filled from Step 2. The first of the 9-Key Elements (identifying causes and sources of pollution that need to be controlled) is addressed in this report. The remaining Key Elements and actions in Steps 1&2, and Steps 3&4 will be included in a future lake management planning grant application by the LRPD. This report summarizes what was learned and lays out a strategy for moving forward.

Watershed

Lake Redstone is located in the Crossman Creek and Little Baraboo River watershed which is 213.80 mi^2 (Figure 3). The Crossman Creek and Little Baraboo River Watershed lies in northwestern Sauk County, southern Juneau County, northeastern Richland County, and the southeast corner of Vernon County. It is also in the Driftless, or unglaciated region of Wisconsin. The watershed includes the main stem of the Baraboo River from Wonewoc to Reedsburg. Land use in the watershed is primarily agricultural (60%), forest (31%) and a mix of suburban (6%) and other uses (4%) (Figure 4). This watershed has 466.61 stream miles, 244.11 lake acres and 6,321.59 wetland acres. The watershed is ranked high in both overall nonpoint source pollution and groundwater nonpoint source pollution; however it is expected that these sources can be controlled with best management practices.

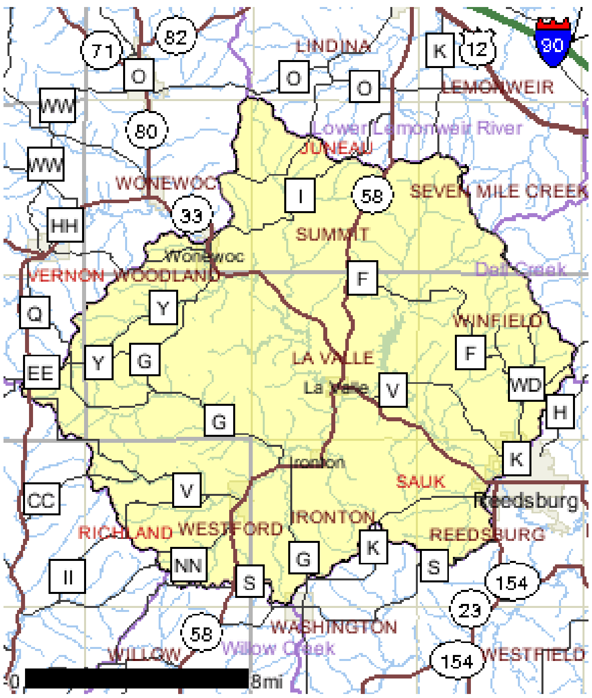


Figure 3 - Crossman Creek and Little Baraboo River Watershed

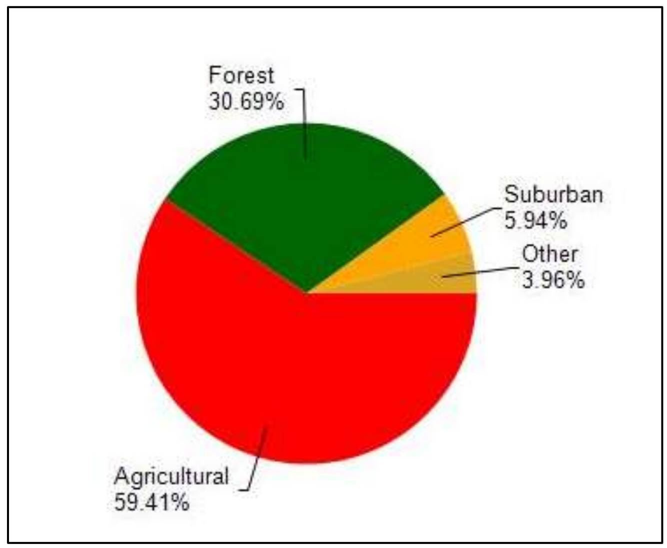


Figure 4 – Land Use in the Crossman Creek and Little Baraboo River Watershed

The direct watershed of Lake Redstone (Figure 5) is a smaller, sub-watershed within the larger Crossman Creek and Little Baraboo River Watershed. It covers approximately 30 square miles, most of which is in Juneau County. Because of the problems associated with nonpoint source pollutions, the watershed of Lake Redstone has been the focus of many studies identifying causes and sources of pollution that need to be controlled (9-Key Element) and projects implemented to reduce sediment and phosphorus loading. These projects will be inventoried in the next section of this report.

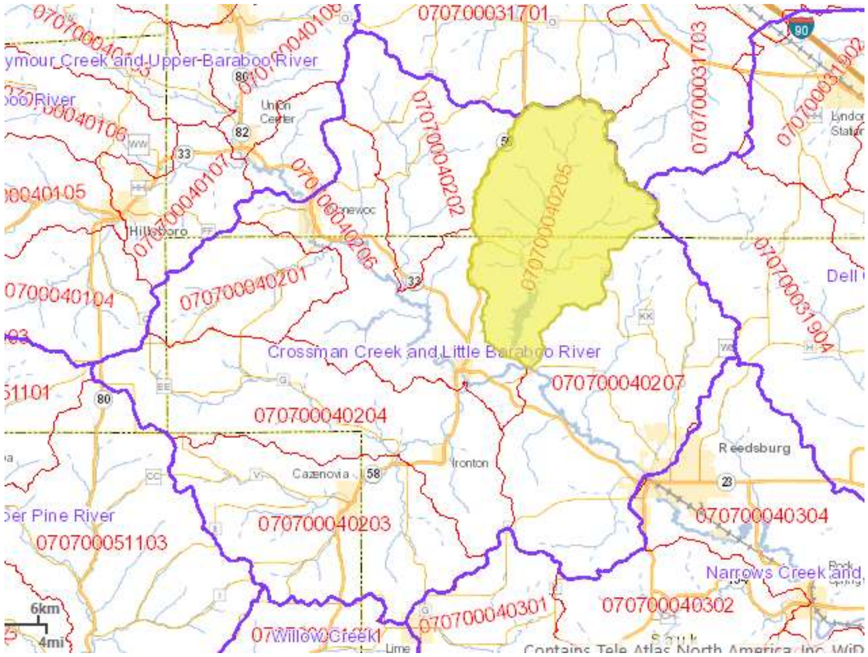


Figure 5 – Direct watershed of Lake Redstone (WDNR, 2016)

Building Partnerships

The first step of the watershed planning and implementation process identified by the EPA (Building Partnerships) includes the following actions: identify key stakeholders, identify issues of concern, set preliminary goals, develop indicators, and conduct public outreach. In 2006, the Lake Redstone Protection District (LRPD) entered into a strategic planning process to guide actions to be taken by the LRPD to improve the lake (Erickson, 2006). During the initial set-up, several of the actions included were completed and remain pertinent to this report. This process continues to this day, with the last strategic planning session taking place in November 2016.

Identification of Key Stakeholders

A stakeholder is any person, group, or organization that can place a claim on the organization's resources, attention, or output, or is affected by its output (Bryson, 1995). With that thought in mind, the LRPD identified the following key stakeholder groups that are important to management planning and implementation success during their initial lake planning process in 2006:

- Wisconsin Department of Natural Resources
- Natural Resource Conservation Service (NRCS) in Sauk and Juneau Counties
- Sauk County
- Juneau County
- Town of LaValle
- Property Owners on Lake Redstone
- Lake Redstone Property Owners' Association
- General Lake Users
- Agricultural and Animal Operations in the Watershed
- State Legislators
- Reedsburg School District

Issues of Concern and Public Outreach

Back in 2006, in an effort to better understand the issues facing Lake Redstone, the LRPD conducted a survey of all 1074 households in the district. The response rate to this survey was 32%. Based on the information from the survey and an internal board assessment, a list of eleven of the most strategic issues facing the LRPD was created. From this list the following issues were determined to be of highest concern:

- How to better educate and communicate with users of Lake Redstone, both resident and day users;
- How to safely and effectively prevent and/or remove sediment build-up in Lake Redstone;
- How to better manage the number of exotic, invasive species found in and around Lake Redstone; and
- How to reduce the amount of nutrients entering Lake Redstone.

The most recent set of issues (November 2016) are as follows:

- How to improve water quality by removing/controlling/preventing sediment and nutrients from entering Lake Redstone;
- How to better manage/prevent the spread of exotic, invasive species in and around Lake Redstone; and
- How to better involve and educate constituents.

Each strategic issue has one or more individual strategies and multiple actions associated with it, identified by the LRPD and its partners, that will help resolve the issue. One such strategy is to meet with partners annually to discuss what has been done, what is currently being done, and what is being planned for the future. The last “partners meeting” was held on November 7, 2016.

Inventory of Existing Data

Since the Lake Redstone Protection District was first formed in 1976, it has been working to collect information and implement projects that would make improvements to water quality in Lake Redstone. Most of these projects have been centered on reducing sediment and phosphorus loading from the watershed to the lake.

1981 UW-Madison Lake Redstone: Water Quality and Management (UW Study)

The first major study of the lake was completed in 1981 by the University of Wisconsin (UW)-Madison Water Resources Management Program, Institute for Environmental Studies (Institute for Environmental Studies, 1981). The purpose of the UW Study was to identify the causes of nutrient and sediment overloading that had created water quality problems; and to prevent management alternatives designed to restore and protect the lake. The analysis included both technical data and perceptions of the area residents. This was the first public use survey of the residents of the lake, and the first serious look at sources of phosphorus and sediment to the lake. Figure 6 shows the breakdown of phosphorus loading from various sources identified during the UW Study.

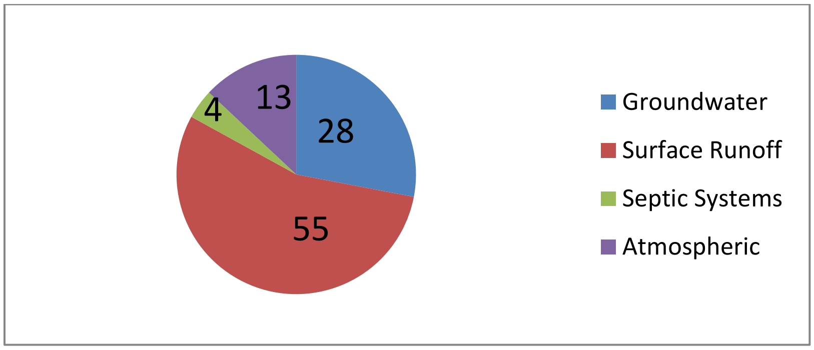


Figure 6 – Phosphorus Budget in 1981 (Institute for Environmental Studies, 1981)

Public input was also a part of the UW Study and a paper survey was sent to all 1270 property owners on Lake Redstone seeking their comment through a variety of questions. The survey had a 43% return rate (545 surveys) with 69% of homeowners and 32% of undeveloped lots represented. The survey identified two important topics of concern to Lake Redstone residents: water quality perception and user conflict. Survey results indicated more people were concerned with user conflicts than water quality and that more people were satisfied with water quality than were not. Most of those unsatisfied with water quality were only occasional visitors to their lake property. Many responses from this survey had “no opinion” as it pertains to water quality, prompting researchers to suggest a greater emphasis on information and involvement programs in the future to increase awareness.

Land use in the watershed was inventoried during the UW Study with nearly 65% involving agriculture including contoured cropland, cultivated, pasture, and pastured woodlots (Figure 7).

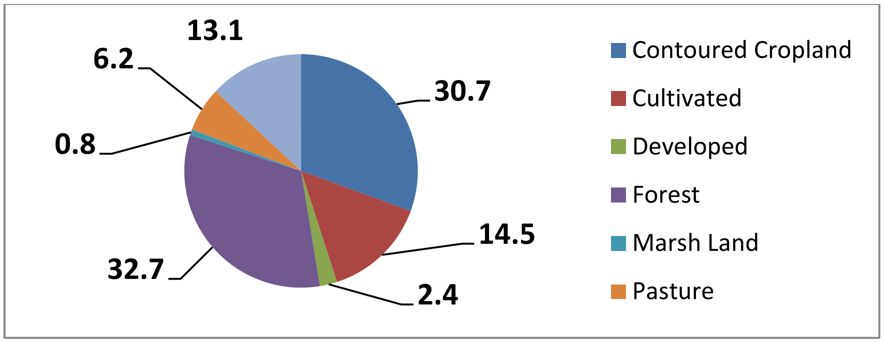


Figure 7 – 1981 Land Use (Institute for Environmental Studies, 1981)

More than 1800 head of cattle were identified in the watershed during the UW Study, the majority being dairy stock. Based on tributary monitoring done in 1978-79, the UW Study concluded that more than 325 tons of sediment per square mile of watershed was being eroded away and either being stored within the watershed or making it directly to the lake. Sediment stored within the watershed and not reaching the lake is a good thing, however even it can be flushed into the lake periodically by large snowmelt and rain events. Water quality data collected during this study suggested a Carlson's Trophic State Index value of 65 placing Lake Redstone in the nutrient rich or eutrophic category.

Trophic State Indices (TSIs) are an attempt to provide a single quantitative index for the purpose of classifying and ranking lakes, most often from the standpoint of assessing water quality. The Carlson (1977) Index has attained general acceptance in the surface water community as a reasonable approach to do this. The Carlson TSI value is a measure of the trophic status of a body of water using several measures of water quality including: depth of sunlight penetration into the water (clarity), chlorophyll-a concentrations (algal biomass), and total phosphorus levels (usually the nutrient in shortest supply for algal growth).

TSI values range along a scale from 0-100 that is based upon relationships between water clarity and surface water concentrations of algal chlorophyll, and total phosphorus for a set of North American lakes. Its major assumptions are that suspended particulate material in the water controls water clarity, and that algal biomass is the major source of particulates. The lowest TSI value of zero would correspond to water clarity of 64 meters; a TSI value of 100 would correspond to water clarity of only 6.4 cm (less than 3 inches) (University of Minnesota - Duluth, 2016). Typically TSI values above 50 are considered high, indicating nutrient rich, fertile lakes with poor water clarity. These types of lakes generally have lots of algae present in the water giving it a green or greenish-brown appearance.

The UW Study concluded that improvements to the watershed and water quality of Lake Redstone could be made, and laid out four possible sets of actions to do so, each with varying levels of effective management actions and cost. The first set consisted of informational programs and individual or group actions that lake property owners could take. This option was the lowest cost, but its effectiveness depended on residents being willing to participate and good leadership provided by the Lake District. The second set of actions focused on in-lake actions that would temporarily improve water quality at a fairly high cost. It included dredging, aeration, creation of wetlands, and management of algae & aquatic plants. The third set of actions focused on the watershed and included heavy emphasis on implementing agricultural best management practices (BMPs), but also on establishing wetlands, installing sediment trapping structures, and installing road bank and construction site erosion control. The fourth set of actions combined elements of all three previously mentioned.

After the 1981 UW Study

Between the 1981 UW Study and the next round of comprehensive lake study in the mid-1990's many (nine) of the bays on Lake Redstone were dredged; four sediment detention ponds were installed upstream of Martin-Meadowlark bay (1984); rock chutes were installed on Oriole Bay (1989) and Mourning Dove and Eagle bays (1995); and other actions aimed at reducing sediment loading to the lake were completed. In addition, the Crossman Creek watershed (of which Lake Redstone is a part) was the focus of a nonpoint source priority watershed project sponsored by WDNR, Department of Agriculture, Trade, and Consumer Protection (DATCP), Juneau, Richland, and Sauk County Land Conservation Departments that started in 1983 and was completed in the mid 1990's. The goals of the project were to protect and improve water quality and fisheries habitat by controlling erosion from farm fields, reducing streambank erosion, reducing or controlling barnyard runoff, and better management of manure spreading in the watershed, ultimately aiming for a TSI value of 58 which lake modeling showed could be generated with a 70% reduction in nutrient load.

A lake model is a mathematical equation that helps to "visualize" how past actions have led to a current condition or helps to "visualize" how future actions could alter the current condition (McGinley, 2014). Like all equations, known data is inserted and used to test the model for accuracy. Once a given model has been determined accurate, then data values can be changed to help predict what would occur under different scenarios. There are many lake models that can be used to predict what changes in trophic status could be generated with changes to the watershed and nutrient loading sources. Several different models have been used in Lake Redstone to set target goals and to estimate changes that would occur if those goals were met.

After modeling indicated that it was reasonable to assume that a 70% reduction in nutrient load could lead to better TSI values in the lake (58 was the goal), the priority watershed project identified various sites within the watershed that could be targeted for corrective measures to reduce nutrient loading to the lake. High and medium priority sites were selected for corrective actions. Farmer participation in the program was voluntary and when the priority watershed project was completed, only 60% of eligible landowners had signed up and only 65% of the identified projects related to those landowners were actually completed. Upon completion of the priority watershed project, it was felt that the goal of a 70% phosphorus reduction and 50% sediment reduction had not been met. However, when the watershed was re-evaluated approximately 10 years later, that conclusion was reversed.

1995-1997 Agricultural Watershed Inventory and Water Quality Model Study

In 1996 MSA Professional Services completed a study (MSA, 1998) of the watershed to determine the location of farming operations and land use. At the same time, the WDNR completed a water quality modeling study (Panuska, 1997) of the Lake Redstone watershed. Data from the MSA Study was compared to the data in the 1981 UW Study to document changes in land use, farming operations, and livestock between then and 1996. The DNR study was used to compare changes in phosphorus and sediment loading to the lake.

In the UW Study, approximately 45% of the total land use was cropland and approximately 20% was pasture or pasture/woodlot. The MSA Study estimated that cropland only made up 15-20% and estimated that 25-30% of the total cropland was in the Conservation Reserve Program (CRP), a federal cost-share and rental payment program that encourages farmers to convert highly erodible cropland and other environmentally sensitive areas to vegetative cover including grasslands, food plots, windbreaks, buffer strips, and riparian buffers. The MSA Study also documented a 28% reduction in the number of livestock in the watershed, and suggested that that a declining trend in livestock would likely continue. These findings suggested a 66% reduction in potential phosphorus loading from animal operations from 1984-1996 according to the MSA Study.

During the summer of 1996 the WDNR conducted a detailed inflow and in-lake sampling study in an attempt to develop seasonal water and nutrient budgets for Lake Redstone to be use in additional lake modeling. Results indicated that growing season phosphorus loads to Lake Redstone came from the following sources: 66% from watershed runoff, 29% from internal recycling, and about 2% from groundwater. Although 29% of the phosphorus was predicted to be coming from internal recycling of phosphorus within the lake, it was concluded that this portion of the load was not contributing to algal growth in the lake. When data collected during the 1996 DNR Study was plugged into lake modeling, the TSI value generated was 58. The results of the MSA watershed inventory indicated approximately a 66% reduction in phosphorus loading since 1985. As discussed previously, the 1985 priority watershed project had limited success in implementing Best Management Practices (BMPs), and reducing phosphorus loading to the lake. However, as identified in the MSA Study, changes in farming operations in the watershed between 1984 and 1996 resulted in an overall reduction of nutrient loads to the tributaries of Lake Redstone. In effect, phosphorus loads were reduced and the lake responded in accordance with what was predicted. In order for this trend to continue, the following recommendations were made in the 1997 DNR Study:

- Continue cooperative efforts in working with watershed farmers to reduce sources of phosphorus to the lake,
- Prevent ground water contamination (and possibly lake discharge) by providing up-to-date septic system management,
- Minimize site runoff of nutrients by using low or no phosphorus fertilizers on the lake shore, and installing lake shore buffers,
- Develop and implement an education program that informs lake residents about issues related to water quality and lake protection and that discusses realistic goals and expectations about Lake Redstone's water quality,
- Work with Sauk County to ensure periodic maintenance and yearly operation of the dam's emergency bypass,

- Continue monitoring the occurrence and distribution of Eurasian water milfoil (an exotic nuisance plant) and possibly spot treat with selective herbicides to protect native plants and minimize expansion,
- Purchase a dissolved oxygen meter and begin periodic winter monitoring to track conditions and provide information for future planning,
- Record information such as ice cover dates, ice and snow thickness and water column dissolved oxygen levels at a variety of locations, and
- Continue coordination with the WDNR Fisheries Manager on issues related to fish management.

After the Mid 1990's Studies

The results of the 1996-97 studies were encouraging, and from 1998 to 2004, the Lake District worked to follow the recommendations in the 1997 DNR Study. The Lake District remained committed to working with the farming community to identify additional methods such as roof drains, grassed waterways, buffers and other BMPs that would be mutually beneficial to both the farmers and the lake. To this, the Lake District sponsored another project in 1997 aimed at making feedlot roof gutter improvements. Specifications for the roof gutter project were completed by MSA, and over the next several years eight farming operations made improvements which were paid for in part by the Lake District.

The Lake District also applied for and received funding through the Environmental Quality Incentives Program (EQIP). EQIP is a voluntary conservation program that helps agricultural producers in a manner that promotes agricultural production and environmental quality as compatible goals. Through EQIP, agricultural producers receive financial and technical assistance to implement structural and management conservation practices that optimize environmental benefits on working agricultural land (NRCS, 2017).

A dissolved oxygen meter was purchased and regular water quality testing in the lake was started. A Shoreland Restoration Workshop was organized and then followed up with the installation of three demonstration shoreland restoration projects on the lake. Soil testing around the lake was completed to see if phosphorus-laden fertilizer applied to lawns by lakeshore property owners was really necessary to keep the grass healthy. The testing showed that more phosphorus was not needed to keep lawns around the lake green and healthy.

Management of Eurasian watermilfoil (EWM), an aquatic invasive plant species, continued through the use of aquatic herbicides. In cooperation with the WDNR an aquatic plant survey was completed to see if EWM and the EWM management program were causing any negative impacts to native plant species in the lake. Common carp, an aquatic invasive fish species was documented in the lake and in response the Lake District began promoting an annual "Carporee" where contests were held for the largest and most carp removed during a bow and arrow fishing competition.

Prior to this time period, the LRPD had been using copper sulfate to treat algae blooms in the lake. This practice was stopped when indications were that the presence of copper in the sediment could be detrimental to many of the lake's important benthic critters, and potentially restrict beneficial aquatic plant growth.

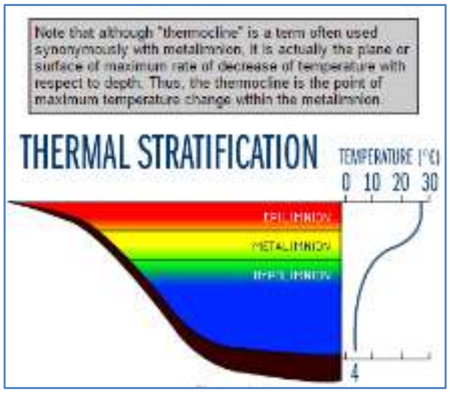
2002 WDNR Hypolimnetic Water Withdrawal Study (Marshall, et al., 2002)

Two additional lake studies were completed during this time frame as well. In response to the 1996-97 reporting that 29% of the phosphorus load in the lake was coming from internal recycling of nutrients already in the lake, a hypolimnetic (bottom water) withdrawal study was completed in 2002 by the WDNR in cooperation with the Lake District and Sauk County. Bottom of the lake water samples were collected and analyzed for phosphorus content from four locations in the lake including in the deeper, stratified portion of the lake immediately adjacent to the dam. The data collected showed that only the deep water area adjacent to the dam remained stratified for a long enough period of time for bottom withdrawal of water to be able to reduce phosphorus loading in the lake. The remaining sites that were tested remained mixed through the majority of the open-water season.

