RED CEDAR LAKES, BARRON & WASHBURN COUNTIES

BALSAM-MUD (2112800)
BASS (1833100)
RED CEDAR (2109600)
HEMLOCK (2109800)
MURPHY FLOWAGE (2110900)

2024-2033 Comprehensive Lake and Watershed Management Plan

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Red Cedar Lakes Association

Mikana, WI 54857

Mission Statement:

To preserve, protect and improve Red Cedar, Balsam/Mud, Hemlock, Bass, and the Murphy Flowage and their watershed and ecosystem.

Acknowledgements

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

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Executive Summary

The Red Cedar Lakes are located in northwestern Barron County, southeastern Washburn County, and western Rusk County, all in northwest Wisconsin in the headwaters region of the Red Cedar River watershed. The Red Cedar River watershed covers nearly 1,900 square miles and includes parts of Barron, Dunn, Chippewa, Washburn, Sawyer, Polk, Rusk, St. Croix, Burnett and Pierce Counties.

The Red Cedar Lakes consist of three mainstem lakes (Balsam, Red Cedar, and Hemlock) on the Red Cedar River, Mud Lake, a small spring-fed lake flowing into Balsam Lake, and Murphy Flowage, an impound on Hemlock Creek located in Rusk County upstream of Hemlock Lake. The lakes cover almost 2,700 acres and have nearly 39 miles of shoreline.

The whole of the Red Cedar River watershed was assessed under a TMDL (total maximum daily load) study that 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[1]. This TMDL was written for lakes Tainter and Menomin in Dunn County, the last impounds on the Red Cedar River before it empties into the Chippewa River, but also includes headwaters area of the Red Cedar River Watershed between the Mikana Dam and the north end of Big Chetac Lake.

After a TMDL study is completed, an implementation plan is developed to describe the management measures and regulatory approaches necessary to address the pollutant load issues affecting the water body, the parties responsible for such management measures, the costs and sources of funds for these measures, methods to get participation from stakeholders, a timeline for implementation, ways to measure success, and also any adaptive management techniques employed as the plan moves forward. For the Tainter and Menomin Lakes TMDL, this plan is titled <u>A River Runs through Us: A Water Quality Strategy for the Land and Waters of the Red Cedar River Basin.</u>

The last Comprehensive Lake Management Plan for the Red Cedar Lakes was completed in 2004 and focused on nonpoint source (NPS) pollution, also known as polluted runoff, and its impacts on the Red Cedar Lakes. 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 (phosphorus and nitrogen), oil, grease, sediment and bacteria from agricultural, urban and residential areas.

The Federal Clean Water Act (CWA) requires states to publish a list of all waters in the state not meeting water quality standards. Updated every two years, this list, known as the Impaired Waters List, identifies those lakes experiencing degradation due to increased nutrients, excess algae (green water), and a host of other concerns.

Of greatest concern for the Red Cedar Lakes is the fact that since the 2004 Plan was completed and management actions within it implemented, both Balsam Lake and Red Cedar Lake have been placed on the Wisconsin Impaired Waters List for eutrophication (nutrient enrichment) and excess algal growth (a by-product of nutrient enrichment); Red Cedar in 2014, and Balsam Lake in 2016.

[1] https://dnr.wisconsin.gov/topic/TMDLs

As in 2004, this updated Comprehensive Plan identifies NPS pollution as the leading cause of water quality issues in the Red Cedar Lakes and it will again be the focus of management actions to maintain and/or improve water quality in the updated Comprehensive Plan.

With the Tainter and Menomin Lakes TMDL Implementation Plan serving as a guide, key strategies, objectives, and management actions for reducing NPS pollution (phosphorus loading) have been developed for three main loading inputs: 1) the immediate watershed of and main tributaries to the Red Cedar Lakes (external loading); 2) in-lake disturbance of the sediment, groundwater, and septic systems (internal loading); and 3) the developed nearshore area of the lakes. A summary of the strategies for each of these areas is given in the following pages. In addition, the capacity of the Red Cedar Lakes Association to implement and fund the management actions is explored. Each of these strategies are explored in greater detail in the greater body of the updated Red Cedar Lakes Comprehensive Lake Management Plan.

Key Strategy 1 – Reduce phosphorus inputs to the Red Cedar Lakes from surface water runoff.

Reduce external total phosphorous (TP) loading into the mainstem lakes (Balsam, Red Cedar, Hemlock) from the four major tributaries (Birch Lake (Red Cedar River), Pigeon Creek, Sucker Creek, Hemlock Creek) by 33.4% (4,676lbs) over the next ten years (2024-2033).

Objective 1: Reduce the total amount of TP loading into Balsam Lake from Birch Lake (Red Cedar River) (4,827lbs) by 10% (483lbs) over the next ten years (2024-2033) (Table 1).

1) Birch Lake into Balsam Lake
    a) Information needed
        i) Evaluate P loading as it is associated with the wetland that is between the Birch Lake dam and the inlet to Balsam Lake.
    b) Possible management actions
        i) Water treatment between the Birch Lake dam and the inlet to Balsam Lake
            (1) Wetland area
            (2) Instream phosphorus treatment
        ii) CLP management in Birch and Big Chetac Lakes
            (1) Needs the cooperation of the Big Chetac and Birch Lakes Association and Constituency
        iii) Evaluate the application of alum in Birch Lake
            (1) Needs the cooperation of the Big Chetac and Birch Lakes Association and Constituency

Objective 2: Reduce the total amount of TP loading into Red Cedar Lake from Pigeon and Sucker Creeks (4,721lbs) by 75% (3,541lbs) over 10 years - 30% (1,417lbs) in the 1st five years; and an additional 45% (2,124lbs) in the 2nd five years.

2) Sucker Creek into Red Cedar Lake
    a) Information needed
        i) Agricultural assessment (cropland, barnyards, livestock fencing, and existing buffers)
    b) Possible management actions
        i) Address issues with cropland, barnyards, livestock fencing, and existing buffers.
        ii) Watershed work in Sucker Creek Sub-basin
            (1) Land Use
            (2) Forestry

3) Pigeon Creek into Red Cedar Lake
    a) Information needed
        i) Agricultural assessment (cropland, barnyards, livestock fencing, and existing buffers)
    b) Possible management actions
        i) Address issues with cropland, barnyards, livestock fencing, and existing buffers.
        ii) Watershed work in Sucker Creek
            (1) Land Use
            (2) Forestry

Objective 3: Reduce the total amount of TP loading in Hemlock Lake from Hemlock Creek (4,663lbs) by 10% (466lbs) over the next ten years (2024-2033)

4) Hemlock Creek from Murphy Flowage into Hemlock Lake
    a) Information needed
        i) Nothing immediate
    b) Possible management actions
        i) Watershed work in Hemlock Creek Sub-basin between Murphy Flowage and Hemlock Lake
            (1) Land Use
            (2) Forestry
5) Hemlock Creek into Murphy Flowage
    a) Information needed
        i) ATV trail evaluation
        ii) Planned forestry management activities
        iii) Additional stream monitoring upstream of Murphy Flowage
    b) Possible management actions
        i) Watershed work in Hemlock Creek Sub-basins upstream of Murphy Flowage
            (1) ATV trail improvement
            (2) Land Use
            (3) Forestry

Objective 4: Reduce the total amount of TP loading into the mainstem lakes (Balsam, Red Cedar, and Hemlock Lakes) from the unmeasured gullies, ravines, and washes (928lbs) by 20% (186lbs) over the next ten years (2024-2033).

6) Unmeasured gullies, ravines, and washes
        i) Information needed
            (1) Inventory or unmeasured gullies, ravines, and washes draining to all of the mainstem lakes
            (2) Perennial and/or storm water sampling for TP and sediment in the worst contributors (6-8 gullies, ravines, or washes)
            (3) Prioritizing of the worst contributors
        ii) Possible management actions
            (1) Stabilization of side slopes
            (2) Changes in upstream land use

Table 1: Estimated external (surface water) TP loading reductions into the three mainstem Red Cedar Lakes

Key Strategy (Goal) 1 - External Loading Reduction to the Red Cedar Lakes									
Surface Water (SW) Load	**acft/day**	**% of Flow**	**TP (mg/L)**	**lbs/day**	**Estimated Annual Load (lbs)**	**% of Load**	**10 yr Target Reduction (%)**	**Total Reduction (lbs)**	**Target Reduction - first 5 years (lbs)**	**Target reduction - second 5 years (lbs)**
Balsam Lake Loading from Birch Lake										
Objective 1: Birch into Balsam (Red Cedar River) - Main Tributary 1	139		0.035	13	4827		10	483		483
Red Cedar Lake Loading										
Balsam into RCL (Red Cedar River) (included in Objective 1))	137	25.3	0.027	10	3670	26.2				
Objective 2: Sucker Creek into RCL - Main Tributary 2	39	7.2	0.059	6	2283	16.3	75	1712	685	1027
Objective 2: Pigeon Creek into RCL - Main Tributary 3	27	5.0	0.091	7	2438	17.4	75	1828	732	1097
Objective 3: Hemlock Creek into Hemlock Lake into RCL - Main Tributary 4	94	17.3	0.05	13	4663	33.4	10	466		466
Gullies, Ravines, and Washes (unmeasured SW flow)	n.c.	n.c.	??	2	928	6.6	20	186	93	93
Precipitation										
	297	54.8		38	13982	100.0		4676 (33.4%)	1510 (10.8%)	3166 (22.6%)
*Groundwater/Septic (internal) (2003 USGS)	245	45.2								
RCL Outlet (Red Cedar River)	542	100	0.026	38	13982					

Key Strategy 2 – Reduce phosphorus inputs to the Red Cedar Lakes from internal loading (sediment release and septic system).

Reduce total internal TP loading in the main stem lakes (Balsam, Red Cedar, and Hemlock Lakes) by 10% (270lbs) over the next 10 years (2024-2033) based on values reported in the 2003 USGS Report, Table 5 (Table 2).

Objective 1: Reduce total internal loading of TP in Balsam Lake (509lbs) by 10% (51lbs) over ten years (2024-2033).

1) Balsam Lake
    a) Information needed
        i) Complete a sediment phosphorus release study in Balsam Lake.
        ii) Boating survey
    b) Possible management actions
        i) Septic system maintenance on all developed properties
        ii) Reduce disturbance of sediment by watercraft
            (1) By education
            (2) By ordinance
        iii) Application of Alum
        iv) Application of iron filings late in the season
        v) Hypolimnetic aeration

Objective 2: Reduce total internal loading of TP in Red Cedar Lake (1,632lbs) by 10% (163lbs) over ten years (2024-2033).

2) Red Cedar Lake
   a) Information needed
      i) Boating survey
   b) Possible management actions
      i) Septic system maintenance on all developed properties
      ii) Reduce disturbance of sediment by watercraft
         (1) By education
         (2) By ordinance

Objective 3: Reduce total internal loading of TP in Hemlock Lake (556lbs) by 10% (56lbs) over ten years (2024-2033).

3) Hemlock Lake
   a) Information Needed
      i) Boating survey
   b) Possible management actions
      i) Septic system maintenance on all developed properties
      ii) Reduce disturbance of sediment by watercraft
         (1) By education
         (2) By ordinance

Table 2: Estimated internal (groundwater and septic) TP loading reductions into the three mainstem Red Cedar Lakes based on the 2003 USGS Report

Key Strategy (Goal) 2: Internal Loading Reductions in the Red Cedar Lakes (from the 2003 USGS Lake Report)										
Internal Load - Groundwater and Septic (2003 USGS Report)	acft/day	% of Flow	TP (mg/L)	lbs/day	Annual Load (lbs)	% of Load	10 yr Target Reduction (%)	Total Reduction (lbs)	Target Reduction - first 5 years (lbs)	Target reduction - second 5 years (lbs)
Objective 1: Balsam Lake					509		10	51		51
Objective 2: Red Cedar					1633		10	163		163
Objective 3: Hemlock Lake					556		10	56		56
					2698			270		270 (10%)
Goundwater (2003 USGS)	245	45.2	0.025		2452		10	245		245
Septic (2003 USGS)					246		10	25		25

Key Strategy 3 – Reduce phosphorus inputs to the Upper Red Cedar River Watershed (upstream of the Mikana Dam) from different land uses.

Reduce surface water phosphorus sediment loading into the mainstem lakes (Big Chetac, Birch, Balsam, Red Cedar, and Hemlock Lakes) from the whole of the northern Red Cedar River Watershed outside the "measured" portions of the watershed (Lake Chetac and Knuteson Creek Sub-basins, that portion of the Red Cedar Lake Sub-basin not already included in the Pigeon Creek Sub-basin – NW of Red Cedar Lake, and the southern portion of the Hemlock Creek Sub-basin) by 20%.

Objective 1: Reduce phosphorus surface water phosphorus loading into the mainstem lakes from the whole of the northern Red Cedar River Watershed outside of the "measured" portions of the watershed by 20% over 10 years - 10% in the 1st five years; and an additional 10% in the 2nd five years.

1) Areas outside of the "measured" potions of the Watershed
   i) Information needed
      (a) Agricultural assessment (cropland, barnyards, livestock fencing, and existing buffers)
      (b) Developed area assessment (roadways, developed properties, businesses, etc.)
   ii) Possible management actions
      (a) Identify three of the "best" opportunities to address issues with cropland, barnyards, livestock fencing, and existing buffers and implement BMPs in the first 3-5 years
      (b) Identify and address additional opportunities in the last 5 years.
      (c) Identify three of the "best" opportunities to address issues with developed properties and implement BMPs in the first 3-5 years
      (d) Identify and address additional opportunities in the last 5 years.

Key Strategy 4 – Reduce sediment and phosphorus inputs to the Red Cedar Lakes from the nearshore area of the lakes (runoff and erosion).

Reduce the number of businesses and private parcels contributing phosphorus and sediment loading through surface water runoff into the Red Cedar Lakes.

Objective 1: Identify, and then prioritize, the top five potential runoff and erosion reduction opportunities associated with resorts, campgrounds, or other tourism-focused businesses and then implement preservation programs with the owners and/or key constituents of these entities in the first five years (2024-2028) of this project. Identify and prioritize an additional five potential opportunities and projects to implement in the second five years (2029-2033).

1) Resorts, campgrounds, or other tourism-focused businesses
   i) Information needed
      (a) Assessment of tourism-focused businesses for potential runoff concerns
         (i) Identify at least 5 of the best opportunities to work with those businesses to implement projects that will reduce runoff
      (b) In-person consultations with owners and operators of tourism-focused businesses
         (i) Identify what owners are willing to do and how the RCLA can assist
   ii) Possible management actions
      (a) Design and Implement BMPs to address the concerns

Objective 2: Reduce the number of private parcels located within 300-ft of the lakeshore that have been or will be assessed and given moderate or high priority rankings based on their potential for contributing phosphorus and sediment loading into the Red Cedar Lakes through surface water runoff by 20% (≈15 parcels) in the first five years (2024-2028); and then by an additional 30% (≈22 private parcels) in the second five years (2029-2033).

2) Private parcels
   i) Information needed

    - (a) Develop a plan to approach property owners identified with the greatest potential to implement improvement projects on their property.
    - (b) Redo the Shoreland Habitat Assessment after year five
  - ii) Possible management actions
    - (a) Implementation of Healthy Lakes and Rivers BMPs

Objective 3: Reduce the number of sites where erosion associated with the many islands within the Red Cedar Lakes occurs by 50% in the next ten years (2024-2033).

3) Islands
  - i) Information needed
    - (a) Continued assessment of the islands within the lakes
    - (b) Develop plans to improve, protect, and preserve the islands
  - ii) Possible management actions
    - (a) Implement plans to improve, protect, and preserve the islands

Key Strategy 5 – Build capacity within the RCLA to be able to effectively and efficiently implement the management actions in this Comprehensive Management Plan over the next ten years (2024-2033)

Develop and put into practice an organizational structure that is scaled to meet the human and financial requirements necessary to implement the tactics, actions and relationship-building efforts outlined in the Comprehensive Plan.

Objective 1: Identify a future Lake Management Consultant

1. Expected Tasks
    a. Assist the RCLA with grant preparation and administration
    b. Help the RCLA guide planning for future studies and management implementation

Objective 2: Identify outside resources to help complete necessary studies identified and implement management actions in the Comprehensive Plan

2. Review of Outside Resources identified in the Comprehensive Plan
    a. Who can do what?
    b. How does the RCLA engage them?

Objective 3: Review the Committee Structure currently in place with the RCLA and modify or add to it if necessary.

3. Define Committee responsibilities and how they pertain to the implementation of the Comprehensive Plan
    a. How do the existing committees help meet the needs of the Comprehensive Plan?
    b. Are new committees necessary?
    c. How does the RCLA engage its Constituency in implementation of the Comprehensive Plan?
    d. How does the RCLA engage with other partners to implement the Comprehensive Plan?

i. Red Cedar River Water Quality Partnership
ii. Big Chetac and Birch Lake Association
iii. Barron, Rusk, Sawyer, and Washburn Counties
iv. Local Townships
v. Villages of Birchwood and Mikana

Objective 4: Review and assess the financial capability of the RCLA to implement the Comprehensive Plan.

4. Identify funding sources for implementation of the Comprehensive Plan
   a. Local funding
      i. Association Dues
      ii. Donations
   b. Grant funding
      i. Federal grant programs
      ii. State grant programs
      iii. County grant programs
      iv. Foundations
      v. Other

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COMPREHENSIVE LAKE AND WATERSHED MANAGEMENT PLAN

RED CEDAR LAKES

PREPARED FOR THE RED CEDAR LAKES ASSOCIATION

1.0 Introduction

The Red Cedar Lakes are located in northwestern Barron County, southeastern Washburn County, and western Rusk County, all in northwest Wisconsin in the headwaters region of the Red Cedar River watershed. The Red Cedar River runs through a large portion of northwest Wisconsin with its headwaters starting in Big Chetac Lake in Sawyer County, eventually draining into the Chippewa River south of Menomonie, WI. The Red Cedar River watershed covers nearly 1,900 square miles and includes parts of Barron, Dunn, Chippewa, Washburn, Sawyer, Polk, Rusk, St. Croix, Burnett and Pierce Counties. The watershed contains 40,000 acres of open water and 4,900 miles of rivers and streams (See Section 1.3.1).

The Red Cedar Lakes consist of three mainstem lakes (Balsam, Red Cedar, and Hemlock) on the Red Cedar River, Mud Lake, a small spring-fed lake flowing into Balsam Lake, and Murphy Flowage, an impound on Hemlock Creek located in Rusk County upstream of Hemlock Lake. The lakes cover almost 2,700 acres and have nearly 39 miles of shoreline. A dam at the outlet of Red Cedar Lake near Mikana with a 21ft structural height and an 11ft hydraulic height maintains the water level. It is considered a low-hazard dam. The Mikana Dam is owned by Barron County. There are four public and several private boat landings on the three mainstem lakes.

Bass Lake is a small, 19 acre seepage lake adjacent to the northeast shore of Red Cedar Lake. Bass Lake is listed as being 39ft deep with an average depth of 13ft. It consists of a warm water fishery with largemouth bass, northern pike, and panfish. There is a public boat landing on the lake.

Upstream of Hemlock Lake on Hemlock Creek is Murphy Flowage, a 172 acre impound with a maximum depth of 14ft. A small dam had been in place for several decades before being replaced in 1994 by a new dam with a 22ft structural height and a 14ft hydraulic height. It is considered a low-hazard dam. Murphy Dam is owned by Rusk County. There are two public boat launches providing access to a warm water fishery that includes panfish, northern pike, bass, and trout. Several trout streams can be found close by.

The Red Cedar Lakes form a unique and important natural resource in northwest Wisconsin. Red Cedar Lake is listed as Outstanding Resource Water and Balsam and Mud Lakes are wild rice waters. The lakes are considered a highly desirable destination for residents and vacationers alike who participate in lake-centered activities year-round. Popular activities include year round fishing, boating, snowmobiling and Nordic skiing. A Barron County campground is located on Red Cedar Lake and several privately operated resorts are located throughout the system, including Stouts Island and Lodge, a high-end resort and restaurant on an island in the center of Red Cedar Lake, only accessible via boat. Murphy Flowage County Campground/Park offers a more rustic camping experience with nine campsites, four with electric hookup, four with electric and water hookup, and one walk-in site without electricity or water. The Ice Age Trail is located nearby and runs for 27 miles in the county forest, giving hikers an opportunity to observe the beauty of northwest Wisconsin.

1.1 Red Cedar Lakes Association

The Red Cedar Lakes Association (RCLA) has been very active in protecting the resources the Red Cedar Lakes provide. Several large-scale lake management planning projects and a lake protection project have been completed. The first Comprehensive Lake Management Plan was completed in 2004. Since that time, RCLA volunteers have been actively involved in data collection and providing input leading to an update of the 2004 Plan in 2022/23.

More information can be found on the RCLA webpage at: https://www.redcedarlakes.com/ or on the RCLA Facebook page at: https://www.facebook.com/redcedarlakesassociation/.

1.2 Problem Statement and Purpose

The last Comprehensive Lake Management Plan for the Red Cedar Lakes was completed in 2004. The 2004 Comprehensive Plan focused on nonpoint source (NPS) pollution and its impacts on the Red Cedar Lakes. 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, oil, grease, sediment and bacteria from agricultural, urban and residential areas[2].

As was determined in 2004, NPS pollution is the leading cause of water quality issues in the Red Cedar Lakes and will again be the focus of management actions to maintain and/or improve water quality in the updated Comprehensive Plan.

1.2.1 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. Assessing surface water quality throughout the state is the responsibility of the Wisconsin Department of Natural Resources (WI-DNR) through the Wisconsin's Consolidated Assessment and Listing Methodology (WisCALM). 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 (Chla), 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 CWA reporting (WI-DNR, 2021).

The Wisconsin acceptable standard for summer (a period of time between June 1 and September 15) TP in the REC category for stratified reservoirs like Red Cedar Lake is a mean concentration ≤30.0μg/L (Figure 1). For natural inland lakes, like Balsam Lake it is considered the same. If the summer mean concentration of TP exceeds this level, the water is considered impaired. However, if a body of water is considered to support a two story fishery (Balsam and Red Cedar), the acceptable standard for summer TP is ≤15.0μg/L (NR102.06(4)(b)1).

The WisCALM assessment protocol for Chla is based on the number of days in a sampling season (July 15-September 15) that have moderate algal levels based on Chla concentrations that exceeds 20.0μg/L. Once that level has been exceeded, the amount of algae in the surface water it represents discourages people from swimming (Figure 2). If the concentration of Chla exceeds 20.0μg/L for more than 5% of the expected lake use days, then the water is considered impaired.

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2 https://dnr.wisconsin.gov/topic/Nonpoint#:~:text=Nonpoint%20source%20(NPS)%20pollution%2C,%2C%20lakes%2C%20wetlands%20and%20groundwater.

Figure 1: Wisconsin numeric water quality standards for phosphorus (WDNR, 2018)

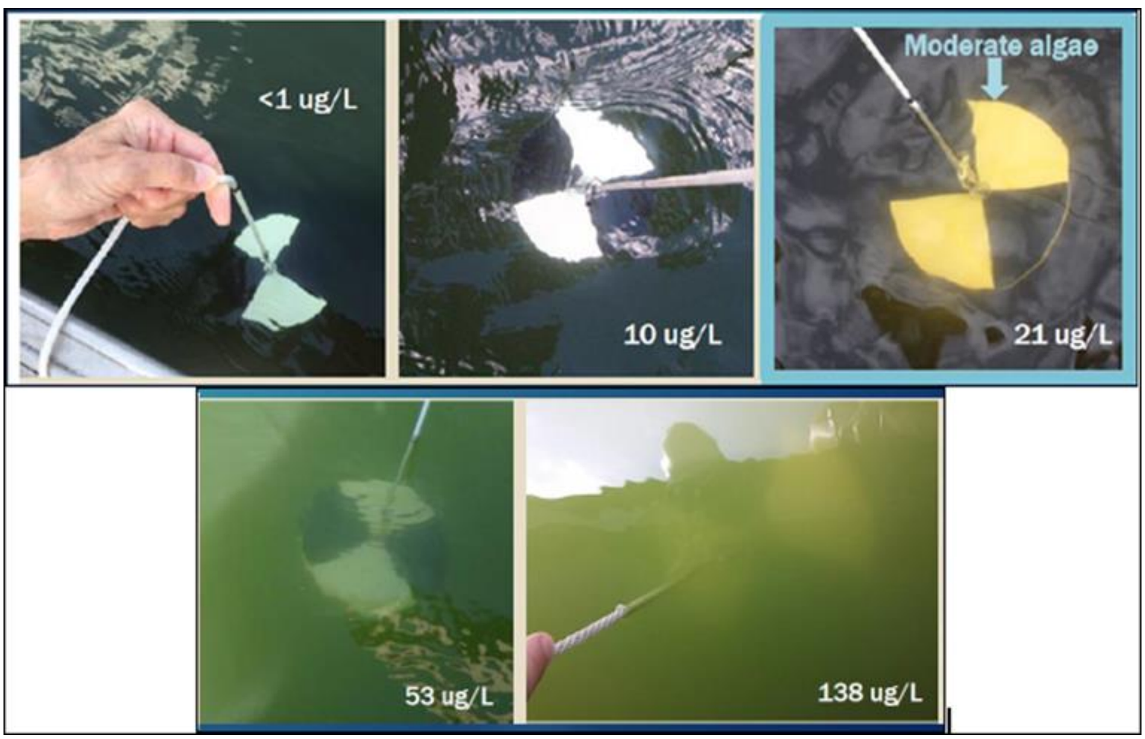

Figure 2: Chl-a concentrations and the corresponding water clarity as measured by a Secchi disk (WDNR, 2018)

Red Cedar Lake was first placed on the Impaired Waters List for TP in 2014 – Eutrophication and Excess Algal Growth. Balsam Lake was first placed on the list for TP – Eutrophication and Excess Algal Growth in 2016. Both remain on the most recent list for 2022. Both are listed for REC and FAL.

Birch and Big Chetac lakes, immediately upstream of the Red Cedar Lakes, and Rice Lake immediately downstream are also on the most recent impaired waters list.

1.3 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[3].

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 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[4].

1.3.1 Lakes Tainter and Menomin TMDL and the Red Cedar River Watershed

The whole of the Red Cedar River watershed is covered under a TMDL written for lakes Tainter and Menomin in Dunn County. Tainter and Menomin lakes are the last impounds on the Red Cedar River before it empties into the Chippewa River. Management strategies in the implementation plan for the Tainter and Menomin TMDL focus on the entire Red Cedar River watershed that drains to these two lakes. This includes the headwaters area of the Red Cedar River made up of Big Chetac, Birch, Balsam, Red Cedar, and Hemlock lakes. The TMDL portion of the Red Cedar River watershed is shown in Figure 3 and includes the 53 smaller, twelve-digit hydrologic unit code (HUC 12) watersheds. The watershed draining to the Red Cedar lakes include five of those individual sub-watersheds or basins – Knuteson Creek (070500070101), Lake Chetac (070500070102), Sucker Creek (070500070103), Hemlock Creek (070500070104), and Red Cedar Lake - including Pigeon Creek (070500070105) (Figure 3).

[3] https://dnr.wisconsin.gov/topic/TMDLs
[4] https://dnr.wisconsin.gov/topic/TMDLs/Overview.html

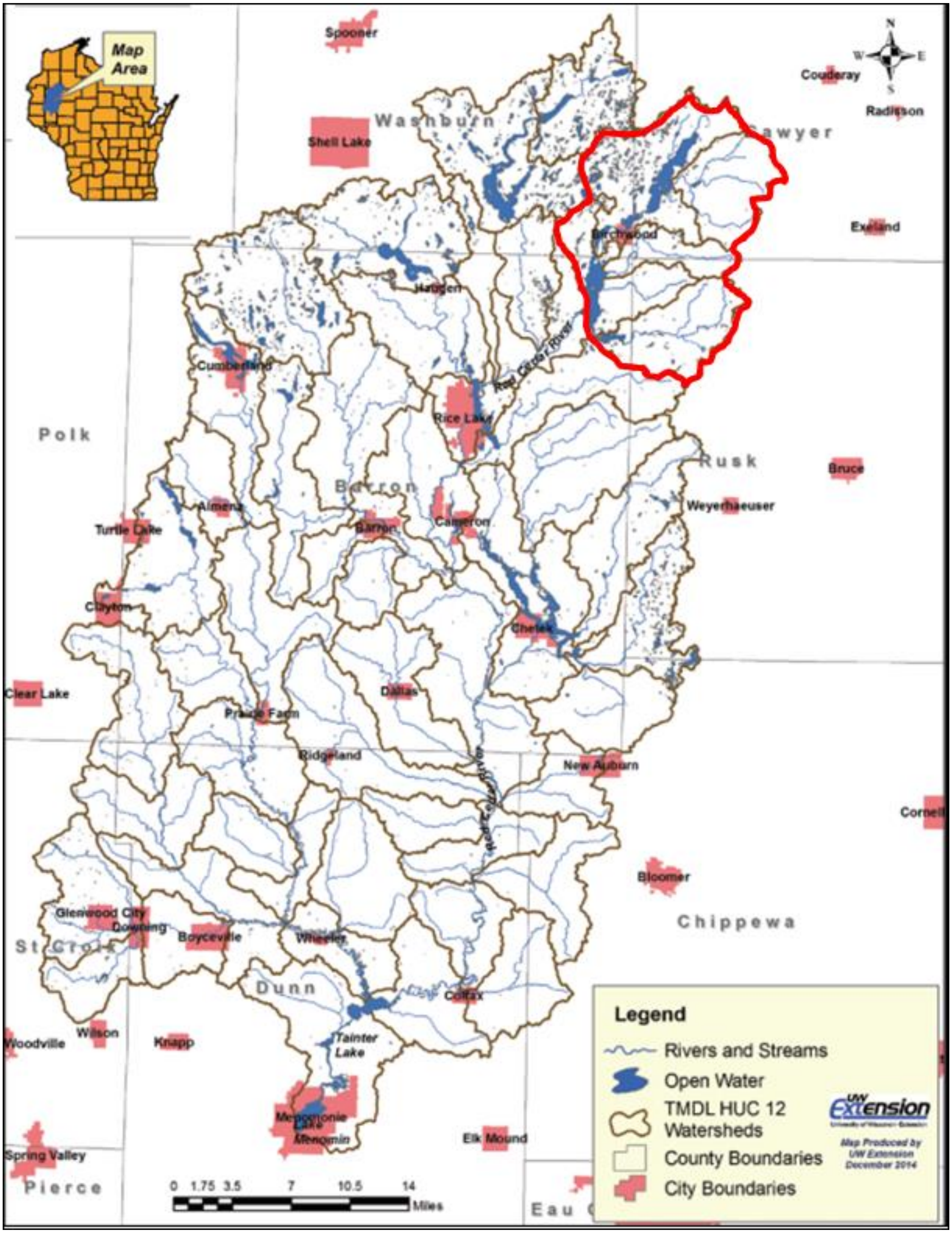

Figure 3: Map of the Red Cedar River watershed above Lakes Tainter and Menomin. Five HUC 12 sub-watersheds that make up the entire Red Cedar lakes watershed (red polygon)

Despite being listed on the impaired waters list, Red Cedar Lake is considered Outstanding Resource Water in WI. Portions of Pigeon, Hemlock, and Sucker Creeks are considered trout waters. Land cover in the five HUCs that make up this portion of the Red Cedar River watershed is dominated by forest with some agricultural land (Figure 4). Village and residential development exists primarily in the communities of Birchwood, Edgewater, and Mikana; and in the nearshore riparian area around all the lakes. Riparian area development is most prevalent around Red Cedar Lake.

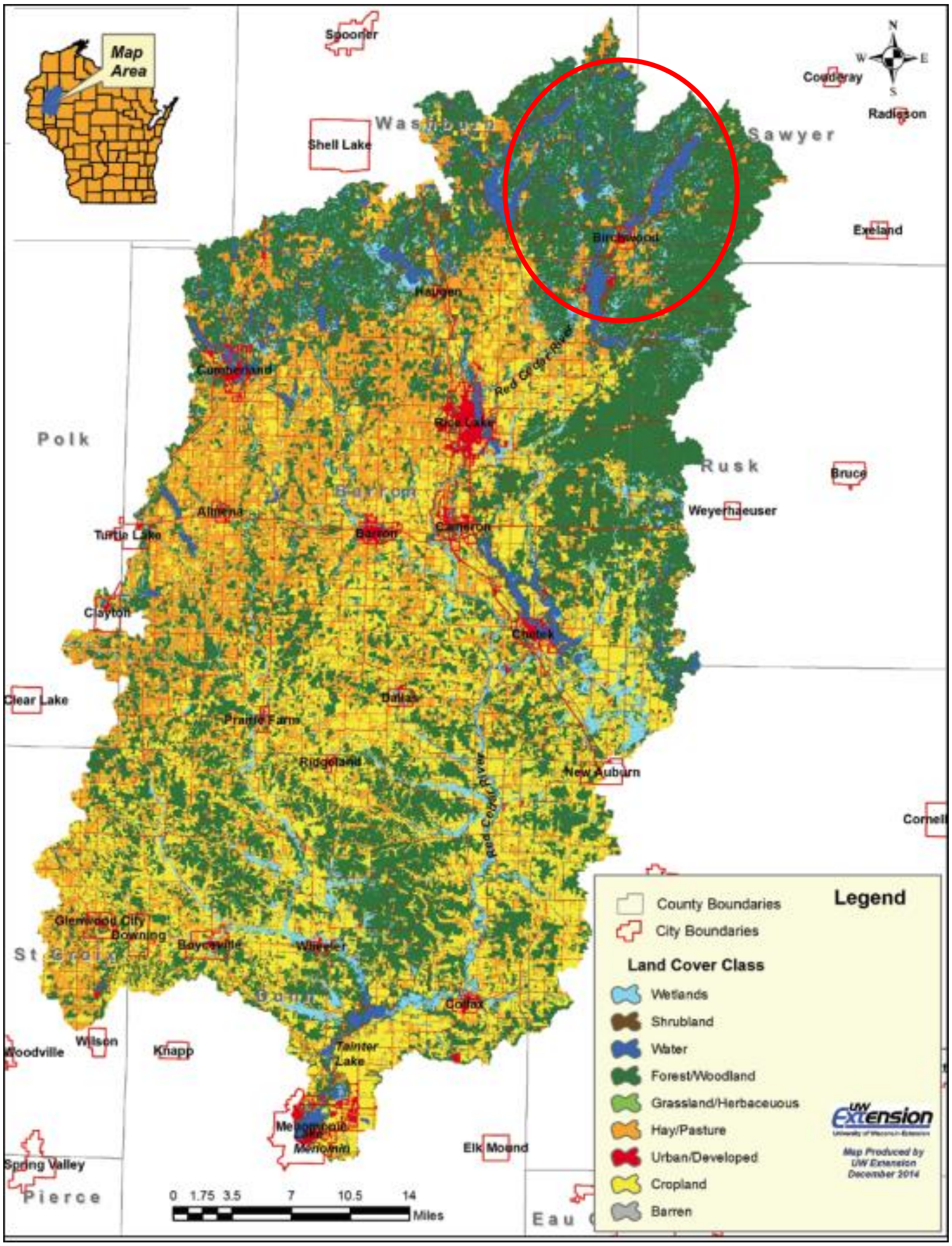

Figure 4: Land cover classes in the Red Cedar River watershed. The red circle surrounds the majority of the four sub-watersheds draining to the lakes.