Stratification and Mixing in Lakes

Deeper lakes or deeper parts of shallow lakes will often stratify during the summer season. Stratification in lakes means that the lake water divide in to different layers based on water density and temperature. Water differs from most other compounds because it is less dense as a solid than as a liquid. Consequently ice floats, while water at temperatures just above freezing sinks. As most compounds change from a liquid to a solid, the molecules become more tightly packed and consequently the compound is denser as a solid than as a liquid. Water, in contrast, is most dense at 4°C and becomes less dense at both higher and lower temperatures. Because of this density-temperature relationship, many lakes in climates like Wisconsin tend to separate into distinct layers (stratify).

During the summer months colder water sinks to the bottom and warmer water rises to the surface. The two layers of water are separated to some degree by a "thermocline", defined as the depth of water at which the temperature changes the most rapidly over a very short depth interval, typically a few inches to a few feet (Figure 8). This generally occurs in deep lakes in WI only during the warm summer months. In both the spring and fall water temperatures throughout the water column of the lake become similar. In the spring the water temperature directly under the ice is about 32°F, while the water temperature at the bottom of the lake is about 40°F. Warming in the spring melts the ice and warms up the water until it is the same top to bottom. In the fall, water is warmer at the surface of the lake than it is in the bottom of the lake. Cooling temperatures reduce the surface water temperature until once again the water temperature is the same top to bottom. In both of these cases, when water temperature is the same top to bottom a mixing event occurs throughout the lake. A lake that does this is called a dimictic lake. The spring and fall mixing events are called "turnover" (Figure 8). During turnover, some good things happen like adding oxygen to the water so fish can survive, but also some bad things happen like adding excess nutrients back into the water that may fuel algae blooms.



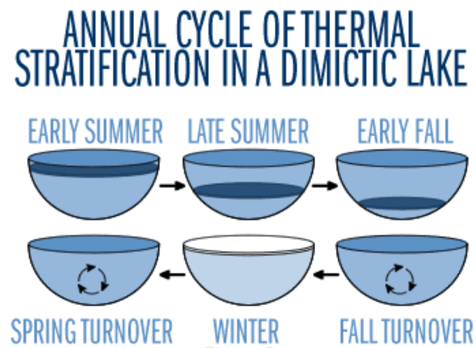
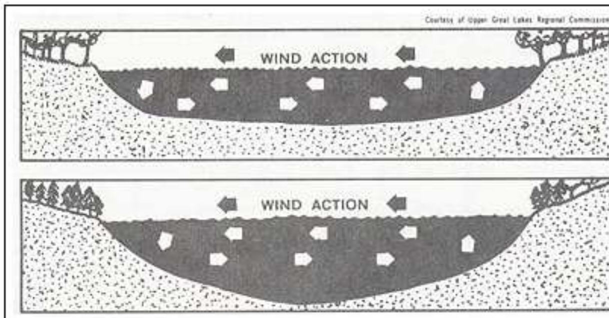


Figure 8 – Thermal Stratification and lakes (University of Minnesota - Duluth, 2016)

Shallow lakes in Wisconsin will often remain "mixed" throughout the summer season; or stratify for short periods only, then mix again. Mixing means that water temperatures at the surface of the lake and at the bottom of the lake never really establish enough of a temperature change to stratify, or only do so for a very short period of time before stratification falls apart. Lakes that stratify and de-stratify numerous times within a summer are known as polymictic lakes. Data collected in 2000 show that Lake Redstone only remains stratified for the whole summer in the deep water area adjacent to the dam. In all other parts of the lake, mixing caused by wind and wave action (natural and those caused by boats) occurs frequently (Figure 9). During the summer this mixing adds phosphorus to the surface waters of Lake Redstone promoting additional algal growth.



Summer mixing of lakes by wind - Shallow lakes are kept well mixed by wind action. Winds mix only a portion of deeper lakes. Courtesy of Upper Great Lakes Regional Commision

Figure 9 – Summer mising in shallow and deep lakes (Grovhac, Inc., 2016)

Hypolimnetic withdrawal or drawing water out of the lake from the deeper, phosphorus laden bottom of the lake was listed along with numerous other potential management alternatives for Lake Redstone as part of 1981 UW-Study. The Lake District proposed hypolimnetic withdrawal in the late 1990's in an effort to reduce internal phosphorus loading and complement ongoing efforts to reduce external nutrient loads from the watershed. As previously mentioned, the 2002 DNR study showed that the only part of the lake that stratifies long enough to mobilize and sustain high phosphorus concentrations in the bottom waters was near the dam. In the greater reservoir basin, long, windswept surfaces and relatively shallow water depth prevented stable stratification and partial mixing occurred. Based on weekly measurements of water clarity in 2000, the small deep-water stratified bay near the dam displayed the best water quality while weak stratification and mixing in the rest of the lake fueled greater algal blooms.

The 2002 DNR Study concluded that pronounced stratification near the dam prevented significant internal phosphorus transfer during the summer season. Internal phosphorus loading that fueled algal blooms was a greater factor in the other parts of the lake. The proposed hypolimnetic withdrawal would at best only provide modest water quality benefit given that phosphorus reduction would only occur near the dam. Additionally, the amount of water that could be withdrawn would likely be limited in order to protect a diverse downstream fishery in Big Creek and the Baraboo River due to the very high concentrations of hydrogen sulfide and ammonia (both harmful to aquatic life) in the bottom water. If the water withdrawn from the lake was not limited, some form of wastewater treatment would be needed, increasing the cost substantially.

Without wastewater treatment, required low withdrawal rates would not have a significant positive effect on the overall phosphorus budget in the lake. Very high hydrogen sulfide concentrations further complicated the issue since significant nuisance odors (rotten egg smell) would be generated within the popular county park that encompasses the dam.

Sediment Release Study – Internal Loading of Phosphorus

Phosphorus is a key nutrient that usually limits primary production in freshwater systems. Increased or excess P loading can lead to cultural eutrophication, degradation of water quality, and development of toxic cyanobacterial blooms. Excessive anthropogenic P loading also leads to various problems, such as loss of oxygen, fish kills, and a loss of biodiversity within the lake. Phosphorus sources can originate from the watershed (i.e. external loading) or from P stored as sediment that is later released and recycled into the water column for uptake by algae (i.e. internal loading) (James, 2016).

Internal phosphorus (P) loading is a term used to describe P movement and recycling between sediment in a lake and the water column. Since sediment P is ultimately derived from the watershed, land use practices that over-fertilize the soil and promote hydrological runoff can result in considerable deposition over decades and centuries of P-rich sediment in lake basins. Lakes are essentially traps for sediment and thus reflect the activities in its watershed. Internal P loading is, in essence, in-lake recycling of P that was derived from the watershed. It is important to quantify external and internal P loading in order to identify important P sources for targeted management strategies (James, 2016).

Simply reducing watershed P loading to eutrophic lakes without also managing internal P loading may not be enough to reverse impaired water quality. Even though internal P loading is ultimately derived from the watershed, it can take years to decades to flush sediment P out of the system after watershed BMP implementation, resulting in delayed recovery and continued impairment. In addition, a symptom of decades of P retention as sediment in lakes is the buildup of a surface sediment P concentration bulge that is usually difficult to bury over time and persists as an important internal P source during hypolimnetic anoxia, stimulating and sustaining algal blooms despite other efforts of remediation (James, 2016).

Extensive water quality data has been collected from four sites in Lake Redstone (Winnebago Court-North, Mourning Dove-Middle, Navajo-South, and Deep Hole) to document surface and bottom water phosphorus concentrations in the lake and this data has been used to estimate internal loading of sediment. An equally extensive data set exists for non-point source loading of phosphorus from the watershed. However a complete evaluation of the actual sediment loading that occurs in the lake has never been done. William James, a professor at UW-Stout in Menomonie WI is one of the foremost researchers of sediment release rates for phosphorus. Each year he does one or more sediment release studies with his students in the UW-STOUT Discovery Center. Through the collection of sediment samples and lab analysis, the amount of phosphorus release into the lake from the sediment is determined under anaerobic (no oxygen) conditions, high pH and other scenarios. A study completed by the Discovery Center or similar entity could finally answer the question about what extent internal loading impacts Lake Redstone.

In lieu of a full phosphorus sediment release study, some additional water quality data could be collected in the three lake sites and the Deep Hole by the dam. Specifically iron and phosphorus sampling throughout the water column may be beneficial to determine if phosphorus released internally is getting into the epilimnion for use by algae, or if sufficient iron exists in the water column to rebind with the available phosphorus when dissolved oxygen in the water column is recharged by fall turnover or periodic mixing events (Kleeburg, 2013).

2002 GIS-Based Sediment Delivery Model Study (MSA, 2002)

As a follow up to the mid 1990’s Agricultural Land Use Inventory and Water Quality Modeling Study that continued to suggest that sediment laden runoff from agricultural fields was a major contributor to the phosphorus load in the lake, a GIS-based Sediment Delivery Study was completed. Similar to what was done in the mid-1980’s Crossman Creek Priority Watershed Study, the objective of the 2002 MSA Study was to identify and rank critical areas in the watershed where runoff from farm fields may be contributing the majority of phosphorus rich sediment to Lake Redstone. Sediment delivery is an estimate of the amount of soil coming off the fields under certain conditions. As in other studies a lake model was chosen to predict reductions in phosphorus load that could be reached by identifying the worst areas of the watershed for soil delivery and then making changes to those areas.

GIS stands for “geographic information system” and is a method to capture, store, manipulate, analyze, manage, and present spatial or geographical data digitally or in a digital format. What makes a GIS-based model different from what was done before is that this more modern version utilizes digital technology to map the watershed and identify spatial intersections. Spatial intersections, as it pertains to this project means places on a map of the watershed where certain features of concern overlap. As an example, areas in the watershed where terrain, soil type, distance to the closest direct runoff path to the lake, and other factors may lead to high levels of sediment delivered to the lake can be identified quickly and easily without actually visiting the area in person. Another example would be finding areas where high soil loss overlap with the high sediment delivery to identify the most critical areas to focus management actions. The ability to do this is accomplished by using a spatial modeling program that reads resource information such as topography (ex. contour lines) and soils, and presents the results (areas) to the user. Aerial photos of the watershed were incorporated into the GIS system. The location and area of farm tracts were determined from the photos. The soil delivery maps were created using the watershed map as a base map, and then digitally adding new layers of information to the base map.

The 2002 MSA Study identified over 600 farm tracts present within the Lake Redstone watershed. Of those farm tracts, 146 were considered to have high soil loss (greater than 4 tons/acre/year). Seven farm tracts had soil loss estimates greater than 10 tons/acre/year and a high of 27.2 tons/acre/year. However, all seven of these farm tracts combined only contributed about 3% of the total loading.

Overall, 22 farm tracts were identified as potentially losing greater than 80 tons of soil each year. The estimated soil loss for the highest ranked farm tract was 305 tons/tract/year. Three farm tracts were estimated to lose greater than 200 tons/year, and 14 were over 100 tons/year.

The modeling used in this project also estimated the potential capability of the land to transport sediment to a stream within the watershed. The potential to transport sediment from an area of land to a stream was ranked as high, medium or low, but because the watershed is highly dissected by streams and has high topographic relief (highlands and lowlands), a large portion of the watershed was ranked as high soil delivery areas.

Finally, high priority farm tracts were identified. High priority farm tracts have soil loss greater than 4 tons/acre/year and are located within the high sediment delivery areas. Portions of 114 high soil loss farm tracts were located within high soil delivery areas. Eight of these farm tracts had total soil loss estimates from high delivery areas greater than 80 tons/year, with five of these exceeding 100 tons/year. Knowing these areas made it possible to focus best management practices like buffer strips, contour strip cropping, grassed waterways, diversions, and streambank stabilization in places where they will be most beneficial.

Recommendations from this study included ground-truthing the findings from the top eight ranked farm tracts which have soil loss estimates from high delivery areas greater than 80 tons/year. Ground-truthing means visiting the site in person to see what is actually occurring there. During the site visit the farm tract and the land leading to the adjacent stream should be inspected for evidence of soil erosion. Crop rotation plans for each of the tracts should be reviewed, and the owner and/or tenant farmer should be informed about Best Management Practices (BMPs) and encouraged to implement ones appropriate for the tract. Examples of possible BMPs include buffer strips, contour strip cropping, grassed waterways, diversions, and streambank stabilization.

After the Early 2000's Studies

Between the early 2000's studies and the mid 2000's tributary and water quality studies, the LRPD implemented several projects in cooperation with other partners. An Environmental Quality Incentive Program (EQIP) grant was awarded to implement BMPs known as the Clearwater diversions. A soil stabilization project was also completed above Timmons Road.

In an effort to demonstrate shoreland improvement projects, the LRPD contracted with a local shoreland restoration expert to completely restore three properties on the lake as demonstration properties aimed at increasing the interest level of other property owners to restore their shores.

Invasive species became a greater issue during this time frame, prompting the LRPD to contract chemical treatment of aquatic plants/Eurasian watermilfoil (EWM) in the lake. An annual carp bow-fishing event to reduce the number of big carp in the lake was also started during this time frame.

Also during this time, soil testing of area lawns around the lake was completed showing that no additional fertilizer needed to be applied to lawns to keep them green and growing.

As previously mentioned, under the guidance of the UW-Extension program, the LRPD also began a lake management planning process aimed at identifying stakeholders, identifying strengths and weaknesses of the Lake District, seeking public input, and prioritizing issues of concern. This process continues to this day with the last planning meeting completed in November 2016.

Mid-2000's Tributary and Water Quality Studies

Beginning in 2006, additional tributary and lake water quality data was collected, analyzed, and compared to similar mid-1990's data. Vierbicher Associates completed a two-year (2006-07) tributary monitoring project of the East and West branches of Big Creek, the two main tributaries entering Lake Redstone (VierbicherAssociates, 2007). From 2007 to 2009 BARR Engineering completed a Watershed and Lake Modeling Study incorporating the data from 2006 & 2007 (BARR, 2009). The BARR study also compared 2007-08 tributary and lake water quality monitoring results to those of 1996-97. Both of these studies were flawed. Tributary data collected by Vierbicher had many issues with equipment malfunction, beavers, vandalism, possible incorrect depth settings, etc. The BARR report used much of the data provided by Vierbicher in its analysis leading to conclusions that were disputed by the WDNR in a review of the BARR report completed in early 2010 (Oldenburg, 2010). The 2010 WDNR Review also brought into question tributary data and the loading assumptions made in the 1996-97 WDNR study particularly for the West Branch of Big Creek.

Future Water and Nutrient Budgeting

Flow data and associated phosphorus and sediment loading calculations for Lake Redstone tributaries were completed in the mid 1990's and again in the mid 2000's. In both cases, there was some question as to the accuracy of the data collected. It is necessary to once again collect stream flow and loading into Lake Redstone, but if it is going to be done, it should be done by an organization that knows what they are doing, has the equipment to do it, and the expertise to make sure the data collected is accurate. One such organization is the United States Geological Survey. It is recommended that the USGS be brought in to collect flow data. At the same time, additional sampling could be done to calculate nutrient and sediment loading values, but most important is to get accurate flow and volume. A fair amount of nutrient and sediment sampling has been done in the two main branches of Big Creek, and in many of the smaller tributaries that feed the main branches, but not flow data.

Installation of Recording Streamflow-Gaging Stations on the West and East Branch of Big Creek

Surface water inflow and outflow may be determined by recording streamflow-gaging stations (Figure 13) near the mouths of major tributaries and at the lake outlet. Surface water flows can also be sampled and analyzed for phosphorus and sediment concentrations. Streamflow data, along with the concentration data, are used to determine the annual phosphorus inputs and losses. It is recommended that this level of streamflow data be collected on the East and West branches of Big Creek.

Figure 10 – Typical U.S. Geological Survey recording streamflow-gaging station with automatic water sampler for load determinations (Garn, Elder, & Robertson, 2003).

Installation of Automatic Water Samplers (pressure transducers) on Smaller Tributaries to the East and West Branches of Big Creek

Submersible pressure transducers increasingly are being used for monitoring stage at surface- water gages. This is due to their ease of installation and maintenance, relatively low cost, and minimal requirements for shelter size, factors which provide more versatility in locating the instrumentation. For surface-water applications, a desirable transducer is accurate over a large range of stage and temperature; maintains its calibration; is easy to install and remove for repair; and is not prone to failure induced by water leakage or voltage surges (Freeman, et al., 2004).

Figure 11 – Installation of pressure transducers (data logger) to measure depth of water (Papanicolauo, 2017)

Several smaller, level one or two stream order tributaries have had TP and TSS data collected from them since at least 2014 by Sauk County and the LRPD (Figure 15). It is recommended that pressure transducers be installed on up to 6 level one or two streams based on previous TP and TSS data collected by Sauk County and the LRPD (Lucht, Pekala, Daugs, Wafle, Pfaff, and Nemitz Roads).

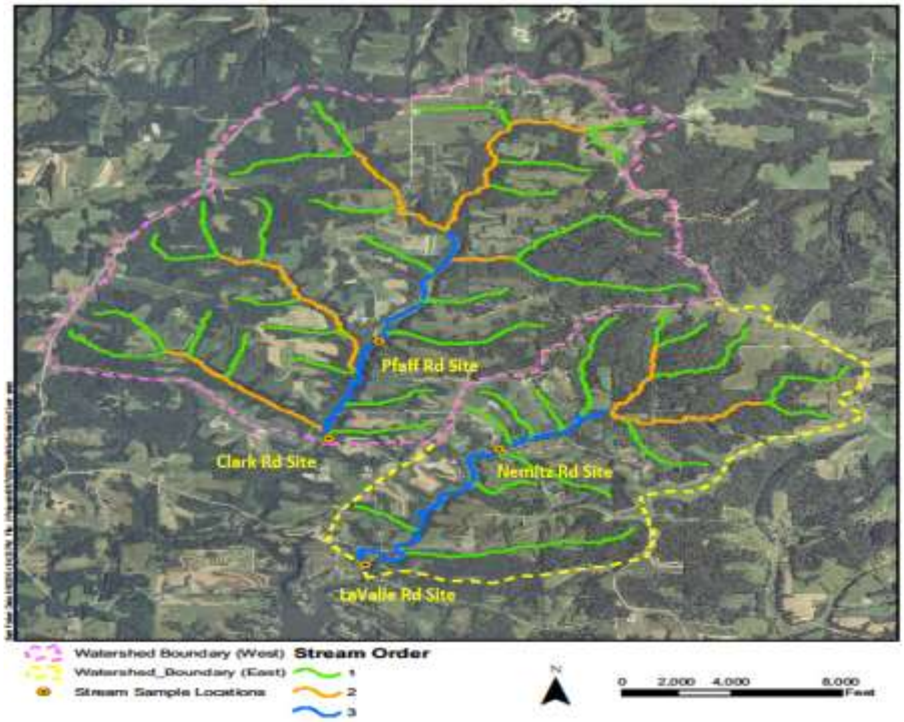


Figure 12 – Level 1-3 stream order tributaries to Lake Redstone (Koenig, 2014)

Late 2000's Activities

In the late 2000's Lake Redstone experienced some torrential rain events leading to massive flooding of and damage to the watershed and nearshore area of the lake. After the 2008 flood several project were completed to repair damages caused. Long-term watershed stream monitoring was begun, and more cooperation (with Dutch Hollow Lake, the Town of LaValle, and Sauk County) was initiated to monitor for and increase community awareness of aquatic invasive species. This effort included the first watercraft inspection program through Clean Boats, Clean Waters, a WDNR and UW-Extension Lakes supported initiative.

Critical Habitat Designation

One of the more controversial studies completed on Lake Redstone was a Critical Habitat Survey and Designation Report completed by the WDNR from 2005-2007 with the final report being completed in January 2009 (Sefton & Graham, 2009). Lake Redstone was chosen for this study for two primary reasons: 1) To protect areas within the lake that are most important for preserving the character and qualities of the lake; and 2) To preserve the reaches of shore that are predominately natural in appearance or that screen man-made or artificial features for the enjoyment of lake residents and visitors.

Critical Habitats are called Public Rights Features in Wisconsin Administrative Code NR1.06. They are characteristics of a lake that fulfill the rights of the public for quality and quantity of water, fishing, swimming, navigation and reaches of shore which are predominately natural in appearance or that screen man-made or artificial features. The study determined that Lake Redstone included the following public rights features: fish and wildlife habitat, including specific sites necessary for breeding, nesting, nursery and feeding; plant communities and physical features that help protect water quality; and reaches of bank, shore or bed which are predominately natural in appearance or that screen man-made or artificial features (Sefton & Graham, 2009).

The designation of critical habitat affects the decision process on Waterway and Wetlands Permits under Ch. 30, Wis. Statutes; and decisions on permitting of aquatic plant management under Ch. NR107 and NR109 of the Wis. Adm. Code. This did not mean these activities would be prohibited, but it did mean that they will undergo more careful review to ensure that the activity does not adversely affect the critical habitat in the area.

There were 20 areas designated as Critical Habitat for Lake Redstone. Fourteen of these were classified as Sensitive Areas for their aquatic vegetation and six were classified as Other Public Rights Features for containing reaches of shore that are predominately natural in appearance or that screen man-made or artificial features, and/or fish and wildlife habitat values. All are classified as Public Rights Features. Fourteen recommendations were made in the report to promote and protect the health of Lake Redstone (Sefton & Graham, 2009):

- Maintain natural shoreland buffers of native vegetation to protect water quality, fish and wildlife habitat and areas with predominantly natural appearance;
- Maintain snag and cavity trees for cavity nesting species, canopy trees for roosting and perching of birds and downed trees for wildlife habitat;
- Maintain the unique natural appearance of the sandstone cliffs and rock outcrops;
- Maintain hemlock-white pine relicts, minimize tree removal and maintain vegetative visual buffers that screen development;
- Maintain overhanging trees and shrubs, fallen trees along the shoreline and large woody cover and boulders in the water for fish and wildlife habitat;
- Encourage lakefront property owners to plant native vegetation (trees, shrubs, perennial forbs and grasses) as a buffer zone to reduce shoreline erosion and runoff of nutrients and other pollutants that affect water quality;
- Minimize removal of native aquatic vegetation to protect fish and wildlife habitat;
- Limit aquatic plant management to methods specific to exotics and/or for navigation channels and reasonable swimming or fishing areas;
- Update the Aquatic Plant Management Plan every 5 years to reflect current lake conditions and emerging management techniques;
- Control invasive plants;
- Maintain aquatic invasive signs at all boat landings to educate lake users about protecting the lake from introduction of new exotic species and consider establishing a Clean Boats, Clean Waters watercraft inspection program;
- Assess location and dimensions of proposed grading on the banks, dredging, placement of pea gravel beds or sand blankets, boat ramps, new or replacement piers, recreational devices such

as rafts or trampolines, and shoreline erosion control (subject to site-specific wave energy calculations) to protect water quality, fish and wildlife habitat and natural appearance;

- Encourage use of bio logs and native vegetation for shoreline erosion control, subject to review of site-specific wave energy calculations; and
- In locations of actively eroding shoreline, consider expanding slow-no-wake buffer zones to reduce erosion caused by boating.

2011 West Branch of Big Creek Watershed Sediment Management Study

In 2011 the LRPD commissioned a study by Montgomery Associates: Resource Solutions and General Engineering Company to evaluate the major sediment sources in the West Branch of Big Creek watershed (Figure 10) and to identify feasible sediment management measures (Montgomery Associates Resource Solutions, LLC, 2011). The study made use of previous studies, the knowledge of local residents and officials, and new field observations and analyses to come up with potential sediment management alternatives based on estimated annual soil loss from the West Branch portion of the watershed.

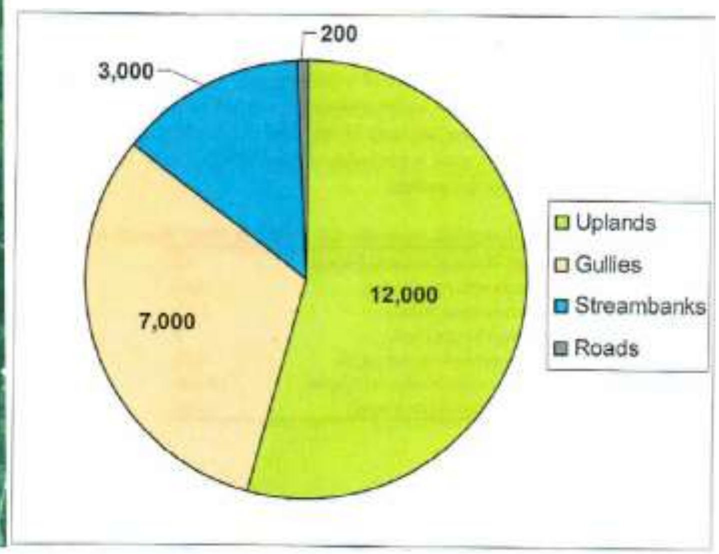


Figure 13 – West Branch of Big Creek portion of the Lake Redstone Watershed (left); estimated annual soil loss (right) (Montgomery Associates Resource Solutions, LLC, 2011)

The only recommendations to come from this study that are actually feasible are the following:

- Reduce upland soil loss through an advocacy role, working with Juneau and Sauk Counties, building relationships with farmers, providing educational information, and supporting and promoting the existing federal conservation programs including additional cost-sharing for specific BMPs,
- Implement targeted dredging to restore suitable lake depths in areas that have already experienced significant sediment buildup, and

- Determine the feasibility of installing structural sediment traps at high priority sites.

Aquatic Plant and Aquatic Invasive Species (AIS) Management Planning

Partly in response to the critical habitat designations, the LRPD hired a consultant in 2012 to help them develop a WDNR approvable aquatic plant management plan (APMP) for EWM, curly-leaf pondweed (CLP), purple loosestrife, and other AIS in Lake Redstone (Blumer, 2015). The same plan explored past and existing management actions for native aquatic plants. Several grants were received to help fund the APMP, and after its approval in 2015, additional grants have been applied for and received to implement it. The APMP made the following recommendations for management:

- Protect, preserve and enhance native aquatic plant communities in Lake Redstone,
- Complete annual monitoring and mapping of aquatic plants most affected by plant management actions,
- Implement physical/manual removal actions to control aquatic invasive species and nuisance growth of native aquatic plants,
- Implement herbicide application to control aquatic invasive species and nuisance growth of native aquatic plants,
- Monitor and manage non-native, invasive plant species other than CLP and EWM identified in Lake Redstone,
- Educate the lake populace so that they become well-acquainted with aquatic invasive species identification, prevention techniques, planning processes, and management actions,
- Promote greater understanding in the lake populace of how their actions impact the aquatic plant and lake community,
- Continue compilation and collection of lake related data to enhance and support current and future lake management planning and implementation,
- Complete APM Plan implementation and maintenance for a period of five years following adaptive management practices, and
- Evaluate and summarize the results of the management actions implemented during the 5-year timeframe of this plan and repeat the whole-lake point-intercept aquatic plant survey implemented in 2012.

Many of the recommendations/actions in the Critical Habitat Survey, Sediment Management Study, and Aquatic Plant Management Plan have been and are continuing to be implemented.

Sauk and Juneau County Projects 2012-2016

Both Sauk and Juneau Counties have been actively working with the LRPD to educate farmers in the watershed, provide cost-sharing for best management projects, improve communication with farmers, and brainstorming additional actions that could be done to reduce sediment and phosphorus loading from the watershed into Lake Redstone. Since 2012, many projects have been either implemented, discussed, or are still in a proposal stage. The following should only be considered a partial list, but represents the efforts being made.

- Dry Dam projects on several local farms

- Summer Intern working through the counties to communicate with farmers
- Feeder Stream Monitoring Projects to pinpoint significant sources of sediment and phosphorus
- Cost-sharing for no till and cover crops
- Cost-sharing to build manure storage containment structures and roofed barnyards
- Nutrient management planning
- Cover crop and rainfall simulator demonstrations
- Small waterway seeding projects
- Gully erosion repair projects
- Promotion of CRP, contour strips, and animal agriculture (hay and forage crops)
- Guest speakers on agricultural topics

Baraboo River Watershed Project (2015-2019)

In January 2015, the USDA announced that the Regional Conservation Partnership Program (RCPP) was going to fund the Baraboo River Watershed Project (BRWP) prepared by the Sauk County Conservation, Planning and Zoning Department in cooperation with Richland, Vernon, Monroe, Juneau, and Columbia Counties and the USDA/NRCS. The RCPP focuses on public-private partnerships enabling private companies, local communities and other non-government partners to invest in efforts to keep our land resilient and water clean, and promote tremendous economic growth in agriculture, construction, tourism and outdoor recreation, and other industries. With the BRWP, partners will collaborate to provide technical and financial assistance to agricultural producers and forest landowners to help implement conservation practices that improve soil health, water quality, restore wildlife habitat, and improve agricultural productivity. Common conservation practices include streambank stabilization, cover crops, nutrient management, and grassed waterways. The project runs from 2015-2019 and provides over $2 million in public-private conservation investments to the Baraboo River Watershed.

According to Melissa Keenan, Resource Conservationist for Sauk County the objectives of the BRWP are preventing soil loss on cropland and pastures; reducing agricultural runoff to surface and ground water; and improving aquatic and wildlife habitat. The first step in doing this is to identify priority farms through the Erosion Vulnerability Analysis for Agricultural Lands (EVAAL). EVAAL identifies areas within a watershed which may be vulnerable to soil erosion; assesses risk for sheet and rill erosion using USLE and gully erosion using the Stream Power Index (SPI) while de-prioritizing internally drained areas (IDA); and produces an erosion vulnerability index value which can be used to prioritize fields within the watershed. Once this is done, the goal is to address 50% of the soil loss using RUSLE2; agricultural runoff using SNAP Plus software and the Wisconsin Barnyard Runoff Model (BARNY). Aquatic and wildlife habitat will be improved by dedicating 10% of RCPP funds for aquatic and wildlife habitat monitoring and dissolved oxygen sampling within streams and the Baraboo River. Actions in this project include outreach and education, technical assistance, financial assistance, and stream monitoring for total phosphorus and total suspended solids, and biotic indices through macroinvertebrates (Keenan, 2015).

2016 Sediment Sampling Project

In preparation to potentially dredge Lake Redstone, the LRPD worked with Ayres Associates to sample deposited lake bed sediments, measure lake depths, and estimate the volume of deposited sediment.

The information included in the sediment sampling report will assist the LRPD with developing a dredging plan. The study provides the necessary information for a dredging company to enable them to determine the feasibility, scope, and cost for dredging the lake. A total of 26 bays on Lake Redstone were studied, with all of them under consideration for dredging activities (Ayres Associates, 2016). The LRPD is currently evaluating the data in the Ayres report to determine its next step in the dredging process.

Water Quality Summary - Lake

Over 15,000 lakes and 84,000 miles of streams and rivers in Wisconsin are managed to ensure that their water quality condition meets state and federal standards. Water quality standards (WQS) are the foundation of Wisconsin's water quality management program and serve to define goals for a waterbody by designating its uses, setting criteria to protect those uses, and establishing provisions to protect water quality from pollutants. Waters are monitored to collect water quality data to determine, or *assess*, its current status or condition. Water quality monitoring results and assessment data are stored in state and federal databases and the majority of data are available online to agencies and the public (Wisconsin Department of Natural Resources, 2016 (Draft Version)).

The WDNR uses four levels of condition to represent waters' placement in the overall water quality continuum (Figure 11). Waters assigned the condition category of excellent are considered to be attaining applicable WQS and fully supporting their assessed designated uses. Waters assigned the condition category of good or fair are also considered to be attaining applicable WQS and supporting their assessed designated uses. Waters assigned the poor condition category may not be attaining WQS or assessed designated use(s) (Wisconsin Department of Natural Resources, 2016 (Draft Version)).

According to the WDNR using one measure of a lakes health, chlorophyll as it relates to the amount of algae in the water and "trophic state" (discussed earlier in this report) Lake Redstone (considered a reservoir) is listed as "Poor" according to water quality standards in place in WI (Wisconsin Lakes Page).

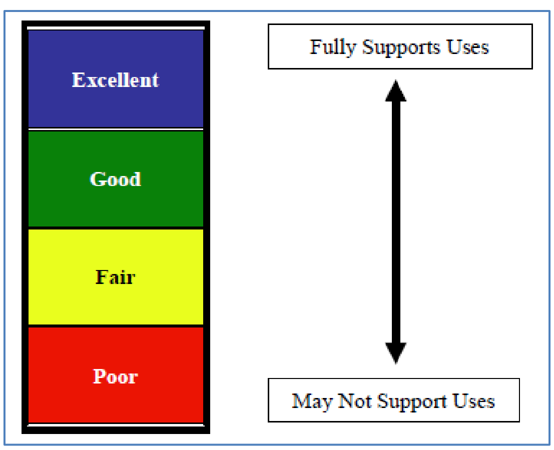


Figure 14 - General water condition continuum (Wisconsin Department of Natural Resources, 2016 (Draft Version))

In addition, to a general assessment of available data, specific assessments are conducted to determine if a waterbody is "impaired" or not meeting WQS. Waters that do not meet WQS are placed on

Wisconsin's Impaired Waters List—also known as the 303(d) list—under Section 303(d) of the Federal Clean Water Act (CWA). Wisconsin is required to submit list updates every 2 years to the United States Environmental Protection Agency (EPA) for approval. The methodology for conducting general and specific assessments is outlined, and updated for 2018, in this Wisconsin Consolidated Assessment and Listing Methodology (WisCALM) guidance document (Wisconsin Department of Natural Resources, 2016 (Draft Version)).

Lake Redstone was first listed on the Impaired Waters List in 2014 when data showed that total phosphorus exceeded listing thresholds for recreational use, but not for fish and aquatic life; and chlorophyll exceeded both recreational and fish and aquatic life use. The listing was confirmed in the most recent 2016 listing cycle. Listing thresholds for recreational uses in deep-lowland, drainage lakes or reservoirs are total phosphorus readings ≥0.030 mg/L for each of two years; and for chlorophyll a is >5% of days in the sampling season having nuisance algal blooms (>0.020 mg/L). For fish and wildlife, the listing threshold for total phosphorus is the same as recreational uses (≥0.030 mg/L); and for chlorophyll a is ≥0.027 mg/L or a TSI value ≥63 for each of two years.

Since at least 1980, lake volunteers and/or the WDNR have been collecting water quality data from Lake Redstone and its tributaries. Volunteers monitor water clarity with a black and white Secchi disk. Some also collect water samples, which are sent to the State Lab of Hygiene to be analyzed. Volunteers are the source of the majority of Wisconsin's lake water quality data. Lake Redstone is also part of DNR's long term trend monitoring project. Additional monitoring has been done through projects funded in part by WDNR Lake Grants and Aquatic Invasive Species Grants. There are several parameters that have been documented, each with its own role to play in the overall evaluation of water quality in and entering Lake Redstone. This report defines each parameter and where possible, summarizes the data.

This report attempts to compile all existing data for the lake and its tributaries and look for gaps. It goes further to interpret others analysis of the data and whether it is considered credible or not.

Water Clarity (Secchi Depth)

Water clarity is not a chemical property of lake water. It is an indicator or measure of water quality related to chemical and physical properties. Water clarity has two main components: true color (materials dissolved in the water) and turbidity (materials suspended in the water such as algae and silt). The algae population is usually the largest and most variable component. Water clarity often indicates a lake's overall water quality, especially the amount of algae present. Algae are natural and essential, but too much of the wrong kind can cause problems. Secchi disc readings are taken using an 8-inch diameter weighted disc painted black and white. The disc is lowered over the downwind, shaded side of the boat until it just disappears from sight, and then raised until it is just visible. The average of the two depths is recorded as water clarity.

Water color can affect the Secchi disc reading. The color of lake water reflects the type and amount of dissolved organic chemicals it contains. Color's main significance is aesthetic. Color may also reduce light penetration, slowing weed and algae growth. Many lakes possess natural, tan-colored compounds (mainly humic and tannic acids) from decomposing plant material in the watershed. Brown water can result from bogs draining into a lake. Before or during decomposition, algae may impart a green, brown or even reddish color to the water.

Turbidity is caused by particles of matter suspended in the water which dissipate light, which affects the depth at which plants can grow. Turbidity affects the aesthetic quality of water. Lakes receiving runoff from silt or clay soils often possess high turbidities. These values vary widely with the nature of the seasonal runoff. Suspended plants and animals also produce turbidity. Many small organisms have a greater effect than a few large ones. Turbidity caused by algae is the most common reason for low Secchi disc readings (Shaw, Mechenich, & and Klessig, 2003).

Secchi disc values vary throughout the summer as algal populations increase and decrease. Measuring several sites may be useful in some lakes, depending upon the uniformity of the lake. Year to year changes result from weather and nutrient accumulation. Weekly or biweekly Secchi records (April-October) over a number of years provide an excellent and inexpensive way to document long-term changes in water clarity. Table 1 lists the total number of Secchi disk readings for each of four sites in Lake Redstone. The Deep Hole is the original Citizen Lake Monitoring Network sample site and the site of WDNR long-term trend monitoring. The remaining three sites were added in the late 1990's.

Table 1 – Secchi Disk Readings of Water Clarity on Lake Redstone

Monitoring Site	Years	Months	# of Readings	Average (ft)	Min (ft)	Max (ft)
Winnebago (north)	1999-2016	April-October	97	3.64	1.5	15
Mourning Dove (middle)	1999-2016	April-October	96	3.81	1.5	14
Navajo (south)	1999-2016	April-October	106	4.56	1.6	22.96
Deep Hole	1980-2016	April-October	193	4.15	1	15.75

Chlorophyll *a*

Chlorophyll *a* is perhaps the single most important parameter in the assessment of the water quality of lakes, particularly in regard to how enriched they are due to the presence of nutrients such as phosphorus and - to a much lesser extent - nitrogen in the form of nitrate. Chlorophyll is the green pigment in most plants including algae. Excessive nutrient presence in lakes promotes the growth of algae which in overabundance cause serious environmental problems. In over-enriched - eutrophic - lakes "algal blooms" can occur. These are surface accumulations of cyanobacteria (formerly classified as blue-green algae), i.e. dense masses of algae which can be swept by the winds into bays or along the lake shore (where they can decay, causing further problems), and which can seriously disrupt the dissolved oxygen regime (Environmental Protection Agency - Ireland, 2001).

In day time, when conditions are bright or sunny, chlorophyll in the algae will carry out photosynthesis, consuming carbon dioxide and releasing oxygen to the waterbody. In darkness, however, the algae respire, consuming dissolved oxygen the levels of which may become critically low - low enough to cause fish mortality. Cyanobacteria, also known as blue-green algae can release trace organic components which can prove toxic to animals ingesting the water in which they are present; and give rise to taste and odor problems if the water is used as drinking water source.

Table 2 lists the total number of chlorophyll a samples collected at each of four sites in Lake Redstone. The Deep Hole is the original Citizen Lake Monitoring Network sample site and the site of WDNR long-term trend monitoring. The remaining three sites were added in the mid 2000's.

Table 2 – Chlorophyll a sampling results on Lake Redstone

Monitoring Site	Years	Months	# of Readings	Average (mg/L)	Min (mg/L)	Max (mg/L)
Winnebago (north)	2005-2016	June-October	40	0.045	0.0028	0.0925
Mourning Dove (middle)	2005-2016	June-October	39	0.042	0.0028	0.0971
Navajo (south)	2000, 2005-2016	June-October	44	0.033	0.0035	0.0845
Deep Hole	1980, 1988-2000, 2002, 2007-2016	June-October	68	0.037	0.003	0.0859

Phosphorus (P)

Phosphorus originates from a variety of sources, many of which are related to human activities. Major sources include human and animal wastes, soil erosion, detergents, septic systems and runoff from farmland or lawns (Shaw, Mechenich, & and Klessig, 2003). The significance of phosphorus is principally in regard to the phenomenon of eutrophication (over-enrichment) of lakes and, to a lesser extent, rivers. Excess phosphorus in water bodies, along with nitrogen as nitrate, promotes the growth of algae and other plants often leading to excess aquatic plant growth, algal blooms, shallow water slimes, and other problems. In more than 80% of Wisconsin's lakes, phosphorus is the key nutrient affecting the amount of algae and weed growth (Shaw, Mechenich, & and Klessig, 2003). Soluble reactive phosphorus (also referred to as orthophosphates) is phosphorus in a dissolved state and is most readily used by aquatic plants and algae. Particulate phosphorus attaches to soil and can be carried into a lake by surface runoff and build up in the sediment of the lake. Total phosphorus (TP), measured in mg/L is a combined measurement of soluble reactive and particulate phosphorus in the lake.

TP is measured in the surface water and often within a foot or two of the bottom of the lake. Surface TP measures what is currently in the water from surface water runoff and mixing with bottom waters. Bottom TP is used to measure the amount of TP being released from the sediment at the bottom of the lake and is typically higher than TP concentrations at the surface, particularly in areas of the lake where sediment builds up. On Lake Redstone this means the Deep Hole by the dam and at the Navajo (southern) sampling site.

Table 3 lists the total number of surface water TP samples collected at each of four sites in Lake Redstone. The Deep Hole is the original Citizen Lake Monitoring Network sample site and the site of WDNR long-term trend monitoring. The remaining three sites were added in the mid 2000's. Table 4 lists the total number of bottom water TP samples that were collected at each of four sites.

Table 3 – Surface water Total Phosphorus sampling results on Lake Redstone

Monitoring Site (surface)	Years	Months	# of Readings	Average (mg/L)	Min (mg/L)	Max (mg/L)
Winnebago (north)	2005-2016	Mar-Oct	54	0.064	0.021	0.129
Mourning Dove (middle)	2000, 2005-2016	Mar-Oct	57	0.066	0.023	0.236
Navajo (south)	2000, 2005-2016	Mar-Oct	65	0.081	0.02	0.851
Deep Hole	1988-2000, 2002, 2004, 2006-2016	Feb-Oct	102	0.051	0.012	0.195

Table 4- Bottom water Total Phosphorus sampling results on Lake Redstone

Monitoring Site (bottom)	Years	Months	# of Readings	Average (mg/L)	Min (mg/L)	Max (mg/L)
Winnebago (north)	2009-2016	Jan-Oct	51	0.072	0.038	0.14
Mourning Dove (middle)	2009-2016	Jan-Oct	62	0.113	0.024	0.692
Navajo (south)	2009-2016	Jan-Oct	61	0.326	0.0369	1.2
Deep Hole	1988-2000	Feb-Oct	60	0.317	0.012	1.5

Table 5 lists the total number of surface water orthophosphate samples collected at each of four sites in Lake Redstone. The Deep Hole is the original Citizen Lake Monitoring Network sample site and the site of WDNR long-term trend monitoring. The remaining three sites were added in the mid 2000's. Table 6 lists the total number of bottom water TP samples that were collected at each of four sites.

Table 5 – Surface water orthophosphates (soluble reactive phosphorus) sampling results on Lake Redstone

Monitoring Site (surface)	Years	Months	# of Readings	No Detects (ND)	Average (mg/L)	Min (mg/L)	Max (mg/L)
Winnebago (north)	2006-07	May-Oct	9	2	0.011	0.002	0.04
Mourning Dove (middle)	2006-07	May-Oct	9	4	0.0134	0.003	0.048
Navajo (south)	2006-07	May-Oct	9	3	0.014	0.003	0.059
Deep Hole	1989-91, 1993,1996-99	April	8	3	0.007	0.003	0.018

Table 6 - Bottom water orthophosphates (soluble reactive phosphorus) sampling results on Lake Redstone

Monitoring Site (bottom)	Years	Months	# of Readings	No Detects (ND)	Average (mg/L)	Min (mg/L)	Max (mg/L)
Winnebago (north)	2006-07	May-Oct	9	2	0.009	0.002	0.043
Mourning Dove (middle)	2006-07	May-Oct	8	2	0.02	0.003	0.059
Navajo (south)	2006-07	May-Oct	8	1	0.061	0.003	0.159
Deep Hole	1989-91, 1993,1996-99	April	8	3	0.0074	0.004	0.021

A surface water concentration of total phosphorus below 0.02 mg/l for lakes and 0.03 mg/l for impoundments should be maintained to prevent nuisance algal blooms. Ideally, soluble reactive phosphorus concentrations should be 0.01mg/l or less at spring turnover to prevent summer algae blooms. TP and orthophosphate concentrations in Lake Redstone exceed these values more often than not since sampling began.

Iron (Fe) and Aluminum (Al)

Phosphorus does not dissolve easily in water. It forms insoluble precipitates (particles) with calcium, iron, and aluminum. In areas of Wisconsin where limestone is dissolved in the water marl (calcium carbonate), precipitates and falls to the bottom. Marl formations absorb phosphorus, reducing its overall concentration as well as algae growth in a lake.

Phosphorus can only bind with iron if oxygen is present. The amount of iron that might react with phosphorus varies widely in Wisconsin lakes. Lakes in the southern part of the state are often low in iron due to a higher pH and more sulfur, both of which limit iron solubility. This in turn affects whether phosphorus mixed into lakes during fall turnover precipitates or stays in solution during the winter. When lakes lose oxygen in winter or when the deep water (hypolimnion) loses oxygen in summer, iron and phosphorus again dissolve in water. Strong summer winds or spring and fall turnover may mix iron and phosphorus with surface water. For this reason, algae blooms may still appear in lakes for many years even if phosphorus inputs are controlled.

Phosphorus control has been attempted in some lakes by adding iron or another metal (aluminum) to precipitate phosphorus. Sewage treatment plants use the same process to remove phosphorus, using alum (aluminum sulfate) to bind with phosphorus. Unlike the precipitate that is formed when iron and phosphorus bind, the precipitate formed when aluminum and phosphorus bind does not re-dissolved when oxygen is depleted.