1.3.1.1 Red Cedar River Water Quality Partnership

Once a TMDL study has been completed by the WDNR, an implementation plan needs to be developed to address the water quality impairment issues facing the water body of concern. Generally, the implementation plan is developed by the counties involved along with any lake organizations and other stakeholders. The plan is developed to describe the management measures and regulatory approaches necessary to address the pollutant load issues affecting the water body, the parties responsible for such management measures, the costs and sources of funds for these measures, methods to get participation from stakeholders, a timeline for implementation, ways to measure success, and also any adaptive management techniques employed as the plan moves forward. For the Tainter and Menomin Lakes TMDL, this plan is titled A River Runs Through Us: A Water Quality Strategy for the Land and Waters of the Red Cedar River Basin (to be referred to as "Implementation Plan".[5]

The authors of the Tainter and Menomin Lakes TMDL Implementation Plan are the members of the Red Cedar River Water Quality Partnership (RWQP), a stakeholder group that came together in 2013. Those involved in the RWQP include UW–Extension, WI-DNR, the Natural Resource Conservation Service (NRCS), county and city officials and departments, citizens, nongovernmental organizations, lake associations, and corporate representatives. The diversity of this group is essential to maintaining inclusive and effective implementation of this strategy. The RWQP is the group overseeing all education, outreach, engagement and implementation activities as the process moves forward.

Because of the efforts of this group, many goals for phosphorus reduction have already been set. Table 1 is a portion of Table 3.4 on p. 38 of the Implementation Plan. The goals and management measures that have been set for the Red Cedar Lakes Comprehensive Plan (this plan) are based on many of the calculations from the Implementation Plan (see Section 5).

Table 1: Estimated total phosphorus loads from the five HUC 12 Sub-watershed included in the Red Cedar Lakes Watershed (HUC column shows last 3 digits of the HUC 12 code (for example, 070500070101 is abbreviated to 101)

	land use (acres)					baseline load (lbs/yr)						goal load (lbs/yr)		
HUC	Cropland	forest	grassland	urban	Total	Cropland	forest	grassland	urban	barnyards	total	Cropland	urban	total
101	57	16120	951	453	17,580	53	920	145	310	0	1427	26	256	1347
102	194	26272	1616	1,459	29,541	180	1499	246	999	0	2923	90	824	2658
103	131	7703	1293	391	9,517	121	439	197	267	0	1025	61	221	917
104	263	17998	628	719	19,608	244	1027	95	492	0	1858	122	406	1650
105	150	14001	1985	1,121	17,257	139	799	302	767	18	2025	70	633	1803

5 https://dnr.wisconsin.gov/sites/default/files/topic/TMDLs/TainterMenomin_NineKeyElementPlanWaterQualityStrategy.pdf

2.0 Identification of Key Stakeholders

A stakeholder is a person, group or organization with a vested interest, or stake, in the decision-making and activities of a business, organization, or project. Stakeholders can be members of the organization they have a stake in, or they can have no official affiliation. Stakeholders can have a direct or indirect influence on the activities or projects of an organization. Their support is often required for business and project success[6]. Over the past several decades, the RCLA has worked at building partnerships with stakeholders who share a common goal of improving water quality in the Red Cedar Lakes. One such stakeholder is the RWQP mentioned in the previous section. Other key stakeholder groups that are important to management planning and implementation success include:

- Red Cedar River Water Quality Partnership (RWQP)
- Barron County (various Departments)
    - Town of Cedar Lake
- Rusk County (various Departments)
    - Town of Wilson
- Sawyer County (various Departments)
    - Town of Edgewater
- Washburn County (various Departments)
    - Town of Birchwood
- Big Chetac and Birch Lakes Association
- Natural Resource Conservation Service (NRCS)
    - Barron, Rusk, Sawyer, and Washburn Counties
- United States Geological Survey (USGS)
- Wisconsin Department of Natural Resources (WDNR)
- Property owners on the Red Cedar Lakes
- Property owners on Big Chetac and Birch Lakes
- General lake users
- Agricultural and animal operations in the watershed
- UW-Systems Programs and Services
- US Army Corp of Engineers (USACE)

More information on many of these Stakeholders is included in Section 9.0.

[6] https://www.techtarget.com/searchcio/definition/stakeholder

3.0 Characterizing the Red Cedar Lakes

The Red Cedar lakes consist of three main stem lakes (Balsam, Hemlock and Red Cedar) on the Red Cedar River in Barron and Washburn Counties, Wisconsin. Mud Lake is attached to Balsam Lake. Bass Lake is separate from all of the lakes. Murphy Flowage is upstream of Hemlock Lake in Rusk County.

The headwaters of the Red Cedar River originate as outflow from Lake Chetac (a large, shallow, productive lake) that flows into and through Birch Lake (a small, deep, productive lake), into and through Balsam Lake, and into Red Cedar Lake. Additional headwaters originate from Louler Creek and two branches of Hemlock Creek that flow into and through Murphy Flowage, into and through Hemlock Lake, and into Red Cedar Lake. Despite narrows separating Balsam Lake to the north and Hemlock Lake to the south and east of Red Cedar Lake, all three are sufficiently large that all have the same water-surface elevation. The Red Cedar River flows out of Red Cedar Lake over the Mikana Dam and into Rice Lake approximately 11 miles downstream. Approximately 70 miles downstream from there, the Red Cedar River joins with the Chippewa River; their confluence is in Dunn County, in west central Wisconsin.

Balsam Lake has a surface area of 293 acres. Its maximum depth is 49ft and average depth is 27ft, giving it a volume of around 7,823 acre-ft. Most of the surface water entering the lake is from outflow from Birch Lake. Additional water comes in from Mud Lake to the east through a long shallow channel. Mud Lake has a surface area of 32 acres with a maximum depth of 25ft and an average depth of 4.3ft giving it a volume of about 140 acre-ft. Water leaves Birch Lake through a bottom withdrawal of a 28ft high dam. Outflow from Balsam Lake is through a connecting channel to the North Basin of Red Cedar Lake.

Hemlock Lake has a surface area of 377 acres and a volume of about 3,170 acre-ft. Its maximum depth is 21ft and average depth is 8.4ft. Most of the water entering the lake is from Hemlock Creek after flowing through Murphy Flowage. Outflow from Hemlock Lake is through a connecting channel or narrows to the South Basin of Red Cedar Lake.

Red Cedar Lake has a total surface area of 1,934 acres and a volume of about 46,000 acre-ft. Its maximum depth is 53ft and average depth is 23.8ft. In addition to flow from Balsam and Hemlock lakes, there are two main tributaries to the Red Cedar Lake: Sucker Creek and Pigeon Creek. Outflow from Red Cedar Lake is over the dam at Mikana into the Red Cedar River.

3.1 Priority Navigable Waterways

Wisconsin's over 15,000 lakes and 12,000 navigable rivers and streams are protected under the Wisconsin Public Trust Doctrine. The Public Trust Doctrine protects the people of Wisconsin's rights to: transportation and navigation on waterways; protection of water quality and aquatic habitat; and recreational activities, including boating, fishing, hunting, trapping and swimming in waterways[7]. Waterways may be specially designated in state statute or by the WDNR as Priority Navigable Waterways (PNW), Areas of Special Natural Resource Interest (ASNRI), or Public Rights Features (PRF)[8]. These designations affect permitting options for some waterways activities. The following lists which of these designations are in effect for waters of the Red Cedar Lakes and their watershed.

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7 https://dnr.wisconsin.gov/topic/Waterways/about_us/whyRegulate.html#:~:text=The%20Public%20Trust%20Doctrine%20protects,trapping%20and%20swimming%20in%20waterways.

8 https://dnr.wisconsin.gov/topic/Waterways/desig_waters/designated_tutorial.html

3.1.1 Balsam and Mud Lakes

Balsam and Mud lakes are both listed as ASNRI waters for wild rice. They are both PRF waters for sensitive habitat areas. Balsam Lake is also designated PNW water for walleye.

3.1.2 Red Cedar Lake

Red Cedar Lake is designated PNW for walleye and wild rice. It is consider ASNRI water as outstanding resource water, and as PRF waters for sensitive habitat areas.

3.1.3 Hemlock Lake

Hemlock Lake is designated PRF water for sensitive habitat areas.

3.1.4 Bass Lake

Bass Lake is designated a PNW as a waterbody less than 50 acres in size.

3.1.5 Murphy Flowage

Murphy Flowage itself is not listed as a PNW water, however three different tributaries to it are listed as PNW ASNRI trout streams enter the waterbody.

3.1.6 Pigeon and Sucker Creeks

Both Pigeon and Sucker Creeks are listed as ASNRI waters for trout and as outstanding streams, mostly upstream of County Hwy F.

3.2 Water Quality

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

3.2.1 Water Clarity

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" "Secchi" 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 5). The water clarity reading is the point at which the disk when lowered into the water can no longer be seen from the surface of the lake. Water color (e.g. water stained by tannins from nearby bogs and wetlands), particles suspended in the water column (e.g. sediment or algae), and weather conditions (clouds, wind, or sunlight) can impact how far down a Secchi disk can be seen 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.

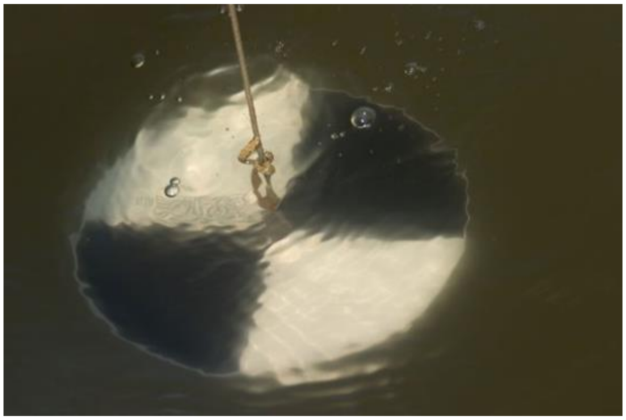


Figure 5: Secchi disk

3.2.2 Phosphorus

Phosphorus (P) is essential to plant growth as a vital nutrient for converting sunlight into usable energy during photosynthesis. Under natural conditions, P is typically scarce in water. In the late 1960s, scientists discovered P contributed by human activity to be a major cause of excessive algal growth and degraded lake water quality. P 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 P to be released back into the lake water. P concentrations in a lake are generally measures as Total Phosphorus (TP) which combines all the forms of phosphorus in the sample (particulate and dissolved). TP concentration is generally considered excessive when it is >17.0–20.0μg/L. At this level, TP may lead to accelerated aging of the lake and increased productivity.

3.2.3 Chlorophyll-*a*

Chlorophyll-a (ChlA) is a photosynthetic green pigment found in algae and other green plants. Its concentration is commonly used as a measure of algal production in a lake. Concentrations >7.0–10.0μg/L indicate eutrophic conditions. Concentrations >20.0–30.0μg/L are generally associated with algal blooms.

3.2.4 Trophic Status

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 P can grow algae (measured by Chla), which can in turn, impact water clarity. All three are used to determine the fertility/productivity or trophic status of a lake, and can be represented in relation to each other on a Trophic State Index (TSI) scale (Carlson R. , 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 2).

Table 2: 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

3.2.5 Thermal Stratification and Turnover

Dissolved oxygen (DO) is essential for the survival of most aquatic animals, just like atmospheric oxygen is essential for most terrestrial animals. Surface waters (also called the epilimnion) exchange oxygen with the atmosphere and are usually oxygen-rich. In deeper lakes, or smaller lakes that are generally sheltered from prevailing winds, the water in the lake stratifies (or separates) into distinct zones during the summer months, impacting water quality and affecting biota. These zones are the epilimnion (oxygen-rich surface waters), the thermocline (the layer separating the surface and bottom waters), and the hypolimnion (oxygen-depleted bottom waters) (Figure 6).

In most cases, a lake does not remain stratified year-round. Monitoring data indicates that all three main stem lakes are dimictic, meaning that at least twice a year (spring and fall) stratification is replaced by a mixing event called “overturn” or “turnover” where all waters in the lake (top and bottom) naturally mix, recharging levels of DO and distributing necessary nutrients throughout the water in the lake (Figure 6). Smaller and often limited “mixing” events can occur in the summer months due to large storm events or heavy recreational use. This type of mixing is a more regular event in Hemlock Lake simply due to it being a shallower lake.

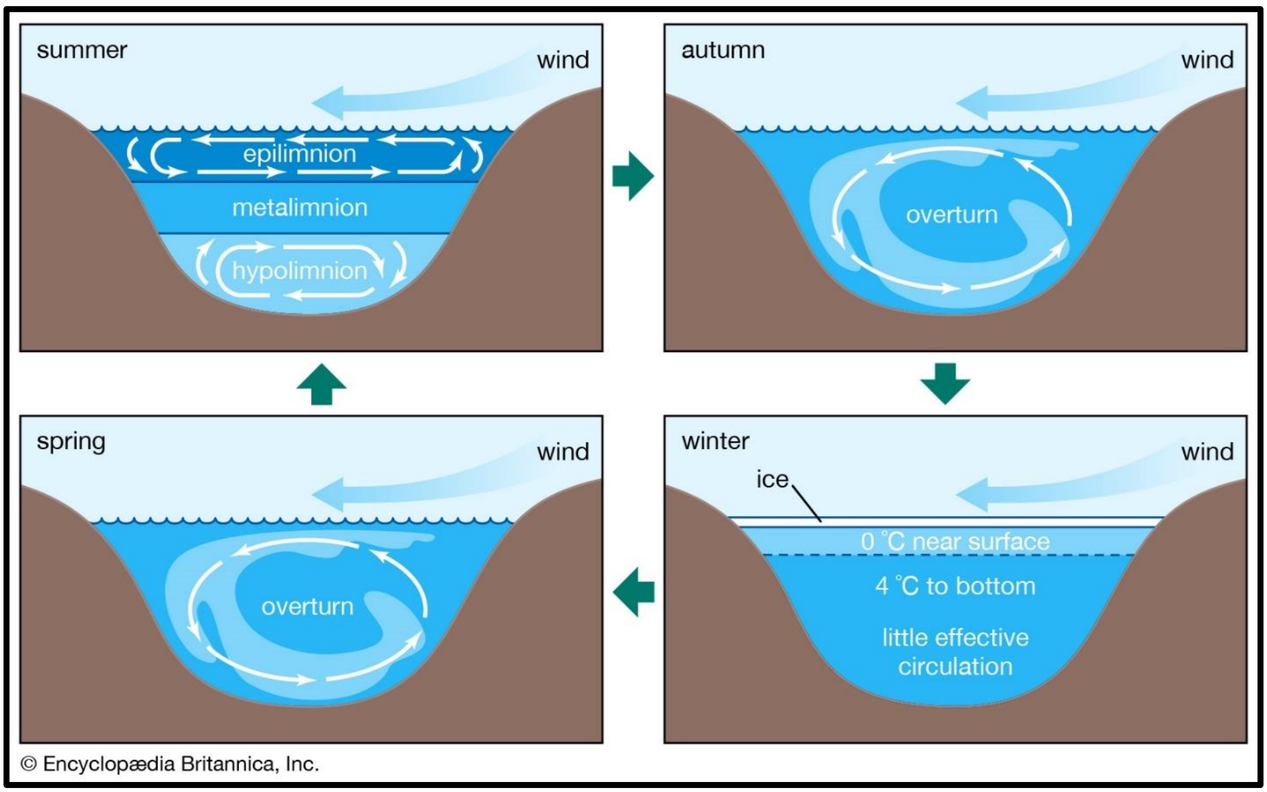


Figure 6: Dimictic stratification and turnover (Williams & Mann, 2022)

3.3 Water Quality in the Red Cedar Lakes

The USGS report that is the basis of the 2004 Comprehensive Plan used water quality data from 2001 and earlier. Since then, RCLA volunteers and resource professionals have collected additional water quality data on each of the lakes as a part of the Citizen Lake Monitoring Network (CLMN)[9] in WI. That data was used in

[9] https://dnr.wisconsin.gov/topic/lakes/clmn

this Plan to evaluate seasonal changes in water quality over the same time. Water quality varies among the Red Cedar Lakes; therefore, the water quality of each lake is described separately.

3.3.1 Balsam Lake

Balsam Lake is a dimictic lake, meaning that the lake thermally stratifies throughout summer. During summer, the thermocline (depth range where there is a rapid temperature change) developed late May to early June and stayed well established through the end of September. Through July, the thermocline usually developed around 15ft from the surface. By late July through early September it dipped to 20ft from the surface, slowly working its way back up until in late September/early October when it was mixed again. DO concentrations were near saturation throughout the lake just after the ice melted, but became depleted below the thermocline by late May/early June. Between early June and early October, anoxic conditions (DO concentrations near or at zero) set up just below the thermocline. Not until late October did the lake completely mix again with DO concentrations at all depths returning to near saturation.

Mud Lake is technically considered part of Balsam Lake, so it is not included in the water quality analysis for Balsam Lake.

3.3.1.1 Water Clarity

Consistent water clarity monitoring using a Secchi disk began in 2005. There is Secchi data available before then, but generally it only reflects one to two readings per year. Figure 7 reflects all Secchi disk data collected at the Deep Hole Near Birchwood (or the south basin) between 2005 and 2022. It shows the average Secchi disk reading for each year as well as the overall average of all Secchi disk readings at 9.0ft. There appears to be a clear trend toward declining water clarity from 2005 to 2022. Average monthly readings follow a normal pattern for deep stratified lakes (Figure 8). During turnover shortly after ice out, water clarity is typically at its worst. Then in May and June it is usually at its best when turnover is complete and the water is not yet warm enough to support a lot of plant and algae growth. Then as the water warms up from July through September, more algae grow reducing water clarity. The decline in water clarity from July to September is only slight; suggesting that internal loading of nutrients is probably not impacting water clarity significantly.

Table 3 reflects the percent of Secchi disk readings less than or equal to or greater than the overall average from 2005-2022. The five year period just prior to 2010 had the best water clarity with 75% of readings taken ≥ the average of 9.0ft. The five year period immediately following 2010 (2011-2015) had the worst water clarity with only 32% of the readings taken ≥ the average of 9.0ft. The five year period between 2016 and 2020 was better at 53% of the readings taken ≥ the average of 9.0ft, this is still not as good as what it was from 2005-2009. The next five year period, 2021-2025, is starting off reflecting worse water clarity.

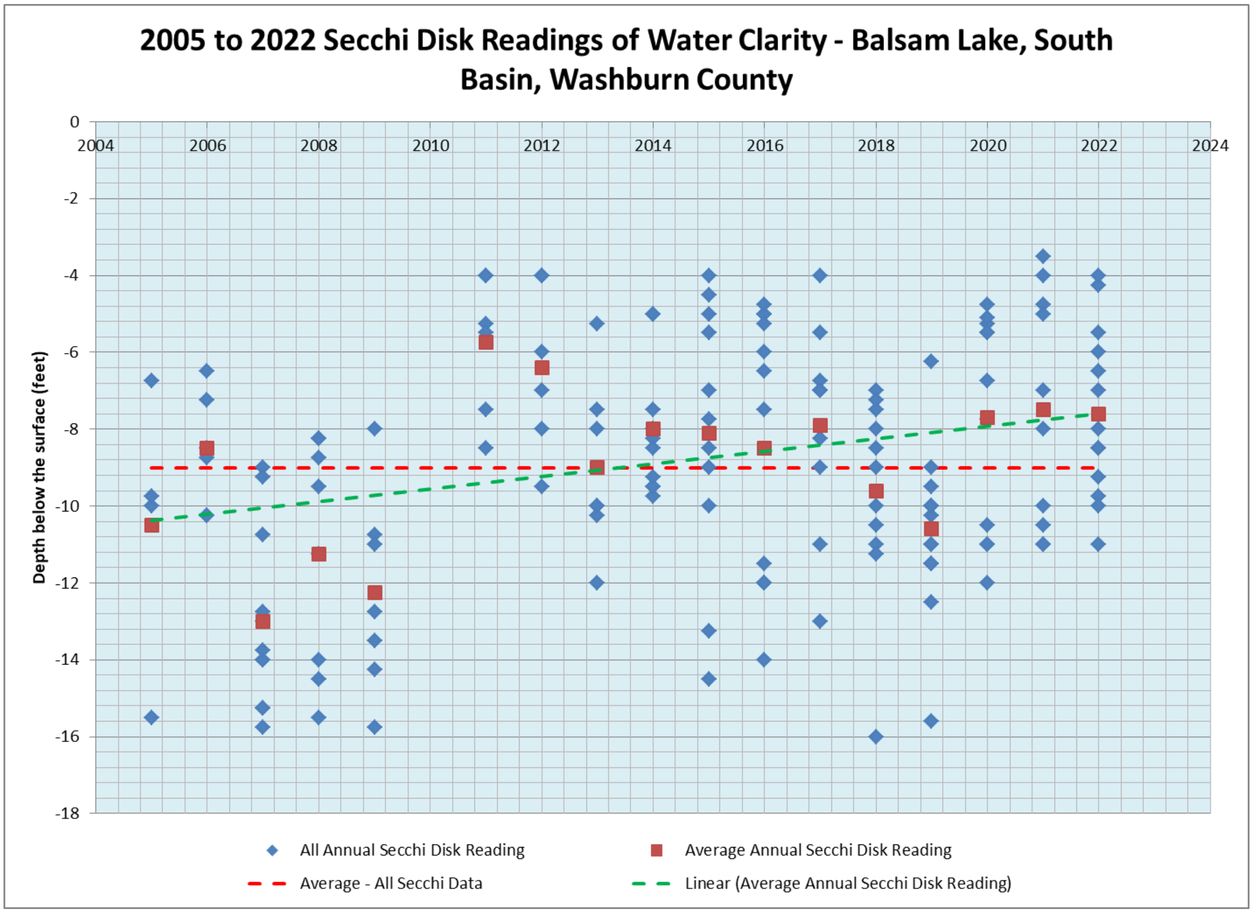


Figure 7: Balsam Lake, Deep Hole Near Birchwood (South Basin) – Secchi disk readings of water clarity (CLMN, 2005-2022)

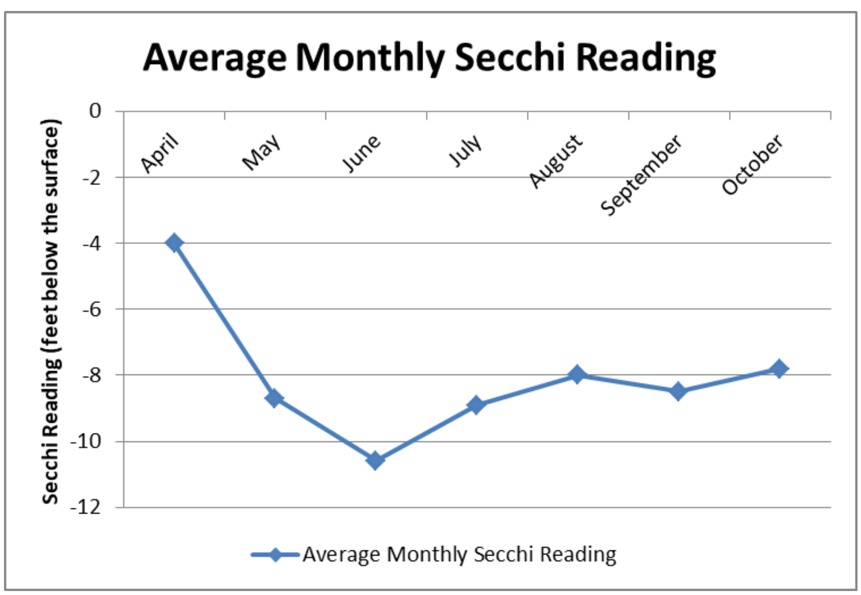


Figure 8: Average monthly water clarity - Balsam Lake, Deep Hole Near Birchwood (South Basin) (CLMN – all data)

Table 3: 5yr breakdown of Secchi disk readings equal to or greater than the average reading and those less than the average reading

Years	≥ ave (%)	< ave (%)
2005-2009	75	25
2011-2015	32	68
2016-2020	53	47
2021-2022	35	65
2005-2022	49	51

3.3.1.2 Surface Water Phosphorus

Near-surface TP concentrations in Balsam Lake ranged from 12.0 to 46.0μg/L in 2001. The average concentration in Balsam Lake in 2001 was 24.8μg/L. When combining 2019 and 2020 data, near-surface TP concentrations ranged from 19.2 to 43.8μg/L with an average concentration of 28.9μg/L. Over time, TP concentrations have ranged from 12.0 to 57.7μg/L, with an average of 29.8μg/L. The average TP concentration in the lake in 2001 was less than the average of all data through 2021, but had increased slightly since 1993. The average TP concentration in 2019-20 was above the average of all data through 2021, and higher than both 1993 and 2001.

3.3.1.3 Chlorophyll-*a*

During the study period associated with the 2003 USGS report, near-surface Chla concentrations ranged from 3.0 to 34.0μg/L. The highest concentrations were measured from 1995 through 1997. The average concentration in Balsam Lake from May through September 2001 was 9.8μg/L. When combining 2019 and 2020 data, Chla concentrations ranged from 2.7 to 23.7μg/L, and averaged 10.7μg/L. Over time, Chla concentrations have ranged from 2.7 to 30.7μg/L with an average of 11.6μg/L. The average Chla concentrations in 2001 and in 2019-20 were both less than the average of all data collected. There was no apparent long-term change in Chla concentrations from 1993 to 2001, however while the range of values decreased in 2019-20, the average was up slightly.

The average summer (July and August) Chla concentration was 15.0μg/L with 2015 and 2020 being the worst years since data was collected.

3.3.1.4 Trophic State Index

Based on long-term trend data for Secchi depth, TP, and Chla retrieved from the WI-DNR SWIMS database, Balsam Lake is classified as a eutrophic, or nutrient-rich, system with TSI values ranging in the 50's. Figure 9 reflects the summer (July & August) mean TSI values for Secchi, TP, and Chla through 2021 in Balsam Lake (WI-DNR, Citizen Lake Monitoring Network).

Of note in Balsam Lake is that TSI values for TP and Chla are generally the same, but much higher than the TSI values for Secchi depth. This is one of several familiar patterns that often emerge when comparing these three values (Carlson & Havens, 2005). This pattern suggests that large chlorophyll-containing particulates, such as Aphanizomenon (a type of algae) flakes, dominate the surface water. As such, there does not exist a good potential to control algal blooms with food web manipulation, unless that manipulation directly affects nutrient inputs to the water column (Carlson & Havens, 2005).

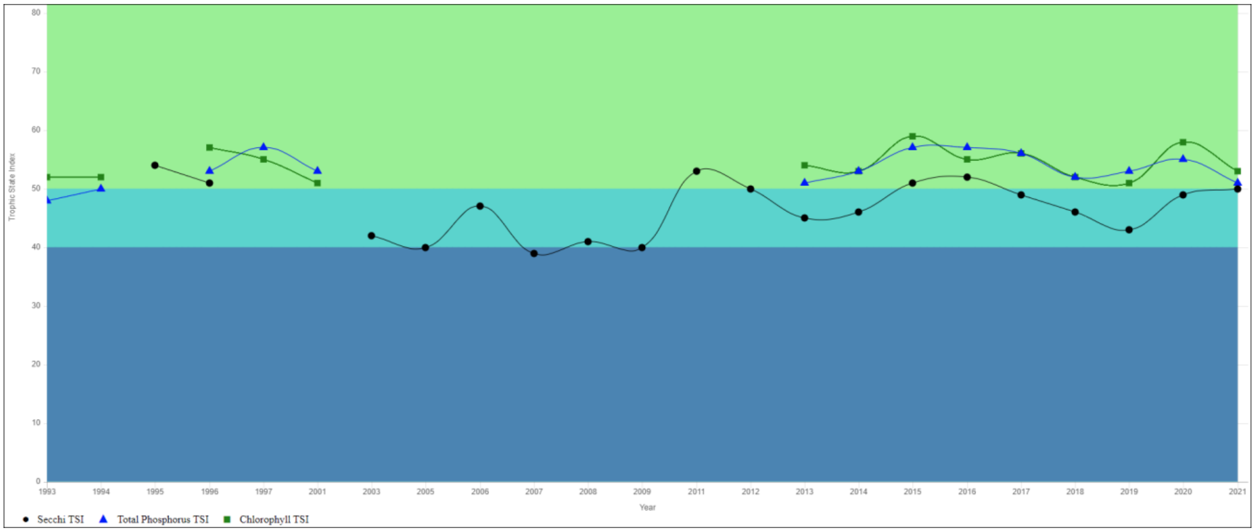


Figure 9: TSI values for Balsam Lake

3.3.1.5 Balsam Lake Deep Chlorophyll-a Maximum

Temperature and DO profiles of Balsam Lake indicate that there may be a "deep chlorophyll maximum" (DCM). A DCM occurs when Chla is at its maximum concentration, not at the surface of the water, but deeper in the water column, near the thermocline. DCMs can result from high zooplankton grazing on surface water phytoplankton, blockages of light near the surface from sediment or other sources, or phytoplankton acclimation to different light environments Moeller et al. (2019). The presence of a DCM often increases the diversity of phytoplankton and may make it easier and faster for grazers (zooplankton) to find and consume phytoplankton. This is turn increases primary production in the lake. The fact that a DCM may be in place in Balsam Lake may have implications for the fishery and other organisms because nutrients and resources may be distributed differently than previously thought.

The presence of a DCM in Balsam Lake has thus far only been indicated by increases in DO near the thermocline as measured in profiles. DO often indicates the presence of algae because when algae photosynthesizes, oxygen is released into the water column. The presence of a DCM may also indicate higher concentrations of phosphorous at depth rather than near the surface.

The RCLA may find value in determining whether there truly is a DCM in Balsam Lake. This information can be obtained by taking profile readings of temperature and DO at one-foot intervals (can be increased below the thermocline) and water quality samples of Chla and TP at the metalimnion (near the thermocline) and near the bottom of the lake. Increased levels of Chla and TP that coincide with increased oxygen would confirm the presence of a DCM. These data would also provide valuable information about potential phosphorus release in the bottom waters of the lake.

3.3.2 Red Cedar Lake

Red Cedar Lake is also a dimictic lake. Water quality data has been collected at two locations in the lake. The north basin is the deepest area of the lake and serves as the main data collection site. The south basin is not quite as deep, and does not have as complete a data collection history.

In the 2003, the USGS reported that the extent of vertical mixing in the two basins in Red Cedar Lake is quite different. The north basin, being deeper, had strong thermal stratification set up in early June, and it stayed stratified through September. As a result of being shallower than the north basin, the south basin had weaker stratification set up with break down at various times during the summer. Data collected in 2019 and 2020 suggest that vertical mixing is more similar now in both basins. The thermocline in both basins sets up in late May/early June around 20 to 25ft and remains stratified through late August into early September. DO below the thermocline usually held up through late June, but by early July was nearly completely depleted below 20ft, sometimes 15ft and did not return to a mixed state until late September/early October.

3.3.2.1 Water Clarity

Consistent water clarity monitoring using a Secchi disk began in 1987 in the north basin (Deep Hole North). Water clarity data was also collected in the south basin, but it is not as complete or extensive as the data from the north basin, so an evaluation of water clarity is based on north basin data only. Figure 10 reflects all Secchi disk data collected from the north basin between 1987 and 2022. It shows the average Secchi disk reading for each year as well as the overall average of all Secchi disk readings at 10.0ft. There appears to be a slight trend toward improving water clarity overall. Average monthly readings follow a normal pattern for deep stratified lakes (Figure 11). During turnover shortly after ice out, water clarity is typically at its worst. Then in May and June it is usually at its best when turnover is complete and the water is not yet warm enough to support a lot of plant and algae growth. Then as the water warms up from July through September, more algae grow reducing water clarity. The decline in water clarity from July to September is somewhat greater than what was evidenced in the Balsam Lake data, suggesting that internal loading of nutrients is probably having a greater impact on water clarity in Red Cedar, than it is in Balsam. One reason for that would be mixing events throughout the summer and fall. Red Cedar is larger and somewhat shallower than Balsam Lake leading to larger waves created by the wind moving across a greater fetch of the lake than what is moving across Balsam.

According to the USGS report, although there was considerable inter-annual variability, no long-term changes were found in Secchi depths from 1987 to 2001. More consistent data from 2005 to 2021 suggests that there is a long-term improvement in Secchi depths, although it is very modest (Figure 10).

When looking at all of the existing Secchi data in years when an annual average can be calculated – 25 years' worth – 44% of the years had a summer averages < the overall average of 10ft, while the remaining 56% had summer averages ≥ the overall average of 10ft.

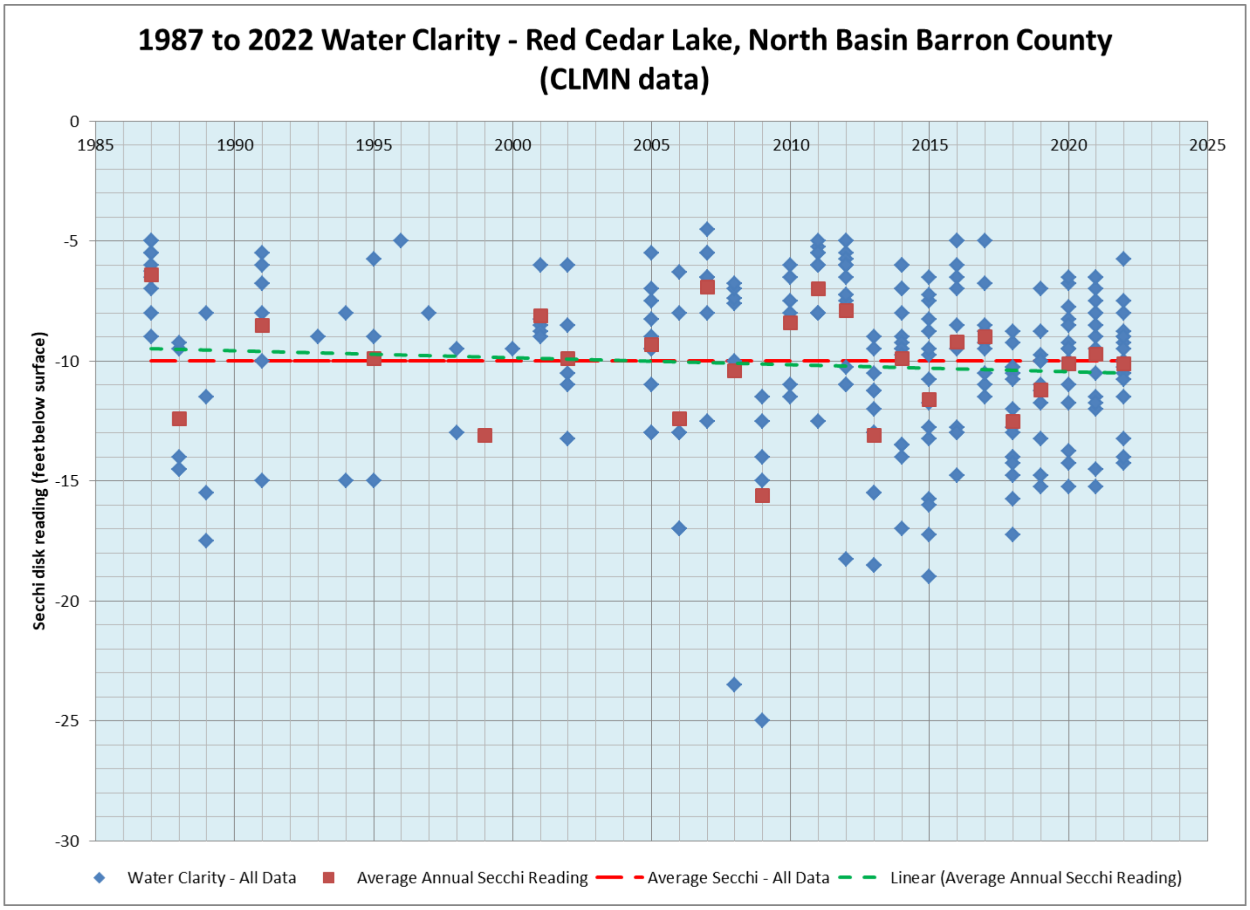


Figure 10: Red Cedar Lake, North Basin – Secchi disk readings of water clarity (CLMN, 1987-2022)

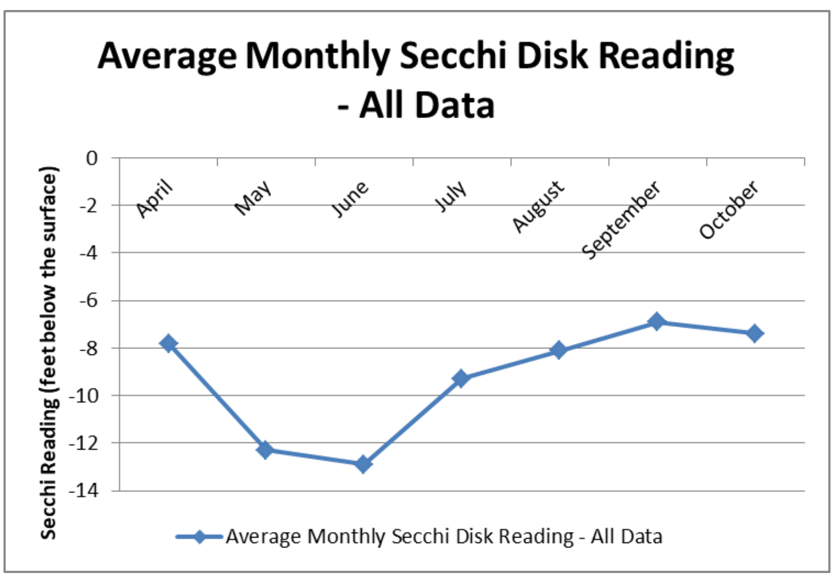


Figure 11: Average monthly water clarity - Red Cedar Lake, North Basin (CLMN – all data)

3.3.2.2 Surface Water Phosphorus

According to the 2003 USGS report, the near surface TP concentrations in both basins ranged from 19.0 to 37.0μg/L in 2001. The average concentration in 2001 was 26.7μg/L, higher than in Balsam at the same time. When combining 2019 and 2020 data, near-surface TP concentrations ranged from 14.9 to 45.1μg/L with an average concentration of 24.4μg/L, lower than Balsam at the same time. Based on 26 years of data collected over a 29 year period, near-surface TP concentrations in the north basin of Red Cedar Lake ranged from 9.0 to 60.0μg/L with an average of 24.6μg/L. In the south basin where only 8 years of data have been collected over the last 29 years, TP concentrations ranged from 9.3 to 47.0μg/L, with an average of 23.7μg/L. The average TP concentration over time in both the north and south basins are less than the average for Balsam Lake.

The combined average TP concentration for the north and south basins in 1993 was 22.9μg/L. In 2001 it was 26.2μg/L, and in 2019-20 it was 24.4μg/L. The 2003 USGS reported that the average value was higher in 2001 than in 1993 due to high concentrations in 1997. The value in 2019-20, though lower than the value from 2001, was still higher than what it was in 1993, suggesting TP is increasing.

3.3.2.3 Chlorophyll-a

In the 2003 USGS report, based on data collected up to 2001, near-surface Chla concentrations ranged from 1.6 to 43.0μg/L with an average concentration during May through September 2001 of 10.5μg/L and 7.7μg/L in the north and south basins, respectively. Chla concentrations in 2019-20 ranged from 2.0 to 25.8μg/L with an average concentration of 10.9μg/L and 10.5μg/L in the north and south basins. While the north basin value is pretty similar to what it was in 2001, the south basin value is much higher. Overall, with 25 years of data from the north basin and 3 years of data from the south basin, Chla concentrations ranged from 0.06 to 42.5μg/L with an average of 11.6μg/L suggesting Chla concentrations are going up. In 1995, the average was just 6.2μg/L ranging from 0.1 to 18.0μg/L.

3.3.2.4 Trophic State Index

Based on long-term trend data for Secchi depth, TP, and Chla retrieved from the WI-DNR SWIMS database, the North Basin of Red Cedar Lake is classified as borderline eutrophic, or nutrient-rich, system with TSI values ranging in the low 50's and occasional upper 40's. Figure 12 reflects the summer (July & August) mean TSI values for Secchi, TP, and Chla through 2021 in the north basin of Red Cedar Lake (WI-DNR, Citizen Lake Monitoring Network).

Between 1993 and 2002 a pattern emerges. TP is higher than Chla, which is also higher than Secchi values. This pattern suggests that zooplankton grazing has reduced the number of smaller particles, leaving larger particles causing algae biomass to be less than what might be predicted from TP. In this case, biomanipulation of the food web has potential to control algal blooms (Carlson & Havens, 2005).

Between 2007 and 2009, and again between 2014 and 2021, a different pattern emerges. TSI values for TP and Chla are generally the same, but much higher than the TSI values for Secchi depth. This is the dominant pattern in the north basin of Red Cedar Lake. Like in Balsam Lake, this pattern suggests that large chlorophyll-containing particulates, such as Aphanizomenon flakes, dominate the surface water. As such, there does not exist a good potential to control algal blooms with food web manipulation, unless that manipulation directly affects nutrient inputs to the water column (Carlson & Havens, 2005).

In 1998, from 2010 to 2012, and again in 2016, TP and Secchi values are similar, and Chla is higher than both. This pattern is not defined by Carlson and Havens.

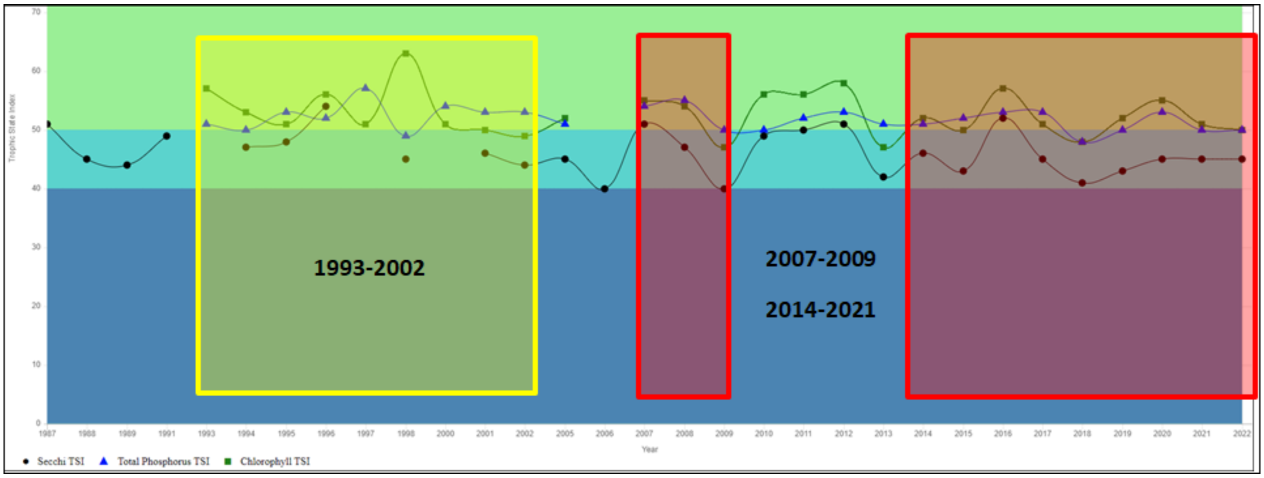


Figure 12: TSI values for Red Cedar Lake - North Basin Deep Hole (black circles – Secchi TSI, blue triangles – TP TSI, and green squares – Chla TSI)

Long-term trend data is not as complete for the south basin so TSI values are not discussed except to say that they are in the same range, occasional upper 40's to low 50's, as the north basin.

3.3.3 Hemlock Lake

Hemlock Lake, the shallowest of the three lakes, is also a dimictic lake. Temperature and DO data collected between the 1990's and 2017 indicates that stratification was somewhat sporadic and less distinct, occurring only in July and August at around 15ft. The year 2018 was the first in collected data where stratification appeared to be very distinct and longer lasting, setting up in mid to late May and extending through mid to late August. As mentioned, prior to 2018, stratification really was only in place in July and August. The temperature gradient in the thermocline was weaker in Hemlock Lake than in both Balsam and Red Cedar lakes. DO in Hemlock Lake was consistently depleted (<1.0mg/L) below about 15ft of water from late May through late August.

3.3.3.1 Water Clarity

Consistent water clarity monitoring in Hemlock Lake using a Secchi disk began in 1992. Figure 13 reflects all Secchi disk data collected from the deep hole between 1992 and 2020. It shows the average Secchi disk reading for each year as well as the overall average of all Secchi disk readings at 5.6ft. There appears to be a slight trend toward improving water clarity overall. Average monthly readings follow a normal pattern for somewhat shallow mixed/stratified lake (Figure 14). During turnover shortly after ice out, water clarity is typically at its worst. Then in May and June it is usually at its best when turnover is complete and the water is not yet warm enough to support a lot of plant and algae growth. Then as the water warms up from July through September, more algae grow reducing water clarity. In October, when the water begins to cool down again, water clarity again improves.

According to the USGS report, no long-term changes were found in Secchi depths from 1992 to 2001. There also appears to be little change from 2001 to 2020. If anything, there is a very slight improvement in water clarity from 1992 to 2020 (Figure 13).

At the time of the 2003 USGS report, Secchi depths in Hemlock Lake ranged from 2.5 to 11.0ft. This did not change when considering all of the data collected since that time. The average Secchi depth from May through September 2001 was 5.2ft. The last complete season of Secchi disk readings was completed in 2018.

At that time, the average annual reading was 7.5ft. While this is better than it was in 2001, with normal annual variation, it still appears no long-term changes were found in Secchi depths from 2001 to 2021 (Figure 11).

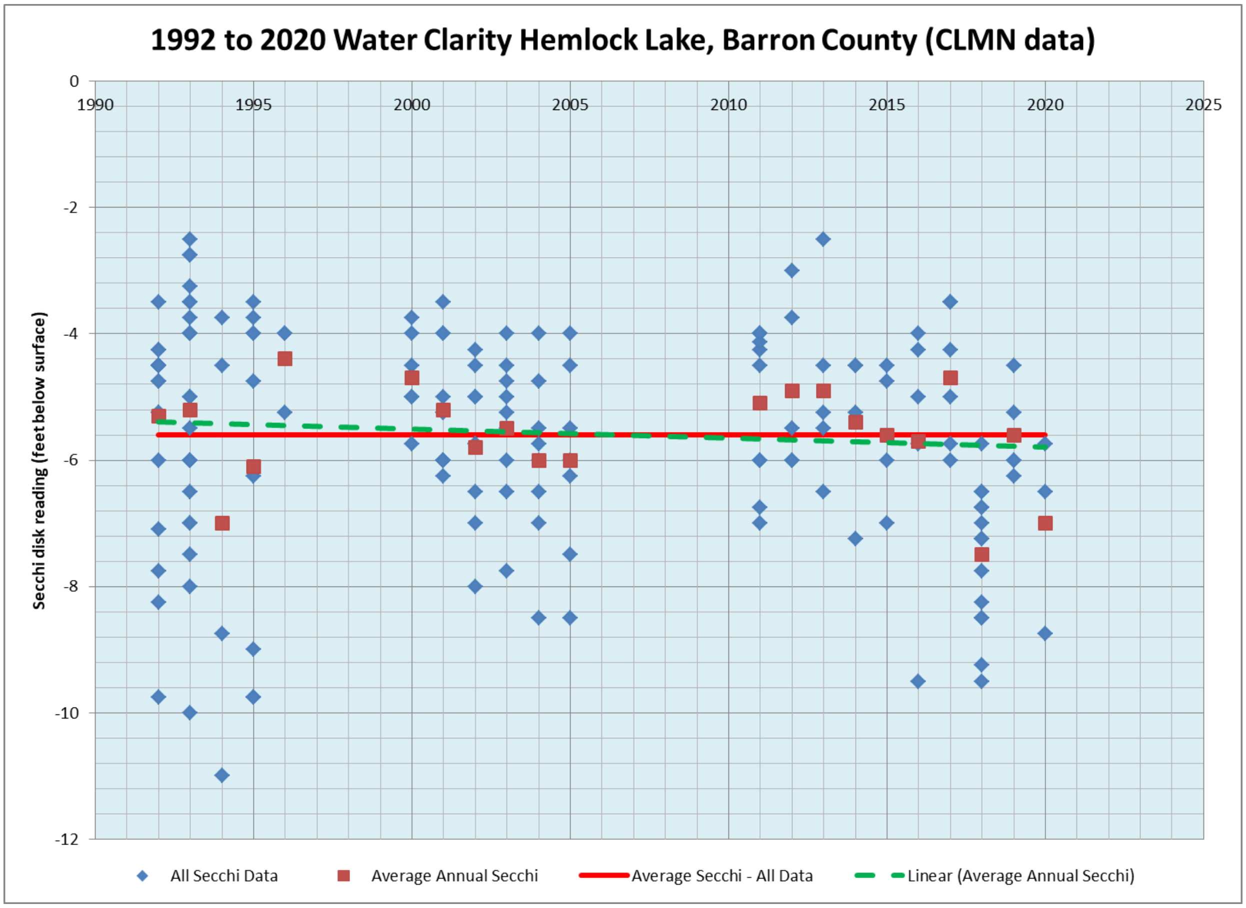


Figure 13: Hemlock Lake – Secchi disk readings of water clarity (CLMN, 1992-2020)

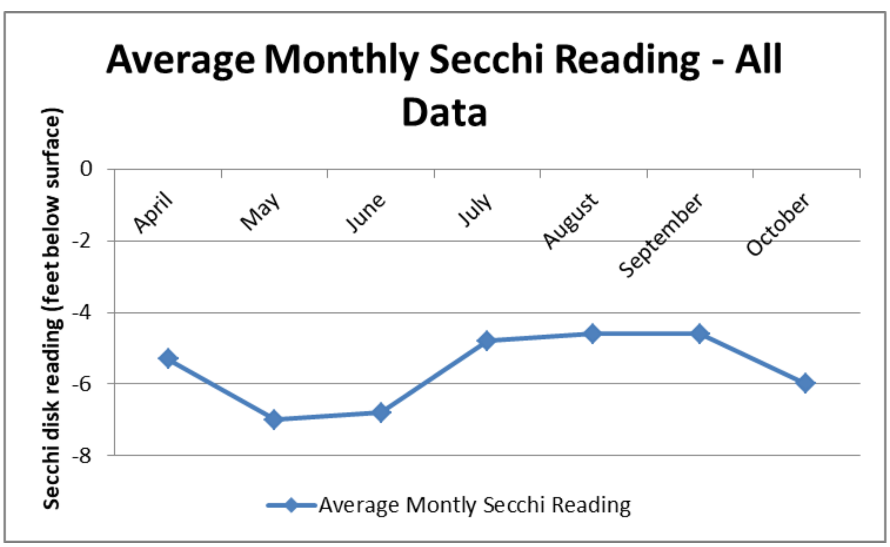


Figure 14: Average monthly water clarity - Hemlock Lake (CLMN – all data)

3.3.3.2 <u>Surface Water Phosphorus</u>

Hemlock Lake still has the highest near-surface TP concentrations of the three lakes. At the time of the 2003 USGS report, near-surface TP concentrations ranged from 17.0 to 60.0µg/L; including all of the data collected since then, the range has increased, now from 12.0 to 65.9µg/L. The average concentration in Hemlock Lake during May through September 2001 was 35.8µg/L. Using 2019-20 data, the average concentration is higher at 38.8µg/L. The highest concentration recorded since data collection began, 65.9µg/L, was collected in September 2020.

When looking at data collected in the 1990's and early 2000's, TP concentrations were trending down (Figure 12). There is a large gap in monitoring between 2005 and 2013, but when monitoring was again completed regularly (from 2013-2022) TP concentrations were trending back up from a low in 2004 (Figure 15). Overall, TP doesn't appear to have changed long-term, however, the recent upwards trend deserves continued monitoring.

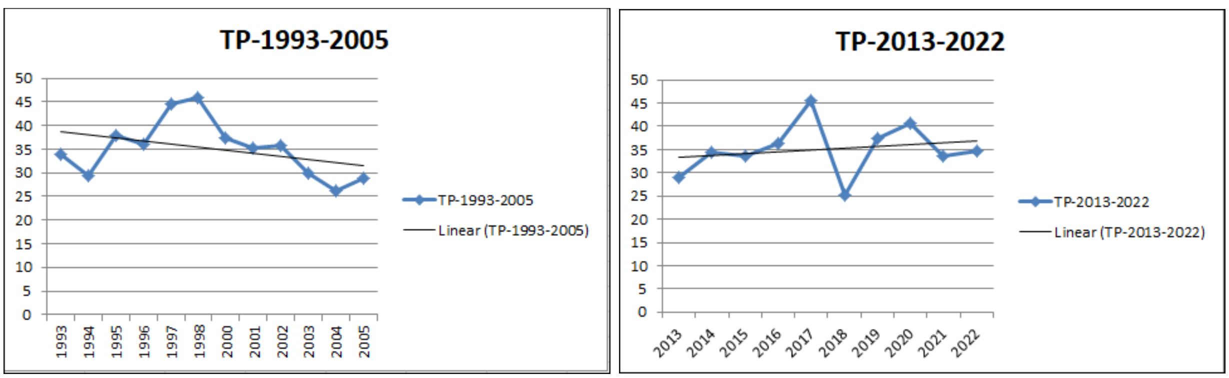


Figure 15: Average Annual Total phosphorus (TP) concentrations in Hemlock Lake, 1993-2005 and 2013-2022)

3.3.3.3 <u>Chlorophyll-a</u>

At the time of the 2003 USGS report, Hemlock Lake had the highest Chla concentrations of the three lakes. Based on data since then, it still has the highest average concentration. The 2003 USGS report stated that the near-surface Chla concentrations ranged from 4.0 to 61.0µg/L. But after reviewing those data, the range appears to be from 4.0 to only 25.6µg/L, with an average concentration of 16.7µg/L. The average concentration during May through September 2001 was 13.7µg/L. Using the 2019-20 data, the average is 14.9µg/L, slightly higher. Using all of the data, the range extends from 2.0 to 41.8µg/L with an average of 16.8µg/L. The 2003 USGS report suggests Chla concentrations may have decreased slightly from 1993 to 2001. If this is the case, then it has increased slightly from 2001 to present, but this review of the data suggests that there has not been a long-term change overall.

3.3.3.4 <u>Trophic State Index</u>

Based on long-term trend data for Secchi depth, TP, and Chla retrieved from the WI-DNR SWIMS database, Hemlock Lake is classified as a eutrophic, or nutrient-rich, system with TSI values from the mid-50's to mid-60's. Figure 16 reflects the summer (July & August) mean TSI values for Secchi, TP, and Chla through 2021 in Hemlock Lake (WI-DNR, CLMN).

Hemlock Lake has TSI values for TP, Chla, and Secchi that are generally the same. This pattern suggests that phosphorus limits algal biomass and algae dominate light attenuation. In this case, algal bloom occurrence may respond more rapidly to P load reduction (Carlson & Havens, 2005).

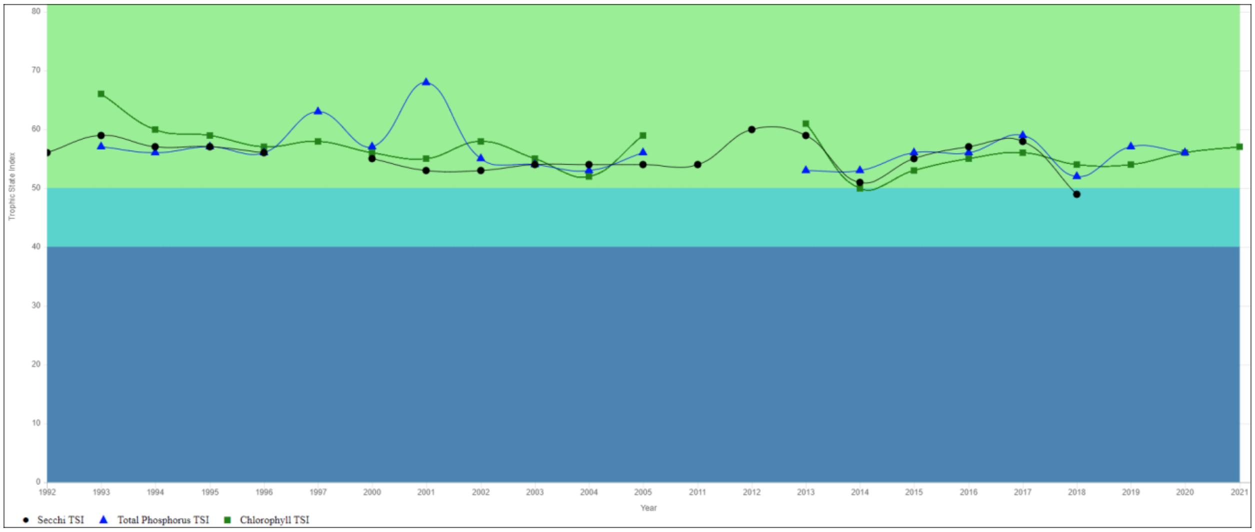


Figure 16: TSI values for Hemlock Lake

3.3.4 Bass Lake

Bass Lake, Barron County was sampled on 10 different days during the 2019 season. They are the only data included in the WDNR SWIMS database. Parameters sampled in 2019 included TP, Chla, water clarity, DO and temperature. The average summer Chla was 2.4µg/l (compared to a Northwest Georegion summer average of 13.2µg/l). The summer TP average was 16.9µg/l. Lakes that have concentrations more than 20.0µg/l and impoundments that have concentrations more than 30.0µg/l may experience noticeable algae blooms.

The overall Trophic State Index (based on chlorophyll) for Bass Lake was 41. The TSI suggests that Bass Lake was mesotrophic. Mesotrophic lakes are characterized by moderately clear water, but have an increasing chance of low DO in deep water during the summer.

This is the case in Bass Lake. Below about 15ft, Bass Lake was anoxic (devoid of oxygen) for a good portion of the summer into early fall. Secchi disk readings of water clarity were only recorded in Sept. and Oct. of 2019, but at the time readings were 11ft.

3.3.5 Murphy Flowage

There is limited water quality data available for Murphy Flowage. Baseline lake water sampling was completed in August 2002 by the WDNR. At that time the Secchi reading was 7ft with a Chla concentration of 7.7ug/L and a TP concentration of 36.0ug/L. All three of these parameters place Murphy Flowage in the mesotrophic range.

3.3.6 Bottom and Water Column Phosphorus

Water column sampling in August and September of 2019 in Balsam Lake and both basins in Red Cedar Lake show increased concentrations of TP near the bottom of the lakes, with combined values from both months indicating a concentration 26 times higher than the surface in Balsam Lake and 21 times higher in Red Cedar Lake. In August and September both lakes are solidly stratified with extremely low or no DO below about 20ft in both lakes.

Between 1993 and 2001 in Hemlock Lake, bottom TP concentrations were measured on 15 different dates in the months of June, July, and August. During that timeframe, bottom TP concentrations were about 9 times higher than surface concentrations. No bottom water TP sampling has been completed since 2001.

3.3.7 Iron in Relation to Phosphorus

When phosphorus from whatever source enters a lake, some of it settles out of the water column to the bottom of the lake. Over time, large amount of P can build up in the bottom of the lake. In the presence of oxygen, that P will bind with iron (Fe) in the bottom sediments and become trapped, not available for plant production. When deeper lakes like Balsam and Red Cedar stratify during the summer season, with warm, oxygen-rich water at the surface, colder water with limited oxygen at the bottom, and a thermocline that establishes between the two layers, the oxygen in the waters at the bottom of the lake is used up by decomposition of bottom detritus. Because the thermocline prevents mixing of the two layers of water, it also prevents any new oxygen from recharging the waters below the thermocline. Eventually the oxygen is completely used up beginning at the sediment-water interface at the bottom and working its way up in the water column to the thermocline.

Once the oxygen has been sufficiently depleted, a reaction occurs which breaks the bond between iron and phosphorus which then releases P back into the water column. If this extra "pulse" of phosphorus somehow gets mixed or entrained in the surface waters (like during a mixing event or at fall turnover) it becomes available to support the accelerated growth of excessive algae – an algae bloom. This process called internal loading of P and can negatively impact a lake long after external inputs of P are cut off.

The duration of internal loading due to P and Fe separating in an oxygen-depleted environment can be shortened if there is enough Fe present in the bottom waters to recapture P when oxygen levels are recharged during fall turnover, usually in late September or early October. If there is not enough Fe present in the bottom sediments to bind all of the available P, then during fall turnover P can be mixed into the surface waters and support excess algae growth causing a late season algae bloom. Research suggests that Fe to P ratios of 8:1 or greater are needed to enable phosphorus retention in oxidized sediment at the bottom of a lake Hansen et al. (2003).

In 2019, volunteers collected water samples for analysis of P and Fe from the hypolimnion (bottom waters) of both Balsam and Red Cedar Lakes in August and September. Table 4 reflects the data from both lakes. In Red Cedar Lake, the Fe to P ratio is sufficient to bind the available phosphorus during fall turnover. In Balsam Lake, the Fe to P ratio is not sufficient to bind the available phosphorus during fall turnover. As a result, it could be expected that there would be a greater pulse of P during fall turnover in Balsam Lake than there is in Red Cedar.

Figure 17 shows the monthly surface TP averages in both lakes. TP in Red Cedar Lake increases in both September and October, suggesting some level of internal loading and mixing, but it is more gradual than the same dynamic in Balsam Lake. In Balsam Lake, the TP remains constant through September, suggesting limited mixing (as discussed before), but spikes in October, suggesting that there is an abundance of available P during fall turnover, more than what is available earlier in the season.

Table 4: 2019 Fe/P ratios in Red Cedar Lake (left) and Balsam Lake (right)

Date of Sample	Depth (m)	Iron (Fe)	Phos (P)	Fe/P Ratio
8/25/2019 8:00	2	ND	0.02	NA
8/25/2019 8:00	4	ND	0.01	NA
8/25/2019 8:00	6	ND	0.02	NA
8/25/2019 8:00	8	0.50	0.04	13 to1
8/25/2019 8:00	10	3.52	0.28	13 to 1
8/25/2019 8:00	12	8.22	0.62	13 to 1
9/30/2019 16:30	2	0.13	0.03	4 to 1
9/30/2019 16:30	4	0.14	0.02	7 to 1
9/30/2019 16:30	6	3.97	0.26	15 to 1
9/30/2019 16:30	8	8.87	0.57	15 to 1
9/30/2019 16:30	10	11.80	0.89	13 to 1
9/30/2019 16:30	12	13.40	1.05	13 to 1

Date of Sample	Depth (m)	Iron (Fe)	Phos (P)	Fe/P Ratio
8/25/2019 9:00	2	ND	0.02	NA
8/25/2019 9:00	4	ND	0.03	NA
8/25/2019 9:00	6	ND	0.02	NA
8/25/2019 9:00	8	0.84	0.17	5 to 1
8/25/2019 9:00	10	3.46	0.49	7 to 1
8/25/2019 9:00	12	4.44	0.61	7 to 1
9/26/2019 14:30	2	ND	0.03	NA
9/26/2019 14:30	4	ND	0.02	NA
9/26/2019 14:30	6	ND	0.04	NA
9/26/2019 14:30	8	2.82	0.42	7 to 1
9/26/2019 14:30	10	4.13	0.59	7 to 1
9/26/2019 14:30	12	4.53	0.64	7 to 1

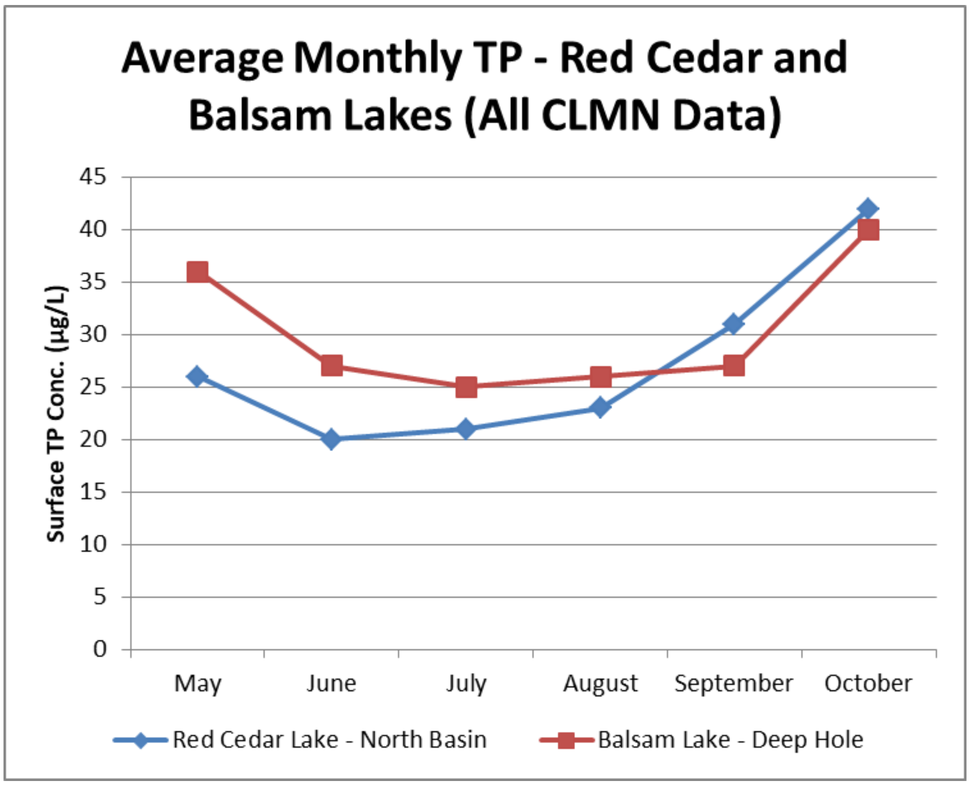


Figure 17: Average monthly TP in Red Cedar and Balsam Lakes (all CLMN data)

Iron was not measured in Hemlock, Bass, or Mud lakes during this study.