Manganese (Mn)

As with iron, manganese is found widely in soils and is a constituent of many ground waters. It, too, may be brought into solution in reducing conditions and the excess metal will be later deposited as the water is reaerated. Normally manganese is contained in bottom sediments as insoluble particulate oxides, but when oxygen near the sediment surface becomes depleted, manganese is converted from oxide forms that are insoluble through bacterial action to manganese ions which are very soluble and now leach out of the sediments. A manganese concentration of just 0.5 mg/L is ten times the drinking water standard and can cause significant color, staining, and taste problems (Environmental Protection Agency - Ireland, 2001).

Sulfate (S) and Chloride (Cl)

Sulfate in lake water is primarily related to the types of minerals found in the watershed and to acid rain. Industries and utilities that burn coal, release sulfur compounds into the atmosphere that are then carried into lakes by rainfall. In Wisconsin, the highest lake sulfate levels are found in the southeast portion of the state where mineral sources and acid rain are more common. In water depleted of oxygen (anaerobic water), sulfate can be reduced to hydrogen sulfide. Hydrogen sulfide gas smells like rotten eggs and is toxic to aquatic organisms (Shaw, Mechenich, & and Klessig, 2003).

The presence of chloride where it does not occur naturally indicates possible water pollution. Chloride does not affect plant and algae growth and is not toxic to aquatic organisms at most of the levels found in Wisconsin. Chloride is not common in Wisconsin soils, rocks or minerals, except in areas with limestone deposits. Sources of chloride include septic systems, animal waste, potash fertilizer (potassium chloride), and drainage from road-salting chemicals. Increases in chloride, either seasonally or over time, can mean that one or more of these sources are affecting the lake. An increase in chloride from human or animal waste suggests that other nutrients are also entering the lake. Higher chloride concentrations from spring to fall may be the effect of lawn fertilizer runoff or septic systems during heavy use by summer residents. Higher values in spring after the snow melts may signify runoff from drainage basins or highways as a major source of chloride. Since lakes vary in their natural chloride content, it is important to have background data or a long term database to document changes (Shaw, Mechenich, & and Klessig, 2003).

Nitrogen (N)

Measured in mg/L, nitrogen is second only to phosphorus as an important nutrient for plant and algae growth. A lake's nitrogen sources vary widely. Nitrogen compounds often exceed 0.5 mg/l in rainfall, so that precipitation may be the main nitrogen source for seepage and some drainage lakes. In most cases, however, the amount of nitrogen in lake water corresponds to local land use. Nitrogen may come from fertilizer and animal wastes on agricultural lands, human waste from sewage treatment plants or septic systems, and lawn fertilizers used on lakeshore property. Nitrogen may enter a lake from surface runoff or groundwater sources.

Nitrogen exists in lakes in several forms. Inorganic forms which include Nitrate (NO3), Nitrite (NO2), and Ammonia (NH4) and can be used by aquatic plants and algae. If these inorganic forms of nitrogen exceed 0.3 mg/l (as N) in spring, there is sufficient nitrogen to support summer algae blooms. Total Kjeldahl nitrogen (TKN) is the combination of organically bound nitrogen and ammonia in the water. Organic nitrogen is often referred to as biomass nitrogen.

Nitrogen does not occur naturally in soil minerals, but is a major component of all organic (plant and animal) matter. Decomposing organic matter releases ammonia, which is converted to nitrate if oxygen is present. This conversion occurs more rapidly at higher water temperatures. In about 10% of Wisconsin's lakes, nitrogen (rather than phosphorus) limits algae growth. This occurs when the ratio of total nitrogen to total phosphorus is less than 10:1.

Larger plants also need nitrogen and may depend on spring runoff for septic systems to recharge the sediments with nitrogen. Growth of Eurasian milfoil has been correlated with such fertilization of the sediment.

Nitrogen data has been collected at the Deep Hole Site in Lake Redstone (Table 7).

Table 7 – Nitrogen Samples from the Deep Hole on Lake Redstone

Monitoring Site (surface)	Years	# of Readings	No Detects (ND)	Average (mg/L)	Min (mg/L)	Max (mg/L)
NH3 (ammonia)	89-91,93-97,99	16	4	0.178	0.005	0.524
TKN (Total Kjeldahl Nitrogen)	89,91,93-97,99,2002,2006-16	32	0	0.857	0.49	1.3
Nitrite and Nitrate (NO3 & NO2)	89-91,93-97,99,2002,2006-16	29	19	0.466	0.0373	0.71
Monitoring Site (bottom)	**Years**	**# of Readings**	**No Detects (ND)**	**Average (mg/L)**	**Min (mg/L)**	**Max (mg/L)**
NH3 (ammonia)	88-91,93,95-96,99-2000	16	0	1.999	0.206	5.74
TKN (Total Kjeldahl Nitrogen)	89,91,93,95-96,99,2002	9	0	1.929	0.6	5.64
Nitrite and Nitrate (NO3 & NO2)	89-91,93,95-96,99,2002	10	1	0.357	0.015	0.589

Sodium (Na) and Potassium (K)

Since natural levels of sodium and potassium ions in soil and water are very low, their presence may indicate lake pollution caused by human activities. Sodium is often associated with chloride. It finds its way into lakes from road salt, fertilizers, and human and animal waste. Potassium is the key component of commonly used potash fertilizer, and is abundant in animal waste. Both are measured in mg/L. Soils retain sodium and potassium to a greater degree than chloride or nitrate; therefore, sodium and potassium are not as useful as pollution indicators. Increasing sodium and potassium values over time can mean there are long-term effects caused by pollution. Although not normally toxic themselves, these compounds strongly indicate possible contamination from more damaging compounds (Shaw, Mechenich, & and Klessig, 2003).

Heavy Metals

Heavy metals refer to a group of elements that are generally considered toxic in a lake. The most commonly referred to metals in this category are arsenic, copper, mercury, and zinc, but it includes many more. The term "heavy metals" is in reference to the high atomic weights of several metals in the broad group, although other metals regarded as in the same group have low atomic weights. Nonetheless, the term both is widely current and a useful descriptor. The following is a listing of the more commonly referred to metals in this class: Antimony, Cobalt, Nickel, Tin, Arsenic, Copper, Selenium, Titanium, Beryllium, Lead, Silver, Uranium, Cadmium, Mercury, Tellurium, Vanadium, Chromium, Molybdenum, Thallium, and Zinc. These individual substances are all more or less toxic to either man or fish or both, and their presence is highly undesirable in raw or finished public waters or in fishery waters, salmonid or cyprinid (Environmental Protection Agency - Ireland, 2001).

Alkalinity and Hardness, Magnesium (Mg), Calcium (Ca)

Measured in mg/L of $CaCO_3$, the alkalinity of natural water is generally due to the presence of bicarbonates formed in reactions in the soils through which the water percolates. Calcium (Ca) and magnesium (Mg) are the primary ions measured when determining alkalinity. Alkalinity is a measure of the capacity of the water to neutralize acids and it reflects its so-called buffer capacity (its inherent resistance to pH change) (Environmental Protection Agency - Ireland, 2001). The amount of alkalinity largely determines lake water's pH. Water with low alkalinity has low pH value (high acid) and highly alkaline lakes have pH values above 7. A poorly buffered water will have a low or very low alkalinity and will be susceptible to pH reduction by, for example, "acid rain."

A lake's hardness and alkalinity are affected by the type of minerals in the soil and watershed bedrock, and by how much the lake water comes into contact with these minerals. If a lake gets groundwater from aquifers containing limestone minerals such as calcite (CaCO3) and dolomite (CaMgCO3), hardness and alkalinity will be high. High levels of hardness (greater than 150 mg/l) and alkalinity can cause marl (CaCO3) to precipitate out of the water (Shaw, Mechenich, & and Klessig, 2003).

Hard water lakes tend to produce more fish and aquatic plants than soft water lakes. Such lakes are usually located in watersheds with fertile soils that add phosphorus to the lake. As a balancing mechanism, however, phosphorus precipitates with marl, thereby controlling algae blooms (Shaw, Mechenich, & and Klessig, 2003).

If the soils are sandy and composed of quartz or other insoluble minerals, or if direct rainfall is a major source of lake water, hardness and alkalinity will be low, leading to soft water lakes. This is the case in much of northern Wisconsin, where glacial deposits contain little limestone or other soluble minerals. Lakes with low amounts of alkalinity are more susceptible to acidification by acid rain and are generally unproductive (Shaw, Mechenich, & and Klessig, 2003).

In Wisconsin, hard water lakes have a total alkalinity that equals or exceeds 50 mg/L. Hard water lakes are less susceptible to acidification because they have a high concentration of hydroxyl, carbonate, and/or bicarbonate ions, which buffer acids. Soft water lakes have a total alkalinity that is less than 50 mg/L. Soft water lakes have low capacity to buffer acids. Lake Redstone is a hard water lake.

Acidity (pH)

The acidity of lake water is measured on a pH scale with values ranging from 0-14. A substance like pure, distilled water with a pH of 7 on the scale is considered neutral, neither acidic nor basic in nature. The lower the pH value the more acidic the water. The higher the value the more basic the water is. In Wisconsin, pH ranges from 4.5 in some acid bog lakes to 8.4 in hard water, marl lakes. A lake with a pH of 6 is ten times more acid than a lake with a pH of 7. While moderately low pH does not usually harm fish, the metals that become soluble under low pH can be important. In low pH water, aluminum, zinc and mercury concentrations increase if they are present in lake sediment or watershed soils (Shaw, Mechenich, & and Klessig, 2003).

Mercury levels in fish are high in acidified lakes. While not usually toxic to fish, high aluminum and mercury levels pose a health problem for loons, eagles, osprey and humans who eat chemically tainted fish. Some aquatic organisms appear unable to maintain calcium levels when pH is low, and consequently develop weak bones and shells (Shaw, Mechenich, & and Klessig, 2003).

Surface water pH values outside of the 6-9 range or changes >0.5 units outside of the natural seasonal maximum (mean) and minimum (mean) are considered impaired (Wisconsin Department of Natural Resources, 2016 (Draft Version)). Lake Redstone has an average pH over time of 7.67.

Conductivity

Conductivity or (specific conductance) measures water's ability to conduct an electric current. Conductivity is reported in micromhos per centimeter (µmhos/cm) and is directly related to the total dissolved inorganic chemicals in the water. Values are commonly two times the water hardness unless the water is receiving high concentrations of contaminants introduced by humans. In itself conductivity is a property of little interest to a water analyst but it is an invaluable indicator of the range into which hardness and alkalinity values are likely to fall, and also of the dissolved solids content of the water (Environmental Protection Agency - Ireland, 2001). Conductivity measurements are often used to determine if septic systems are leaking into a lake as the conductivity in the water near a leaking system will typically be higher than in other parts of the lake.

Table 8 reflects data from additional water quality parameters collected at the Deep Hole on Lake Redstone between 1980 and 2016 by the WDNR and lake volunteers. Similar data exists at least three other sites, but not as much.

Table 8 – 1980-2016 Water quality parameters from the Deep Hole on Lake Redstone

Other Water Quality Parameters - Deep Hole				
Parameter	**# of Samples**	**Average (mg/L)**	**Min (mg/L)**	**Max (mg/L)**
Iron	21	0.61	0.1	3.5
Manganese	16	0.5175	0.13	1
Sulfate	18	5.76	3	8
Chloride	17	5.48	4.2	7
Sodium	18	2.93	2	3.3
Potassium	18	2.45	1.3	4.6
Heavy Metals (Copper, mg/kg)	30	16.86	2.1	40
Alkalinity	61	132.5	79.6	541
Hardness	8	116.63	93	130
Magnesium	18	13.61	10	18
Calcium	27	27.86	21	37
Acidity (pH, 0-14)	279	7.67	2.1	10.69
Conductivity (umhos/cm)	216	238.93	163.5	339

Temperature and Dissolved Oxygen (DO)

Oxygen (O2) is the most important of the gases dissolved in water, since most aquatic organisms need it to survive. The solubility of oxygen and other gases depends on water temperature. The colder the water, the more gases it can hold. Boiling water removes all gases.

Oxygen is produced whenever green plants grow, even under water. Plants use carbon dioxide and water to produce simple sugars and oxygen, using sunlight as the energy source. Chlorophyll, the green pigment in plants, absorbs sunlight and serves as the oxygen production site. This process is called photosynthesis. Photosynthesis occurs only during daylight hours and only to the depths where sunlight penetrates. The amount of photosynthesis depends on the quantity of plants, nutrient availability, and water temperature. Plants and animals also constantly use oxygen to break down sugar and obtain energy by a process called respiration, basically the reverse of the photosynthesis.

During daylight hours, it is not uncommon to find extremely high oxygen values in surface waters (supersaturation), while at night or early morning before photosynthesis begins they may fall below those values. At lake depths below the reach of sunlight, the only reaction that occurs is oxygen-consuming respiration. The deep waters of productive lakes often experience oxygen depletion in the bottom waters.

Deep lakes in Wisconsin will usually stratify during the summer months. Stratification means the water in the lake separates into distinct levels due to temperature and water density. Warm water has less density than cold water and will rise to the upper reaches of the lake's water column in the summer. Cold water, which is denser, will sink to the lower depths of the lake. Two distinct layers are formed: warm, oxygen rich water at the surface of the lake; and cold, oxygen depleted water at the bottom of the lake. The two distinct layers are separated by a layer known as the thermocline. The thermocline effectively prevents oxygen rich surface water from mixing with oxygen depleted bottom water (Shaw, Mechenich, & and Klessig, 2003). Shallow lakes or lakes with shallow areas will usually stay mixed all year maintaining adequate levels of dissolved oxygen.

Concentrations of phosphorus, ammonia, iron and manganese are greatly influenced by the presence or lack of oxygen in lake water and sediments. Ammonia is a breakdown product of proteins. When little or no oxygen is present at the sediment-water interface, concentrations of ammonia can be quite high. Ammonia is toxic and represents a threat to aquatic life. Sediments in lakes can contain a lot of iron, manganese and phosphorus. These can be released in large quantities from the bottom of the lake when oxygen levels are very low (Environmental Protection Agency - Ireland, 2001). Phosphorus released from the sediment under oxygen depleted condition is called internal loading, which is often the cause of summer algae blooms in Wisconsin lakes.

Dissolved oxygen and temperature profiles were collected at the Deep Hole (36-ft) of Lake Redstone in 1999, 2004, and from 2006-2016. A profile includes collecting a reading for DO and Temp roughly every meter from the surface to the bottom. These data indicate that at the Deep Hole, Lake Redstone stratifies with the thermocline establishing between 3 & 4 meters from late May through September. Oxygen depletion in the area below the thermocline occurs from June through early September.

Dissolved oxygen and temperature profiles collected at three other sites: Winnebago (north, 14-ft deep), Mourning Dove (middle, 20-ft deep), and Navajo (south, 30-ft deep) between 1998 and 2016 indicate that Lake Redstone stratifies in all but the northern portion of the lake at around 3-4 meters between late June and early September. Oxygen depletion occurs below 14-ft from late June through early September.

Water Quality Summary – Tributaries

Lake Redstone is an impound on Big Creek. There are two main branches of Big Creek that drain more than 19,000 acres to the lake. The West Branch of Big Creek drains approximately half of the entire watershed and the East Branch and immediate shoreland around the lake drains the rest. Water quality data including total phosphorus (TP), orthophosphates (ortho), total suspended solids (TSS), dissolved oxygen (DO), temperature, and flow/volume has been collected, with major years for data collecting in 2006-07, and 2010-2014. Figure 12 shows all the sites where water quality data has been collected. There are several other sites where biotic indices (macroinvertebrates) have been measured.

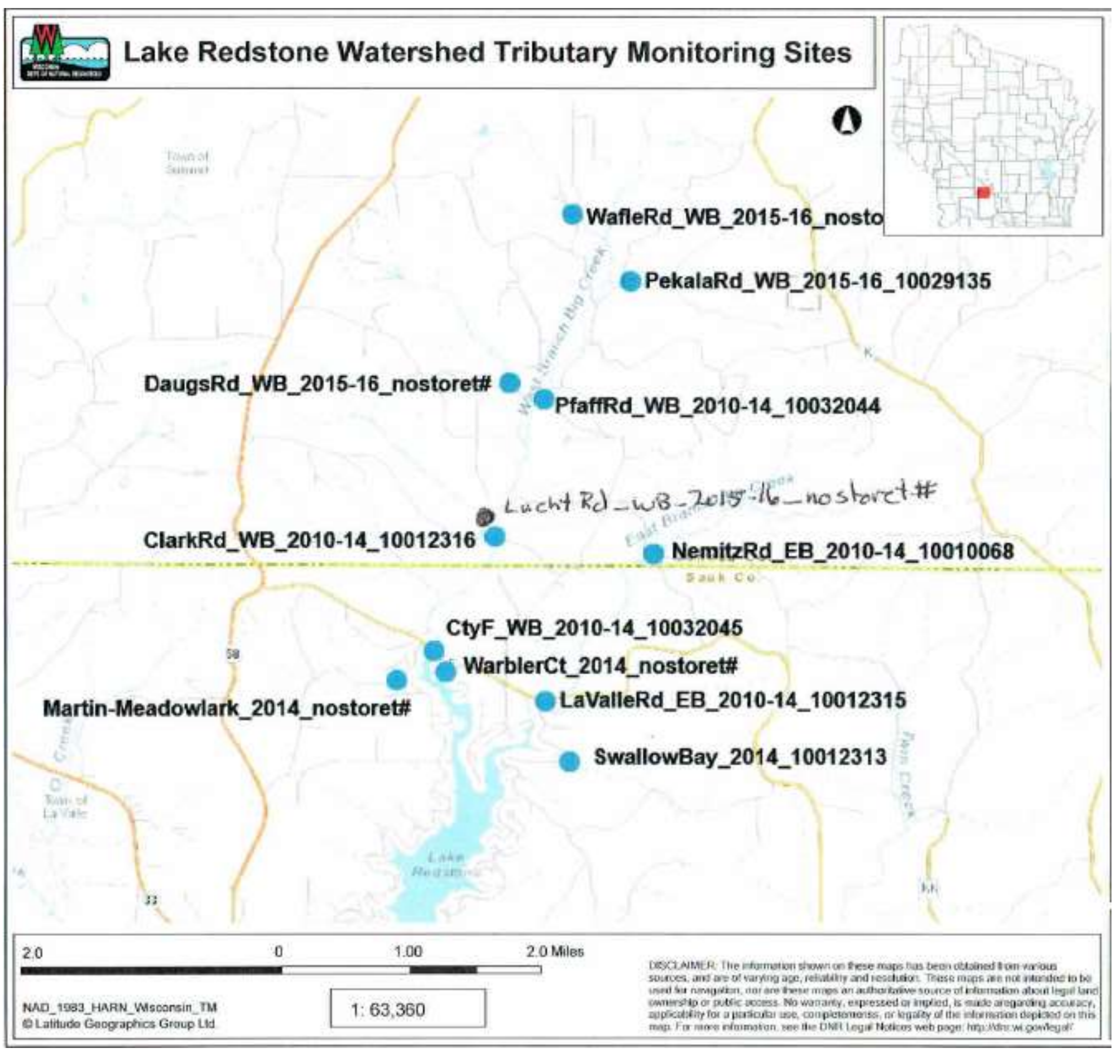


Figure 15 – Lake Redstone Watershed Tributary Monitoring Sites for Water Quality

Table 9 reflects TP and TSS data for the sites in Figure 12. TP averages ≥0.075 mg/L in streams is considered past the threshold for an impaired water (Wisconsin Department of Natural Resources, 2016 (Draft Version)). Table 10 reflects ortho data for the sites in Figure 12.

Table 9 – Lake Redstone Watershed Tributary Water Quality Data 2006-07, 2010-14, 2015-16

Lake Redstone Watershed Tributary Data - 2006-07, 2010-14, 2015-2016								
Site Name	**Branch**	**Storet#**	**Years**	**Samples**	**Ave-TP**	**Min-TP**	**Max-TP**	**Ave-TSS**
Wafle Road	West	none	2015-16	12	0.104	0.08	0.12	7.74
Pekala Road	West	10029135	2015-16	11	0.088	0.067	0.12	17.3
Daugs Road	West	none	2015-16	12	0.099	0.069	0.16	25.24
Lucht Road	West	none	2015-16	12	0.082	0.068	0.11	15.06
Pfaff Road	West	10032044	2010-14	12	0.159	0.084	0.473	13.07
Clark Road	West	10012316	2006-07, 2010-14	50	0.141	0.059	0.447	9
Cty F	West	10032045	2010-14	11	0.171	0.079	0.286	9.16
Nemitz Road	East	10010068	2010-14	12	0.11	0.048	0.295	10.45
LaValle Road	East	10012315	2006-07, 2010-14	50	0.166	0.032	0.981	14.57
Warbler Court	Lake	none	2015-16	12	0.079	0.039	0.13	3.84
Martin-Meadowlark	Lake	none	2014	?	0.08			7.23
Swallow Bay	Lake	10012313	2006-07, 2014	17	0.353	0.077	1.26	21.87

Table 10 – Lake Redstone Watershed Tributary Water Quality Data – Orthophosphates, 2006-07, 2010-14, 2015-16

Lake Redstone Watershed Tributary Data - 2006-07, 2010-14, 2015-2016							
Site Name	**Branch**	**Storet#**	**Years**	**Samples**	**Ave-Ortho**	**Min-Ortho**	**Max-Ortho**
Wafle Road	West	none	2015-16	12	0.067	0.046	0.089
Pekala Road	West	10029135	2015-16	11	0.055	0.015	0.096
Daugs Road	West	none	2015-16	12	0.042	0.026	0.064
Pfaff Road	West	10032044	2010-13	11	0.055	0.02	0.077
Clark Road	West	10012316	2006-07, 2010-13	48	0.063	0.017	0.259
Cty F	West	10032045	2010-13	10	0.047	0.023	0.081
Nemitz Road	East	10010068	2010-13	11	0.047	0.024	0.09
LaValle Road	East	10012315	2006-07, 2010-13	49	0.049	0.008	0.184
Warbler Court	Lake	none	2015-16	12	0.013	0.005	0.021
Martin-Meadowlark	Lake	none	2014	?			
Swallow Bay	Lake	10012313	2006-07	16	0.089	0.032	0.257

Recommendations for Future Management Planning and a Lake Management Planning Grant Application

Based on a thorough review of the data collected on Lake Redstone, its tributaries, and watershed the following recommendations are suggested.

Lake Shoreland and Shallows Habitat Assessment Survey

Recent guidance documents provided by the WDNR has created a standard methodology for surveying, assessing, and mapping habitat in lakeshore areas, including the Riparian Buffer, Bank, and Littoral Zone (WDNR; UW-Estension; Green, Jefferson, Waupaca County Land and Water Conservation Dept., 2016). The data collected provides important and useful information resource managers, community stakeholders, and others who are interested in protecting and enhancing Wisconsin's lakes. Data collected can be used for any or all of the following:

- Teaching and outreach
- Prioritizing areas in need of improvements
- Identifying areas for protection and restorations
- Creating lake management plans
- Creating county comprehensive plans
- Aiding management at the county level
- Planning aquatic plant management
- Evaluation trends in lakeshore habitat over time
- Understanding trends in lake ecology (fish, wildlife, invasive species.

Examples of information gathered lake-wide through this survey include the % of impervious surface, mowed lawn or plants in the Riparian Buffer Zone; number of parcels around the lake with erosion concerns; total length of modified banks; density of human structures within 35-ft of the lakeshore; and density of coarse woody habitat in the lake.

The condition of the shoreline/land around Lake Redstone has been a concern, as many of the lots touching the lake are fully developed with mowed lawn to the edge of the water. There has been discussion related to ways to encourage property owners to make improvements to their shores either on their own or as prerequisites to aquatic plant treatment or dredging adjacent to their properties. Demonstration sites were even set up in years past. Recent grant funding through the WDNR Healthy Lakes Initiative makes it possible to get state cost-sharing to install small-scale shoreland BMPs including native plantings, rain gardens, runoff diversions, French drains, and Fish Sticks habitat improvement projects. All it takes is the commitment of the property owner to take part. By completing a shoreland assessment like discussed here, the LRPD would have a document that could guide years of implementation projects based on high, moderate, or low priority need for each parcel. Each parcel would be evaluated and prioritized using the same system, eliminating any perceived bias. The document would also give the LRPD information that could be used if it is ever decided to base plant management or dredging on the condition of the adjacent shoreline. The assessment would also fulfill one of the recommendations of Sauk County, for the LRPD to support a massive shoreland buffer/rain garden campaign on the lake. This recommendation was made by Sauk County in response to a question about how the LRPD could support County efforts.

Sediment Pond Feasibility Study

In the past, sediment ponds/traps have been installed at the head of several washes into Lake Redstone. The 2011 Sediment Management Study recommended installing sediment traps at high priority sites across the entire watershed however, with an estimated 800 gullies in the West Branch watershed alone, literally hundreds could be installed. Recent conversations between the LRPD and the WDNR have suggested that cleaning out previously installed traps could be considered an important first step, followed, perhaps by a feasibility study to look at just the heads of the multiple bays on Lake Redstone to determine whether additional sediment traps similar to the one installed at the head of Mourning Dove Bay (Figure 16) would be effective sediment management tools.

Figure 16- Sediment Trap at Mourning Dove Bay (Montgomery Associates Resource Solutions, LLC, 2011)

Dredging

Related to building sediment traps, is dredging of multiple bays within Lake Redstone. Dredging has been a discussion item for at least the last 10 years, or longer. Back in the 1980's, 20 years after Lake Redstone was build, dredging of many of the bays was completed. Since that time, many BMPs have been installed on and around the lake and in the watershed to reduce sediment loading. These actions have reduced the sediment load to the lake, and more are planned to further reduce it. This bodes well for a dredging project, as it would be expected that cleaning the bays out to get them back to depths recorded in the 1980's would maintain them for many years to come, perhaps 30-40 years verses the 25 years gained from the last dredging project.

While the discussion of dredging has been going on for 10 years or more, getting to the point where it could actually be implemented has taken quite a bit of time. However, it is now a realistic management action that could be implemented as soon as 2018. A big step forward was the completion of the Sediment Sampling Project by Ayres Associates in 2016. Through this study, 26 bays in Lake Redstone were measured for lake depth, sampled for deposited lake bed sediments, and the volume of deposited sediment estimated. Additionally, sediment samples were collected from each bay and sent to a lab for chemical and physical analysis.

Through this study, significant amounts of sediment were observed in most, but not all bays. Only arsenic exceeded accepted thresholds of safety, and only or Non-Industrial Direct Contact and Soil to Groundwater. According to the study, high arsenic levels will not be an issue for dredging work, as the level is well below the Surficial Soils Background Threshold Value (BTV) for arsenic (8 parts per million) set by the WDNR's Remediation and Redevelopment Program in 2013 (WDNR, 2013). The BTV for surface soils is based on a summary of USGS soil data from 664 locations across the state of Wisconsin, collected in 2006 and 2007.

The LRPD is moving forward with plans to implement dredging actions in at least the worst bays identified in 2016, with 2018 being the first year dredging actions will likely take place.

Native Aquatic Plant Restoration

Aquatic plant management actions over the last 5-years or longer have stressed the importance of protecting native aquatic vegetation while removing EWM. One of the concerns with dredging of the bays is that native vegetation that has made a comeback in certain bays of the lake will be again set back by dredging activities. It is possible that the areas could be left alone to naturally recover after disturbance, with selective control of EWM to reduce its impact on native vegetation. However a more direct action would be to include re-establishing native aquatic vegetation in post-dredging plans. There are many ways to do this, but traditionally it is a difficult task with limited success. Evaluating the methods of re-establishing native aquatic vegetation and coming up with a plan that might work on Lake Redstone after dredging occurs is an important action in support of dredging and should be included in the next lake management planning project.

Adding Nitrogen Parameters to Water Quality Sampling

Two other actions have been suggested for future management planning. To date, little nitrogen data has been collected from the lake and tributaries. Since nitrogen, along with phosphorus can be a significant factor in the fertility of a lake system, it has been suggested that water sampling include nitrogen variables. The forms of nitrogen that are of greatest interest to lake studies are nitrate-nitrite nitrogen ($NO_3 + NO_2$), total ammonia nitrogen (NH_4), and total Kjeldahl nitrogen (TKN). The inorganic nitrogen forms (nitrate and ammonia) are readily utilized by algae for growth. Research has found that inorganic nitrogen concentrations about 0.30 mg/L are able to stimulate algae growth (Illinois Environmental Protection Agency, 1998).

Preparation of a Comprehensive Lake Management Plan

Using past data and new data collected via a lake management planning grant, a Comprehensive Lake Management Plan (CLMP) for Lake Redstone should be prepared in accordance with the EPA and WDNR 9-Key Elements Planning Guidance. Lake Redstone is currently listed as a high priority lake for the development of a TMDL, a process that typically takes a long time to accomplish.

A TMDL is a pollution budget and includes a calculation of the maximum amount of a pollutant that can occur in a waterbody and allocates the necessary reductions to one or more pollutant sources. A TMDL serves as a planning tool and potential starting point for restoration or protection activities with the ultimate goal of attaining or maintaining water quality standards. Under section 303(d) of the Clean Water Act, states, territories and authorized tribes (included in the term State here) are required to submit lists of impaired waters. These are waters that are too polluted or otherwise degraded to meet water quality standards. The law requires that the states establish priority rankings for waters on the lists and develop Total Maximum Daily Loads (TMDL) for these waters (EPA, 2017).

According to the last correspondence with the WDNR, it is unknown when the process of developing a TMDL for Lake Redstone will begin (Personal Correspondence, Susan Graham, November 2016). However, it was felt that developing a CLMP would not negatively affect the TMDL process.

The CLMP would complete the last seven steps in the 9-Key Elements Planning Guidance and be a tool to help guide present and future actions to improve Lake Redstone.

Lake Management Planning Grant Application

To complete the recommendations in the previous section of this report, it is highly recommended that the Lake Redstone Protection District work with a consultant, the WDNR, and potential partners to develop a large-scale lake management planning grant application to be submitted in December 2017. It is very likely that a project of this scale would require multiple phases, as each individual phase is limited to maximum state share of $25,000.00. However, if grant funds were awarded, a Comprehensive Lake Management Plan for Lake Redstone could be in place and ready for full implementation in 2020.

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Appendix C

Wisconsin River TMDL: Bathtub Lake Model Setup and Results for Minocqua Lake, Kawaguesaga Lake, and Redstone Lake

Introduction

This report summarizes the setup and results of Bathtub modeling for Kawaguesaga and Minocqua Lakes in Oneida County, and Redstone Lake in Sauk County. These lakes are on Wisconsin's 303(d) list of impaired waters for phosphorus related impairments and are part of the larger Wisconsin River basin Total Maximum Daily Load for total phosphorus.

Model Setup and Development

Steady-state modeling was conducted using Bathtub (Version 6.1, Walker 1996). Bathtub is a windows-based software program that provides a suite of empirical equations for predicting lake averages of phosphorus, chlorophyll, and Secchi transparency. Model outputs were only analyzed for phosphorus and no additional modeling evaluation was conducted for chlorophyll and Secchi.

Lake surface area and volume were based on values reported on WDNR lake survey maps (http://dnr.wi.gov/lakes/maps/). Mixed layer depth was based on model predictions. Redstone Lake was modeled as a single basin, while Minocqua and Kawaguesaga Lakes were modeled as two separate but connected basins. All model runs were based on annual loadings.

Table 1: Lake morphology information

Lake	WBIC	Surface Area (km^2)	Length (km)	Mean depth (m)	Mixed Layer Depth (m)
Minocqua	1542400	5.332	4.0	7.05	5.7
Kawaguesaga	1542300	2.792	2.9	5.18	4.7
Redstone	1280400	2.450	4.28	4.35	3.0

Long term annual average water and nutrient loads to each lake (Table 2) were estimated using the SWAT model developed for the Wisconsin River basin TMDL (WDNR 2016). Atmospheric loading rates were based on a precipitation rate of 0.8 m/yr and a phosphorus load of 30 $mg/m^2/yr$.

Table 2: Water and nutrient loading information

Lake	Watershed Area (km²)	Mean Annual Flow (hm³/yr)	Tributary Flow Weighted Mean TP (µg/L)	Tributary P loading (kg/yr)	Atmospheric P Loading (kg/yr)	SWAT Sub-basin(s)
Minocqua	164.51	54.3	22.8	1,240	99.0	134, 133, 168, 226
Kawaguesaga	15.63	4.99	21.4	107	51.8	135
Redstone	74.61	21.5		3,524	73.5	13, 15, 16

Surficial total phosphorus results for the modeled lakes were acquired from the department's comprehensive 2014 Lake Assessment data set developed for Wisconsin's 2014 Impaired Waters List. This data set encompassed the period from 2003 through 2012.

The total phosphorus sub-model was selected based on overall model fit. Model fit was adequate in all cases and no site-specific calibration was required.

Table 3: Monitoring and Modeling Results

Lake	Assessed Years	# Sample Results	Observed TP (µg/L)	Predicted TP (µg/L)	% diff	TP Sub-model
Minocqua	2003-2011	31	16.7	17.0	2%	Canfield Bachman - Lakes
Kawaguesaga	2003,2006, 2010-2012	14	17.7	17.3	2%	Canfield Bachman - Lakes
Redstone	2006-2012	13	57.1	61.0	6%	Canfield Bachman - Reservoirs

Loading Capacity

To determine loading capacity for each lake, upstream tributary concentrations were sequentially lowered until modeled in-lake total phosphorus matched the waterbody's phosphorus criterion under NR 102.06 Wis. Admin. Code. Atmospheric phosphorus loading rates were held constant as were hydraulic loading rates.

Table 4: Loading Capacity

Lake Name	TP Criteria (µg/L)	Tributary P loading (kg/yr)	Tributary Flow Weighted Mean TP (µg/L)	Predicted in-Lake P (µg/L)	% reduction
Minocqua	15	1,032	19	15	17%
Kawaguesaga	15	94.8	19	15	11%
Redstone	30	1,175	60	30	67%

Wisconsin River TMDL: Lake Model Setup and Results for Lake Delton

Introduction

This report summarizes the setup and results of modeling for Lake Delton in Sauk County. This lake is on Wisconsin's 303(d) list of impaired waters for phosphorus related impairments and are part of the larger Wisconsin River Basin Total Maximum Daily Load for total phosphorus.

Model Setup and Development

Steady-state modeling was conducted using Wisconsin Lake Modeling Suite (WiLMS Version 3.318.1, WDNR 2001). WiLMS is a windows-based software program that provides a suite of empirical equations for predicting lake averages of phosphorus.

Lake surface area and volume were based on values reported on WDNR lake survey maps (http://dnr.wi.gov/lakes/maps/). All model runs were based on annual loadings not seasonal loading.

Table 1: Lake morphology information

Lake	WBIC	Surface Area (acres)	Mean Depth (ft)
Minocqua	1295400	249	12

Long term annual average water and nutrient loads to each lake (Table 2) were estimated using the SWAT model developed for the Wisconsin River basin TMDL (WDNR 2016). Atmospheric loading rates were based on the default loading rates from WiLMS and comprised a minor fraction of the total phosphorus budget (30 kg/yr).

Table 2: Water and nutrient loading information

Lake	Watershed Area (km^2)	Mean Annual Flow (hm^3/yr)	Tributary P loading (kg/yr)	SWAT Sub-basin(s)
Delton	202.3	63.04	7,385	30, 31, 32

Surficial total phosphorus results for the modeled lakes were acquired from the department's comprehensive 2016 Lake Assessment data set developed for Wisconsin's 2016 Impaired Waters List. This data set encompassed the period from 2010 through 2014.

The total phosphorus sub-model was selected based on overall model fit.

Table 3: Monitoring and Modeling Results

Lake	Assessed Years	# Sample Results	Observed TP (µg/L)	Predicted TP (µg/L)	% diff	TP Sub-model
Delton	2010-2014	10	73	74	1%	Canfield Bachman – Artificial Lakes

Loading Capacity

To determine loading capacity for each lake, the WiLMS load back calculation routine was used to back calculate an annual loading to match the in-lake total phosphorus criterion under NR 102.06 Wis. Admin. Code. Atmospheric phosphorus loading rates were held constant as were hydraulic loading rates.

Table 4: Loading Capacity

Lake Name	TP Criteria (µg/L)	Tributary P loading (kg/yr)	% reduction
Delton	40	3,371	54%

Appendix D – Best Management Practices (BMPs)

Watershed and Agricultural BMPs

- Conservation tillage: crop residue (plant material from past harvests) is left on the soil surface to reduce runoff and soil erosion, conserve soil moisture, and keep nutrients and pesticides on the field. Conservation tillage typically increases crop residue levels above 60% on fields.
- Contour strip farming: farming hilly fields across the slope to impede runoff and soil movement downhill reducing erosion and sediment production.
- Nutrient management planning: managing and accounting for all nutrient inputs to a field, ensuring that there are sufficient nutrients available for crop needs while preventing excessive nutrient loading, which may result in leaching of the excess nutrients to the ground water, or contained in surface water runoff from the land into local lakes and waterways.
- Cover crops: crops that are grown at times when agricultural fields may otherwise be left with bare soils exposed between annual cash crops like corn and soybeans. Cover crops can be a cash crop of their own or be incorporated into the soil before the planting of the main crops.
- No-till farming: an agricultural technique for growing crops or pasture without disturbing the soil through tillage. No-till farming decreases the amount of soil erosion tillage causes in certain soils, especially in sandy and dry soils on sloping terrain. Other possible benefits include an increase in the amount of water that infiltrates into the soil, soil retention of organic matter, and nutrient cycling. These methods may increase the amount and variety of life in and on the soil. No-till farming typically maintains crop residue levels at 90% or greater on fields.
- Conservation buffers: grassed waterways, wetlands, and natural riparian areas that act as an additional barrier of protection by capturing potential pollutants before they move to surface waters.
- Cows can be kept away from streams by streambank fencing and installation of alternative water sources, and designated livestock stream crossings can provide a controlled crossing or watering access, thus limiting streambank erosion and streambed trampling.

Riparian Area BMPs (compiled from resources available from the University of Minnesota Extension Service).

- Limit covered areas that prevent water from seeping into the ground.
- Retain trees and shrubs; trees provide a natural umbrella by shedding water and can reduce runoff by as much as 50%.

- Be aware and watch for runoff and erosion on your property, particularly during storm events. Know where your runoff goes.
- Limit clearing and grading on slopes and minimize cutting and filling for roads, sidewalks, and footpaths.
- Where paved areas are necessary, locate them as close to the main road as possible to minimize the length of paved driveway.
- Leave wasted space such as corners near buildings that are not large enough for parking or driving unpaved.
- Locate driveways, sidewalks, stairways, and footpaths away from slopes because steeper slopes have greater erosion potential; if you must cross a hillside, follow the contour of the slope.
- Use steps when a walkway must go directly up and down a slope, particularly near the waterfront.
- Minimize driveway and road crossings over waterways including ditches and swales, and cross at a right angle to the stream if possible.
- Sweep driveways or sidewalks instead of washing them down with a hose, to prevent sediment, salt, and petroleum products from washing into waterways; cover stockpiles of salt and sand with a tarp or store them in a building.
- Install water bars on sloping paths, driveways, or roadways to slow and divert runoff.
- Use paving stones instead of solid concrete for walkways and patios; this allows water to seep around the stones instead of running off.
- When landscaping, stage construction so one area is stabilized before another area is disturbed.
- Avoid construction in areas with little vegetative cover, erodible soils (sands, or soils that appear fluffy when dry), that are mainly bedrock with a thin covering of soil, or that are on steep slopes.
- Control erosion during construction by using temporary methods such as diversions, silt fences, or hay bales to carry water away or to trap before it enters the lake.
- Inspect construction projects immediately after initial installation of erosion control measures, during construction, following any severe rainstorm, before reseeding, and when nearing the completion of construction work; temporary erosion controls should be removed; ensure that stabilization is complete and drainage ways are in proper working order.
- Install rain gutters along the edge of rooftops to help carry water off of the roof and away from the building to areas where soil won't be eroded; make sure there is erosion protection where the gutters outlet onto soil.

- Keep gutters free from debris and draining properly.
- Position rooftops so they are perpendicular to the slope, instead of parallel, to slow down runoff.
- Construct all docks to allow free flow of water beneath them to prevent erosion and sedimentation along the shore.
- Use the smallest possible dock to meet your needs.
- Never apply wood preservatives or paint to decks or docks while they are in or over the water.
- Minimize the amount of ground surface covered with decks and patios to avoid increasing runoff and erosion.
- Eliminate paths to the waterfront that cut directly up and down slopes or over bluffs because they decrease stability of the shoreline and increase erosion; replace with stairways when necessary.
- Maintain trees and other vegetation that will help reduce your home's visibility from the water and adjacent property.
- Store gasoline, oil, and other potentially hazardous materials away from the water in a building with a solid floor; store emergency clean-up materials with the chemicals.
- Drain greywater from hot tubs, laundry, and showers through the septic system or connect with sewer lines to avoid adding soaps, oils, and bacteria to your water.
- Locate firepits at least 50-ft away from the lake.
- Keep leaves and grass clippings out of ditches, waterways, and street curb and gutter – rake and bag, mulch, and/or compost.
- Practice careful auto, boat, and lawn implement care.
- Be careful not to "over care" for your lawn with fertilizers, pesticides, and other chemicals.

In-lake BMPs (compiled from resources available from the University of Minnesota Extension Services)

- Minimize disturbance of aquatic vegetation.
- Remove aquatic plants only where they seriously interfere with recreational use of water and then clear only the smallest possible area.
- Never use chemicals for controlling aquatic plants without first obtaining a permit from the DNR.

- Never use soap or shampoo on watercraft, docks, boat lifts, dishes, pets, or yourself while in the water.
- If swimming, boating, or fishing (including ice fishing) do not use the lake as a bathroom.
- Avoid spilling gas, oil, paint, varnish, or stripper; never pour over the water during fueling or boat maintenance; do not "top-off" fuel tanks while on the water; fuel the boat on the trailer or portable tanks on shore whenever possible.
- Properly store and dispose of all wastewater, both greywater (laundry, sump pumps, campers, houseboats) and human waste.
- Adjust your speed to reduce the wake and consequent wave action that can damage the shoreline.
- Observe surface water use guidelines, including "no-wake" and low speed zones, power loading, and motor startups in shallow water.
- Fish responsibly following local rules and regulations; it is illegal to deposit fish entrails or parts into public waters or onto lake or stream shores.
- Inspect boats and trailers to avoid moving non-native plants or animals from one water body to another.
- Drain live wells on shore, away from the lake before launching and again after removing your fishing boat from the lake.
- Dispose of live bait (worms and minnows) in waste receptacles, not in the lake or on the ground.
- Pick up pet waste and dispose of properly
- Properly dispose of all garbage, including litter you find in the lake.