3.4 Phosphorus Load in the Lakes

At the same time that iron was being measured at different depths in Balsam and Red Cedar lakes, TP was being measured. In each lake, TP was measured every two meters. By estimating the volume of lake water at each given depth, and then multiplying that by the measured TP concentration, it is possible to get a snapshot of the total amount of phosphorus in the lakes. The volume of a lake near the surface is always the largest because the surface area is the greatest. The surface area of the lake under which a designated depth of water is located goes down as the water gets deeper. The deepest part of a lake may only be a small fraction of the overall surface area of the lake.

Using the results from the aquatic plant, point-intercept survey, the volume of water in a designated depth range can be estimated, at least down to the depth of the deepest points surveyed. Unfortunately, in both lakes, the point-intercept survey data only goes down to about 10-meters, so beyond that depth the volume cannot easily be broken down into additional 2-meters layers. Tables 5 and 6 reflect estimates of lake water volume and phosphorus content (in pounds (lbs)) at each designated layer. Total volume below 8-meters in Balsam Lake, and below 10-meters in Red Cedar Lake (north and south basins combined) are each considered one layer, even though the layer is more than 2-meters.

Table 5: Estimated volume and total phosphorus load from August and September 2019 in Balsam Lake

Depth (ft)	Depth (m)	# of Pts	acres/pt	Surface Area (Ac)	Mean Depth (ft)	Vol (acft)	Vol (liters)	TP Load (mg)	TP Load (kg)	TP Load (lbs)
0-6.5ft	0-2m	1020	0.2843	290	3.6	1043.95	1287189857	29219209.75	29.22	64.42
6.5-13ft	2-4m	900	0.2843	256	3.25	831.58	1025335058	29888516.93	29.89	65.89
13-20ft	4-6m	846	0.2843	241	3.3	793.71	978642876.4	21481211.14	21.48	47.36
20-26ft	6-8m	800	0.2843	227	3.65	830.16	1023582348	108755624.5	108.76	239.76
26-49ft	>8m	762	0.2843	217	20	4332.73	5342258556	2922215430	2922.22	6442.37
						7832.12				**6859.81**

Table 6: Estimated volume and total phosphorus load from August and September 2019 in the north and south basins (combined) of Red Cedar Lake

Depth (ft)	Depth (m)	# of Pts	acres/pt	Surface Area (Ac)	Mean Depth (ft)	Vol (acft)	Vol (liters)	TP Load (mg)	TP Load (kg)	TP Load (lbs)
0-6.7ft	0-2m	1208	1.57	1897	3.38	6410.37	7903989662	177049368.4	177.05	390.33
6.7-13ft	2-4m	1070	1.57	1680	2.65	4451.74	5488989255	107721414.1	107.72	237.48
13-19.6ft	4-6m	955	1.57	1499	3.37	5052.81	6230114114	524731361.2	524.73	1156.83
19.6-25.8ft	6-8m	901	1.57	1415	3.45	4880.27	6017368595	1246197036	1246.20	2747.39
25.8-32.8ft	8-10m	873	1.57	1371	3.01	4125.54	5086786011	2411136569	2411.14	5315.64
32.8-53ft	>10m	841	1.57	1320	15.3	20201.66	24908648013	20823629739	20823.63	45908.19
						45122.38				**55755.87**

Knowing these values, and the estimated values for different sources of phosphorus (measured areas of the watershed through tributaries, nearshore loading, internal loading, atmospheric deposition, septic systems), it is possible to estimate a phosphorus budget for the lake.

3.5 Top-Bottom Paleocore

Paleolimnology is a scientific sub-discipline closely related to both limnology and paleoecology. Paleolimnological studies focus on reconstructing the past environments of inland waters (e.g., lakes and streams) using the geologic record. Paleolimnological studies are mostly conducted using analyses of the physical, chemical, and mineralogical properties of sediments, or of biological records such as fossil pollen, diatoms, or chironomids.

On September 23, 2015, sediment cores were collected near the deep areas of Balsam, Red Cedar and Hemlock lakes with a gravity corer (Onterra, 2016). When completing paleocore sampling, it is assumed that the top sample represents present day conditions while the bottom sample represents conditions at least 150 years ago. In all three cores there was a distinct color change near the bottom of the cores which usually signifies that the deep sample was deposited prior to the arrival of European settlers (Onterra, 2016).

Aquatic organisms are good indicators of a lake's water quality because they are in direct contact with the water and are strongly affected by the chemical composition of their surroundings. Most indicator groups grow rapidly and are short lived so the community composition responds rapidly to changing environmental conditions. According to the authors of the 2016 paleocore report, one of the most useful organisms for paleolimnological analysis is diatoms. These are a type of algae which possess siliceous cell walls, which enables them to be highly resistant to degradation and are usually abundant, diverse, and well-preserved in sediments. They are especially useful, as they are ecologically diverse. Diatom species have unique features which enable them to be readily identified. Certain taxa are usually found under nutrient poor conditions while others are more common under elevated nutrient levels. Some species float in the open water areas while others grow attached to objects such as aquatic plants or the lake bottom (Onterra, 2016).

By determining changes in the diatom community it is possible to determine water quality changes that have occurred in the lake. The diatom community provides information about changes in nutrient concentrations, water clarity, and pH conditions as well as alterations in the aquatic plant (macrophyte) community (Onterra, 2016).

3.5.1 Paleocore Study Results Summary (Onterra, 2016)

Hemlock Lake is shallower than the other two lakes and this is reflected in the diatom community. In Hemlock Lake the dominant diatoms are those associated with aquatic macrophytes (plants). The dominant diatoms in the deeper Red Cedar and Balsam lakes are those taxa that float in the open water (planktonic diatoms).

The diatom community indicates that all of these lakes are naturally eutrophic with historical concentrations being around 20 to 25μg/L. The present day phosphorus concentration in Red Cedar Lake is about 23μg/L while it is about 33μg/L in Balsam and Hemlock lakes. It appears that phosphorus concentrations in Red Cedar have only increased a small amount, less than 5μg/L while phosphorus levels in Balsam and Hemlock have increased a bit more.

Nitrogen concentrations have increased in Hemlock and Balsam lakes but less so in Red Cedar Lake. The former lakes are upstream of Red Cedar and it appears that much of the additional nitrogen that enters these lakes is assimilated before it reaches Red Cedar Lake. This probably is also happening with phosphorus as present day concentrations in Balsam and Hemlock lakes are higher than they were pre-settlement, compared with Red Cedar Lake where phosphorus does not appear to be higher.

Other paleolimnological studies on lakes in northern WI have shown that lakes with shoreland development have experienced little change in phosphorus but significant changes in habitat. Studies conducted found that in northwestern Wisconsin the macrophyte community often changed in seepage lakes, from one dominated by low growing plants to a community dominated by larger macrophytes, as a result of shoreline development. The structure of the macrophyte community changes because the increased runoff of sediment during construction on the shoreline enables the establishment of the larger plants. With the larger plants there is much more surface area available on which diatoms and other periphytic algae are able to grow (Onterra, 2016).

One bit of good news from the 2016 paleocore sampling is that shoreline development has apparently not yet impacted the Red Cedar lakes like it has in other lakes (Onterra, 2016).

3.6 Fisheries

The Red Cedar Lakes contain a diverse variety of fish species including gamefish species such as bass and walleye, panfish like crappie, perch, and bluegills, and a variety of less sought after, but still ecologically useful species like bullheads and bowfins. While the three lakes are all connected, the fisheries vary a fair bit between each lake.

3.6.1 Balsam Lake

In the 2016 survey, black crappies were the most common species found within Balsam Lake. 39 black crappies per mile of shoreline were captured ranging in size from 8.5 inches to 11 inches with an average size of 10.2 inches. Other panfish species found included bluegills, yellow perch, and pumpkinseeds (Table 7).

The most commonly found gamefish species within Balsam Lake in 2016 was largemouth bass. Smallmouth bass was the second most common, and walleye and northern pike were tied for third. On average largemouth bass were 14.3 inches in length, smallmouth bass were 11.9 inches, northern pike were 19.9 inches, and walleye were 16.5 inches (Table 7).

Table 7: 2016 Balsam Lake fisheries summary

Balsam Lake: 2016 Late Spring Fisheries Assessment				
Species	Relative Abundance (catch per mile)	Minimum Length (Inches)	Maximum Length (Inches)	Average Length (Inches)
Walleye	4.25	13.5	22.5	16.49
Black Crappie	39	8.5	11	10.15
Bluegill	10	3	8.5	6.85
Largemouth Bass	12.25	7.5	16.5	14.31
Northern Pike	4.25	11.5	30.5	19.93
Pumpkinseed	1	7	7	7
Rock Bass	3	7	8.5	7.92
Smallmouth Bass	6	7.5	15	11.88
Yellow Perch	4	4	9.5	8.25

3.6.2 Red Cedar Lake

In 2008, Heath Benike, then the WDNR Fisheries Biologist for Barron County, indicated that Red Cedar Lake was known to anglers as a walleye lake. However, at that time, it was evident that the walleye population had declined due, in part, to a large amount of harvesting pressure (Benike, 2008). In the surveys conducted in 2016, the highest average length for walleye was 15.3 inches, and only 48% of the 2,322 walleye captured in that survey were considered to be WDNR "quality size" of 15 inches or larger.

Unlike Balsam Lake, largemouth bass are only the third most common gamefish species found in Red Cedar Lake. Despite this, the average size for largemouth bass in Red Cedar Lake (14.3 inches) is very close to those found in Balsam Lake (14.3 inches). Within Red Cedar Lake, the most common gamefish is smallmouth bass. These range in size from 7.5 to 18.5 inches with an average size of 12.2 inches. Northern pike can also be found within Red Cedar Lake, but to a lesser extent than other gamefish species (Table 8)

The panfish found in Red Cedar Lake are comprised primarily of bluegills and black crappies. The most common panfish within Red Cedar Lake are bluegills which range from 4 to 9 inches and average 6.6 inches. Black crappies are found in lesser numbers, and have a larger size distribution than other panfish species within the lake. Yellow perch and pumpkinseeds are less common, but also present in Red Cedar Lake (Table 8).

Table 8: 2016 Red Cedar Lake fisheries summary

Red Cedar Lake: 2016 Late Spring Fisheries Assessment				
Species	Relative Abundance (catch per mile)	Minimum Length (Inches)	Maximum Length (Inches)	Average Length (Inches)
Walleye	6.5	5.5	19.5	12.25
Black Crappie	12	6	13	10.67
Bluegill	38	4	9	6.64
Largemouth Bass	5.13	6.5	18	14.32
Northern Pike	3.38	9.5	28	19.97
Pumpkinseed	0.5	6.5	6.5	6.5
Rock Bass	34	4.5	10.5	8.04
Smallmouth Bass	15.13	7.5	18.5	12.47
Yellow Perch	1.5	5.5	8	6.58

3.6.2.1 Two-story fishery in Balsam and Red Cedar lakes

Both Balsam and Red Cedar Lakes are considered to be "two-story" fisheries. A two-story fishery is a lake capable of supporting warm-water fish species like bass and northern pike in its "top story", while at the same time, capable of supporting cold-water species like cisco or whitefish in its deeper, well-oxygenated "lower story". In Wisconsin there are only about 200 of these lakes. Recent WDNR (Minahan, 2017) documentation suggests that cisco need DO levels >6.0mg/L and water temperatures <73°F to survive in a lake. The survival of cold water fish species like cisco depends on conditions in and below the thermocline that allow them to move up in the water column as oxygen levels in the bottom of the lake decline, while at the same time staying in cold enough water to keep them alive (Figure 18).

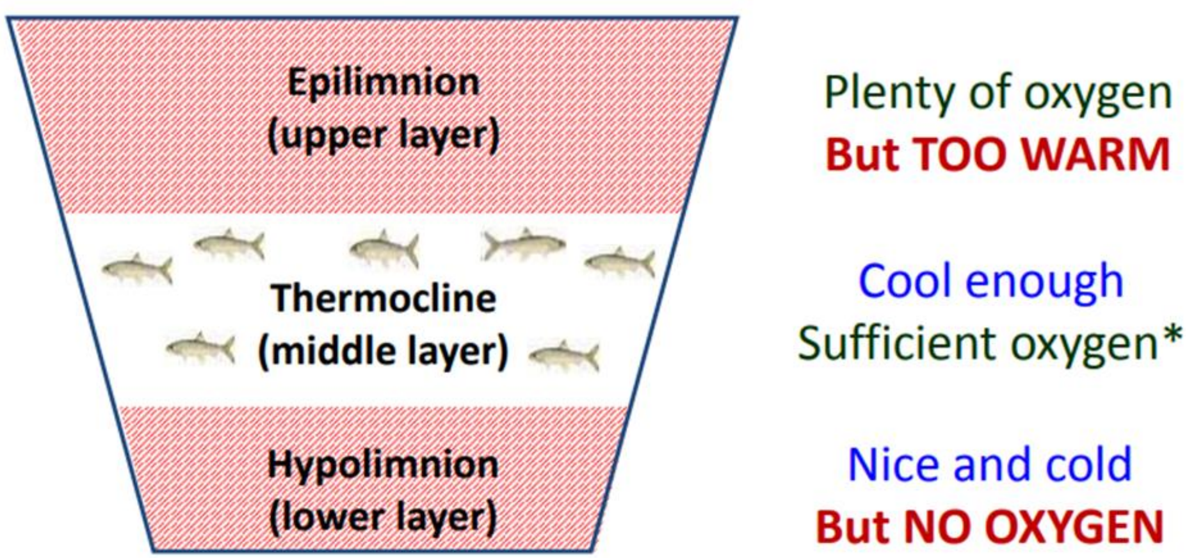


Figure 18: Lake stratification zones necessary to support a two-story fishery (Minahan, 2017)

Cold-water habitat in lakes is by its very nature fragile and imperiled. As organic matter dies and sinks, its decay uses up oxygen in deeper water. The amount of decay and the rate of oxygen loss depend upon how fertile the lake is. Imagine a first floor (lower story) where the floor and ceiling squeeze together for three or four months. Then a “normal” September brings surface cooling. Cisco and whitefish squeezed by low oxygen in the first floor now have an open stairway to the second floor (top story) because surface waters are now cool enough to meet their survival needs. If, however, summer hangs on well into September, a full month of squeeze is added and the proverbial stairs are blocked. The basement is plenty cold, but devoid of oxygen most of the time during the summer. The lower story can become devoid of oxygen as well, and if at the same time, the surface waters remain too warm, there is no escape. Under these conditions, the cold water fishery suffers. Longer summers and warmer temperatures brought on by climate change lead to even greater loss of oxygen in the “basement” and “first floor”.

Using the 2019 and 2020 temperature and dissolved oxygen data (2018 and 2019 data for Red Cedar Lake South Basin), a picture can be drawn to show when and if the cold water fishery can be sustained. In the following figures (19-24), any area that is above the blue line (line where DO is >6.0mg/l) and at the same time, below the red line (line where water temperature is <73°F) is shaded light blue and could potentially support a cold water fishery. The values on the left side of each figure represent the depth below the surface for each point. It is pretty clear that current conditions in the lakes already make it difficult to maintain a two-story fishery. Current conditions in Balsam Lake and the south basin of Red Cedar Lake provide the greatest potential for sustaining the two-story fishery.

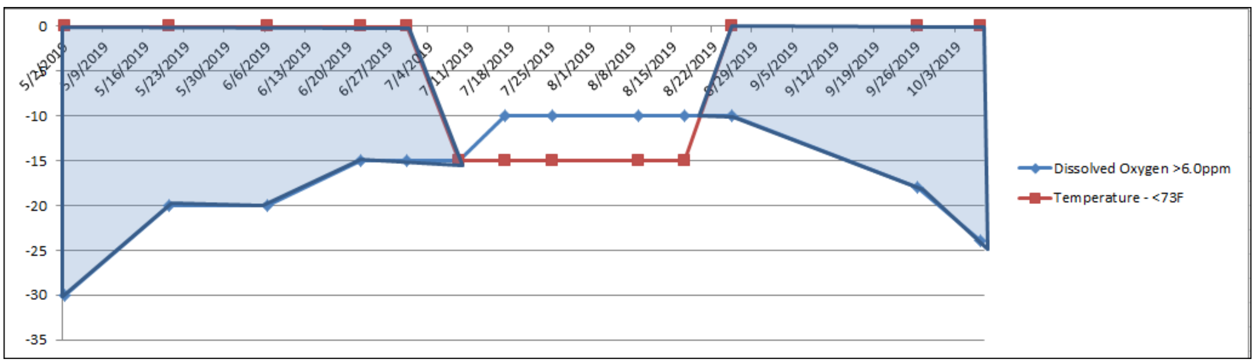


Figure 19: 2019 Cold water fishery in Balsam Lake

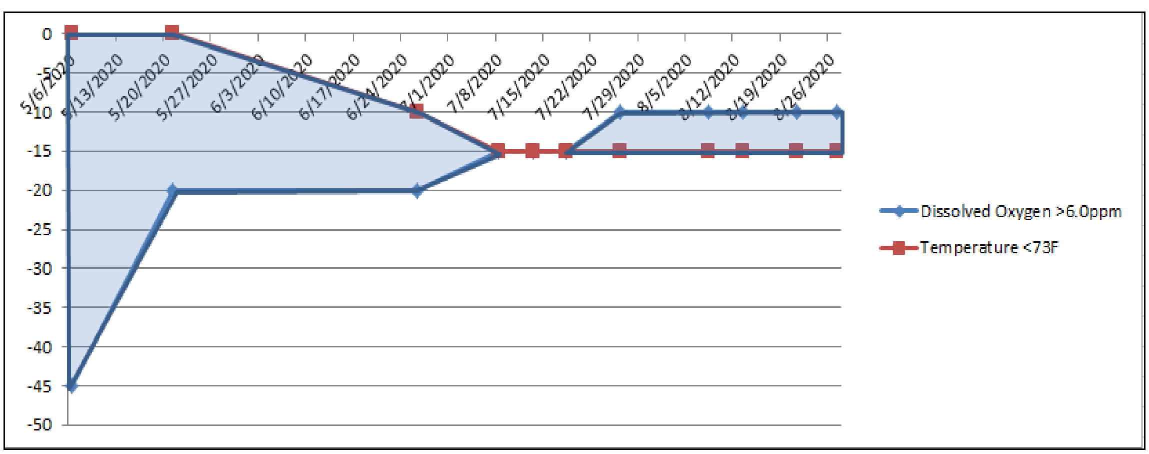


Figure 20: 2020 Cold water fishery in Balsam Lake

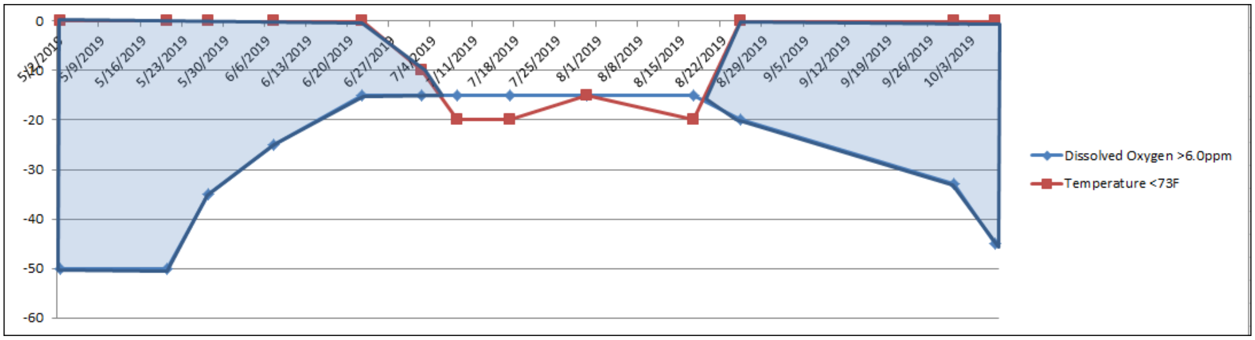


Figure 21: 2019 Cold water fishery in Red Cedar Lake North Basin

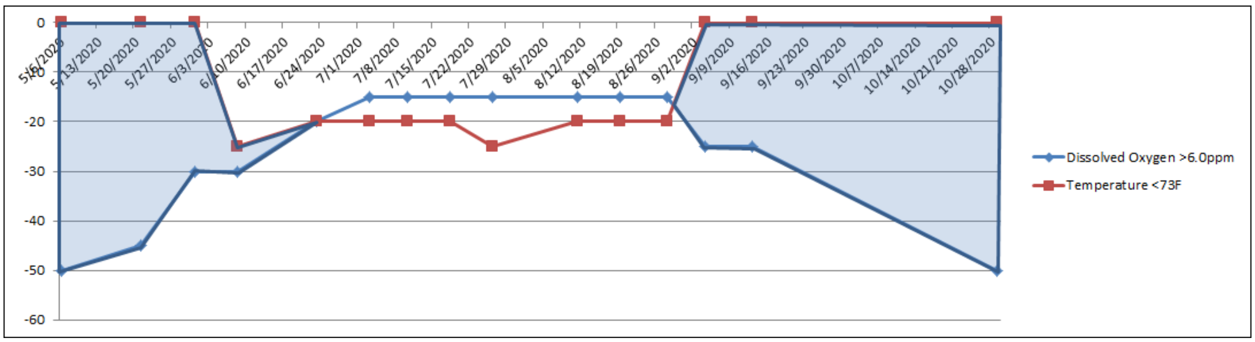


Figure 22: 2020 Cold water fishery in Red Cedar Lake North Basin

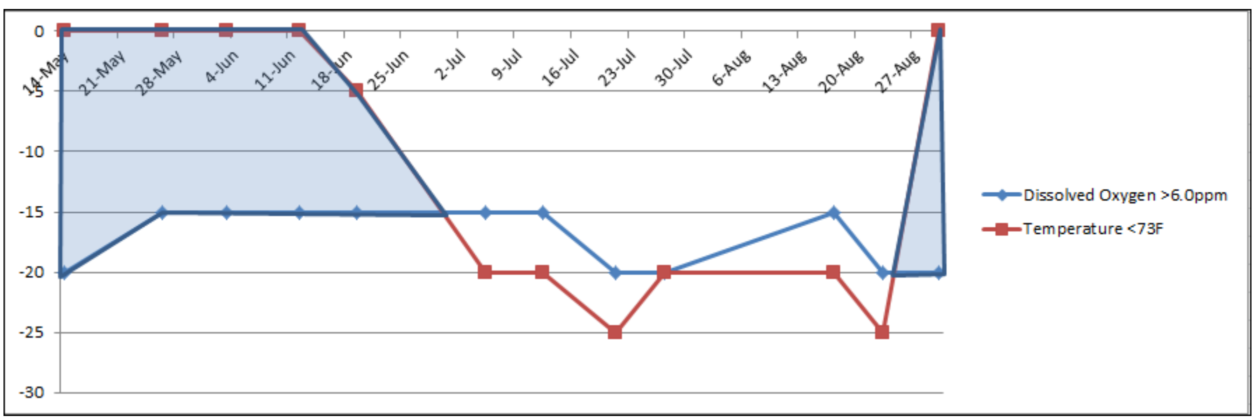


Figure 23: 2018 Cold water fishery in Red Cedar Lake South Basin

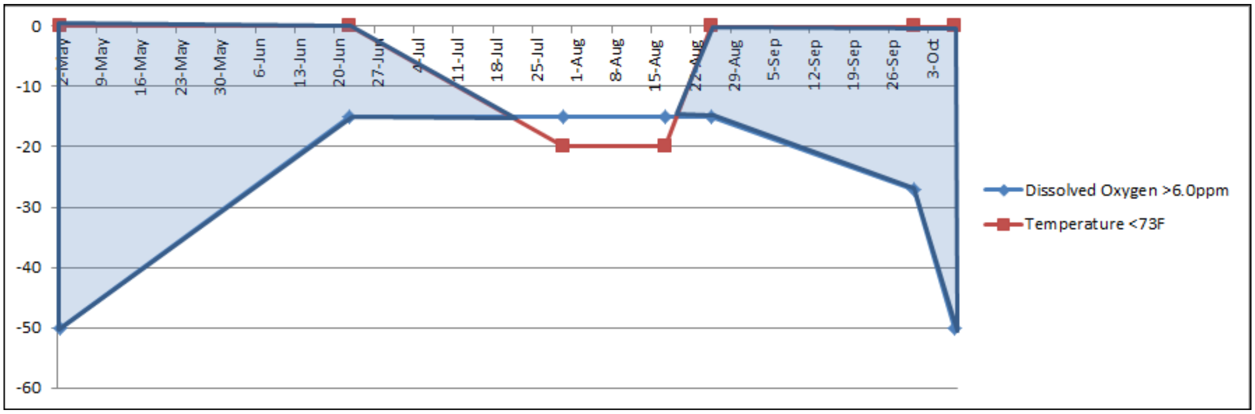


Figure 24: 2019 Cold water fishery in Red Cedar Lake South Basin

The cold water fishery is important in Balsam and Red Cedar lakes for at least two reasons: 1) It provides food for other fish and is one of the reasons the Red Cedar lakes are such a quality fishery; and 2) It is an important indicator of lake conditions. If a cold-water fishery can no longer be sustained, it foretells a series of problems for the lakes including loss of water clarity, increased weed growth/nutrient loading, imbalanced fishery, decreased property values, and other economic damage.

The best management prescription for protecting any two-story fishery is preventive maintenance – keep nutrient levels at or below their current levels. Protecting the watershed protects the lakes and protects the fish.

3.6.3 Hemlock Lake

Hemlock Lake has the fewer walleye than both Balsam and Red Cedar Lakes. What it lacks in quantity, Hemlock Lake's walleye population makes up for in quality. Most of the walleyes within Hemlock Lake range in size from 12 to 26 inches with an overall average of 21.2 inches (Table 9).

Largemouth bass are, by far, the most common gamefish species with Hemlock Lake, but the largemouth bass here are, on average, smaller than those found in Red Cedar and Balsam Lakes. Northern pike and smallmouth bass are also found in Hemlock Lake, but in significantly lower numbers than the largemouth bass (Table 9).

Hemlock Lake has the largest overall panfish population of the three lakes with bluegill being the most common fish species. The size distribution and average for bluegills in Hemlock Lake is on par with Balsam and Red Cedar Lakes. By comparison, the populations of other panfish species within Hemlock Lake are significantly smaller. Yellow Perch and black crappies can be found in Hemlock Lake, but are significantly fewer in number than bluegills, and the 2016 surveys did not encounter any pumpkinseeds (Table 9).

Table 9: 2016 Hemlock Lake fisheries summary

Hemlock Lake: 2016 Late Spring Fisheries Assessment				
Species	Relative Abundance (catch per mile)	Minimum Length (Inches)	Maximum Length (Inches)	Average Length (Inches)
Walleye	1.5	12	26	21.17
Black Crappie	3	9.5	11.5	10.58
Bluegill	152	3.5	8.5	6.62
Largemouth Bass	19.25	6	20	13.07
Northern Pike	1.5	13	23	19
Rock Bass	2	6.5	6.5	6.5
Smallmouth Bass	0.5	10.5	13	12
Yellow Perch	2	9.5	10.5	10.25

3.6.4 Bass Lake

No fisheries data exist for Bass Lake except that it is considered a warm water fishery by the WDNR supporting largemouth bass, panfish, and northern pike.

3.6.5 Murphy Flowage

No fisheries data exists for Murphy Flowage except that it is considered a warm water fishery by the WDNR supporting largemouth bass, panfish, and northern pike.

3.7 Critical Habitat[10]

Every waterbody has critical habitat - those areas that are most important to the overall health of the aquatic plants and animals. Remarkably, 80% of the plants and animals on the state's endangered and threatened species list spend all or part of their life cycle within the near shore zone.

Wisconsin law mandates special protections for these critical habitats. Critical Habitat Designation is a program that recognizes those areas and maps them so that everyone knows which areas are most vulnerable to impacts from human activity. A critical habitat designation assists waterfront owners by identifying these areas up front, so they can design their waterfront projects to protect habitat and ensure the long-term health of the lake they where they live. Areas are designated as Critical Habitat if they have Public Rights Features, Sensitive Areas or both. Public rights features (defined in NR 1.06, Wis. Adm. Code) include the following:

1. fish and wildlife habitat;
2. physical features of lakes and streams that ensure protection of water quality;
3. reaches of bank, shore or bed that are predominantly natural in appearance; and
4. navigation thoroughfares.

Sensitive Areas offer critical or unique fish and wildlife habitat, are important for seasonal or life-stage requirements of various animals, or offer water quality or erosion control benefits.

[10] https://dnr.wisconsin.gov/topic/lakes/criticalhabitat

3.7.1 Sensitive Area Reports for Balsam, Red Cedar, and Hemlock Lakes

The WI-DNR completed Lake Sensitive Area Reports on the Red Cedar Lakes in the late 1990s. The Sensitive Area surveys identified 9 areas on Balsam Lake and Mud Lake, 23 areas on Red Cedar Lake, and 12 areas on Hemlock Lake that merit special protection of the aquatic habitat (Figures 25-27). Sensitive areas on the lakes fell into two basic categories: aquatic plant communities providing important fish and wildlife habitat, and gravel and coarse rock rubble which provide important walleye spawning habitat.

In general, the reports recommend that aquatic vegetation removal should be limited to navigation channels, preferably mechanically harvested, and only when severely impaired navigation or nuisance conditions are documented. It is important to maintain vegetated shoreland buffers in sensitive areas, and stumps and woody habitat, which provides fish cover, should not be removed from sensitive areas. Although restrictions are in place to protect these areas during plant management operations, in some cases, short-term disruptions to habitat during the removal of monotypic stands of aquatic invasive species such as curly-leaf pondweed may lead to positive long-term improvements to the habitat of the lake. Disruptions to the sensitive areas may be warranted when responding to the discovery of a new invasive species.

A sensitive areas survey has never been completed for Bass Lake.

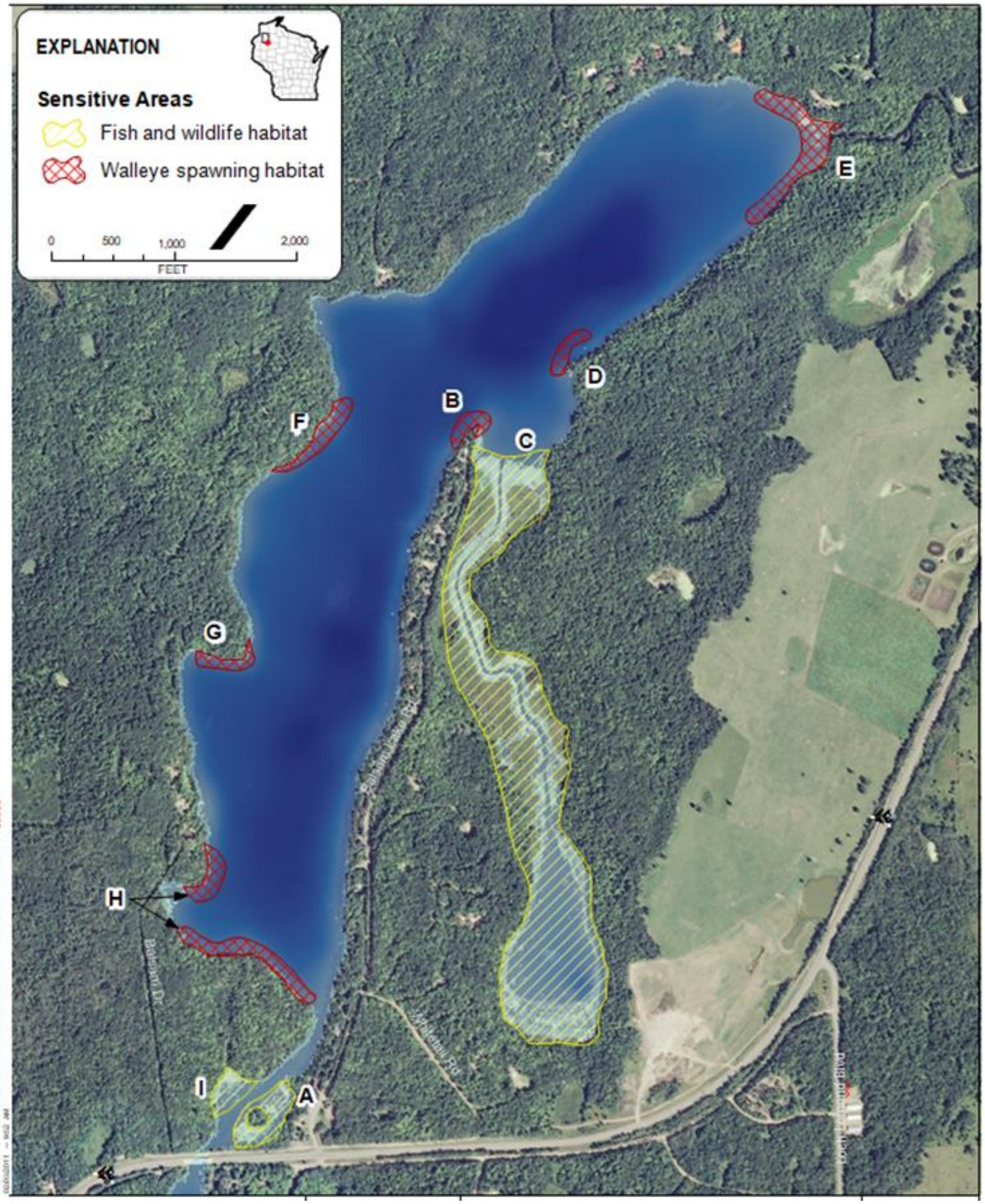


Figure 25: Sensitive areas in Balsam and Mud lakes

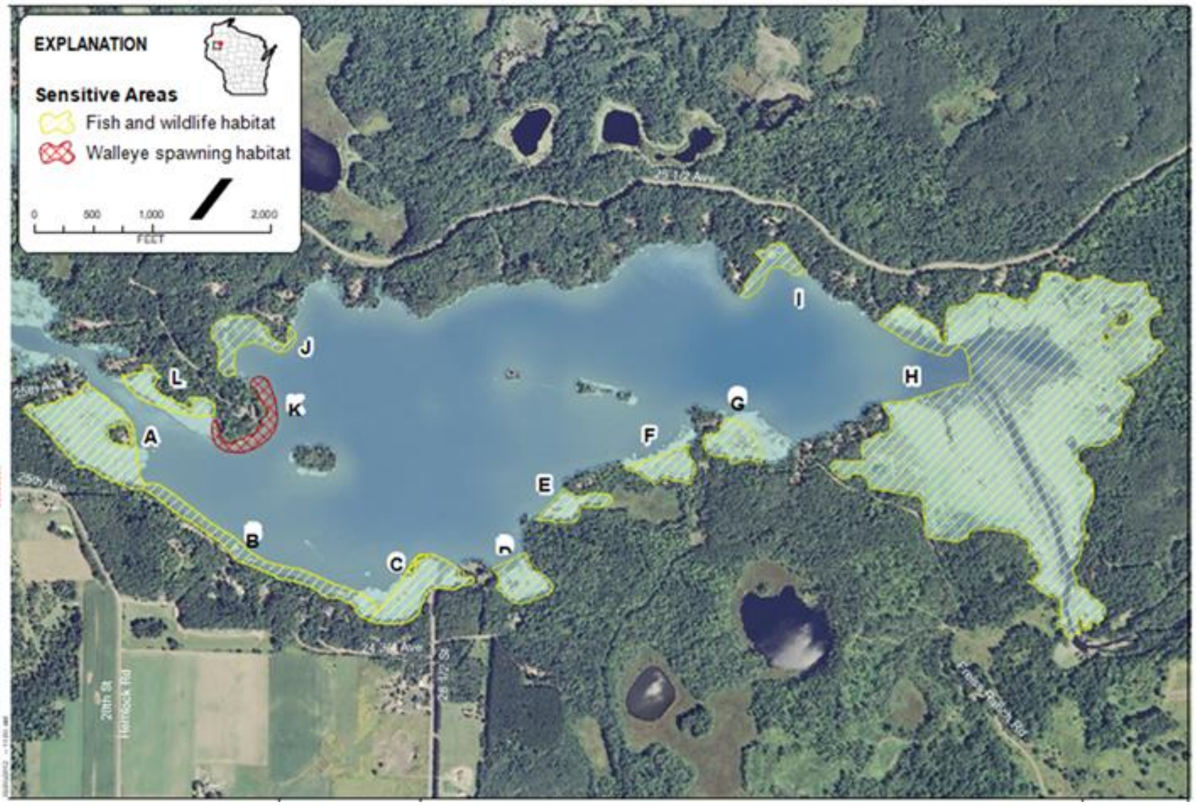


Figure 26: Sensitive areas in Hemlock Lake

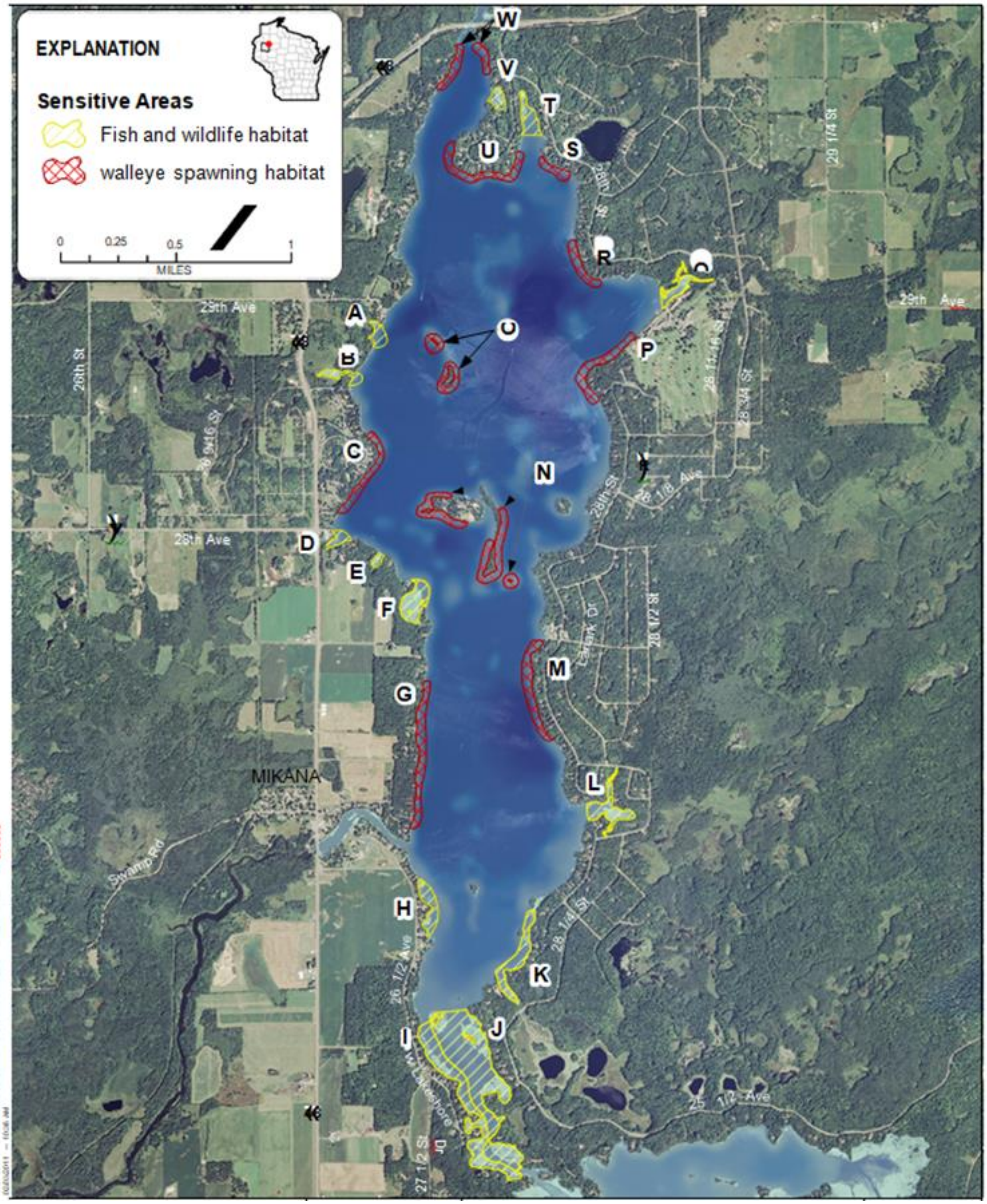


Figure 27: Sensitive areas in Red Cedar Lake

3.7.2 Wild Rice

Wild rice is an aquatic grass which grows in shallow water in lakes and slow-flowing streams. This grass produces a seed which is a nutritious source of food for wildlife and people. The seed matures in August and

September with the ripe seed dropping into the sediment, unless harvested. It is a highly protected and valued natural resource in Wisconsin. Only Wisconsin residents may harvest wild rice in the state.

There are many benefits to having wild rice in a lake. Wild rice is one of the most important waterfowl foods in North America, largely because its seeds ripen at the same time as fall migration. Wild rice beds provide stopover habitat for ducks and other migrating waterfowl. Rice beds provide nursery areas for small fish, frogs, and other aquatic prey items for common loon, great blue heron, and other fish-eating bird species. Wild rice also benefits water quality through its ability to bind loose soils, tie up nutrients, and act as a buffer by slowing winds (and therefore reducing waves) across shallow wetlands. By stabilizing water quality, wild rice helps reduce algal blooms and improve water clarity (Wisconsin Wetland Association, 2016).

According to the WI-DNR, Balsam Lake (of which Mud Lake is considered to be a part) and Red Cedar Lake are wild rice waters while Hemlock and Bass Lakes are not. A 2012 survey completed by RCLA volunteers found wild rice at the head waters of Mud Lake into Balsam Lake. The 2018 aquatic plant surveys confirmed the presence of wild rice in both Balsam and Mud Lakes. In 2019, wild rice was again found in the Balsam Lake bay adjacent to the Mud Lake channel, and lining in a portion of the channel between Balsam and Mud. In 2019, wild rice covered an area of about 1.5 acres made up of two beds, each about a half-acre, and four other smaller areas. In both 2020 and 2021, it was again documented in the same area, but only as scattered plants (Figure 28). No other wild rice has been found in the system since before 2012.

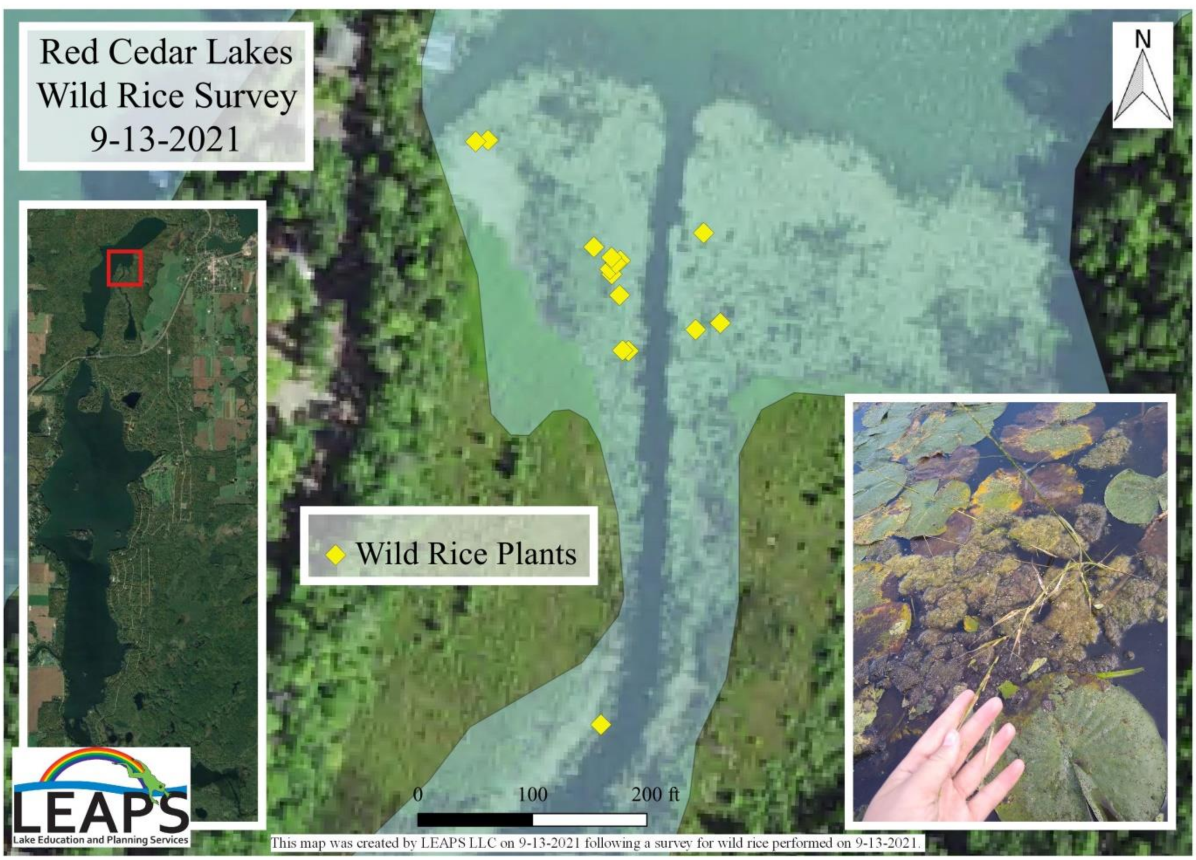


Figure 28: Wild rice in Balsam and Mud lakes

The presence of wild rice adds another level of concern to management actions taken. Wild rice seedlings are susceptible to the killing effects of most of the aquatic herbicides used for invasive species management Nelson et al. (2003). As such, the use of aquatic herbicides near, within or upstream of any area of wild rice is not recommended. How far away or how far upstream an herbicide can be used when wild rice is present is subject to individual waterbody characteristics and the opinions of management stakeholders (WDNR, Tribal Resources, Lake Organization, etc.).

3.8 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 necessary 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 (EWM), 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. Plants such as water lilies, arrowhead, and pickerelweed have flowers or leaves that many people enjoy. Aquatic plants can provide an aesthetically pleasing, beautiful shoreland, nearshore, and/or whole-lake environment, often adding to the serenity felt by many when on or visiting a lake. In order to maintain healthy lakes and rivers, healthy native aquatic plant communities must be maintained (WI-DNR, Aquatic Plants).

3.8.1 Measurements of a Healthy Aquatic Plant Community

The Simpson's Diversity Index (SDI) allows the diversity entire plant community at one location to be compared to the diversity of 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 changes 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. Generally, greater diversity indicates a healthier ecosystem. Plant communities with high diversity also tend to be more resistant to invasion by exotic species (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. The Red Cedar Lakes are in the Northern Lakes and Forest ecoregion.

3.8.2 Aquatic Plant Species Percent Frequency of Occurrence and Changes in Aquatic Plant Species Makeup

Both the 2011 and 2018 whole-lake, point-intercept surveys documented plant frequency in the lakes. Plant frequency is the percent of sampled points where a given plant species was found. This indicates how common each plant species is. During the surveys, plant density at each point for each species was also documented. Changes in the number of points with each species and a chi-square analysis were completed to determine which changes were significant, either because there were more points with a particular plant species or because there were less points with a particular plant species. The following sections briefly discuss the findings from 2011 to 2018. For more information about the aquatic plant species in the five lakes, consult the Aquatic Plant Management Plan for the Red Cedar Lakes.

3.8.2.1 Balsam Lake

In 2011, only five aquatic plant species in Balsam Lake showed a frequency of 10% occurrence or more. In 2018, that number increased to ten species. No aquatic plant species in either survey was documented to grow to nuisance levels. Wild rice was documented in Balsam Lake in both 2011 and 2018, although its frequency of occurrence and density were very low. In Balsam Lake, 18 species showed significant changes with only 4 of those being negative changes.

3.8.2.2 Mud Lake

In 2011, eight aquatic plant species in Mud Lake showed a frequency of 10% occurrence or more. In 2018, that number increased to thirteen species. No aquatic plant species in either survey was documented to grow to nuisance levels. Wild rice was documented in Balsam Lake in both 2011 and 2018, although its frequency of occurrence and density were very low. In Mud Lake, 17 species showed significant changes with only 7 of those being negative changes.

3.8.2.3 Red Cedar Lake

In 2011, nine aquatic plant species in Red Cedar Lake showed a frequency of 10% occurrence or more. In 2018, that number increased to twelve species. No aquatic plant species in either survey was documented to grow to nuisance levels. In Red Cedar Lake, 18 species showed significant changes with only 4 of those being negative changes.

3.8.2.4 Hemlock Lake

In 2011, eight aquatic plant species in Hemlock Lake showed a frequency of 10% occurrence or more. In 2018, that number increased to seventeen species. No aquatic plant species in either survey was documented to grow to nuisance levels. In Hemlock Lake, 20 species showed significant changes with only 2 of those being negative changes.

3.8.2.5 Bass Lake

In August of 2020, a whole-lake, point-intercept survey of Bass Lake was completed by LEAPS. This was the first time a whole-lake PI survey was completed to document the status of the aquatic plant community. Since it was the first time a plant survey had been completed, there are no data to compare changes in aquatic plant species from before to now.

Depth soundings taken at Bass Lake's 139 survey points revealed a bowl-shaped basin with shallow shorelines and steadily increasing depth until reaching the middle of the lake. The central basin reached a maximum depth of 40 feet (Figure 29).

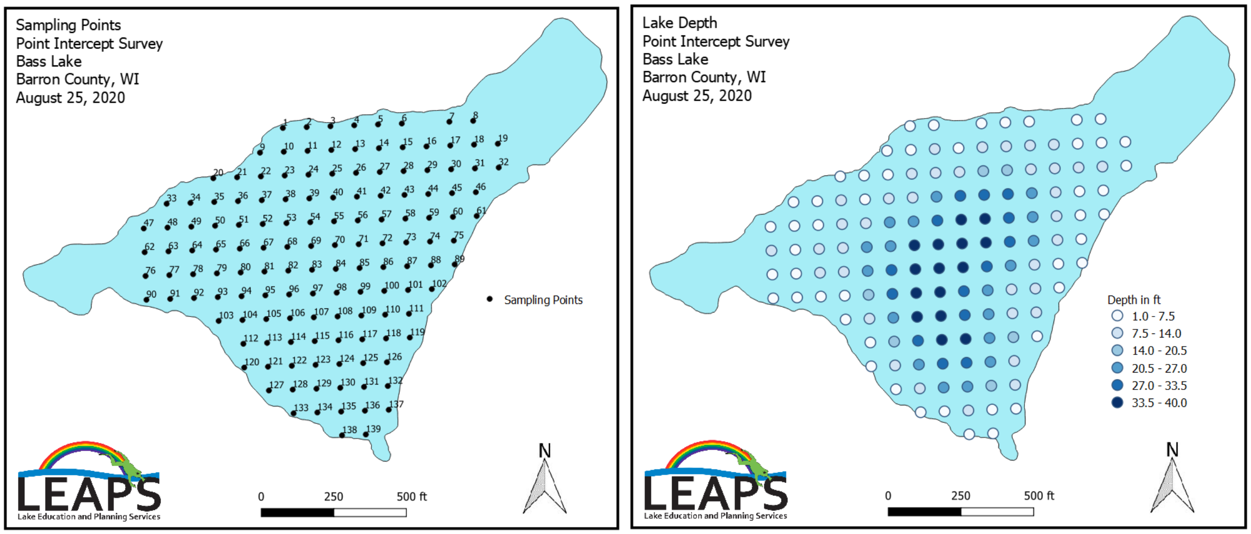


Figure 29: Bass Lake survey points and lake depth

Every point in the survey was identified as having muck substrate, and no other substrate textures were recorded (Figure 30). At the time of the survey, Secchi disc readings were in the 11.5ft range. The high water clarity produced a littoral zone that extended to 25.0ft, but the majority of plants were found in water <12ft deep (Figure 30). The mean depth of sites with plants was 7.8ft, and the median depths of plants was 7.0 (Table 10). Plants were fairly uniform in distribution as 63.8% of the total lake bottom and 86.7% of the littoral zone were colonized. Total diversity was high with a Simpson Index Value of 0.88. Species richness was typical for a small lake with only 15 species observed on the rake, and including visual surveys, the total richness was 19.

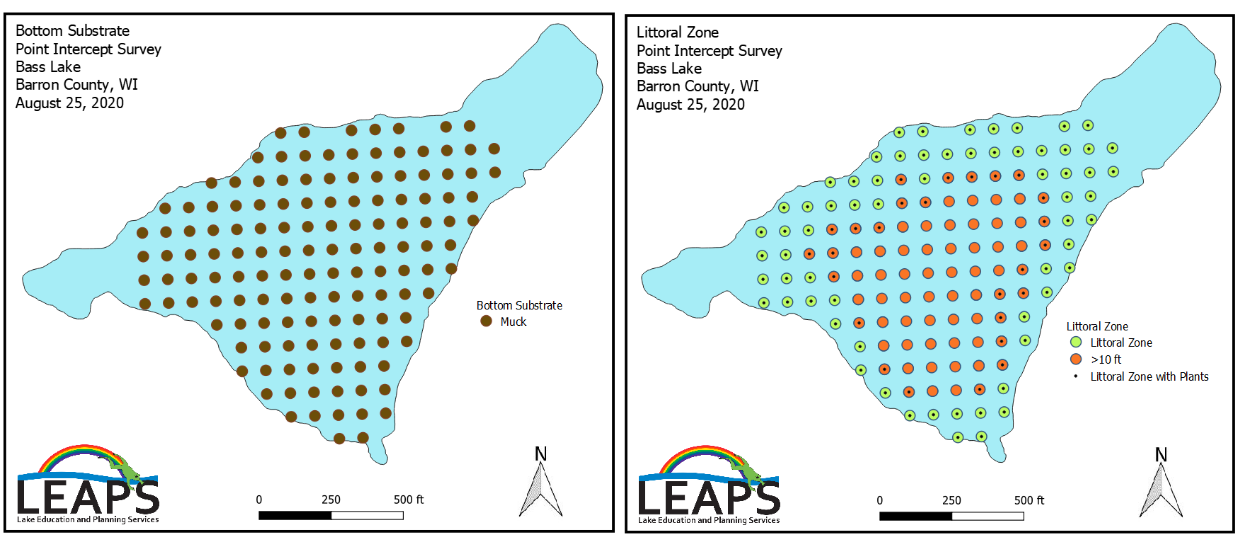


Figure 30: Lake substrate and littoral zone

Table 10: Aquatic Macrophyte PI Survey Summary Statistics Bass Lake, Barron County August 25, 2020

Summary Statistics:	
Total number of points sampled	138
Total number of sites with vegetation	88
Total number of sites shallower than the maximum depth of plants	105
Frequency of occurrence at sites shallower than maximum depth of plants	83.81
Simpson Diversity Index	0.88
Maximum depth of plants (ft)	25.0
Mean depth of plants (ft)	7.8
Median depth of plants (ft)	7.0
Average number of all species per site (shallower than max depth)	2.97
Average number of all species per site (veg. sites only)	3.55
Average number of native species per site (shallower than max depth)	2.97
Average number of native species per site (veg. sites only)	3.55
Species richness	15
Species richness (including visuals)	19
Mean total rake fullness (veg. sites only)	2.47

Lake wide, 42 of the 91 sites with vegetation had four or more native species present on the rake when sampled – 2.17 on average. Overall, plant density was high with a mean rake fullness of 2.47 at sites with vegetation (Figure 31).

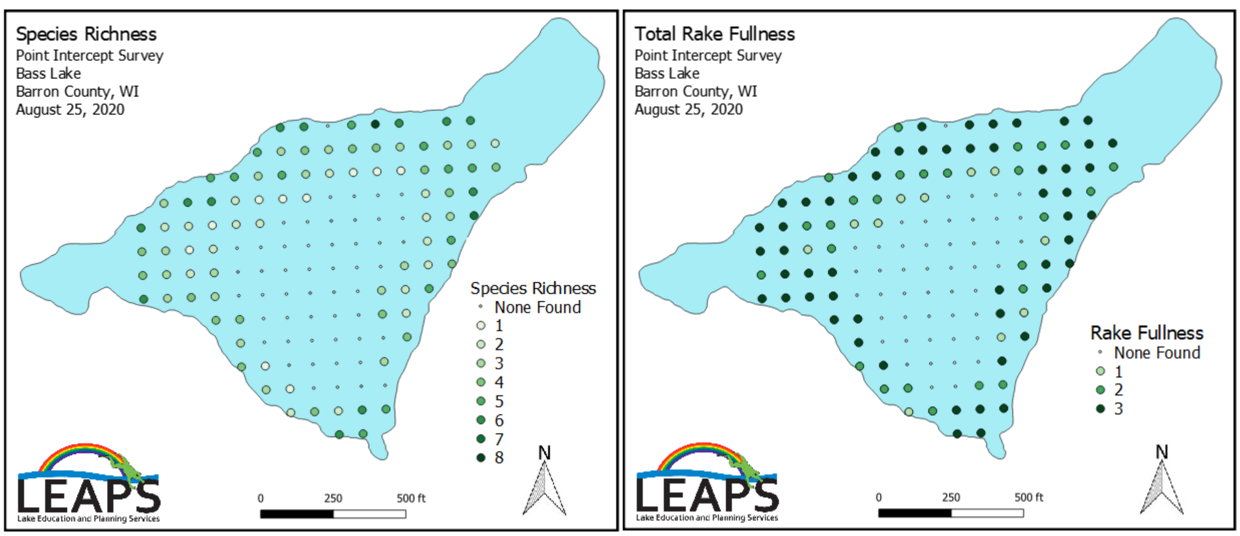


Figure 31: Native species richness and total rake fullness rating

Slender waterweed, coontail, watershield, and small pondweed were the most common vascular species, and they were found at 60.2%, 59.1%, 48.9%, and 42.1% of survey points with vegetation respectively. Collectively, they accounted for 59.3% of the total relative frequency. A total of 14 native index species were identified in the rake during the point intercept survey. They produced a mean Coefficient of Conservatism of 5.93 and a Floristic Quality Index of 22.18. Nichols (1999) reported an average Mean C for the Northern Central Hardwood Forests Region of 5.6 putting Bass Lake just above average for this part of the state. The FQI was also approximately the median FQI of 20.9 for the Northern Central Hardwood Forests Region (Nichols, 1999).

No evidence of Eurasian watermilfoil or curly-leaf pondweed was found in Bass Lake during the survey. However, reed canary grass (*Phalaris arundinacea*), another exotic invasive species was visually observed.

3.8.2.6 Murphy Flowage

A whole-lake, PI survey has never been completed on the Murphy Flowage.

4.0 Red Cedar Lakes Watershed

A watershed is an area of land that drains or "sheds" water into a specific waterbody. Every body of water has a watershed. Watersheds drain rainfall and snowmelt into streams and rivers. These smaller bodies of water flow into larger ones, including lakes, bays, and oceans. Gravity helps to guide the path that water takes across the landscape. Not all rain or snow that falls on a watershed flows out in this way. Some seeps into underground reservoirs called aquifers. Other precipitation ends up on hard surfaces such as roads and parking lots, from which it may enter storm drains that feed into streams. A lot evaporates into the air. Watersheds can vary in size. A watershed for a tiny mountain creek might be as small as a few square meters. Some watersheds are enormous and usually encompass many smaller ones.

The watershed of the Red Cedar lakes covers approximately 99,782 acres spread over portions of four different counties – Barron, Rusk, Sawyer, and Washburn (Figure 32). The watershed consists mostly of forest (67%), barren/shrub/grassland (2%), open water (7%), wetland (13%), agriculture (6%), and developed (5%). Developed area primarily consists of the villages of Birchwood, Edgewood, and Mikana and development around the nearshore area of the lakes. A few parts of the watershed, mostly north and southeast of Hemlock Lake, do not drain directly into the lakes, but drain internally to closed depressions. Agricultural land includes a split of about 25/75% cropland/hay-pasture land.

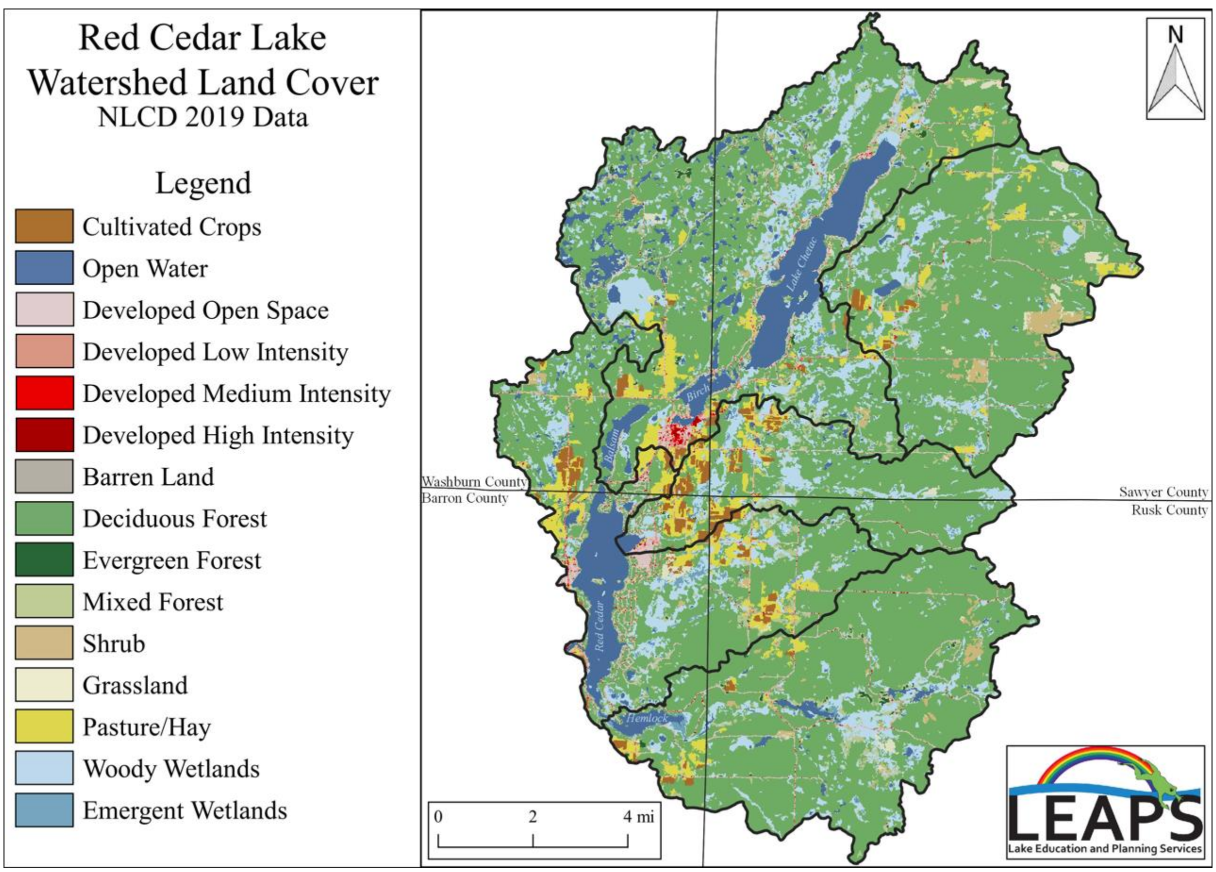


Figure 32: Land use in the Red Cedar Lakes watershed

4.1 Sub-basins of the Red Cedar Lakes Watershed

The larger watershed of the Red Cedar lakes is made up of five smaller sub-basins classified on the HUC 12 level (Figure 33). Four of them are defined by the creeks running through them – Knuteson Creek, Sucker Creek, Pigeon Creek (east side of the Red Cedar Lake sub-basin), and Hemlock Creek. In order to prioritize BMPs, land use within each sub-basin is broken down.

The Lake Chetac sub-basin is the largest including all of the land that drains into Big Chetac and Birch lakes. The Knuteson Creek sub-basin also drains directly to Big Chetac Lake. Drainage from both of these sub-basins combine and then drain into Balsam Lake. Little can be done by the RCLA alone to implement BMPs in these two sub-basins. To make changes, a cooperative effort is needed with the Big Chetac and Birch Lakes Association and other entities in the sub-basins.

The Sucker Creek sub-basin drains directly to Red Cedar Lake. Sucker Creek runs through much of the agricultural lands included in the watershed.

The Red Cedar Lake sub-basin includes all of the Pigeon Creek drainage, a portion of the watershed on the west side of Red Cedar and Balsam lakes, and a tiny portion that drains into and through Bass Lake. Both the west side of the Red Cedar Lake sub-basin and the east side (Pigeon Creek) sub-basin run through agricultural lands.

The Hemlock Creek sub-basin includes that area of the watershed that first drains into the Murphy Flowage in Rusk County and then into Hemlock Creek and Hemlock Lake, and a small area of direct drainage into Hemlock Lake. A majority of this is in Barron and Rusk County forest. The greatest amount of disturbance in this sub-basin is due to timber harvest and ATV trails.