Appendix E
Watershed Milestones Table

Recommendations	9-Key Plan Reference	Indicator Units	SubWatershed	Milestones 0-5 yrs	Milestones 6-10 yrs	Priority	Timeline	Approach	Method	Implementation	Funding
Objective1A: Reduce the amount of sediment and phosphorus loading from the watershed											
a) Convert 40% of current (2021) cropland acres to pasture	5.1.1	# of acres converted	Pfaff	215	215	High	20% in yrs 1-5, an additional 20% in yrs 6-10	The PLRW in cooperation with Sauk and Juneau Counties will provide information and approach agricultural producers in the watersheds to promote conversion.	Education and/or incentives	PLRW, Sauk County, Juneau County	Federal, State, and County agricultural programs, PLRW program funds, LRPD provided incentive enhancements through surface water grants and their own funds
			Daugs	34	34						
			Lucht	49	49						
			Clark	55	55						
			LaValle	182	182						
			Lower Redstone	244	244						
b) Application of BMPs that improve soil health to 75% of remaining cropland, primarily no-till planting and/or the use of covercrops	5.1.1	# of cropland acres with BMPs applied	Pfaff	344	301	High	Application of BMPs to 40% in yrs 1-5, an additional 35% in yrs 6-10	Maintain existing (2021) acreage with these BMPs (779 no-till, 355 covercrop) and strive to reach or exceed the stated objective	Education and incentives	PLRW, Sauk County, Juneau County, LRPD	Federal, State, and County agricultural programs, PLRW program funds, LRPD provided incentive enhancements through surface water grants and their own funds
			Daugs	54	48						
			Lucht	80	69						
			Clark	89	77						
			LaValle	290	255						
			Lower Redstone	390	341						
			TOTAL	**1247**	**1091**						
c) Reduce the number of acres impacted by animal feedlots by 100%	5.1.1	# of feedlots addressed	Pfaff	x		High	LaValle, Pfaff, and Daugs feedlots will be addressed in yrs 1-5; Clark and Lower Redstone in yrs 6-10	Identify and then work with the producers to design and implement improvements	Direct contact with owners of feedlots	Juneau County, Sauk County	Federal, State, and County agricultural programs, PLRW program funds, LRPD provided incentive enhancements through surface water grants and their own funds
			Daugs	x		High					
			Lucht			Moderate					
			Clark		x	Moderate					
			LaValle	x	x	High					
			Lower Redstone			Low					
d) Reduce the number of miles with gully/ravine erosion	3.3.2.3	# of miles and severity of gully and ravine erosion	Pfaff		x	Moderate	Based on preliminary data, the Daugs, Lucht, and Lower Redstone sub-basins are potentially the worst and will be focused on in yrs 1-5. The other sub-basins will be focused on in yrs 6-10	Identify potential BMPs including grassed waterways, streambank restoration and/or stabilization (see Iowa DNR document referenced in Section	Follow guidelines from NRCS Field Office Technical Guide https://efotg.sc.egov.usda.gov/#/state/WI	Juneau County, Sauk County, Discovery Farms, PLRW	
			Daugs	x		High					
			Lucht	x		High					
			Clark		x	Moderate					
			LaValle		x	Moderate					
			*Lower Redstone	x		High					
e) Increase the number of total agricultural acres covered under nutrient management plans by 10%	5.1.2	# of acres under nutrient management plans	Pfaff	76	76	Low	10% in yrs 1-5 and an additional 10% in yrs 6-10.	Maintain existing (2021) acreage covered under NMP (287) and add at least 43 more in yrs 1-5, and 330 more in yrs 6-10.	Direct contact with agricultural producers	Juneau and Sauk County	
			Daugs	14	14						
			Lucht	20	20						
			Clark	24	24						
			LaValle	75	75						
			Lower Redstone	121	121						
			TOTAL	**330**	**330**						
f) Work with WI-DNR and County foresters to make sure appropriate BMPs are incorporated in MFL harvests	3.3.5	Knowledge of forestry operations in the watershed	All	x	x	Low	While this is a low priority, it is something that the LRPD can keep tabs on throughout the implementation of this project	Consult with WI-DNR foresters on the number of harvests going on each year	Personal contact via email	WI-DNR, LRPD	
Objective1B: Data gathering to support efforts to reduce the amount of sediment and phosphorus loading from the watershed											
a) Redo the Stream Power Index (SPI) from the WRB TMDL for each subbasin	3.3.2.3	Calculated/modeled values identifying those streams in the sub-basin with potential issues	All	x		HIgh	This will be completed in the first year of plan implementation	The LRPD will work with the WI-DNR to address how to get the SPI survey completed	EVAAL - SPI protocol	WI-DNR	
b) Develop additional financial incentives to encourage implementation of BMPs	5.1.2.1	Successful incentive programs that support and complement existing programs	All	x	x	High	Discussion of appropriate incentive programs and payments will be discussed in Yr 1 of implementation and funding solicited	Existing incentive programs and how they are implemented will be evaluated and used to develop new incentive programs	Working with Juneau and Sauk County and others, appropriate incentive programs will be created and added to existing programs	LRPD, Juneau and Sauk Counties, PLRW, NRCS, and others	WI-DNR SW grants
c) Evaluate subbasins for gully/ravine erosion	3.3.4.2	# of miles and severity of gully and ravine erosion	Pfaff		x	Moderate	Daugs, Lucht, and Lower Redstone sub-basins will be completed immediately following the SPI project likely in yrs 1 or 2; Pfaff, Clark, and LaValle will likely be completed in yrs 2 or 3	A process similar to what was done in 2007 with monitors actually traversing those streams identified with the most potential for erosion issues		Consultant, LRPD, Juneau County, Sauk County, PLRW	
			Daugs	x		High					
			Lucht	x		High					
			Clark		x	Moderate					
			LaValle		x	Moderate					
			*Lower Redstone	x		High					
d) Determine the number of active POWTS in the greater watershed of Lake Redstone	3.2.3	Map of active POWTS	All	x		Moderate	This will be done in the first 3 yrs of implementation	Count the number of likely active POWTS in the watershed	Using aerial or satellite imagery or by creating and distributing a paper survey	LRPD	

*Lower Redstone gully/ravine erosion is also considered part of riparian milestones

Appendix F
Riparian Area
Milestone Table

Recommendations	9-Key Plan Reference	Indicator Units	SubWatershed	Milestones		Priority	Timeline	Approach	Method	Implementation	Funding
				0-5 yrs	6-10 yrs						
Objective2A: Reduce the amount of sediment and phosphorus loading from the riparian area											
a) Reduce the number of moderate to high priority properties from the SHA	5.2.1.1	# of properties identified when the SHA assessment is redone in yr 6	Lower Redstone	x		High	In the first 3 yrs of implemenation, with a redo of the SHA completed in yr 4. Then in the next 3 yrs of implementation	Workshops focusing on education, information, and implementation of projects	Education and shoreland improvement projects likely through the Healthy Lakes and Rivers Program	LRPD, local contractors and planners, Sauk and Juneau Counties, Town of LaValle	Surface water Healthy Lakes and Rivers grants and Sauk County grants
b) Repair existing sediment and stormwater control BMPs	5.2.1.2	A list of projects that gets shorter as projects are identified and completed	Lower Redstone	x	x	High	A weir on Martin-Meadowlark damaged in 2018 is currently out for bids for repair. New projects like dredging of sediment basins on Martin-Meadowlark and have been and will be identified	Once identified, the LRPD will contract with the appropriate resources to complete the projects	Remove identified projects from repair lists and address new projects as they are added to the list	LRPD, local contractors and planners, Sauk and Juneau Counties, Town of LaValle	Surface water restoration and plan implementation grants, LRPD funds
c) Provide initial and on-going maintenance for existing sediment and stormwater control BMPs	5.2.1.2	Sediment basins are dredged	Lower Redstone	x	x	High	Two sediment basins on Martin-Meadowlark and another on Swallow are candidates for dredging to allow them to hold more sediment	At least these three basins should be sampled for sediment depth and a plan devised to get them dredged	Planning and then implementation	LRPD, local contractors, Town of LaValle, property owners	Lake District Funds, possibly Sauk County funds
d) Reduce the number of miles with gully/ravine erosion	3.2.2.1	# of miles (or some other measurement) of the severity of gully, ravine, and wash erosion	Lower Redstone			High	Based on preliminary data, the Daugs, Lucht, and Lower Redstone sub-basins are potentially the worst and will be focused on in yrs 1-5. The other sub-basins will be focused on in yrs 6-10	Identify potential BMPs including grassed waterways, streambank restoration and/or stabilization (see Iowa DNR document referenced in Section	Follow guidelines from NRCS Field Office Technical Guide https://efotg.sc.egov.usda.gov/#/state/WI	Juneau County, Sauk County, Discovery Farms, PLRW	
e) Bring faulty septic systems and drain fields into compliance	3.2.3	# of projects	Lower Redstone	x	x	Low	Over the course of the 10 year project - as faulty or failing sites are identified	Education and information	County identification of failing systems and possible systems identified by a conductivity survey of the lake	LRPD, Sauk County, Property owners	
f) Reduce the number of beach club and other cooperatively owned parcels contributing to sediment and phosphorus loading	3.2.4	# of projects	Lower Redstone		x	Low	Beach club and other cooperatively owned lots will be evaluated and plans for implementation made when the number of private parcels with projects begins to decline annually	Education and information, group meetings, workshops	Education and shoreland improvement projects likely through the Healthy Lakes and Rivers Program	LRPD, local contractors and planners, Sauk and Juneau Counties, Town of LaValle	Healthy Lakes and Rivers grants, Sauk County grants

Recommendations	9-Key Plan Reference	Indicator Units	SubWatershed	0-5 yrs	6-10 yrs	Priority	Timeline	Approach	Method	Implementation	Funding
Objective2B: Data gathering to support efforts to reduce the amount of sediment and phosphorus loading from the riparian area											
a) Repeat the SHA for the entire lake	5.2.1.1	Completed survey report	Lower Redstone		x	High	In yr 4 of implementation, the SHA completed in 2018 will be redone.	A comparison of the 2018 and 2024 (yr 3) survey will be compared to identifiy changes in priority properties	The SHA will follow the same guidelines and parameters used in the 2018 survey (2020 WI-DNR SHA Protocols)	LRPD, Consultant	Surface water planning grants
b) Document the level of sediment entering the individual bays of Lake Redstone during storm events	3.2.2	Concentration of sediment	Lower Redstone	x		High	Within the first 3-yrs of implementation	Collect storm event water samples for sediment including total suspended, total dissolved, and total settled solids (TSS, TDS, and Settled)	water samples collected by LRPD volunteers, SLOH analysis, and the use of settling cones	LRPD, Consultant	
c) Evaluate streams, gullies and washes entering directly into Lake Redstone for stormwater runoff and erosion issues	3.2.2.1	# of miles (or some other measurement) and the severity of gully, ravine, and wash erosion	Lower Redstone	x		High	Each of the 28 bays will be evaluated during runoff events over the course of the first and second years of implementation	The Sediment Control Committee established by the LRPD will work with partners to establish a visual protocol to evalute each potential site with issues	Visual, boots-on-the-ground survey with water sampling	LRPD, Sauk County, Consultant	
d) Develop a sediment model to aide in establishing goals for sediment reduction from gullies, ravines, and washes directly entering the bays of Lake Redstone	4.2.1	A working model for use	Lower Redstone	x		Moderate	Yr 1 - a plan to develop a sediment model will be devised. Yr 2 - the model will be developed. Yr 3 - the model will be completed and put into practice. By years 5-10 the model will be used to help set target goals for sediment reduction.	The LRPD and their consultant will work closely with Paul McGinley from UWSP to devise a plan for creating the model and how it is to be used.	Existing WinSLAMM and P-8 models will be modified in an attempt to create a sediment delivery model for each of the bays	Paul McGinley, UWSP; WI-DNR, Consultant, LRPD	
e) Update Septic System data in the riparian area of Lake Redstone	5.2.1.4	New data to add to existing water quality modeling	Lower Redstone	x		Moderate	by year 3 of implementation	a paper survey will be sent out to all property owners to collect time at the lake and other people factors to use in default septic system loading calculations	Post card survey to update past time at the lake and people data for use in default spetic system loading calculations	LRPD, property owners	
f) Determine potential extent of septic system leaching into Lake Redstone	3.2.3	Results for a conductivity survey of the entire shoreland area	Lower Redstone	x		Moderate	by year 5 of implementation	A conductivity survey using a conductivity meter will be completed with sampling points adjacent to each property around the lake	Survey conducted by a consultant, data results compared around the lake. Places with elevated conductivity could be indicative of leaching from septic systems	LRPD, Consultant	

g) Evaluate the use of EutroPHIX to reduce phosphorus loading	5.2.1.2	Claims (by EutroPHIX) of greatly reduced phosphorus in the water	All, with a focus on Lower Redstone	**x**		High	In the first year or two of implementation, the LRPD will have further discussion with the Team at EutroPHIX	Complete gathering of more information leading to a decision by the LRPD to move forward with the EutroPHIX process	Discussions with the EutroPHIX team, WI-DNR, USGS and others about whether or not this process should be considered on Lake Redstone	LRPD, EutroPHIX team, WI-DNR, USGS, and other resource professionals	
h) Evaluate beach club and other community lots for erosion and other issues	3.2.4	Visual survey with documented evaluation results	Lower Redstone		x	Low	Initial focus in the riparian area are single owner parcels. Beach club lot evaluation will likely not occur until around Yr 5 of implementation	Identify locations and meet with beach club and other community lot owners	Review maps and complete boots-on-the-ground surveys	LRPD, Consultant, Community lot owners	

Appendix G
Lake Redstone Milestones Table

Recommendations	9-Key Plan Reference	Indicator Units	Sub Watershed	Milestones 0-5 yrs	Milestones 6-10 yrs	Priority	Timeline	Approach	Method	Implementation	Funding
Objective3A: Reduce the amount of sediment and phosphorus loading within Lake Redstone											
a) Aquatic Plant Management	3.1.4.3	Follow recommendations in a WI-DNR approved Aquatic Plant Management Plan	NA	x	x	High	A timeline related to management planning including plant survey work, permitting and actual implementation are laid out in the APM Plan	Phyiscal removal, mechanical harvesting, application of aquatic herbicides, and biological controls	Following Integrated Pest Management guidelines from the WI-DNR	LRPD, WI-DNR, Property Owners	WI-DNR surface water grants - AIS Small or Large-scale Population Control grants, LRPD
b) Prevent the introduction and spread of AIS	3.1.4.4	No new infestations, records of efforts, future responses on social surveys distributed to the constituency	NA	x	x	High	Continual education and information related to how AIS can impact water quality and lake usability throughout implementation of this project	Participation in CBCW, AIS monitoring, education of property owners and lake users	Physical presence at boat landings, dissemination of materials at meetings and in newsletters and other publications, and on-the-water survey	LRPD, Town of LaValle,	CBCW grants and other AIS education grants from the WI-DNR
c) Hypolimnetic withdrawal from the dam	4.3.1	Time when bottom withdrawal is implemented each year	NA		x	Moderate	Yr 3 if recommendations are made in the completed study	If the hypolimnetic withdrawal study suggests it might be beneficial it will be implemented	Further study and implementation plan development	LRPD, Sauk County	
d) Carp removal	3.1.2.2	# of successful events and carp removed	NA	x	x	Low	At present, the LRFC sponsors carp shoots in late spring early summer in many years	Carp Shoots - bowfishing contests	Promotion of events	LRFC, local businesses, Sauk County	LRPD, LRFC, Community Support
e) Minimize bottom disturbances caused by boating in shallow water	3.1.1.6	documentation of efforts to education and inform boaters on the lake	NA	x	x	Low	Continual education and information throughout the implementation of this project	Distribute education and information, posting of no-wake zones, and the emergency high water restriction	Education and information	LRPD	
f) Application of alum or other phosphorus binding agents	5.3.1	Planning and implementation as determined necessary	NA		x	Low	Yr 5 or later if recommendations are made in the completed study	Go with what research and study results show/suggest	Working with partners to determine best way to move forward if necessary	LRPD, Consultant, UW-System, Applicator	Lake Management Plan implementation grants, lake protection grants
g) Selective dredging	5.3.2	Amount of sediment removed	NA		x	Low	Near the end of the 10 yr plan if at all. This will only be done as a last resort				
Objective3B: Data gathering to support efforts to reduce the amount of sediment and phosphorus loading within Lake Redstone											
a) Update the APM Plan	3.1.4.3	A new APM Plan approved by the LRPD and the WI-DNR ready for implementation by 2023	NA	x		High	Completion of this milestone is already in the works with grant funding applied for in 2021 for update in 2022.	Work with a consultant to do what is necessary to update the existing APM Plan	Following Integrated Pest Management guidelines from the WI-DNR	LRPD, Consultant, WI-DNR	WI-DNR SW Planning
b) Update existing lake response modeling	4.1.2	Updated results	NA	x		High	First or second year of implementation, dependent on the available data and resources	After collection of several years worth of automated sampler data at Clark and Lavalle the USGS will redo lake response modeling	USGS modeling of new data	LRPD, WI-DNR, USGS	Partner funding and WI-DNR SW planning
c) Complete an internal loading study	3.1.1.5, 4.1	Final report with recommendations	NA	x		High	YR 1 - Study design and grant funding request. Yr 2 - Study completed.	Increased temp/DO profiles, bottom sampling for phsophorus, phosphorus in the sediment release study	Combine additional lake sampling data with phosphorus release from sediment in a laboratory setting	LRPD, Consultant, UW-System	WI-DNR SW Planning or Plan Implementation
d) Re-evaluate hypolimnetic withdrawal	4.3.1	Final report with recommendations	NA	x		High	Yr 1 - study design and grant funding request. Yr 2 study completed.	Work with WI-DNR, Sauk County, and other partners to develop a plan	The most likely method is to redo what was done previously	LRPD, WI-DNR, Consultant, Sauk County	WI-DNR SW Planning or Plan Implementation
e) Recalculate sediment and phosphorus loading to Lake Redstone from all sources based on new data	4.1	A new phosphorus budget is created	NA	x		High	In Yrs 1 and 2 new data will be collected and evaluated with a new or updated phosphorus budget for the lake created by the end of Yr 3	Results from improved data collection from the Clark and La Valle tributaries, gullies and washes, septic system data, and internal loading will be evaluated	Data analysis will lead to the development of a new phosphorus budget for the lake	LRPD, USGS, WI-DNR, Consultant	WI-DNR SW Planning or Plan Implementation
f) Survey sediment in bays, compare before and after implementation of Plan	4.2	Comaprison of Yr 2 sediment deposition in bays to Yr 10 sediment in bays	NA	x	x	Moderate	Yr 1 - study design and grant funding. Yr 2 Complete the first study. Yr 10 complete the second study	This action could be tied in with creating a sediment delivery model as discussed in the riparian table	Repeat the survey done by Ayres in 2018 in Yr 2, and again in Yr 10.	LRPD, WI-DNR, Property Owners, contractors	WI-DNR SW Planning or Plan Implementation
g) Survey sediment in main body of the lake	4.2	A final assessment of how much sediment is in the lake	NA	x		Moderate	In the first five years of implementation additional conversation will be had as to how and when to do this type of survey	This action could be tied in with creating a sediment delivery model as discussed in the riparian table	perhaps core sampling at multiple locations in the main basin of the lake	LRPD, USGS, Sauk and Juneau Counties, UW System, private contractors/consultants	WI-DNR SW Planning or Plan Implementation

Appendix H
Monitoring Milestones Table

Recommendations	9-Key Plan	Indicator Units	SubWatershed	Milestones 0-5 yrs	Milestones 6-10 yrs	Priority	Timeline	Approach	Method	Implementation	Funding
Watershed and Riparian Area Monitoring											
a) Land Use Changes and Implementation of BMPs	9.1.1	# of acres under different BMPs	Pfaff	215	215	High	1) National Land Cover Database (NLCD) - 2021, 2026, and 2031. 2) Satellite and transect surveys - Annually	1) National Land Cover Database 2)Satellite Imagery 3)Transect Surveys	1) Familiarity with the database. 2) Work in cooperation with the WI-DNR to interpret satellite imagery. 3) Establish a transect survey plan and have LRPD volunteers or PLRW partners complete it under the tutelage of Sauk County	LRPD, PLRW, Sauk County, Juneau County	
			Daugs	34	34						
			Lucht	49	49						
			Clark	55	55						
			LaValle	182	182						
			Lower Redstone	244	244						
b) East (Lavalle) and West (Clark) Branches of Big Creek	9.1.2.1	Sediment concentrations, phosphorus concentrations, flow, and discharge	Clark	x	x	High	Between 2021-2023; and again between 2029-2031; longer if funds are available	Automated samplers set up by the USGS and supported by LRPD volunteers and Juneau and Sauk County staff	Automated samplers can collect water samples and flow and discharge continuously regardless of flood stage	USGS, LRPD, Juneau and Sauk Counties	
			LaValle	x	x						
			Outlet	x	x						
c) Daugs, Lucht, Pfaff	9.1.2.1	Sediment concentrations, phosphorus concentrations, flow, and discharge	Daugs	x	x	Moderate	3-yrs of continuous monitoring from 2023-2025; and again from 2028-2031	Baseline tributary sampling following WisCALM protocol	Volunteer water sampling following WisCALM protocol with the possible installation of pressure transducers, staff gauges	LRPD, Sauk County, Juneau County	
			Lucht	x	x						
			Pfaff	x	x						
			LaValle (at Nemitz)	x	x						
d) Gully and wash sampling	9.1.2.2	Sediment concentrations, phosphorus concentrations, flow, and discharge	Lower Redstone	x		High	This will be completed in the first year of plan implementation	The LRPD will work with the WDNR to address how to get the SPI survey completed	Volunteer water sampling following WisCALM protocol with the possible installation of pressure transducers, staff gauges	LRPD, Sauk County, Juneau County	
e) Install up to three stream erosion monitoring sites in each sub-basin	9.1.2.3	Documented installation sites, and data analysis	All	x	x	Moderate	Installation of stream erosion monitoring sites will be completed after the gully/ravine evaluation but before implementation of BMPs	Following available guidelines, up to three sites per basin will be installed after the evaluation	Kearney, Fonte, Garcia, & Smukler, 2018; Rathbun, 2009	Consultant, LRPD, Sauk and Juneau Counties	
Lake Redstone Monitoring											
a) CLMN Expanded water quality monitoring	9.2.2	CLMN monitoring results	Deep Hole and Middle sites	x	x	High	May through Spetember in every year of implementation	The LRPD will collect water quality data following CLMN expanded monitoring protocol, and add TP and Chla water sampling in September	CLMN expande monitoring protocol, plus additional monitoring to meet WisCALM guidelines	LRPD	WDNR and UW-Extension Lakes
b) Long Term Trend water quality monitoring	9.2.2	Long Term Trend monitoring results	Deep Hole Site	x	x	High	LTT monitoring in every year of implementation	In cooperation with the WI-DNR, the LRPD will collect water quality data in the Deep Hole following LTT monitoring protocol	LTT guidelines for Secchi, TP, Chla, dissolved oxygen, temperature, conductivity, pH, alkalinity, color, nitrate/nitrites, and total Kjeldahl nitrogen every year, and calcium and magnesium every five years	LRPD WDNR	WDNR
c) Secchi, dissolved oxygen and temperature profiles	9.2.1	Data results	Deep Hole and Middle sites	x	x	High	Every 2-3 weeks from ice out to ince in (follow remote sensing satellite schedule)	Monitoring completed by LRPD volunteers	CLMN and remote sensing satellite	LRPD	
d) Water column sampling for TP and maybe othophosphates	9.2.2	Data results	Deep Hole and Middle sites	x		High	At least in the first two to three year of implementation. After that, the data can be used in concert with internal loading study results to get a better understanding of the role of internal loading on the lake	Monitoring completed by LRPD volunteers	Following a monitoring plan developed before implementation	LRPD	Surface water planning or implementation grants
e) Aquatic plant monitoring	9.2.3	Survey maps and comparisons	Whole lake	x	x	High	Whole lake, point-intercept survey work in 2022, 2027, and again in 2032 if active management is occuring; Possible annual pre and post-treatment PI survey work; and annual late season mapping	The LRPD in cooperation with an aquatic plant survey/management specialist will complete these surveys as determined in an updated Aquatic Plant Management Plan	Following WDNR guidelines for aquatic plant survey work	LRPD, Consultant	Surface water planning grants
f) AIS monitoring	9.2.3	Survey maps, documentation of new AIS	Whole lake	x	x	High	Annually	LRPD volunteers and Consultant surveys and documentation	Following CLMN AIS Monitoring Guidelines	LRPD, Consultant	Surface water education grant funds

Appendix I
Overview of Plan Actions, Interim Milestones, Cost Estimates, and Responsible Entities

Appendix I - Overview of Plan Actions, Interim Milestones, Cost Estimates, and Responsible Entities

	Plan Action	Milestones			Cost*	Implementation
		Years 1-3 (2022-24)	Years 4-6 (2025-27)	Years 7-10 (2028-2031		
1	**Surface Water Monitoring**					
a	USGS – Maintain 3 sites (East, West, and Outlet (2022-23; 2029-2031) $41,700/yr sampling (2022, 2023, 2029, 2030, 2031) + $15,900 to Establish 3 sites (2029)	X	TBD	X	$229,400	LCD, LRPD, USGS, DNR
b	LRPD – Maintain 4 sites (Daugs, Lucht, Nemitz, Pfaff) $490.00/site/yr sampling TP and TSS (2029-31) + $300/site establishment and maintenance (2029)			X	$7,080	LRPD, DNR, LCD
c	LRPD - Maintain 7 sites (Chickadee North, Chickadee South, Eagle, Fox Court, Heron, Martin-Meadowlark, Swallow) $343/site/yr sampling TP and TSS (2023-24, 2030-31) + $300/site establishment and maintenance (2023 and 2030)	X		X	$13,804	LCD, LRPD
d	Discovery Farms Edge of Field – Maintain 2 sites $4,000/yr sampling + $500/yr site maintenance	X	TBD	TBD	$13,500	LCD, UW-DF, LRPD
2	**Lake Monitoring**					
a	Deep Hole (LTT and CLMN site) + TP (Apr, Sept-Oct), ChlA (Sept-Oct), $142/yr sampling (2022-31)	X	X	X	$1,420	LRPD, DNR
b	Middle Site TP (Apr-Oct), ChlA (Jun-Oct), $342/yr sampling (2022-31)	X	X	X	$3,420	LRPD, DNR
c	Water Column - Middle and Deep Hole, TP-Ortho-Fe (10 depths, Jun-Oct), $4,600/yr sampling (2023-24)	X			$9,200	DNR, LRPD
3	**Reduce Sediment and P loading - Watershed**					
a	Convert 40% of existing cropland acres (3,896 acres) to grazing/pasture $55-65/acre	390 acres (10%)	390 acres (10%)	778 acres (20%)	$93,480	LCD, LRPD, PLRW
b	Cropland BMPs – conservation tillage, cover crops – 75% of remaining acres (3896-1558=2338x.75=1754 acres)	701 acres (30%)	701 acres (30%)	352 acres (15%)	$134,575	LCD, LRPD, PLRW, NRCS, DNR
	An additional 10% of remaining acres (2338x.1=234acres) Cons Tillage $17/acre(NRCS); Cover Crop $65/acre (Producer Led); $55/Acre (NRCS)			234 acres (10%)	$17,954	
c	Increase agricultural acres covered under nutrient management plans to 10% of all agricultural acres (an additional 390 acres over 10 years) $40/acre (LWRD-SEG)	100 acres	145 acres	145 acres	$15,600	LCD, PLRW, LRPD, NRCS
d	Convert 10% remaining cropland acres (3896-1558=2338x.1=234 acres) to Prairie - $4,000/acre			234 acres	$936,000	LCD, LRPD, PLRW, RP
e	Feedlot BMPs – 5 operations Waste Storage - $150,000/unit; Fencing, roof runoff, critical area planting, walls, etc.)- 70% Cost share	2 units	3 units	TBD	$750,000	LCD, DNR, NRCS, LRPD, PLRW
f	Reduce verified gully/ravine erosion areas (see 6B) in the watershed **outside** of the riparian zone via source and/or erosion control BMPs. $10-20,000/site; 1 site/yr Grassed Waterways – 2/units/year; 200-250 ft length; ~$5/foot or 70% Grade Stabilization Structure – $12,000/unit or 70%	2 sites 4 units 2 units	3 sites 6 units 4 units	4 sites 6 units TBD	$135,000 $20,000 $72,000	DNR LCD, LRPD, NRCS, PLRW
g	Contour Farming – 25% acres that do not already use the practice $7/acre	135 acres	135 acres		$1,890	LCD, LRPD, PLRW
h	Help repair faulty POWTS so they comply with current regulations	See 6e	See 6e	See 6e	See 6e	LRPD, LCD, DSPS, DNR, PLO, RP
i	Identify landowners and work with them and DNR to adopt appropriate forestry and mining BMPs in the watershed 1 site/3yr cycle; $1,000/site	1 site	1 site	1 site	$3,000	LRPD, DNR, LCD, PLO, RP

4	**Reduce Sediment and P loading - Riparian Area**					
a	Shoreland Improvement Workshops 1/yr, $250/workshop Contact Landowners and Implement BMPs on 20% of high priority shoreline parcels (214 parcels x .2 = 43 parcels). Use Lakeshore Assistance Program for larger projects (>$1500) (25%=11projects); and Healthy Lakes Initiative Program for projects up to $1500 (75%=32projects)	2 workshops 18 sites	3 workshops 25 sites	3 workshops TBD	$2,000 $59,500	DNR, LRPD, LCD, RP, PLO
b	Address shoreland issues on all of the high (4) and moderate (9) risk beach club and other cooperatively owned parcels identified in the SHA Use Lakeshore Assistance Program for larger projects (>$1500) (25%=3 projects); and Healthy Lakes Initiative Program for projects up to $1500 (75%=10 projects)	3 sites	5 sites	5 sites	$17,500	LRPD, LCD, DNR, PLO, RP
c	Help repair faulty POWTS so they comply with current regulations	See 7c	See7c	See 7c	See 7c	LRPD, LCD, DSPS, DNR, PLO, RP
d	Evaluate and repair existing runoff and sediment control structures $32,000/project; 10 projects total.	2 projects	4 projects	4 projects	$320,000	LRPD, LCD, DNR, RP, ToLV
e	Reduce verified gully/ravine erosion areas **within** the riparian zone (See 7b) via source and/or erosion control BMPs. $10-20,000/site; 1 site/yr	2 sites	3 sites	4 sites	$135,000	LRPD, LCD, DNR, NRCS, ToLV
5	**Reduce Sediment and P loading - Lake Redstone**					
a	Aquatic Plant Management - Planning ($1000), Surveys ($5500), Permits ($700), and Treatments –Diver Aided Suction Harvest, herbicides, etc. ($9000) $16,200/yr every other year	2 yrs	1 yr	2 yrs	$81,000	LRPD, DNR, LCD, RP
b	Carp Removal	TBD	TBD	TBD	TBD	LRPD
c	Application of alum (see 8c)			TBD	TBD	LRPD, DNR, UW, LCD
d	Hypolimnetic withdrawal (see 8d)			TBD	TBD	LRPD, DNR, UW, LCD
e	Adapt/adopt new boating ordinances (see 8e)	X			TBD	LRPD, ToLV
6	**Gathering Additional Data - Watershed**					
a	Streambank Erosion and Lateral Recession Rate Monitoring Identify 2 representative sites in two sub-basins and monitor annually - $500 site/year	X	X	X	$18,000	DNR, LRPD, LCD, PLO, PLRW
b	Complete Stream Power Index (SPI) + gully/ravine inventory **outside** of the Lake Redstone Subbasin (riparian zone)	X			$8,000	LRPD, LCD, DNR, PLO, PLRW
c	Monitor Land Use Changes via Satellite Imagery and Cropland Data Layer $500/year	3 checks	3 checks	4 checks	$5,000	LRPD, DNR, LCD, RP
d	Cropland roadside transect surveys within entire watershed $2500/year	X	X	X	$25,000	LCD, LRPD, DNR, PLRW
e	Complete inventory of active POWTS **outside** of the Lake Redstone Subbasin (riparian zone) and reduce faulty or failing POWTS in the watershed Prioritize POWTS for repair/maintenance, contact landowners, and connect them with programs to help deal with faulty or failing septic systems. Support repair and replacement of faulty or failing septic systems. $10-20,000/site	X 2 sites	 3 sites	 4 sites	$5,000 $90,000	LRPD, LCD, DNR, DSPS, PLO. RP
	Send septic system info and maintenance brochures to property owners around the lake about septic maintenance and water quality impacts. At least once in each time period.	X	X	X	See 11a	LRPD, LCD

7	**Gathering Additional Data - Riparian**					
a	Repeat Shoreline Habitat Assessment in five years – compare to 2018 analysis, $7,000		X		$7,000	LRPD, DNR, RP
b	Complete Stream Power Index (SPI) and gully/ravine inventory **within** the Lake Redstone Subbasin (riparian zone)	X			$2,000	LRP, LCD, DNR, PLO
c	Complete inventory of active POWTS **within** the Lake Redstone Subbasin (riparian zone) and reduce faulty or failing POWTS in the watershed	X			$5,000	LRPD, LCD, DNR, DSPS, PLO, RP
	Prioritize POWTS for repair/maintenance, contact landowners, and connect them with programs to help deal with faulty or failing septic systems. Support repair and replacement of faulty or failing septic systems. $10-20,000/site	2 sites	3 sites	4 sites	$90,000	
	Send septic system info and maintenance brochures to property owners around the lake about septic maintenance and water quality impacts. At least once in each time period.	X	X	X	See 11a	LRPD, LCD
d	Evaluate all streams, gullies and washes entering directly into the bays of Lake Redstone for stormwater runoff and erosion issues. Prioritize for further documentation and implementation of BMPs	2022-23 Inventory			TBD	LCD, LRPD, PLO, RP
e	Document the level of sediment and nutrients entering into an estimated 14 individual bays (not included the bays covered in 1c) from streams, gullies, and washes **during storm events** to determine TP and TSS contributions from upgradient gullies and washes (14 sites x 3 storm events x 2 yrs x $49.00 (TP&TSS costs))	7 bays	7 bays		$4,116	LRPD, LCD, UW, PLO, PLRW
f	Develop a sediment model to predict future sediment loading to the lake		X		TBD	LRPD, DNR, UW
8	**Gathering Additional Data – Lake Redstone**					
a	Update the Aquatic Plant Management Plan		2027		$10,000	LRPD, DNR, RP
b	Update existing lake response modeling 1x every 3 years - $500	X	X	X	$1,500	LRPD, DNR, RP, USGS, UW
c	Develop scope and complete an internal phosphorus loading study	Scope	Study Start	Study finish	TBD	LRPD, DNR, USGS, UW
d	Reevaluate hypolimnetic withdrawal from the lake		Study Start	Study finish	TBD	LRPD, LCD, DNR, USGS
e	Review of boating ordinances	X			TBD	LRPD, TofLV
f	Recalculate sediment and phosphorus loading to Lake Redstone from all sources based on new watershed data and practices adopted	X	X	X	See 10c. Plan Implement Tracking	LRPD, DNR, LCD, USGS, RP
g	Survey sediment in the main basin of Lake Redstone to quantify deposition*		TBD	TBD	TBD	LRPD, UW, RP
9	**Staff and Technical Assistance**					
a	1 new County LCD position- $55,000/year Salary Plus Fringe Benefits	X	X	X	$550,000	LCD
b	Hire private contractor to assist with plan implementation $40,000 /year	2 years	2 years	2 years	$240,000	PLRW, PLRW, LRPD
10	**Plan Implementation Tracking**					
a	Conservation Practices - $2000/year	X	X	X	$20,000	LCD, LRPD, DNR, PLRW, NRCS
b	Education Efforts - $4000/year	X	X	X	$40,000	LRPD, LCD, PLRW
c	Modeling Pollutant Sources or Reductions – $1,500/year STEPL modeling, In-lake Modeling, DATCP Producer Led Reports, Sediment Modeling	2 years	3 years	4 years	$15,000	LCD, DNR, LRPD, RP
d	NR 151 Implementation Compliance - $5,000/year; 2 farms/year	X	X	X	$50,000	LCD, DNR, NRCS, PLRW

11	**Education and Outreach**					
a	Provide education and informational materials to public via brochures, demonstrations, displays, notices, and other publications. - $1000/yr	X	X	X	$10,000	LCD, LRPD, PLRW
b	Summer/fall field events: cover crop/soil health field days, small acreage landowner workshops, pasture walks, nutrient management farmer education classes – 1 event/year at $3000/yr	3 events	3 events	4 events	$30,000	LCD, LRPD, PLRW, DNR
c	Conference in cooperation with other localities currently working on developing or implementing 9-Key Element Plans, 1 conference in each 3yr timeframe $3500/conf	1 conf.	1 conf.	1 conf.	$10,500	LCD, LRPD, PLRW, DNR, RP, UW
d	Tours on non-agricultural conservation practices like stream bank, shoreline, rain gardens gardens, etc. - $1000/yr	2 tours	2 tours	3 tours	$7,000	LCD, LRPD, PLO, RP
e	Producers of Lake Redstone Watershed Group DATCP grant helps farmers reach out to other farmers to join the group; offer incentives to implement best management practices, including cover crops, community manure sharing, establishing nutrient management plans, and sponsoring community events, field days, and training. $25,000/yr grant award	2 years grant award	2 years grant award	2 years grant award	$150,000	DNR, LCD, PLRW, RP, LRPD
f	LRPD Board and Stakeholders Meetings – Review 9 element plan implementation actions and adapt plan milestones, as necessary– 2 x/yr	6 mtgs	6 mtgs	8 mtgs	TBD	All Stakeholders
g	LRPD meetings with the Constituency (Annual Meetings) 1x/yr	1 mtg	1 mtg	1 mtg	TBD	LRPD
	TOTAL COST*			**$**	**$4,465,439**	

X = plan action will be completed during this 3-year interim period
* = cost estimate may change as new or additional cost information (e.g., contractor bids, operating budgets, grant resources) is determined during the 10-year plan implementation schedule.

TBD = To Be Determined

BMP = Best Management Practices
CLMN = Citizen Lake Monitoring Network
DATCP = Dept. of Agriculture, Trade & Consumer Protection
DNR = Wisconsin Dept. of Natural Resources
DSPS = Dept. of Safety & Professional Services
LCD = Juneau or Sauk County Land Conservation Dept.
LRPD = Lake Redstone Protection District
LTT = Long Term Trend
NRCS = Natural Resource Conservation Service
PLO = Private Land Owners
PLRW = Producers of Lake Redstone Watershed
POWTS = Private Onsite Wastewater Treatment System
RP = Research Professional
TofLV = Town of LaValle
TP = Total Phosphorus, TSS = Total Suspended Solids, ChlA = Chlorophyll-a, Fe = Iron, Ortho = Orthophosphates
USGS = United States Geological Survey
UW = University of Wisconsin
UW-DF = Discovery Farms

Producer-Led Watershed
Protection Grant Program

Appendix J

2019 CONSERVATION BENEFITS REPORT

Producers of Lake Redstone

TABLE OF CONTENTS

The Producers of Lake Redstone are

focused on improving water quality and soil health in the watershed, with particular interest in:

- Developing viable ways to interseed cover crops,
- Developing a community manure application/ sharing system, and
- Using cover crops to meet late-season nutrient needs of crops.

SOIL & WATER QUALITY MODELING

Farmer-led groups are demonstrating and promoting conservation practices and rotations that can help reduce soil erosion and improve soil quality.

Reducing the amount of soil lost from farm fields and improving the ability of soils to function is connected to water quality. The degree of benefits that we see from each of these farmer-led groups' conservation projects is dependent upon the unique climate conditions, soil types, and farming practices used in the particular watersheds where they farm.

→ Using SnapPlus nutrient management planning software, potential soil quality benefits were estimated for solely cropland practices implement by the Dodge County Farmers HSHW.

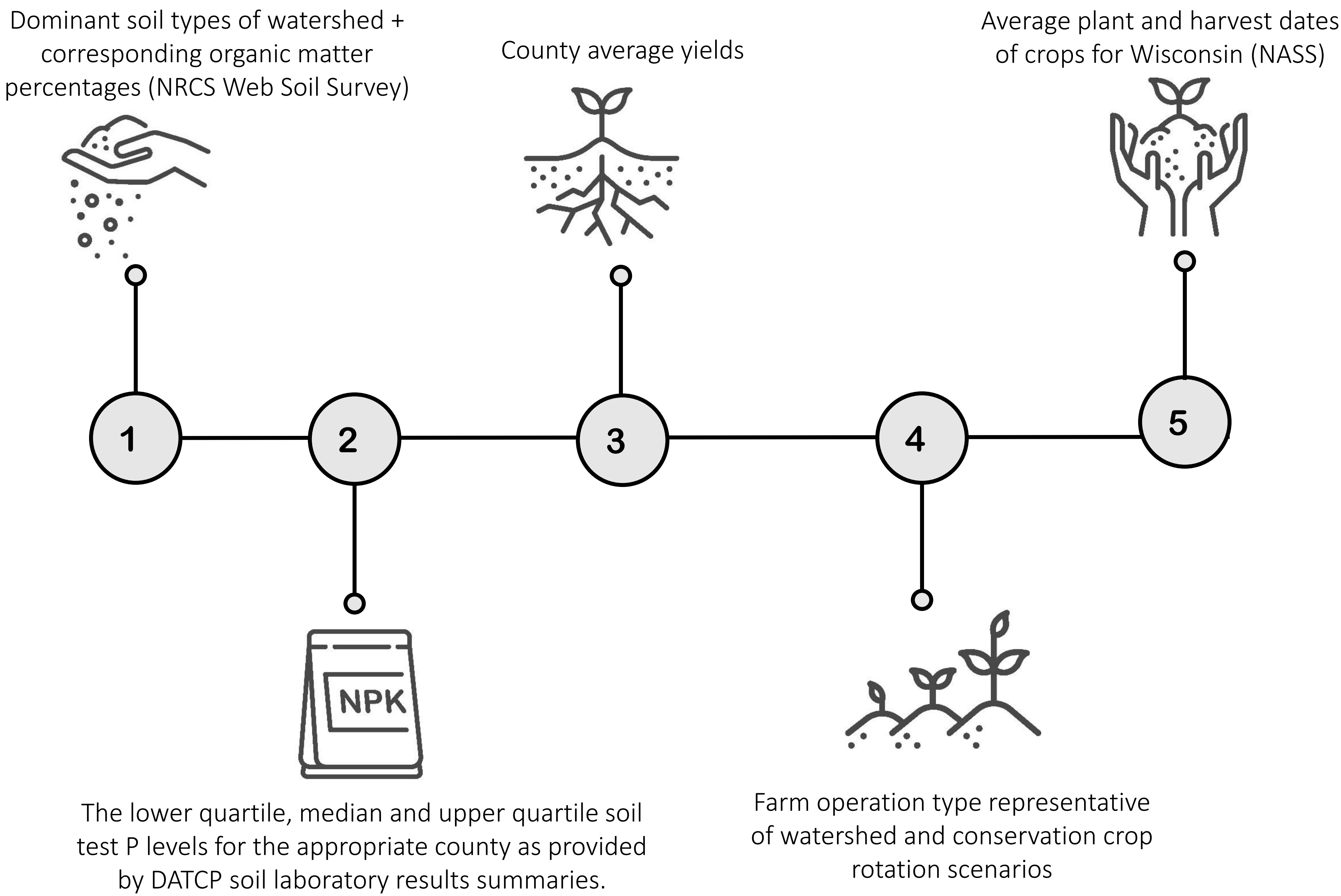
→ These practices include primarily cover crops and reduced tillage.

→ Crop rotations with varying levels of conservation integration were modeled to estimate the potential phosphorus and sediment reductions, and soil organic matter building potential that can occur from adopting different practices.

→ Rotations were selected that **best reflect the practices used by farmers in this watershed area,**

→ These estimations do not consider other conservation practices that may be present in a field such as a grassed waterway, water and sediment control basin, or buffers.

ESTIMATING SOIL & WATER QUALITY BENEFITS | Model Inputs



GENERALLY SPEAKING…

+ Greater risk of soil erosion on fields under corn-soybean and corn-silage systems relying on chisel plowing
+ Adding winter wheat back into corn-soybean systems may decrease phosphorus loss from fields
+ Higher Soil Conditioning Index (soil building potential, in simple terms) as conservation practices are integrated into grain and dairy systems
+ Hay/grass systems experience lowest soil erosion and phosphorus loss on farm fields

Let's break it down →

Modeling Results:

GRAIN

OPERATIONS

CROP ROTATIONS: Grain

The majority of farm operations in this watershed project area are either dairy or cash grain operations. For each operation type, crop rotations for three different levels of conservation were identified for the purpose of modeling soil and water conservation benefits:

Conventional Rotation

Corn grain- Soybeans
Fall chisel plowing
No cover crops

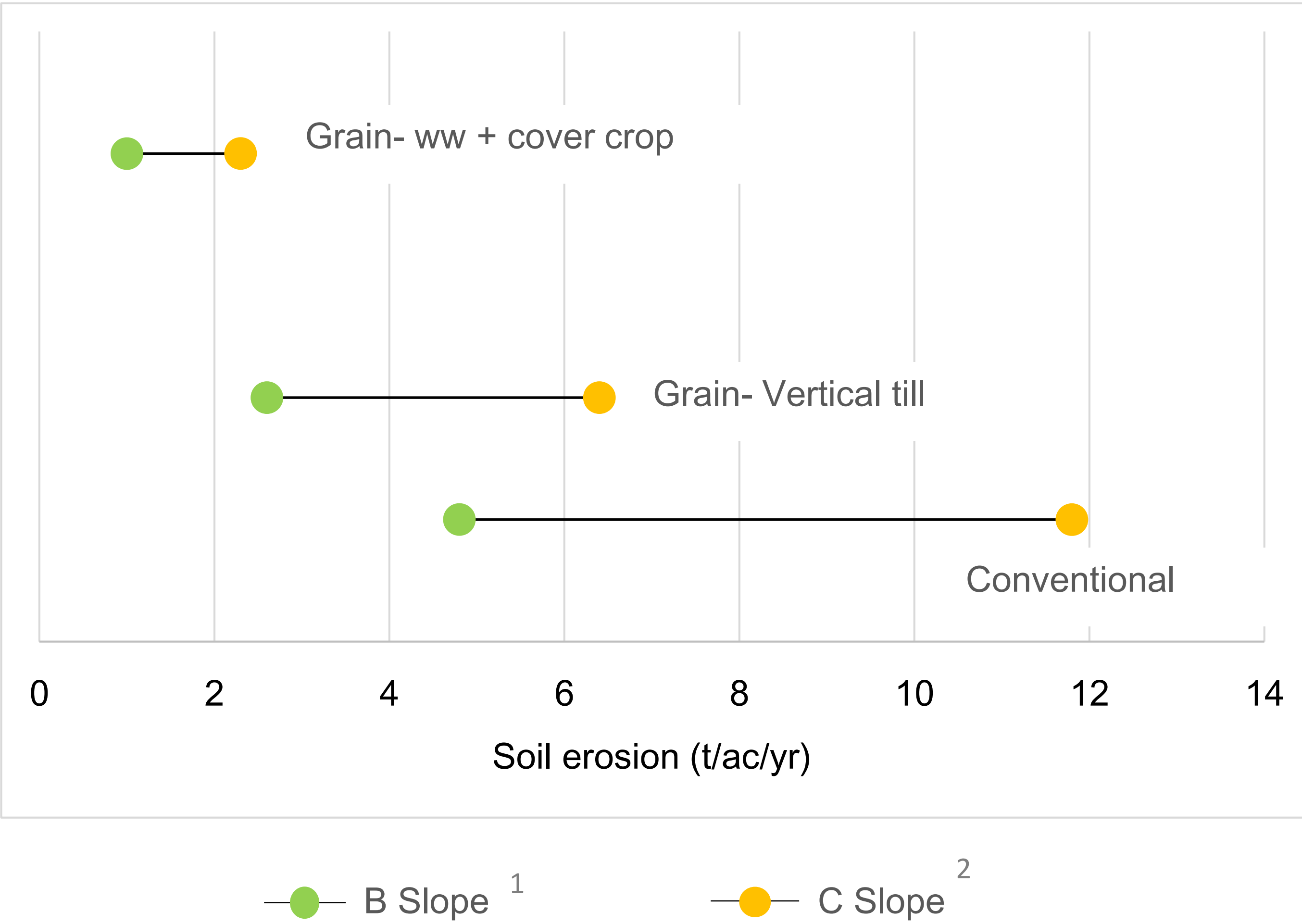
Intermediate- Vertical Tillage (VT)

Corn grain (2 years)- Soybeans
Fall vertical tillage;
No cover crop

Conservation Rotation- Winter wheat + cover crops

Corn grain- winter wheat
Multi-species cover crop after wheat
Corn planted green into cover crop

Less variability in soil erosion across fields with different slopes when using conservation practices



1.3 t/ac/ yr

Difference in soil loss from the dominant C-slope soils in this watershed compared to B-slope soils when farmers **include winter wheat and plant cover crops**

COMPARED TO

7 t/ac/ yr

Difference in soil loss on C-slope soils compared to A-slope soils with **fall chisel plowing in a corn-soybean rotation without cover crops.**

Soil Loss in this publication refers to the amount of soil lost from a field in t/ac/year over a set rotation as calculated by RUSLE2[1]. This value takes into account factors including field slope, soil type, climate, and ground cover.