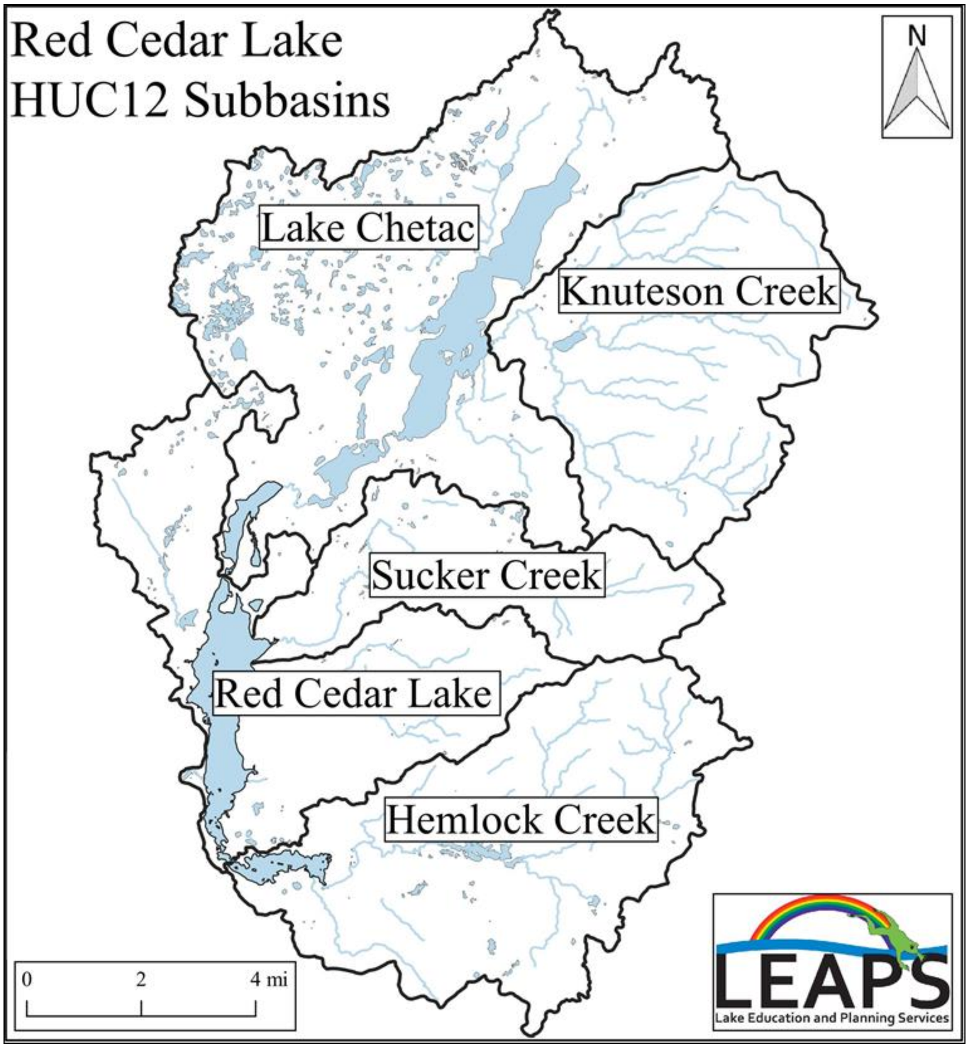


Figure 33: Sub-basins in the Red Cedar Lakes watershed

4.1.1 Land Use in the Sub-basins

Land use in each of the sub-basins was determined by USGS 2019 National Land Cover Database (Table 11; USGS, 2019). These are used in calculating P loads and load reductions across the watershed. There is always some level of natural background pollutant loading entering a body of water. Runoff from natural or undeveloped land contributes to pollutant loading, as does groundwater moving through different types of substrate. Agriculture and human development are often the land uses that increase pollutant loading the most, but they are not the only land uses that do. Current, past, and future logging on the thousands of acres in the overall watershed of the Red Cedar Lakes can also contribute. In the last five years (2018-22) Rusk County Forestry has put up for harvest bids an average of 2,864 acres of county forest land each year. Not all of this in in the watershed of the Red Cedar Lakes, but the value provides some level of knowledge related to the impact logging can have in the land and surrounding waters. Miles of ATV trails crisscross the forested areas of the watershed adding their own level of disturbance.

The following sections provide more detail about each sub-basin. Individual maps of land use in each sub-basin are included in Appendix A.

Table 11: Total land use (acreage & %) in each sub-basin of the Red Cedar lakes watershed

Sucker	acres	%	Pigeon	acres	%	Lake Chetac	acres	%
Open Water	162.28	1.7	Open Water	10.64	0.2	Open Water	4437.17	15.2
Developed	421.67	4.4	Developed	505.87	8.0	Developed	1475.3	5.0
Forest	6333.94	65.4	Forest	3837.36	61.0	Forest	17554.93	60.0
Barren/Shrub/Grassland	84.15	0.9	Barren/Shrub/Grassland	157.8	2.5	Barren/Shrub/Grassland	502	1.7
Agriculture	1166.04	12.0	Agriculture	770.07	12.2	Agriculture	1134.47	3.9
Wetlands	1514.98	15.6	Wetlands	1013.1	16.1	Wetlands	4132.51	14.1
	9683.06	100.0		6294.84	100.0		29236.38	100.0

Hemlock	acres	%	Red Cedar	acres	%	Knuteson Creek	acres	%
Open Water	594.74	3.0	Open Water	2036.17	11.7	Open Water	111.79	0.6
Developed	538.34	2.8	Developed	1134.08	6.5	Developed	475.95	2.7
Forest	15544.06	79.5	Forest	9685.28	55.9	Forest	13783.75	77.9
Barren/Shrub/Grassland	403.41	2.1	Barren/Shrub/Grassland	269.55	1.6	Barren/Shrub/Grassland	818.76	4.6
Agriculture	450.41	2.3	Agriculture	1908.11	11.0	Agriculture	742.93	4.2
Wetlands	2017.86	10.3	Wetlands	2299.68	13.3	Wetlands	1752.89	9.9
	19548.82	100.0		17332.87	100.0		17686.07	100.0

4.1.1.1 Lake Chetac and Knuteson Creek Sub-basins

With the exception of a very small portion surrounding Balsam Lake, the Lake Chetac and Knuteson Creek sub-basins do not drain directly into the Red Cedar Lakes system (Figures 34 & 35). The Knuteson Creek sub-basin drains directly into Big Chetac Lake. The Big Chetac sub-basin drains through Birch Lake into Balsam. Neither sub-basin has much agriculture in it, yet what comes out of Birch Lake through Balsam Lake carries the largest portion of the phosphorus load (>30%) to Red Cedar Lake (See Section 4.2.3). This is not entirely surprising given that it also brings more water (>36%) into Red Cedar Lake system than any of the other sub-basins. Management actions to reduce phosphorus loading from these sub-basins depend directly on the amount of support and involvement provided by the Big Chetac and Birch Lakes Association.

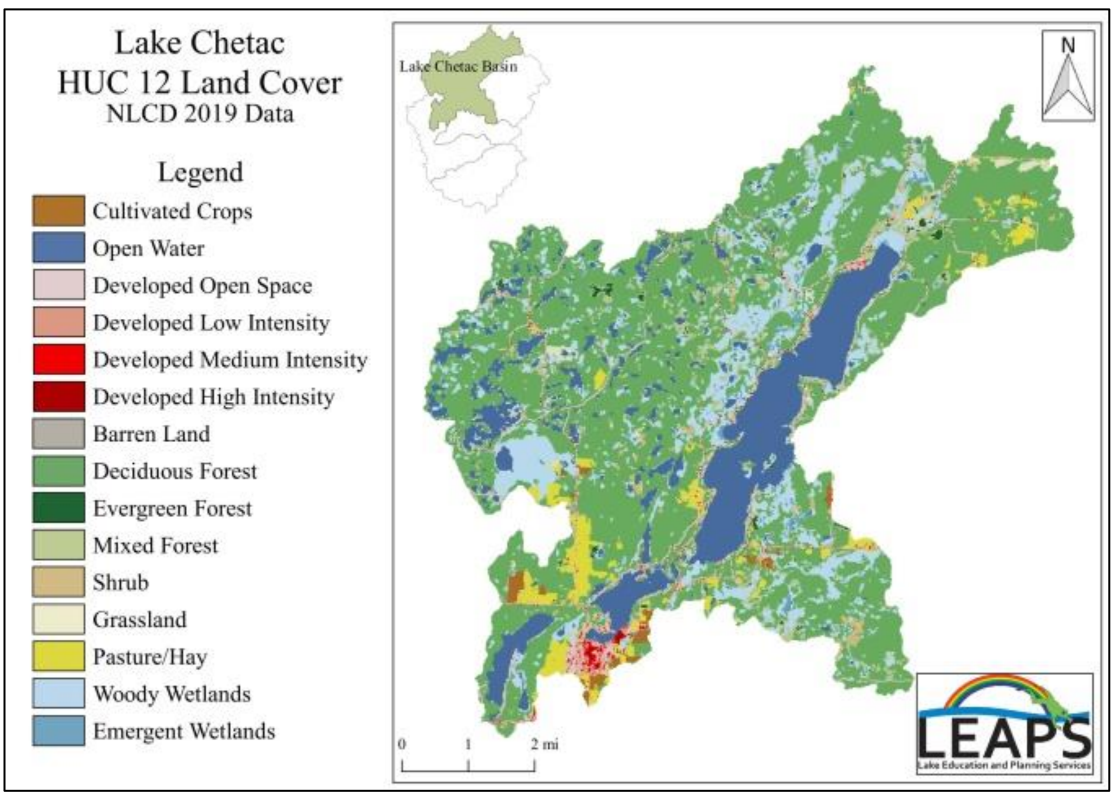


Figure 34: Big Chetac sub-basin

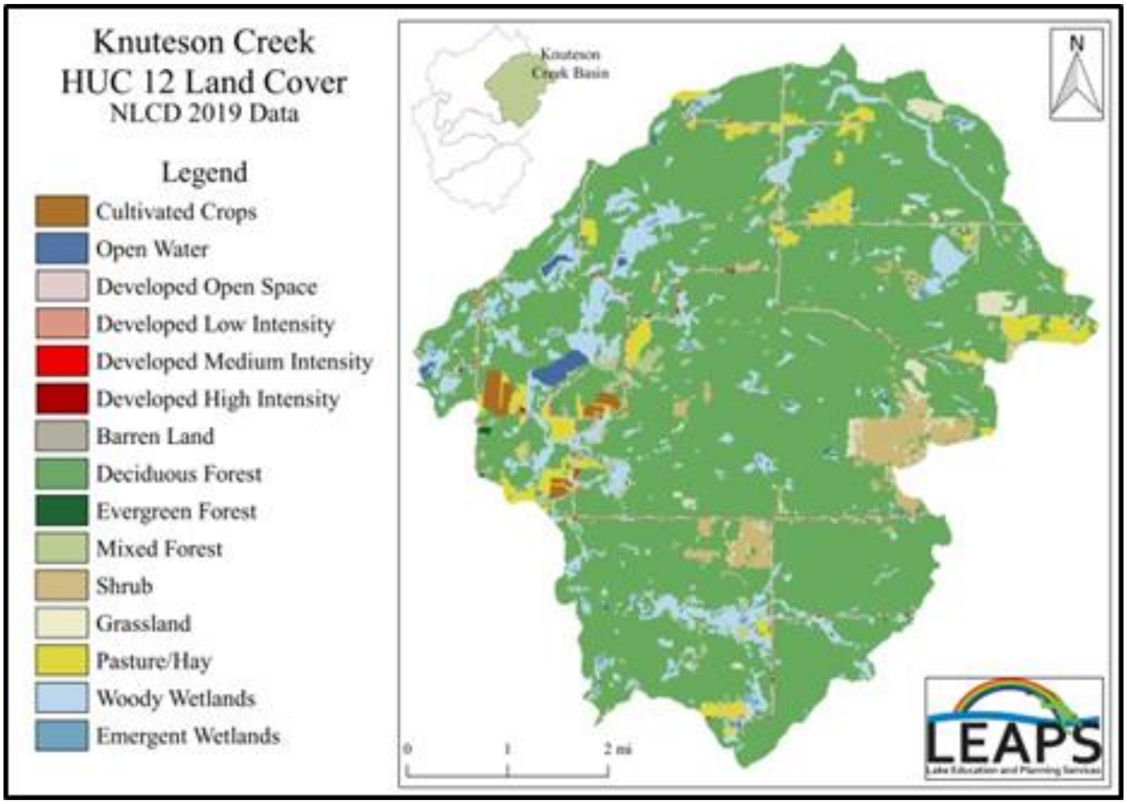


Figure 35: Knuteson Creek sub-basin

4.1.1.2 North and West Portions of the Red Cedar Lake Sub-basin

Figure 36 reflects that part of the Red Cedar Lake sub-basin that does not include the Pigeon Creek sub-basin. The Red Cedar Lake sub-basin has the most agriculture (1,908 acres) and developed area (1,134 acres) that drains directly to the lake. The entire nearshore, developed area of Red Cedar Lake is in this sub-basin.

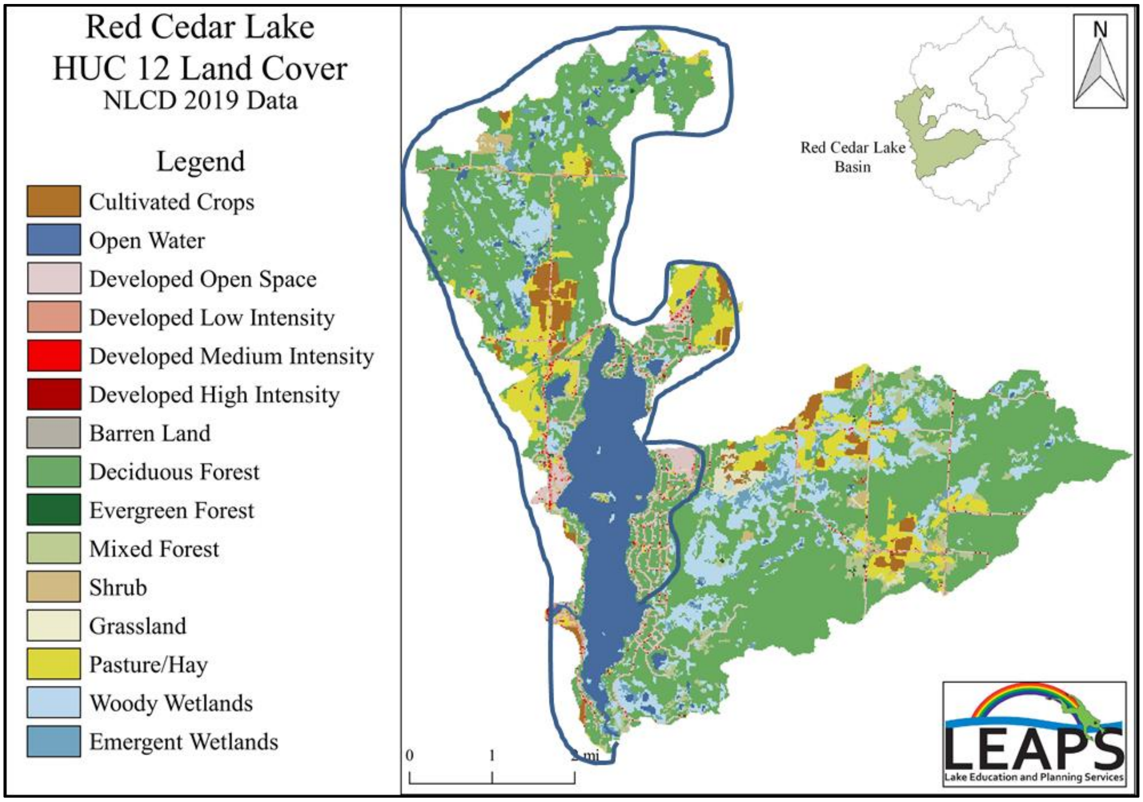


Figure 36: Portion of the Red Cedar Lake sub-basin (blue line) not included in the Pigeon Creek sub-basin

4.1.1.3 Pigeon and Sucker Creek Sub-basins

The Pigeon Creek sub-basin was separated from the Red Cedar Lake sub-basin to provide a better comparison between the Sucker and Pigeon Creek sub-basins (Figures 37 & 38).

The Sucker Creek sub-basin contributes nearly 13%, and Pigeon Creek contributes nearly 15% of the phosphorus load to Red Cedar Lake (see Section 4.2.3). The Sucker and Pigeon Creek sub-basins have the greatest amount of agriculture with an estimated 1,936 acres. A review of aerial imagery in these two sub-basins located several farmsteads adjacent to the two creeks with potential issues including barnyard runoff, livestock in the waterway, tractor crossings, and direct field runoff. Between the two sub-basins, there are an estimated 928 acres of developed area. Forests cover another 10,171 acres, with most of that being Rusk County Forest.

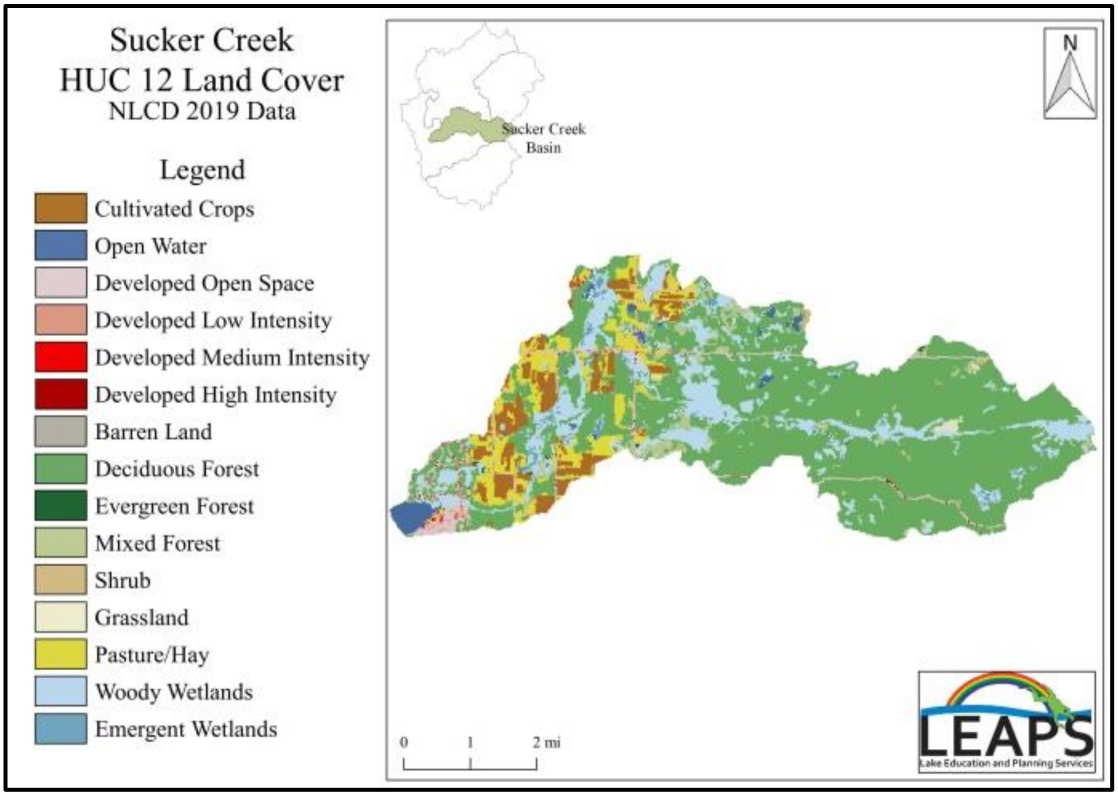


Figure 37: Sucker Creek sub-basin

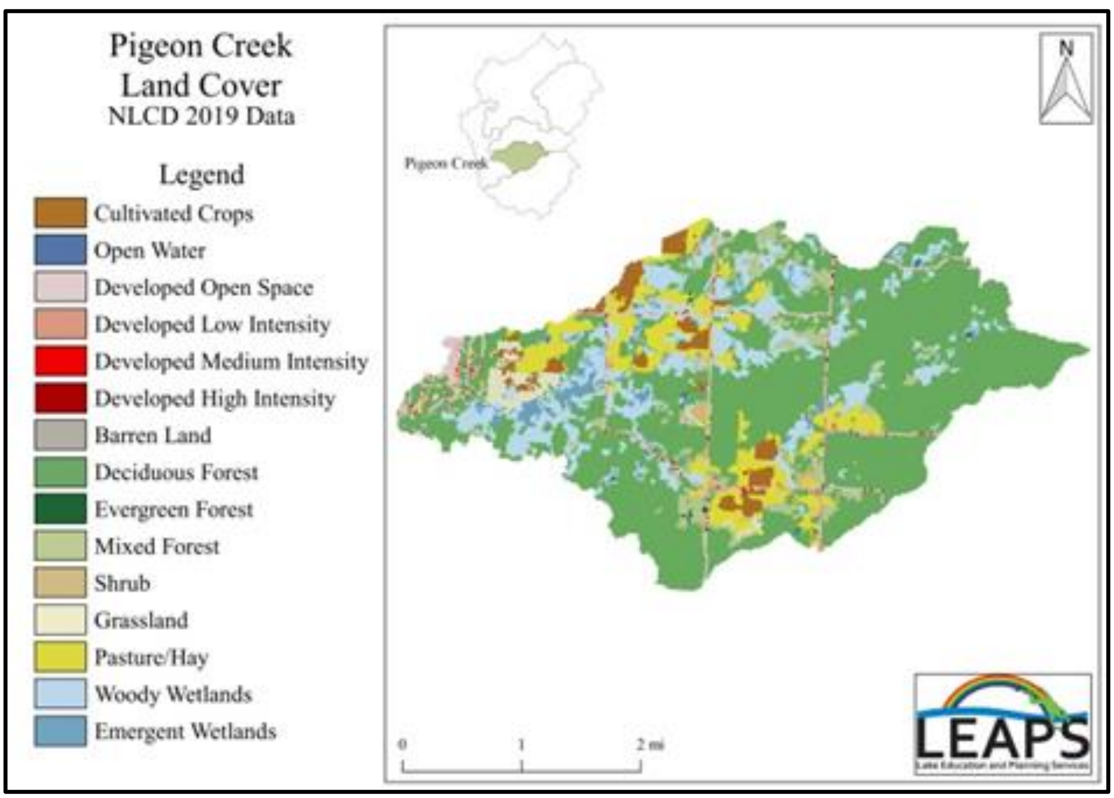


Figure 38: Pigeon Creek sub-basin

4.1.1.4 Hemlock Lake Sub-basin

The Hemlock Lake sub-basin has an estimated 15,554 acres of forest (Figure 39). Almost all of it is Rusk County forest land. Less than 5% of the land is developed or included in agriculture. Despite this, water coming from Hemlock Lake carries almost a quarter of the total phosphorus inputs to Red Cedar Lake (see Section 4.2.3). The Hemlock Lake sub-basin includes both Murphy Flowage and Bucks Lake (a smaller flowage upstream of Murphy on Hemlock Creek). A day long survey of many of the road crossings over Hemlock Creek, the South Fork of Hemlock Creek, and Louler Creek (the main streams in the watershed) completed in September 2022 identified one crossing in particular, on Hemlock Creek just upstream of Bucks Lake, which is part of an ATV trail. The crossing had no bridge, just the trail through the creek. On either side of the creek crossing hills worn away down to dirt and gravel served as turn-arounds for ATVs that would drive through the pool of water created by the crossing again and again. Sediment laden water leaves the pool and continues downstream in Hemlock Creek, into Bucks Lake and on downstream. While the water may not flow 100% of the time, when it does, a large amount of sediment and phosphorus in the water can be expected.

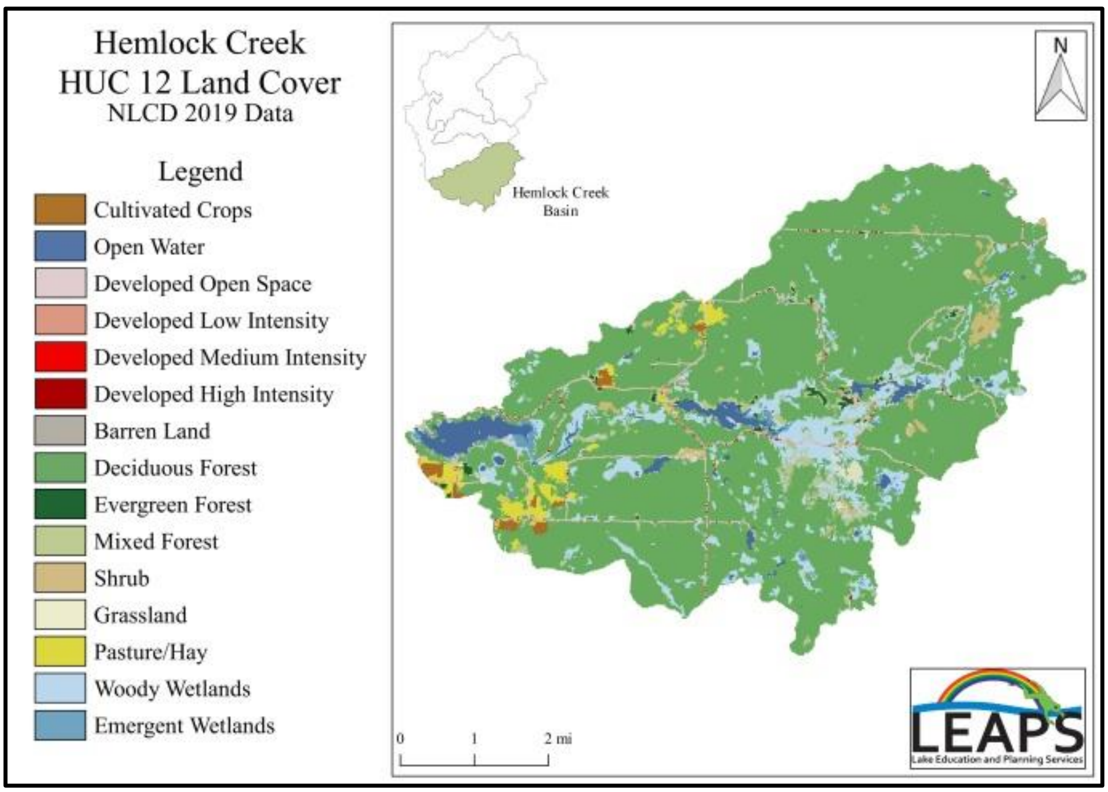


Figure 39: Hemlock Creek (Hemlock Lake) sub-basin

4.2 Tributary and In-between Lakes Monitoring

From 2018 to 2020, Biologists from the University of St. Thomas, RCLA, and LEAPS completed tributary monitoring at multiple sites in the watershed and between lakes (Figure 40). This included two sites each on Sucker and Pigeon Creeks, a site on Hemlock Creek, and sites between lakes (Big Chetac into Birch, Birch into Balsam, and Balsam into Red Cedar) to help determine watershed loading into the lakes, and loading between lakes. Basic stream flow and volume determination using pressure transducers, stream gauges, and volunteer data collection following guidelines in the Water Action Volunteer Stream Monitoring Program11 along with collection of water samples to test for an array of water quality parameters (Table 12) were collected by St. Thomas and RCLA volunteers. Loading calculations were completed by the cooperating St. Thomas Professor.

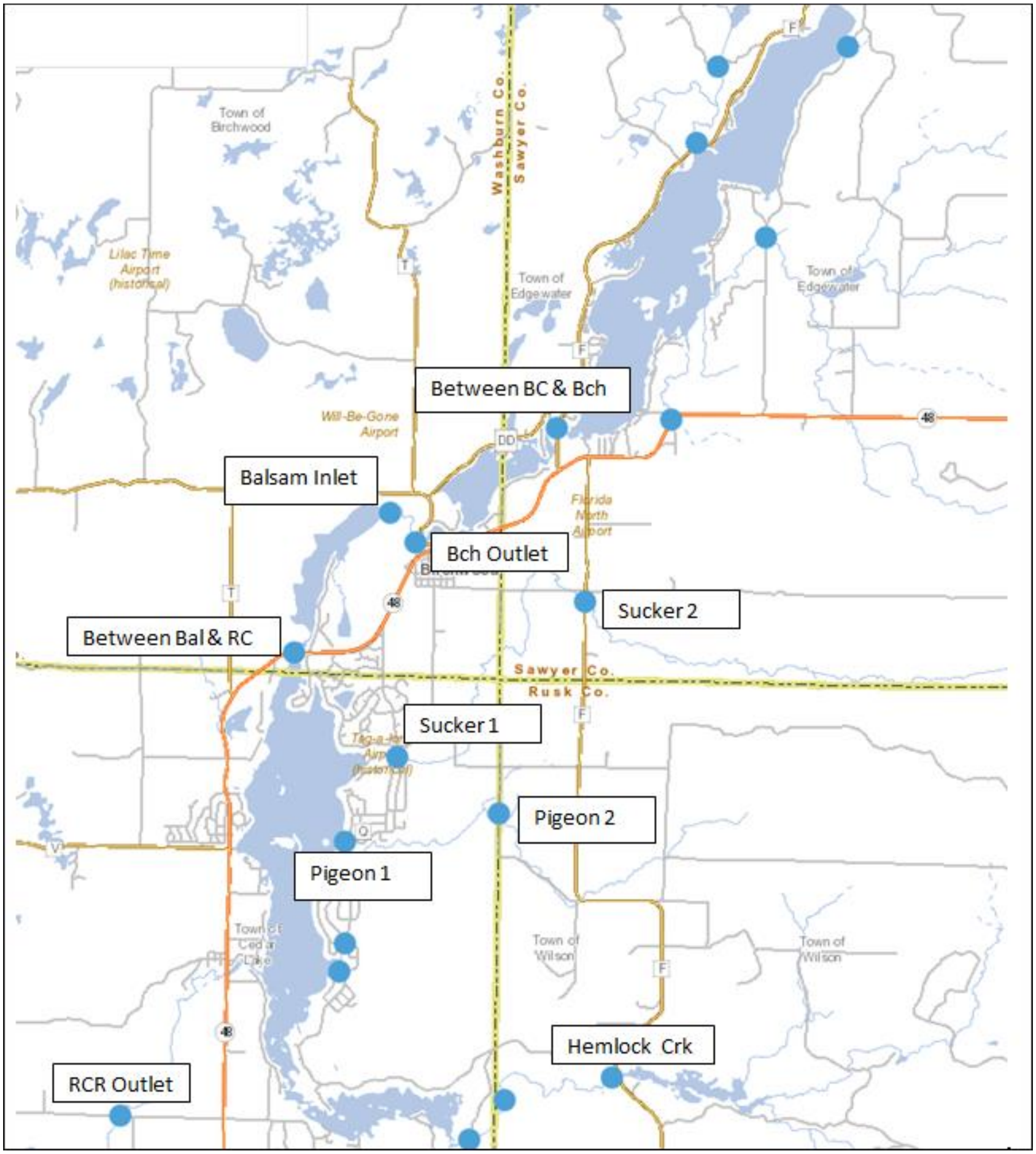


Figure 40: 2019-2020 tributary and in-between lakes Sampling Sites

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

Table 12: Tributary and in-between lakes monitoring parameters 2019-2020

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)	

Tributary and in-between lakes monitoring had several goals. The first was to try to establish a flow regime between all of the lakes in the Upper Red Cedar River Watershed. These lakes consist of Big Chetac Lake at the top or headwaters of the Red Cedar River; Birch Lake that receives a majority of its water directly from Big Chetac; Balsam Lake that receives its water from Birch Lake and also Mud Lake; Hemlock Lake that receives it water from Hemlock Creek; and Red Cedar Lake that receives its water from Balsam and Hemlock lakes, and perennial flowing Sucker and Pigeon Creeks. Additional sources of water include precipitation and ground water. Ground water was not measured or sampled for this project.

Total phosphorus and total suspended sediment data was also collected.

4.2.1 Tributary and In-between Lakes Water Flow - Monitoring Results

Figure 35 reflects the flow-through regime as measured in 2019 and 2020. The blue boxes and arrows represent flow between lakes. The green boxes and arrows represent tributary flow into the lakes. Orange boxes represent the estimated residence time of each lake. The red box and arrow represents outflow from Red Cedar Lake into the Red Cedar River.

4.2.1.1 Red Cedar Lake Water Budget

Surface water from Balsam Lake (through Birch Lake first) flowing into Red Cedar Lake accounts for a little more than 36% of the total water input. The 2003 USGS Report also indicates that 36% of the inflow of water to Red Cedar Lake comes from Birch Lake (through Balsam Lake). According to the USGS Report, the remaining inflow to the lake (64%) comes from groundwater and the un-gaged portion of the watershed which would include Hemlock Lake, groundwater, tributary inflow, overland runoff, and precipitation. Monitoring in 2019-20 broke this percentage down further. Based on 2019-20 monitoring, Hemlock Lake contributes 18.3% of the inflow. Sucker Creek adds another 7.7%, Pigeon Creek another 5.4%, and finally groundwater, precipitation, and the rest of the ungagged watershed contribute 32.4% (Figures 41 & 42)).

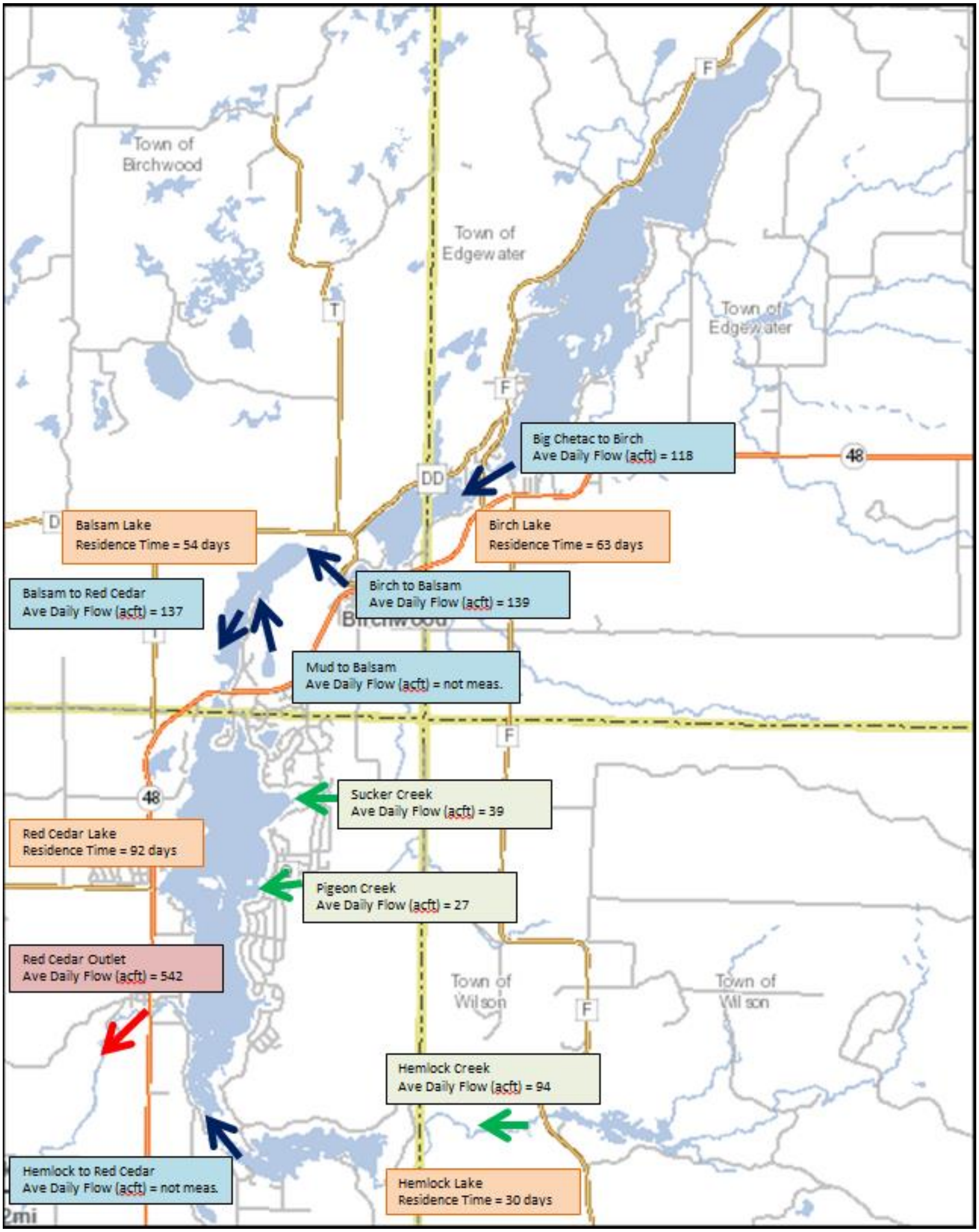


Figure 41: 2019/2020 mean flow (acre-feet/day) between lakes and into Red Cedar Lake; and lake residence time

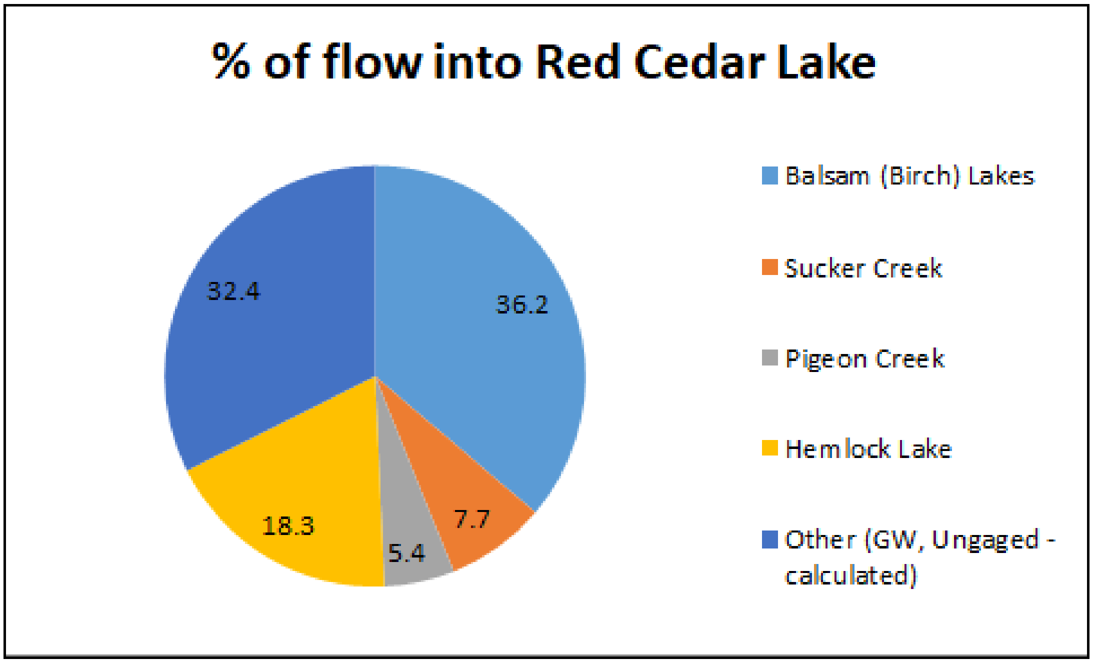


Figure 42: Water budget for Red Cedar Lake based on 2019-20 monitoring results

4.2.2 Lake Residence Time and Flushing Rate

From flow and volume data, lake residence time and annual flushing rate can be determined. Residence time and flushing rate are important to lake function and many management options. A lake with a residence time of less than two weeks is unlikely to develop algae blooms, as the water does not stay around long enough to let blooms form. Lakes with very long residence times, more than a year, are less subject to watershed influences on a day to day or even season to season basis; there is simply not enough inflow to alter water quality over a short space of time (NALMS, 2017).

Residence time and flushing rate are not constants, however, and vary over time with changing inflows. For a lake with long average residence times, this is not a major influence, but for lakes with average residence times of days to a few months, the variation within a year can be meaningful. A lake with an average residence time of a month could experience much lower summer inflows and have the same water present for 3 months, while spring thaw and related snowmelt and rain may reduce the residence time to a matter of days in April (NALMS, 2017).

Residence time and flushing rate can vary over space as well. A "dead-end" part of a lake may have a much longer residence time and be flushed much less than an area in the main path of inflows, leading to stagnation and possible water quality problems. Rerouting water through the dead-end may improve circulation and reduced residence time for that area but unless this is new inflow to the system, it will not change the average residence time for the whole lake (NALMS, 2017).

Table 13 relays the residence time and flushing rate of each main stem lake, including Birch based on the 2019-20 monitoring completed. Residence time and flushing rate of the Red Cedar Lakes as a whole system is referenced in Table 14. Similar values are referenced in the 2003 USGS Water Quality Report (USGS, 2003) (Table 15).

Table 13: Individual lake residence times and flushing rate based on 2019-20 data

Lake	Volume (acft)	Inflow (acft/day)	Outflow (acft/day)	Residence Time (days)	Flushing Rate (times/year)	# of months
Birch	8736	139	139	62.8	5.8	every 2 months
Balsam	7375	185.5	185.5	39.8	9.2	every 1.3 months
Hemlock	2856	94	94	30.4	12	every month
Red Cedar	49707	Hemlock - 94	513	96.9	4	every 3 months
		Pigeon - 27.5				
		Sucker - 39.5				
		Balsam - 185.5				
		Other - 166.5 (groundwater, other drainage)				

Table 14: Whole system residence time and flushing rate based on 2019-20 data

Lakes	Volume (acft)	Inflow (acft/day)	Outflow (acft/day)	Residence Time (days)	Flushing Rate (times/year)	# of months
Balsam, Red Cedar, Hemlock	59938	513	513	116.8	3.125	approx. every 4 months

Table 15: 2003 USGS morphometric characteristics of the Red Cedar Lakes, Wisconsin

Lake/Basin	Area (acres)	Length (miles)	Maximum depth (feet)	Mean depth (feet)	Volume (acre-feet)	Drainage area (acres)	Residence time (days)	Phosphorus turnover ratio (for annual loading)
Balsam Lake	295	1.99	49	25.1	7,400	[1]46,500	46	13.0
Hemlock Lake	357	1.95	21	8.4	2,990	17,400	31	16.0
Red Cedar Lake	1,840	4.52	53	25.7	47,300	18,000	76	7.1
Red Cedar - North Basin	1,130	2.34	53	27.6	31,300	15,200	126	4.7
Red Cedar - South Basin	708	2.18	42	22.6	16,000	2,760	42	12.1

4.2.3 Tributary and In-between Lakes Phosphorus Loading – Monitoring Results

Analysis of the results of TP sampling completed by volunteers gives a snapshot of the main sources of phosphorus to Red Cedar system. Figure 43 reflects TP inputs from lake to lake and from the main tributaries to the system.

A review of the data suggests that the amount of phosphorus coming into Birch Lake from Big Chetac Lake is less than what is leaving Birch Lake and entering Balsam Lake. Data from two sampling sites – immediately below the Birch Lake dam, and another site just before the Red Cedar River enters Balsam Lake, suggest that a large wetland system between the Birch Lake dam and the inlet to Balsam Lake is adding phosphorus to the surface water. When this study began, the researchers thought that perhaps this wetland complex would capture phosphorus rather than add phosphorus to the surface water. This appears not to be the case. Further study on the role of this wetland in increasing or reducing P loading to Balsam Lake is necessary to better understand this relationship.

Less phosphorus is leaving Balsam Lake and entering Red Cedar Lake than is entering Balsam Lake from Birch Lake. This suggests that Balsam Lake continues to be a phosphorus sink, removing as much as 21% of the phosphorus entering Balsam from Birch before it enters Red Cedar Lake.

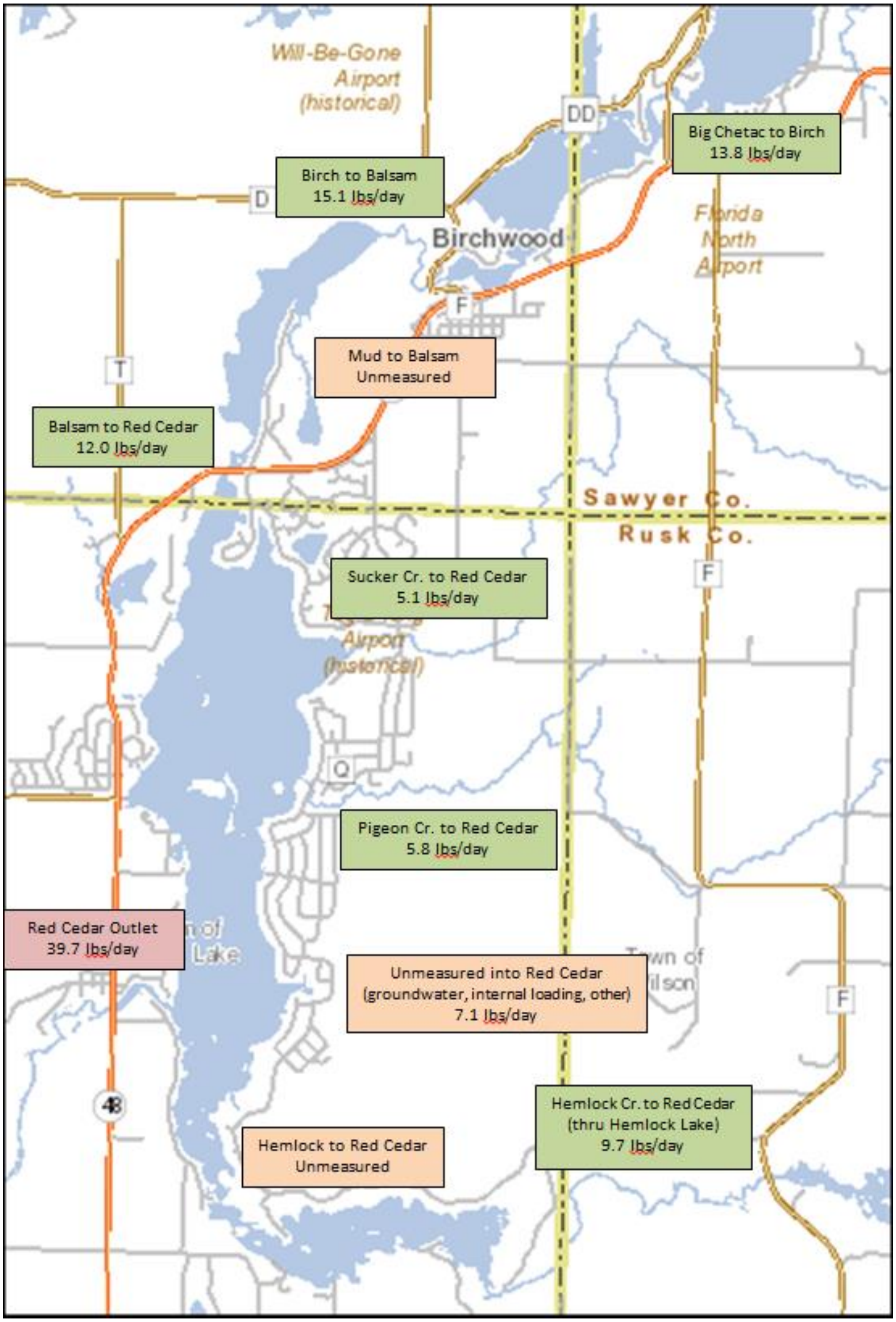


Figure 43: Daily phosphorus loading between lakes and from the tributaries based on 2019-20 monitoring

Figure 44 reflects the percentage of phosphorus coming from each major source. Balsam Lake contributes a little more than 30% of the surface water phosphorus load to Red Cedar Lake. Hemlock Creek (through Hemlock Lake) contributes the next largest amount at 24.4%. Pigeon Creek contributes the next largest measured sum of 14.7%, followed by Sucker Creek contributing 12.9%. The Pigeon Creek value is surprising because it has less flow and less agricultural land use than Sucker Creek. Unmeasured inputs of phosphorus come from internal loading, un-gaged areas of the watershed, the nearshore area of the lake, septic systems, groundwater flow, and atmospheric deposition. All of these sources total about 17.8% of the total load.

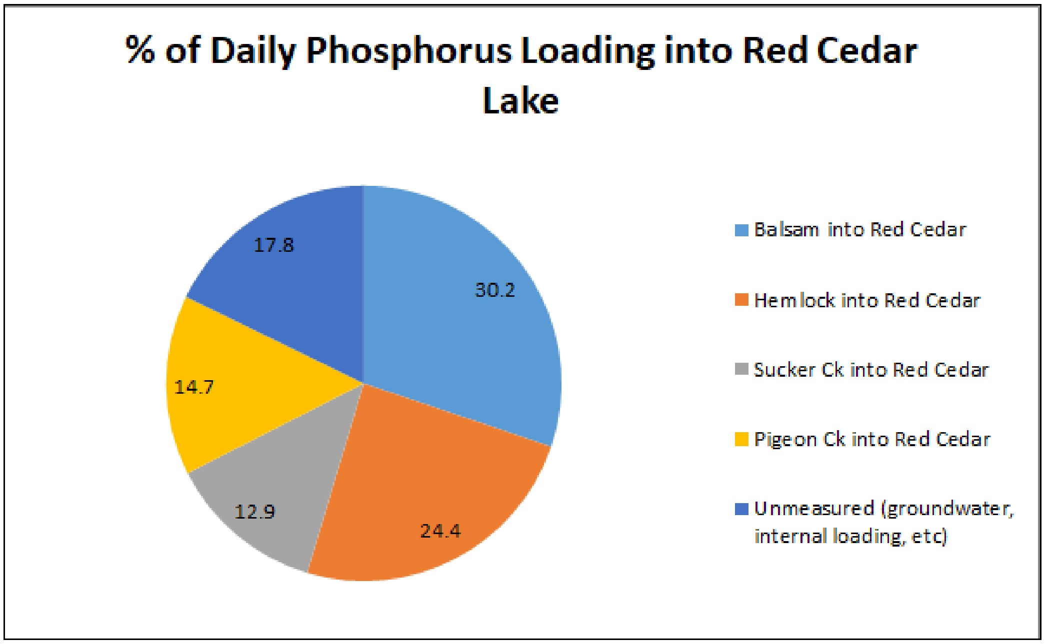


Figure 44: Percent of daily phosphorus loading into Red Cedar Lake based on 2019-20 monitoring

4.2.4 Current and Past Tributary Monitoring

Three of the tributary sites monitored between 2018 and 2020 were also monitored in 2001 – the Red Cedar River at Hwy D below the Birch Lake Dam, Sucker Creek at Loch Lomond Blvd, and Hemlock Creek at Hwy F. When comparing the average TP load from all the data collected between April and September for each of these monitoring sites, Table 16 shows that only Sucker Creek has higher TP values from 2018-2020 then values from 2001. No previous data exists to make comparisons related to the other tributary and in-between lakes sites monitored between 2018 and 2020.

Table 16: Average TP for all data collected between April 15th and Sept 15th at three tributary sites

Monitoring Site	Site ID#	Year	Mean TP (µg/L)	Min TP (µg/L)	Max TP (µg/L)
Red Cedar River at Hwy D (Apr-Sept)	663152	2001	0.037	0.023	0.054
		2017-20	0.034	0.023	0.052
Sucker Creek at Loch Lomond Blvd (Apr-Sept)	33188	2001	0.055	0.019	0.126
		2018-20	0.062	0.025	0.151
Hemlock Creek at Hwy F (Apr-Sept)	33189	2001	0.059	0.027	0.127
		2018-20	0.041	0.016	0.105

4.2.5 Watershed Sediment Loading and Soil Erosion

Sediment loading from a watershed into streams, rivers, and lakes is directly related to soil erosion. Dirt washed off of a field, gravel along a road that is carried away, or material eroded 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. 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 agricultural fields may 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 lose large amounts of phosphorus that can be transported to water bodies where it can further degrade the quality of the water by contributing to algal blooms.

4.2.5.1 Soil Health

Soil erosion can be avoided by maintaining good soil health. Soil health, also referred to as soil quality, is defined by the USDA[12] as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans. 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.

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).

[12] https://www.nrcs.usda.gov/conservation-basics/natural-resource-concerns/soils/soil-health

4.2.5.2 Tributary and In-between Lakes Sediment Loading – Monitoring Results

Sediment loading into and between the lakes does not appear to be a major component of deteriorating water quality. Based on 2019 and 2020 monitoring, Red Cedar Lake receives an estimated 181.5lbs of sediment per day from all sources. In a season that runs from April through October, this amounts to about 19.4tons of sediment entering Red Cedar Lake. This amount of sediment equates to approximately twelve cubic yards of sediment, or a typical dump truck seen on WI highways that is completely full. Figure 45 reflects the percent of daily sediment load from the main inflows to Red Cedar Lake. Overland runoff from the nearshore area and un-measured portions of the watershed has not been calculated.

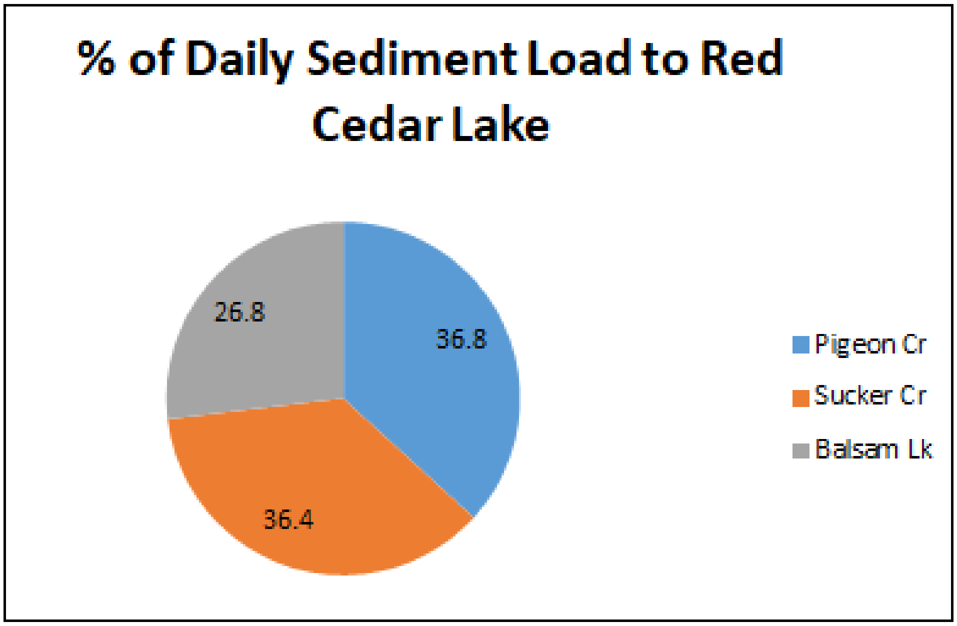


Figure 45: Percent of daily seasonal sediment load to Red Cedar Lake.

East of Murphy Flowage, Hemlock Creek has two branches. The main creek flows through Bucks Lake and then enters Murphy Flowage from the northeast. The south fork of Hemlock Creek flows into Murphy Flowage from the southeast. The volume of water and the amount of sediment moving from these tributaries into Murphy Flowage has not been quantified.

Sediment monitoring data collected from Hemlock Creek over three years (2018-2020) just downstream of Murphy Flowage was used to calculate the daily sediment load into Hemlock Lake. Results indicated 45.5lbs of daily sediment loading into Hemlock Lake.

Flow between Hemlock Lake and Red Cedar Lake was not measured, nor was sampling for total suspended sediment completed, so calculating the sediment load into Red Cedar Lake from Hemlock Lake is not possible at this time.

Based on 2019 monitoring data only, daily sediment directly into Balsam Lake from the Red Cedar River was calculated at 110.0lbs per day. Only about a third of that daily sediment leaves Balsam Lake and enters into Red Cedar Lake. Both Pigeon and Sucker Creeks individually contribute more sediment to Red Cedar Lake than what is coming in from Balsam Lake.

4.2.5.3 Pigeon and Sucker Creek Loading Upstream

In addition to monitoring Pigeon and Sucker Creeks where they enter Red Cedar Lake, upstream monitoring was done on each for the purpose of better identifying possible problem areas within the sub-basins. Total phosphorus measured at the inlet of Sucker Creek into Red Cedar Lake in 2019 and 2020 was on average 2.9 times greater than what was measured at the upstream site. Sediment at the inlet was 1.9 times greater than what was measured at the upstream site.

For Pigeon Creek, the total phosphorus measured at the inlet into Red Cedar Lake was 2.5 times greater than what was measured at the upstream site. Sediment at the inlet was 5.8 times greater than what was measured at the upstream site.

These monitoring results suggest that land use in the area between the inlets and the upstream sites on both Sucker and Pigeon Creek can be improved to reduce the amount of both phosphorus and sediment carried between them. Both streams move through agricultural land (Figures 46 & 47). Pigeon Creek apparently has greater issues with sediment. One reason for this, based on aerial imagery, is that Sucker Creek may be better buffered from agricultural fields and animal feed lots than Pigeon Creek. In addition, if Pigeon Creek is followed upstream beyond the Valley Road monitoring site, it splits into north and south branches, along which there are several agricultural properties that could be contributing excessive amounts of P and sediment.

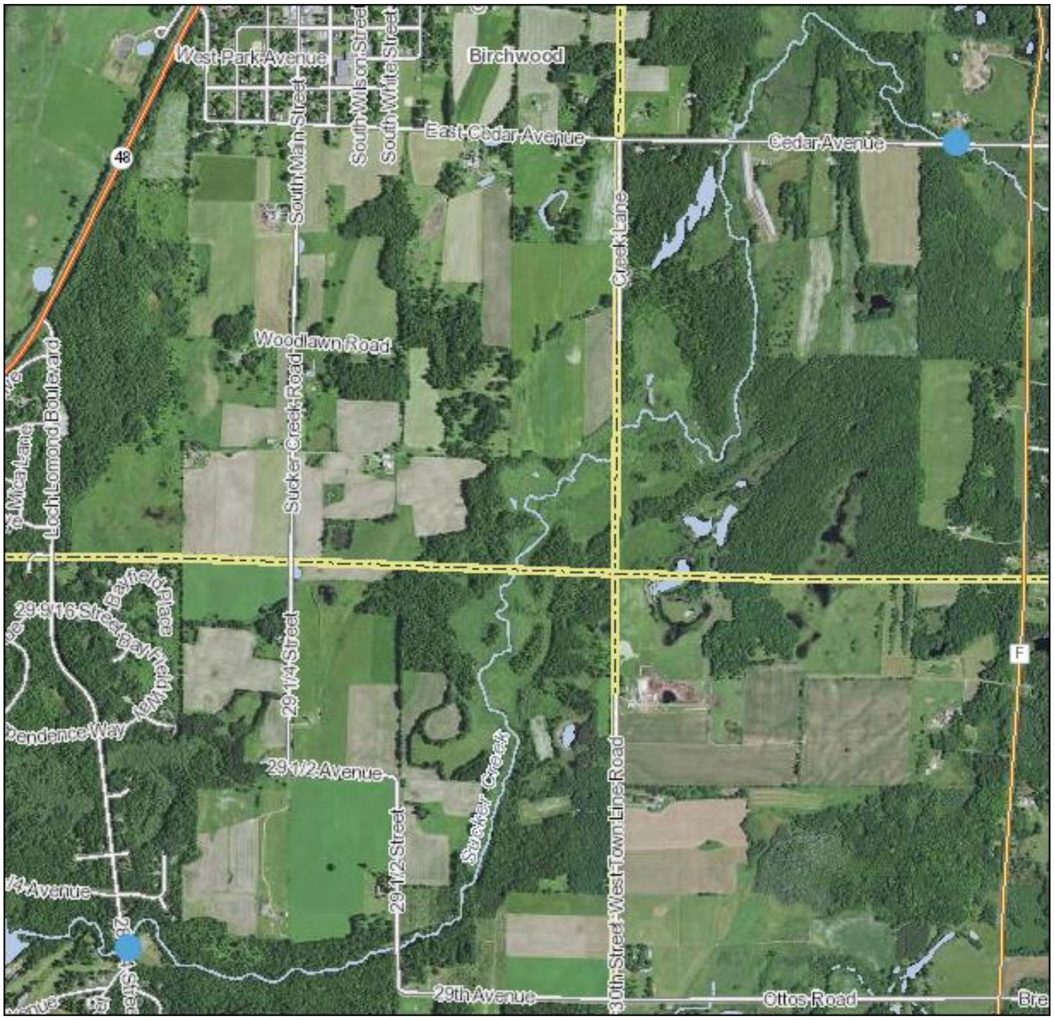


Figure 46: Land use between the inlet and upstream monitoring site on Sucker Creek

Figure 47: Land use between the inlet and upstream monitoring site on Pigeon Creek

4.2.5.4 2018-2020 Total Phosphorus and Total Suspended Solids for the Five Main Tributaries

In the previous sections, tributary data from nine different monitoring sites with the same data collected in both 2019 and 2020 are discussed. Actual tributary monitoring started in 2018, with only five main sites included – Red Cedar River at Cty D (Balsam Lake inlet), Red Cedar River at 25th (Red Cedar outlet), Pigeon Creek at 28th, Sucker Creek at Loch Lomond, and Hemlock Creek at Cty F. When comparing just the concentration of TP (not flow) across three years (2018-2020) Pigeon Creek has by far, the highest TP level (Figure 48). Sucker Creek, Hemlock Creek, and the Inlet to Balsam Lake at Cty D (just below the dam in Birchwood) all have about the same TP concentration (Figure 48). What leaves Red Cedar Lake through the outlet has a much lower concentration of TP suggesting most of the TP that enters Red Cedar Lake, stays in Red Cedar Lake.

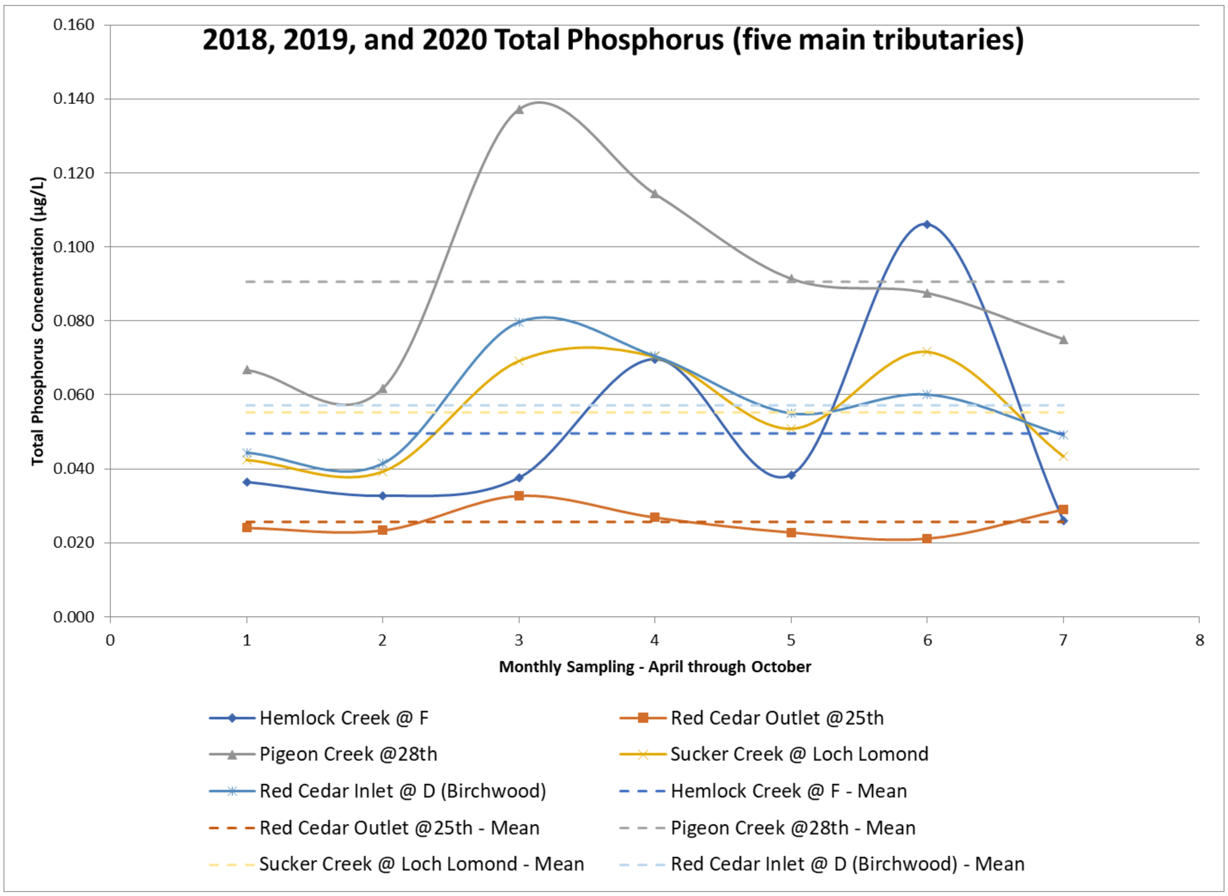


Figure 48: Monthly total phosphorus concentrations (actual values and mean) over three years (2018-2020) from the four main tributaries to the Red Cedar Lakes and the outlet of Red Cedar Lake

When looking at just the concentration of TSS (not flow) across three years, Pigeon Creek also has the highest level (Figure 49). Sucker Creek comes in a relatively close second, with Hemlock Creek and the Inlet to Balsam Lake at Cty D being tied as a distant third (Figure 49).

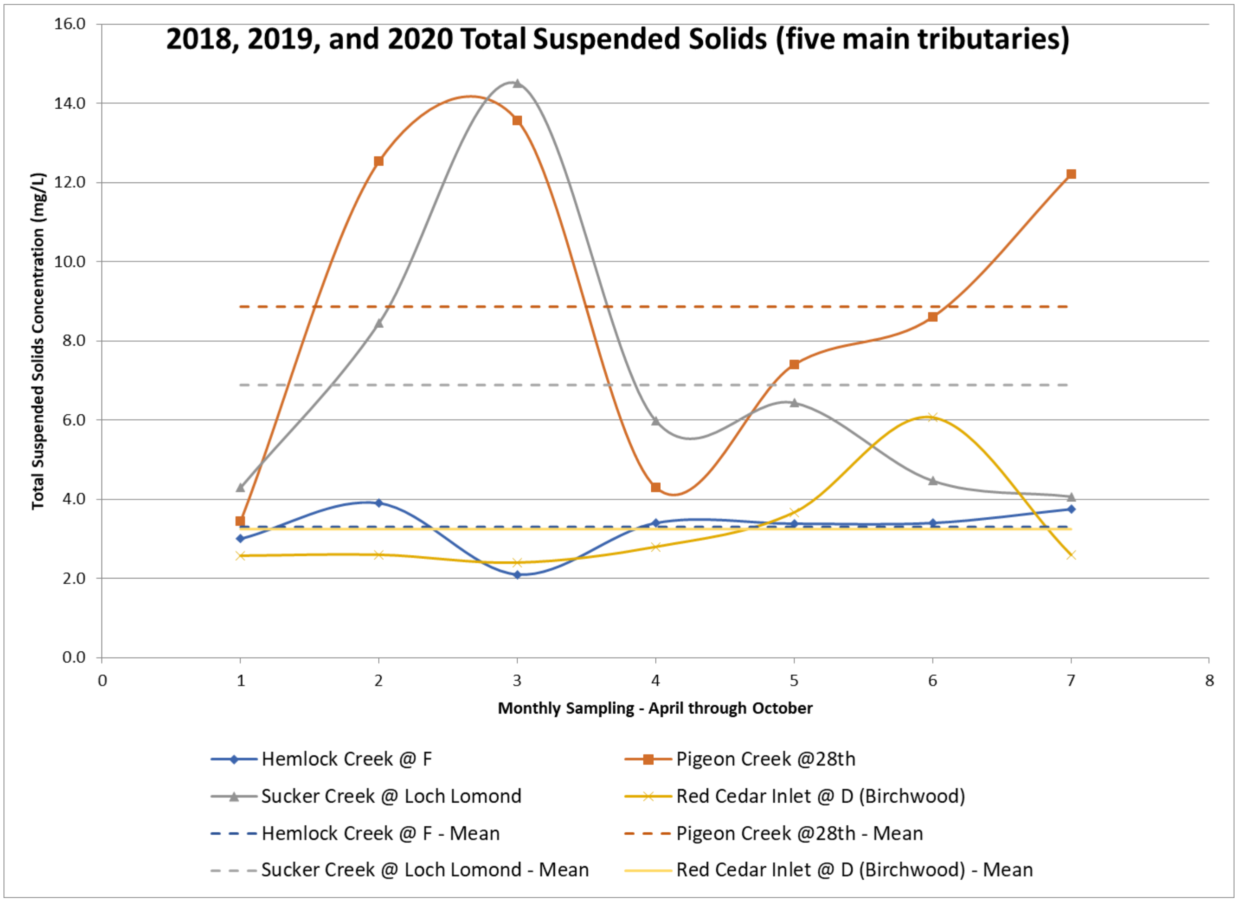


Figure 49: Monthly total suspended solid concentrations (actual values and mean) over three years (2018-2020) from the four main tributaries to the Red Cedar Lakes (there is no outlet of Red Cedar Lake data)

These numbers support the finding that water moving through the Pigeon and Sucker Creek sub-basins pick up the most nutrients and sediment and carry them into Red Cedar Lake. While their volume of flow may not be as high, the water they carry into Red Cedar Lake has the highest concentrations of both, suggesting that changes in land use in these two sub-basins that reduce TP and TSS could benefit the lakes.