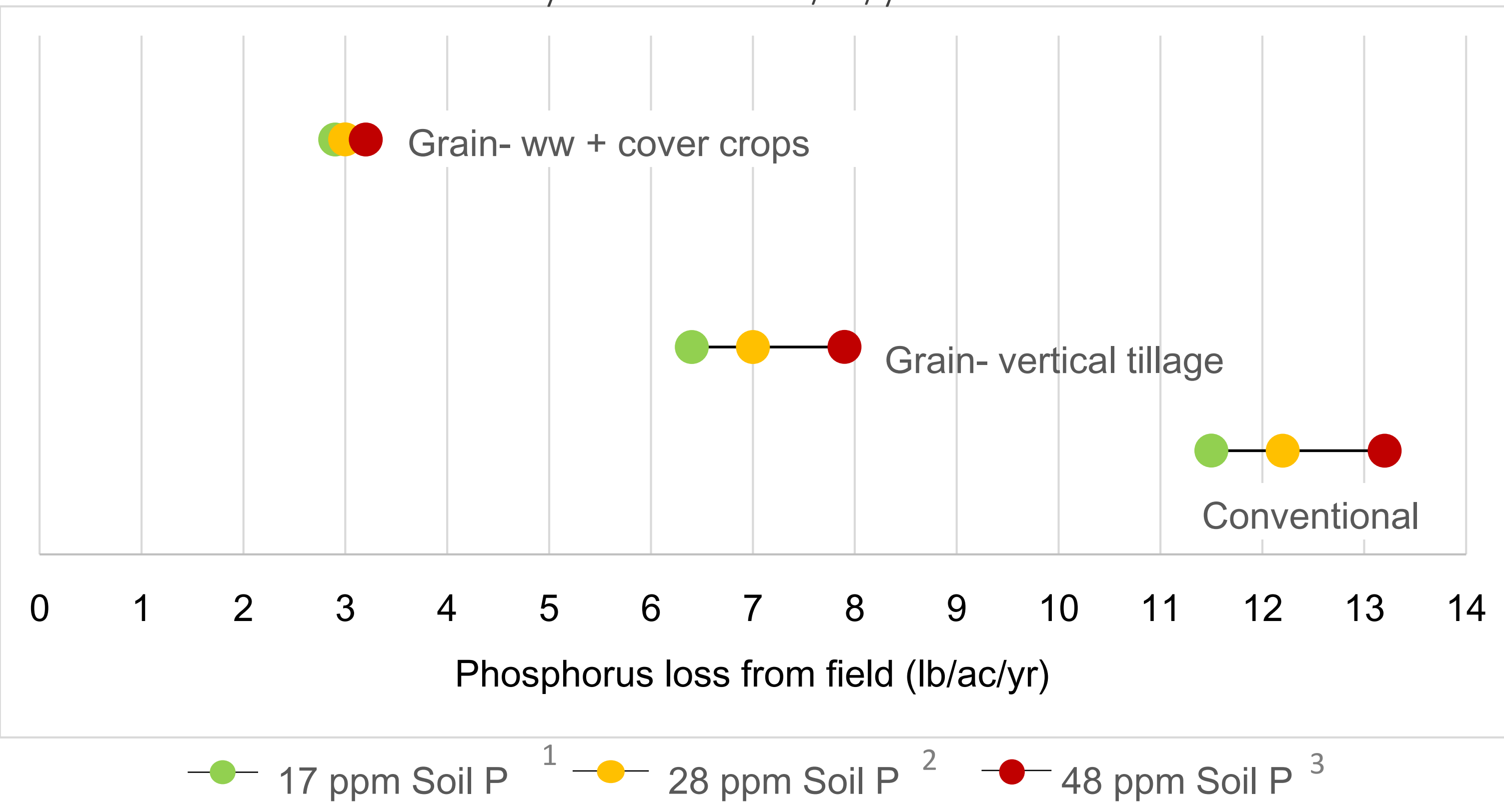
1 'B slope' refers to the soil types in this watershed with slope of 2-6%

2 'C slope' refers to the soil types in this watershed with slope of 6-12%

Higher phosphorus loss from fields in corn-soybean, chisel plow systems

5.3 lb/ac/ yr — At a soil test level of 48 ppm P using a Vertical Till implement instead of a chisel plow to prep soil for planting can reduce phosphorus loss by 5.3 lb/ac/yr.

4.7 lb/ac/ yr — At the High P level, transitioning from Vertical Till to planting green into living covers can decrease phosphorus loss from fields by another 4.7 lb/ac/yr.



The Wisconsin Phosphorus Index (PI) estimates the average annual runoff P from a farm field based on: manure application rate and timing, P fertilizer additions, soil test P, crop rotation and field operations.

1 Lower quartile of the Juneau County soil test P soil data summary
2 Median of the Juneau County soil test P soil data summary
3 Upper quartile of the Juneau County soil test P soil data summary

Modeling Results:

DAIRY OPERATIONS

CROP ROTATIONS: Dairy

Dairy Rotation - Conventional

Corn silage (3 years) - Alfalfa Hay (3 years)
Spring disk
8,000 gallons/acre spring manure application, Incorporated; No cover crop

Dairy Rotation – No-till

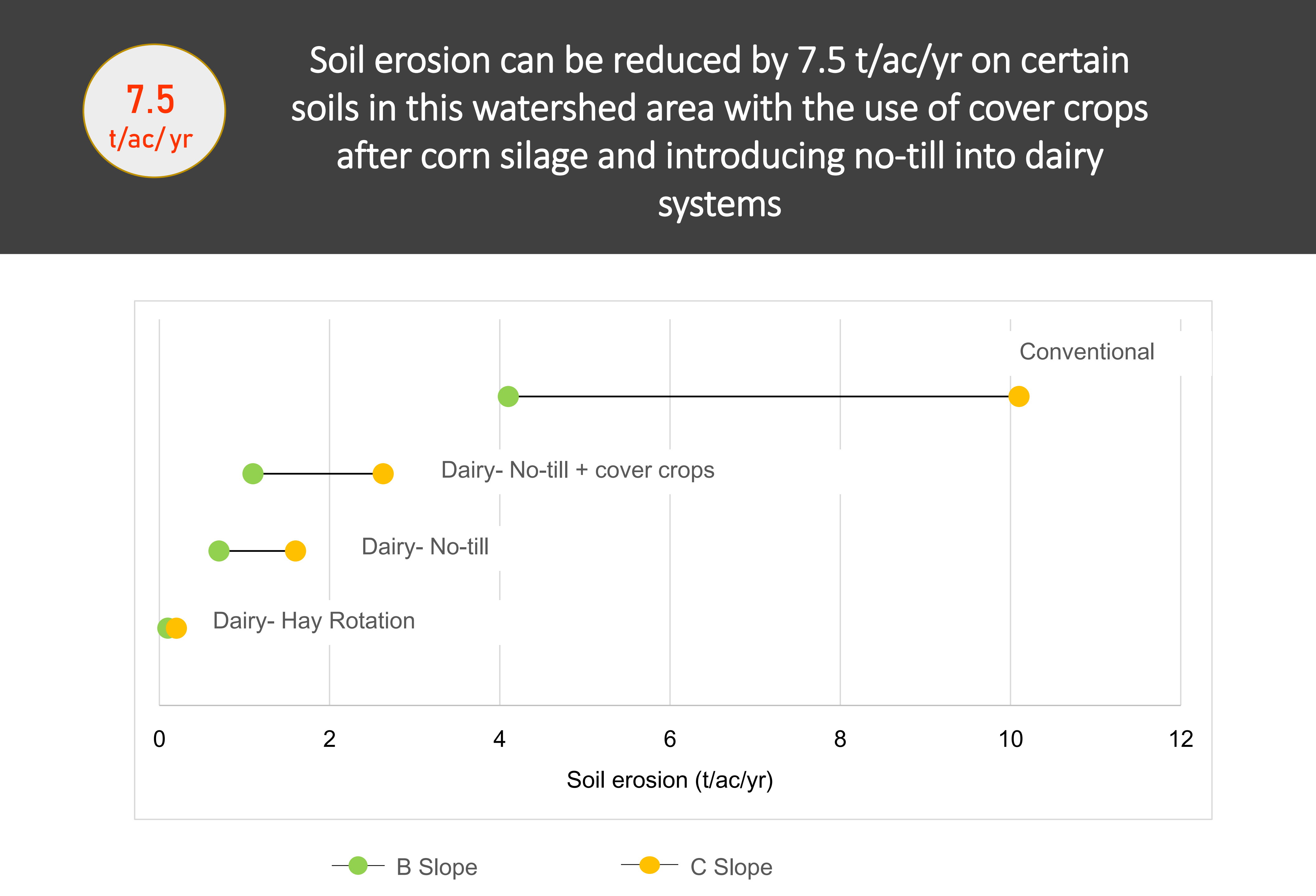
Corn silage (3 years) - Alfalfa Hay (3 years)
No-till
8,000 gallons/acre spring manure surface application

Dairy Rotation – No-till + cover crops

Corn silage (3 years) - Alfalfa Hay (3 years)
Spring disk
8,000 gallons/acre spring manure surface application, Rye cover crop after corn silage

Dairy Rotation - Hay

Straight alfalfa/grass crops
Tillage only in seeding years

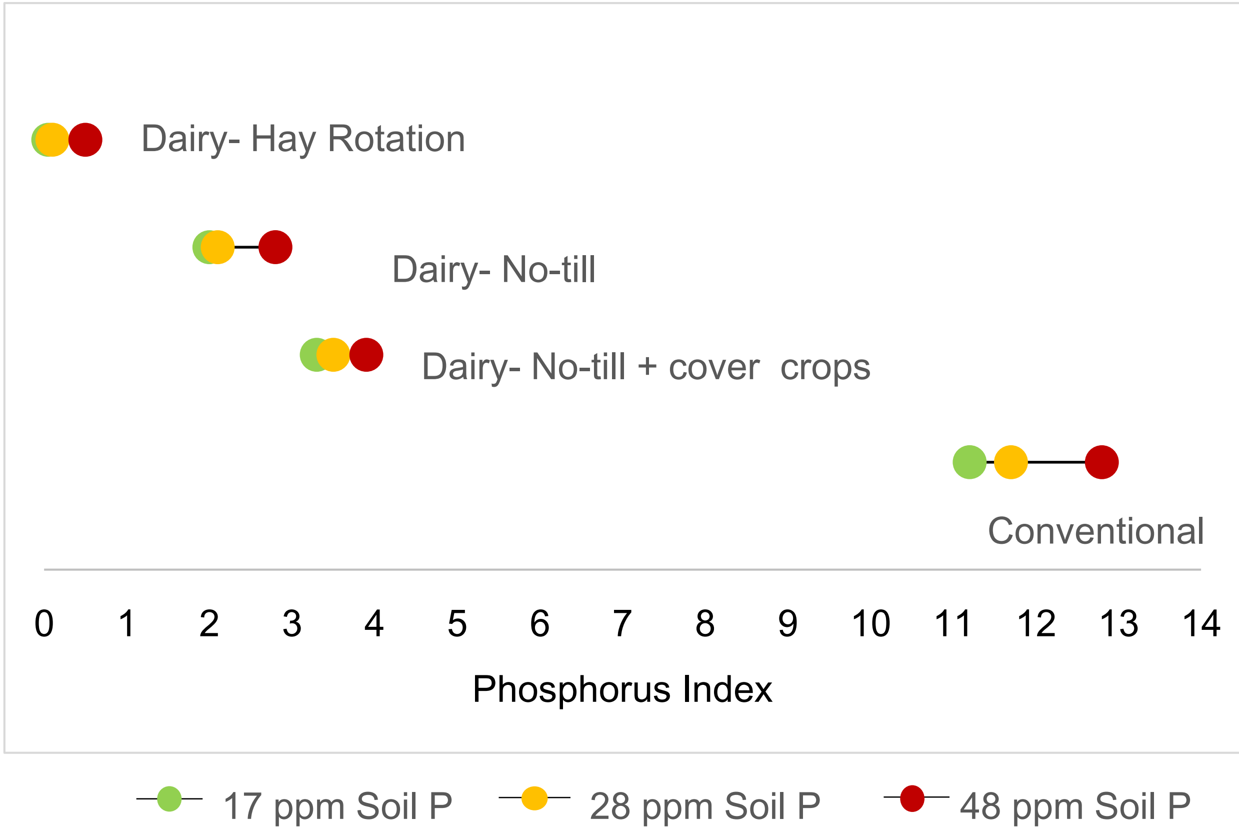

7.5
t/ac/yr
Soil erosion can be reduced by 7.5 t/ac/yr on certain soils in this watershed area with the use of cover crops after corn silage and introducing no-till into dairy systems
Conventional
Dairy- No-till + cover crops
Dairy- No-till
Dairy- Hay Rotation
0
2
4
6
8
10
12
Soil erosion (t/ac/yr)
B Slope
C Slope

Higher risk of phosphorus loss from fields in dairy rotations when disking in the spring and incorporating manure using tillage

On dairy operations, **manure is an important part of the system**. Some fields may receive more frequent or higher volume manure applications than others on a regular basis, leading to a variability in soil test P levels across the farm.

Conservation practices can not only **lower risk of P losses** from the field, but also **reduce the *variability* in phosphorus losses** across fields with different soil phosphorus concentrations.

Decreasing tillage in dairy systems can lower phosphorus loss from fields.



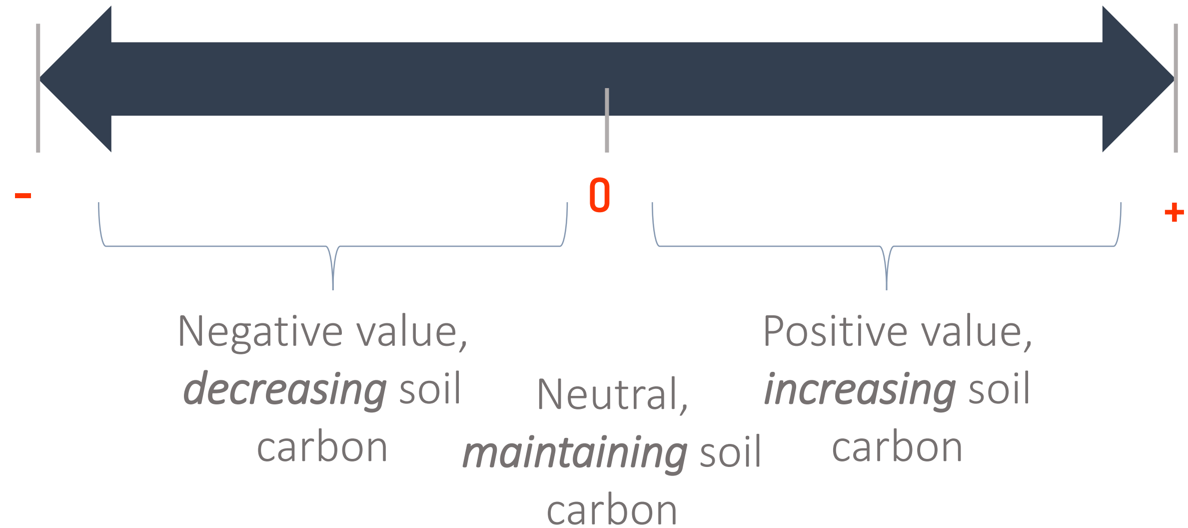
8.9 lb/ac/yr

At a soil test level of 48 ppm P, **no-till planting corn crops** instead of using conventional tillage can reduce phosphorus loss by 8.9 lb/ac/yr on average on soils in this watershed.

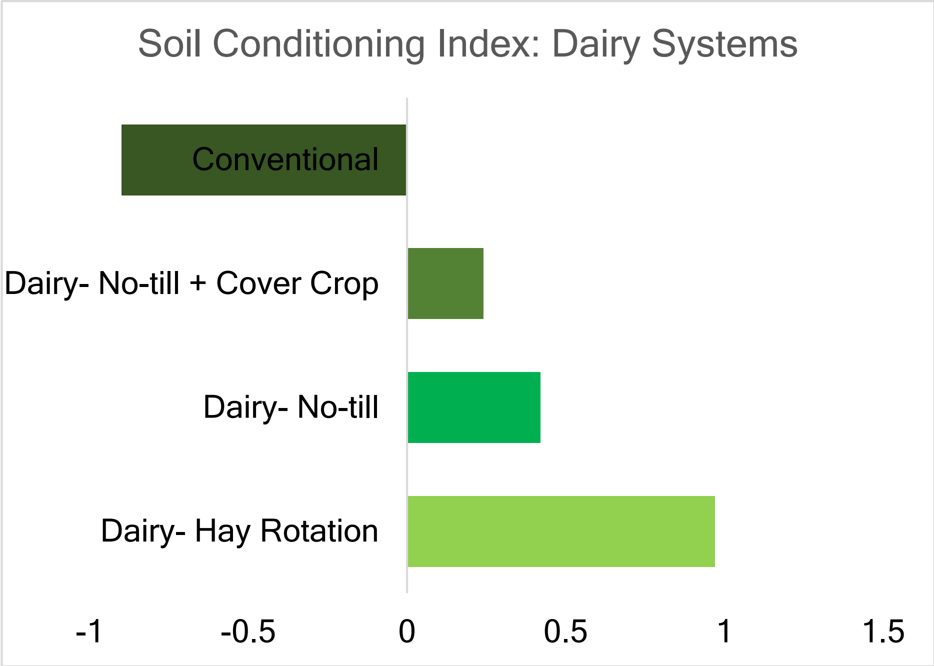
1.1 lb/ac/yr

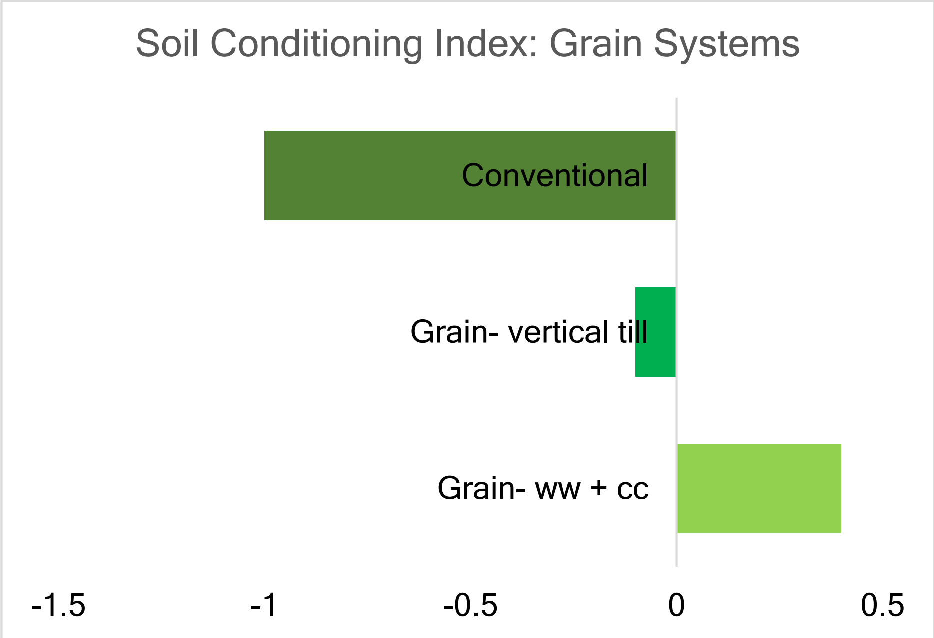
Sometimes additional disturbance from either tillage or the drill when **planting a cover crop after corn crops** *may* increase P losses from the field, however not always; on average on these soils, by 1.1 lb/ac/yr.

A higher Soil Conditioning Index means farming practices are encouraging the building of soil organic matter



The SCI predicts whether field soil is **gaining or losing carbon.** Values indicate direction of soil carbon building based off management practices like tillage. It does not reflect the actual quantity of carbon stored in the soil and **a value near zero doesn't necessarily indicate good management** if soil carbon levels have already degraded and they are being maintained at a low level.





- Reducing tillage,
- Increasing surface residues left on the field
- Integrating cover crops into a rotation

will often raise the SCI

PRODUCERS OF LAKE REDSTONE

Conservation Dashboard

3,211 acres

Covered by participating farms in 2019

240 acres

Of cover crops planted across 6 farms through the group's cost-share incentive program.

118 acres

Receiving soil testing to help inform soil nutrient needs.

PRODUCERS OF LAKE REDSTONE CONSERVATION PROGRESS

Potential Sediment + Nutrient Reductions

Conservation efforts can reduce sediment and phosphorus from reaching waterways.

Here we apply the reductions we've modeled for the different scenarios on 3,000 acres of cropland to get an idea of potential impacts to water quality.

Currently the group membership covers 3,211 acres. Many producer- led watershed groups seek to expand their farmer participation in their group, while promoting these practices in their communities.

Potential Sediment + Nutrient Reductions

3,000 acres of cropland managed under a **grain system** could experience the following reductions* when switching from a **corn-bean system with chisel plowing** to:

Vertical Tillage → 14,322 Tons Sediment | 15,539 Pounds of P

No-till and cover crops → 25,115 Tons Sediment | 27,692 Pounds of P

*Estimates based on numbers averaged across rotation years, all dominant soil types in watershed, slope classes and soil test P values. Actual reductions will vary based on practice particulars and placement on landscape

PRODUCERS OF LAKE REDSTONE CONSERVATION PROGRESS

Potential Sediment + Nutrient Reductions

3,000 acres of cropland managed under a **dairy system** could experience the following reductions* when switching from **silage and alfalfa rotations with spring disking and manure incorporation** to:

	Sediment	P
No-till + cover crops	19,631 Tons Sediment	25,000 Pounds of P
Perennial forage system	26,130 Tons Sediment	35,076 Pounds of P

*Estimates based on numbers averaged across rotation years, all dominant soil types in watershed, slope classes and soil test P values. Actual reductions will vary based on practice particulars and placement on landscape

Looking ahead, the Producers of Lake Redstone are looking to expand their activities and outreach through partnerships with UW Discovery Farms and neighboring Producer-Led groups.

They will continue to develop their manure sharing program and learn more about how to make cover crops a viable practice in their systems.

If you have questions regarding this report, contact Dana Christel, Conservation Specialist:

Dana.Christel@Wisconsin.Gov
(608) 640- 7270