4.2.6 Murphy Flowage Watershed

While Pigeon and Sucker Creeks may have the highest concentration of TP and TSS in water samples collected, Hemlock Creek has the highest daily phosphorus load based on flow, calculated at 9.7 lbs/day. Water samples were taken from a stream site just below the Murphy Flowage Dam upstream of Hemlock Lake (Hemlock Creek at Cty F).

Murphy Flowage is a 169-acre impound on Hemlock Creek. Three streams draining a mostly forested watershed flow into Murphy Flowage - Louler Creek from the north, Hemlock Creek from the northeast, and the South Fork of Hemlock Creek from the southeast. The watershed is made up of primarily Rusk County forest land. The area is heavily logged and has ATV/snowmobile trails crisscrossing throughout. Only one tributary sampling event (September 2022) covering nine different locations within the watershed of Murphy Flowage has been completed. Results from that sampling event identified several locations with elevated phosphorus and one location in particular, an ATV trail stream crossing on Hemlock Creek just off 3-Lakes

Road in the Rusk County Forest, which has served as a "mud bog" of sorts for ATV riders since at least the early 2000's (Figure 50). While this stream crossing likely provides a great deal of ATV recreation during the season, negative impacts to stream water quality are likely significant below the area, particularly during periods of high water runoff.

There may be other ATV trail stream crossings on the Rusk County (and Barron, Sawyer, and Washburn Counties) forest ATV trail system with similar issues, but this one in particular is likely contributing to water quality issues.

Figure 50: Hemlock Creek ATV Crossing on 3-Lakes Road in the Rusk County Forest. (Left - Sept. 2012; Right – Sept. 2022)

4.3 Nearshore/Riparian Area

Riparian areas are the zones along all water bodies 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, fish, 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). Unfortunately, many riparian areas are heavily, and often negatively impacted by human activities including 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).

4.3.1 Nearshore/Riparian Area of the Red Cedar Lakes

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 WDNR in 2015 and updated in November 2020.[13] 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 a "score" and a priority ranking. As assessment of each lake, including Bass Lake was completed in 2020 and 2021.

The second part of this assessment involved mapping land use in a wider 300ft 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.

4.3.2 Shoreland Habitat Assessment

The priority rankings that accompany each parcel evaluation were developed by 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, 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 (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 which determine the color to be assigned (Table 17). 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. Depending on the most common assessment parameters for each lake, a "worst possible" score is determined. After the assessment of each parcel, the points generated are summed and the properties prioritized based on the point range for the entire lake.

[13] 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 17: 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)

4.3.2.1 Balsam-Mud Lakes SHA

For Balsam and Mud lakes, the "worst possible" score was 12 points, but the worst scoring parcels only received 9 points. From here, four levels of concern were established: red, orange, yellow, and white. Red properties are of high concern, orange is moderate, yellow is low, and white parcels are of no concern (Table 18, Figure 51).

Table 18: Score ranges and priority rankings for the 97 parcels immediately adjacent to Balsam and Mud Lakes

Color	Overall Score	Priority	Number of Parcels
Red	7-9 Points	High	3
Orange	4-6 Points	Moderate	9
Yellow	2-3 Points	Low	17
White	0-1 Points	No Concern	68

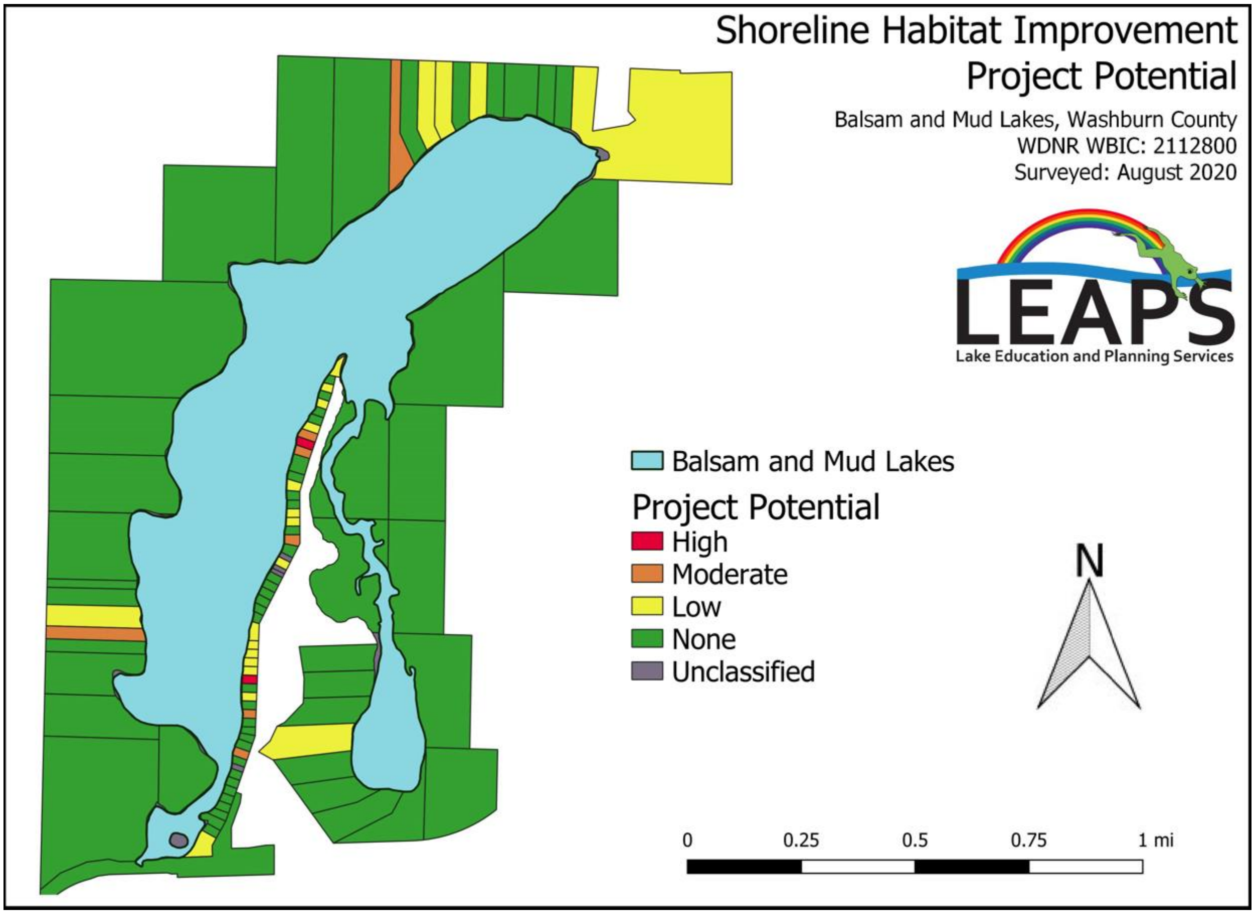


Figure 51: Lake-wide SHA results map – Balsam and Mud Lakes

4.3.2.2 Red Cedar Lake SHA

For Red Cedar Lake, the worst possible score was 16 points, but the worst scoring parcels received only 8 points. Red properties are of high concern, orange are moderate, yellow is low, and white parcels are of almost no concern (Table 19, Figure 52). The Stout's Island Lodge was not included in the assessment.

Table 19: Score ranges and priority rankings for the 360 parcels immediately adjacent to Red Cedar Lake

Color	Overall Score	Potential	Number of Parcels
Red	6-8 Points	High	19
Orange	4-5 Points	Moderate	35
Yellow	2-3 Points	Low	51
White	0-1 Point	No Concern	255

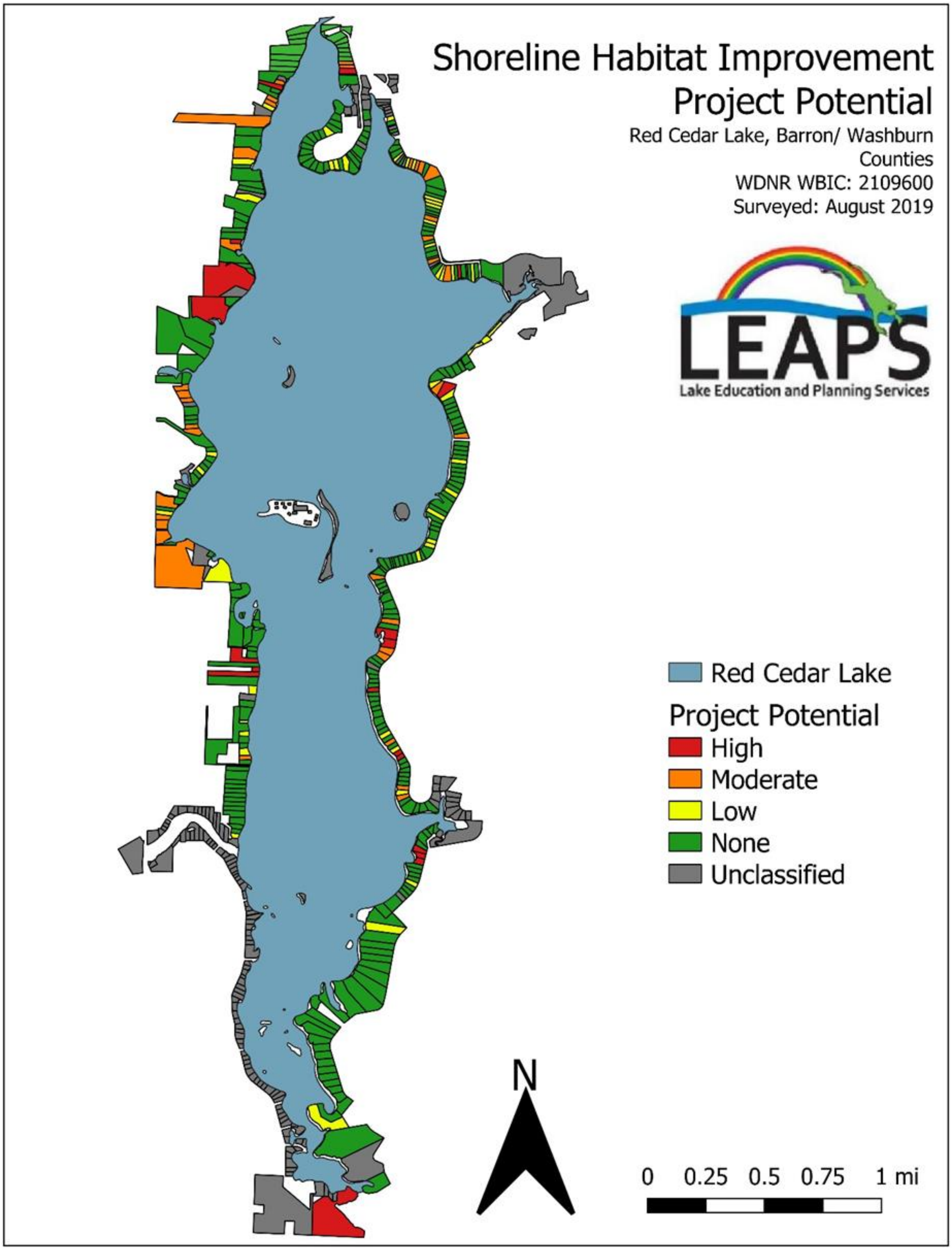


Figure 52: Lake-wide SHA results map – Red Cedar Lake

4.3.2.3 Bass and Hemlock Lakes

For these two lakes, the worst possible score was 12 points for each lake, but the highest scoring parcel only received 7 points. Because of this, no parcel received a ranking of high concern (yellow). Lime green properties are of moderate concern, green is low, and dark green parcels are of no concern (Table 20 and Figures 53 and 54 summarize the survey results for each lake.

Table 20: Score ranges and priority rankings for the 41 parcels immediately adjacent to Bass, and the 85 parcels immediately adjacent to Hemlock Lake

Project Potential	Overall Score	Bass Lake	Hemlock Lake
High	8-12 Points	0	0
Moderate	5-7 Points	3	5
Low	2-4 Points	8	8
No Concern	0-1 Points	30	72

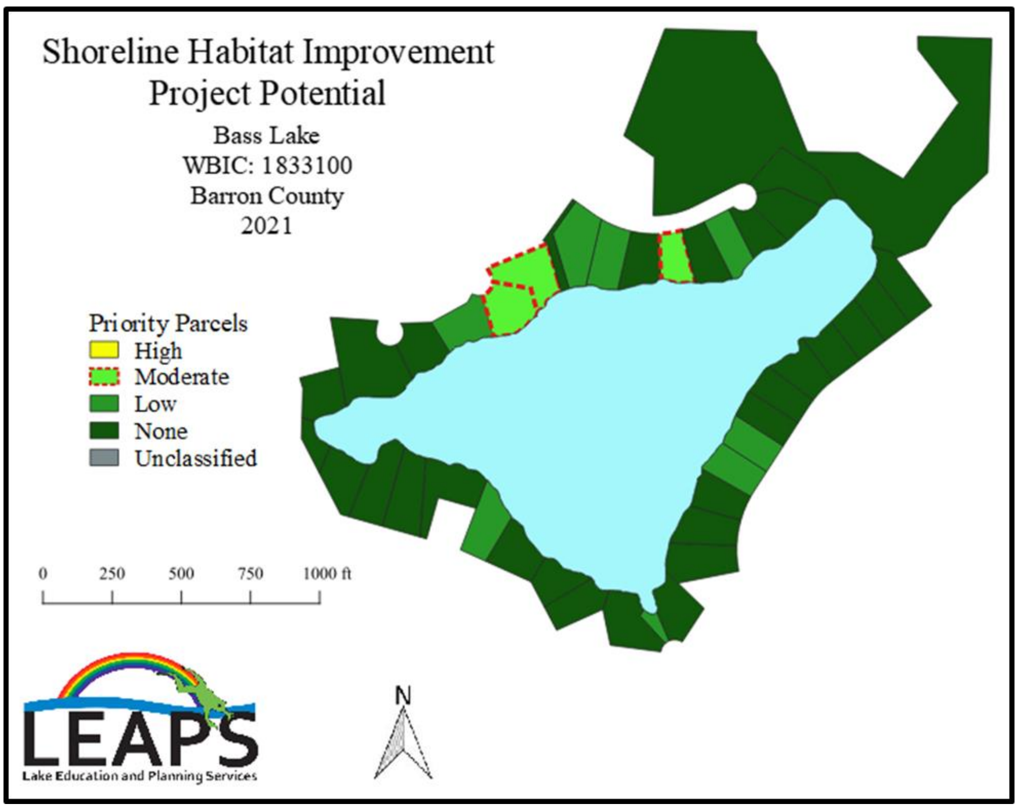


Figure 53: Lake-wide SHA results map – Bass Lake

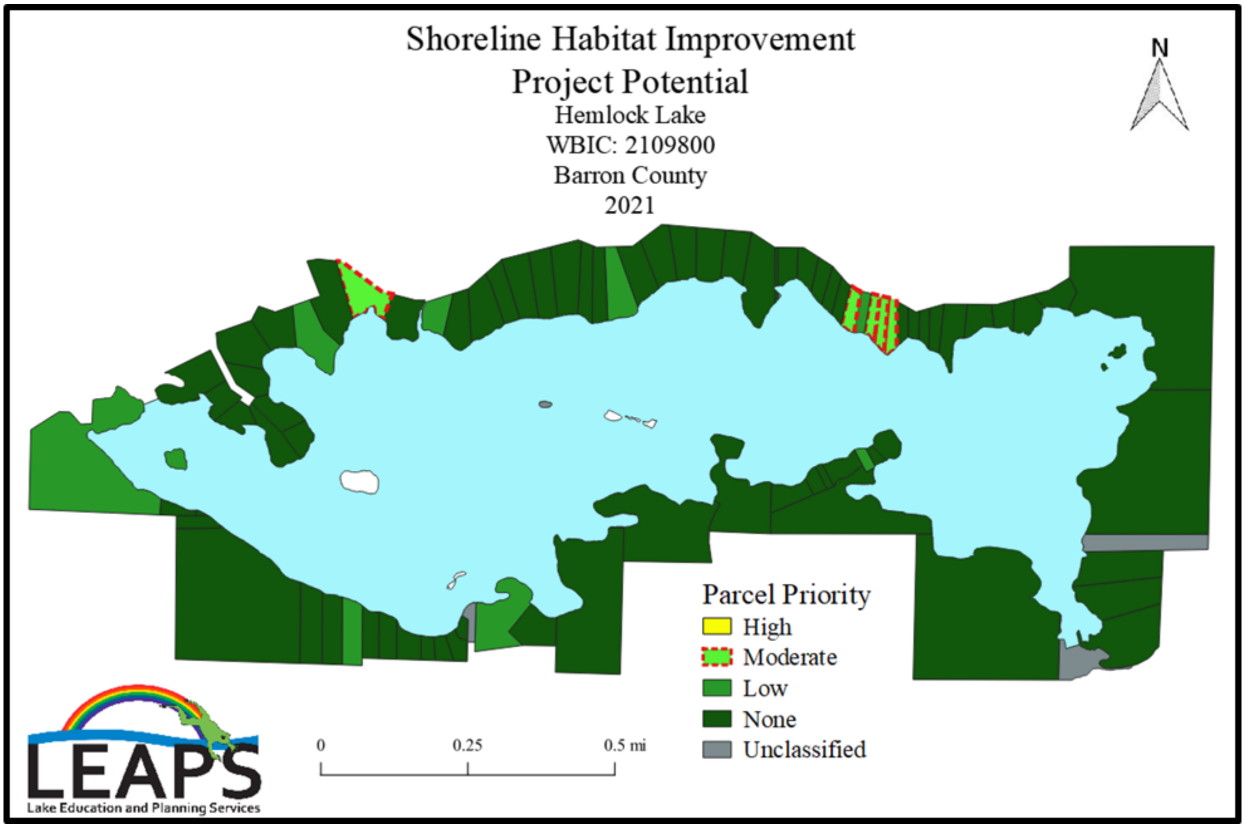


Figure 54: Lake-wide SHA results map – Hemlock Lake

Of the 583 total parcels evaluated on all lakes, only 3.8% were considered high priority or with high potential to implement shoreland runoff reduction and habitat improvement projects; only 8.9% were considered to have moderate potential (Table 21). When compared to SHA completed by the same consultant on other lakes, the shoreland of the Red Cedar Lakes is well below the average for the other SHA surveys that were completed, however, there is still room for improvement (Figure 55).

Table 21: Priority or Potential Rankings for parcels evaluated on all the lakes

Project Potential	Balsam-Mud Lakes	Red Cedar Lake	Bass Lake	Hemlock Lake	Total
High	3	19	0	0	22 (3.8%)
Moderate	9	35	3	5	52 (8.9%)
Low	17	51	8	8	84 (14.4%)
No Concern	68	255	30	72	425 (72.9%)
Total	**97**	**360**	**41**	**85**	**583**

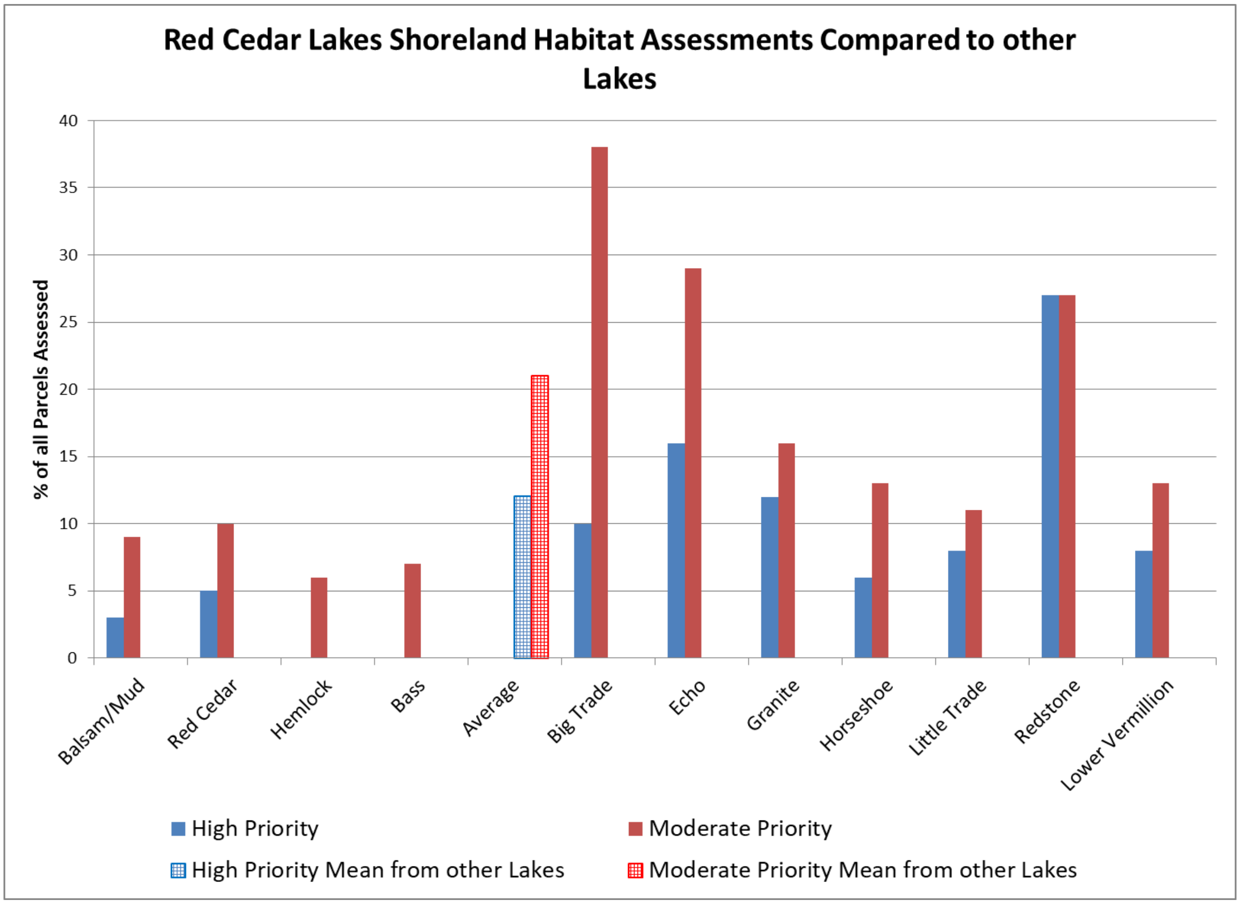


Figure 55: Percent of all parcels of high and moderate concern from the Red Cedar Lakes compared to other lakes (LEAPS)

Individual Shoreland Habitat Assessment Results books are available for each lake. The intent of these books is to help guide the RCLA in its efforts to get property owners more involved in or interested in implementing practices that will help maintain or improve the lakes over time. 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 minimize potential error 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 a lake-view photo.

4.3.3 Land Use Digitizing of the developed Area around the Lake

When assessing each parcel during the SHA, only the 35-ft wide band along the shoreline was considered. A land use digitizing evaluation of a 300-ft band around all of the lakes was completed in 2020. The purpose of this evaluation was to determine the amount of impervious surface (rooftops, driveways, sidewalks, and roadway), lawn, natural/wooded, and wetland within the developed area of the lake by viewing aerial photos, and then creating geospatial files for each land use. Approximately 1,095 acres in the developed area around the lakes were digitized. Table 22 shows how much of each land use was identified. Figures 56-62 show the distribution of that land use for each individual lake.

Table 22: Nearshore/Riparian Area Land Use around the Red Cedar Lakes

Red Cedar Lakes Land-use Digitizing (300-ft)		
Land Use	**Acres**	**% of Total**
Agriculture	6.6	0.6
Impervious	87.7	8.0
Lawn	143.1	13.1
Wetland	62.2	5.7
Forest	795.5	72.6
TOTALS	**1095.1**	**100.00**

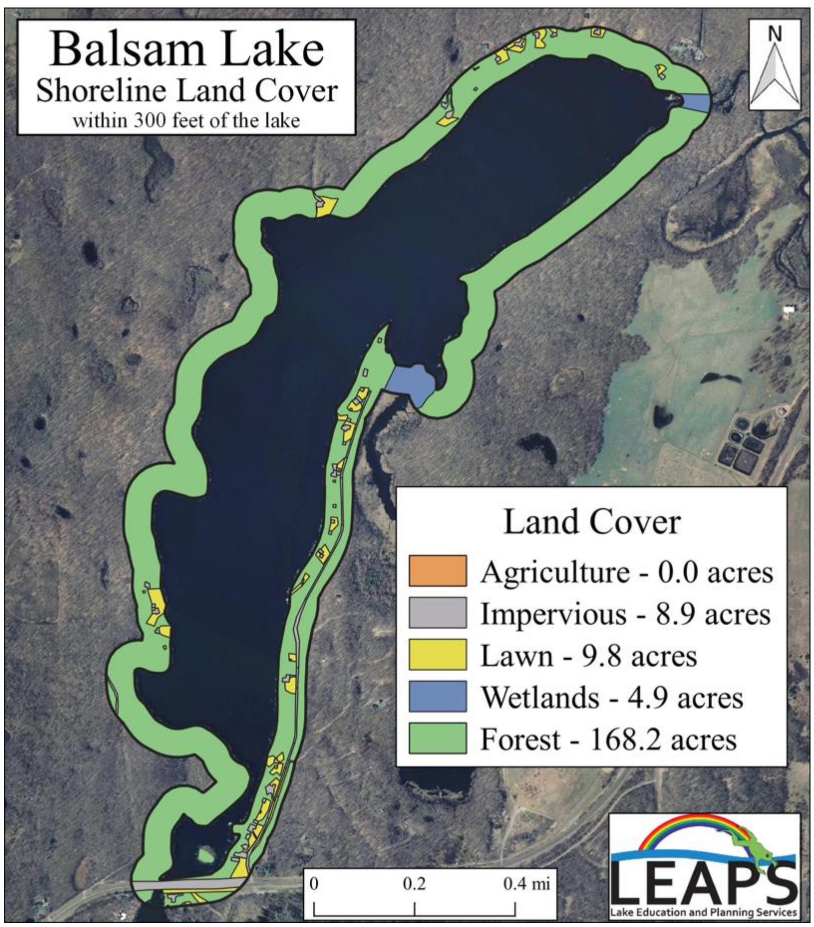


Figure 56: Balsam Lakes nearshore/riparian land use

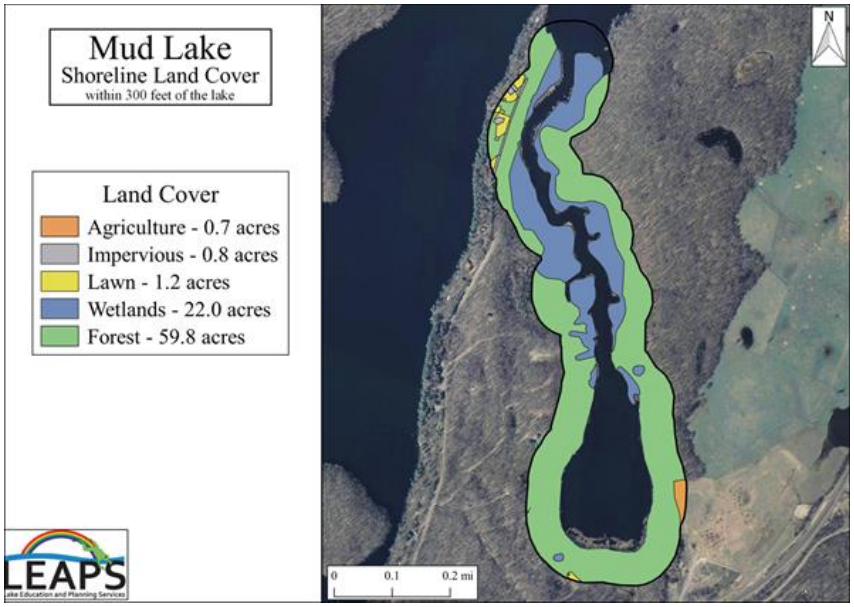


Figure 57: Mud Lake nearshore/riparian land use

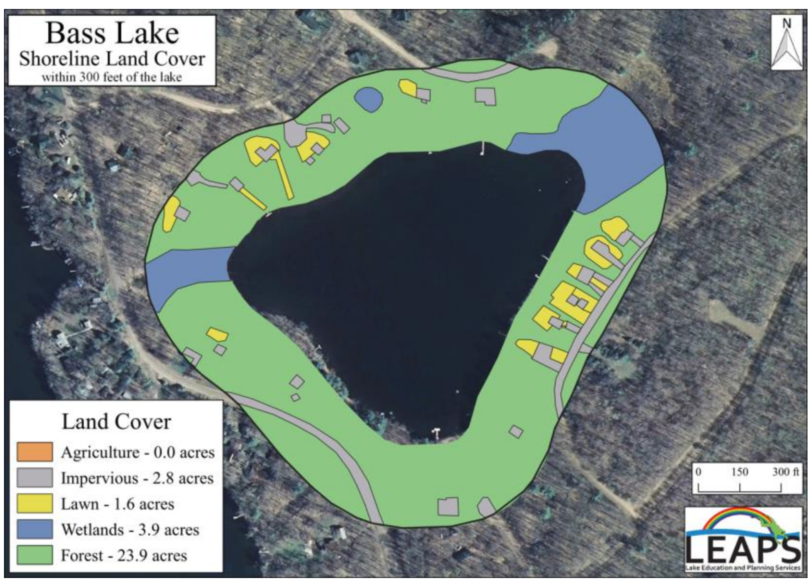
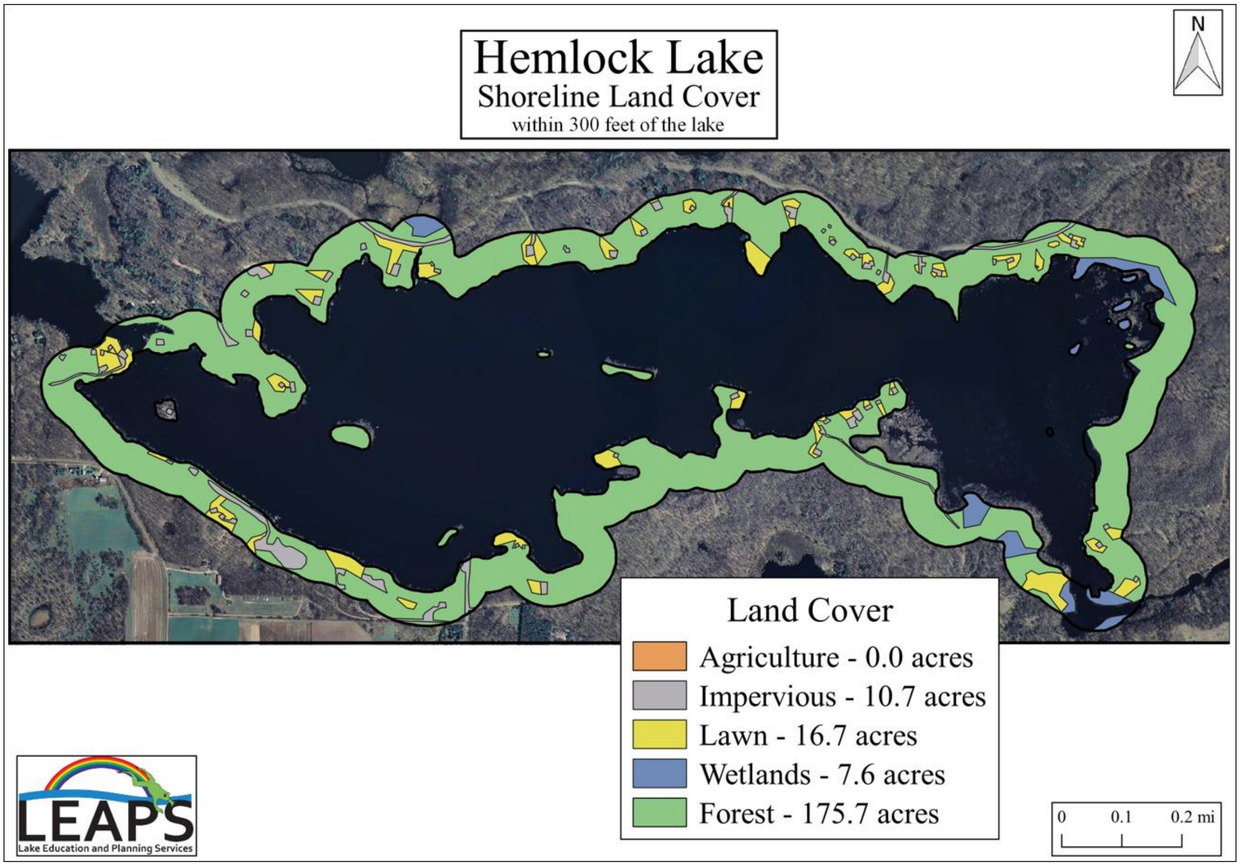


Figure 58: Bass Lake nearshore/riparian land use



1974

1975 **Figure 59: Hemlock Lake nearshore/riparian land use**

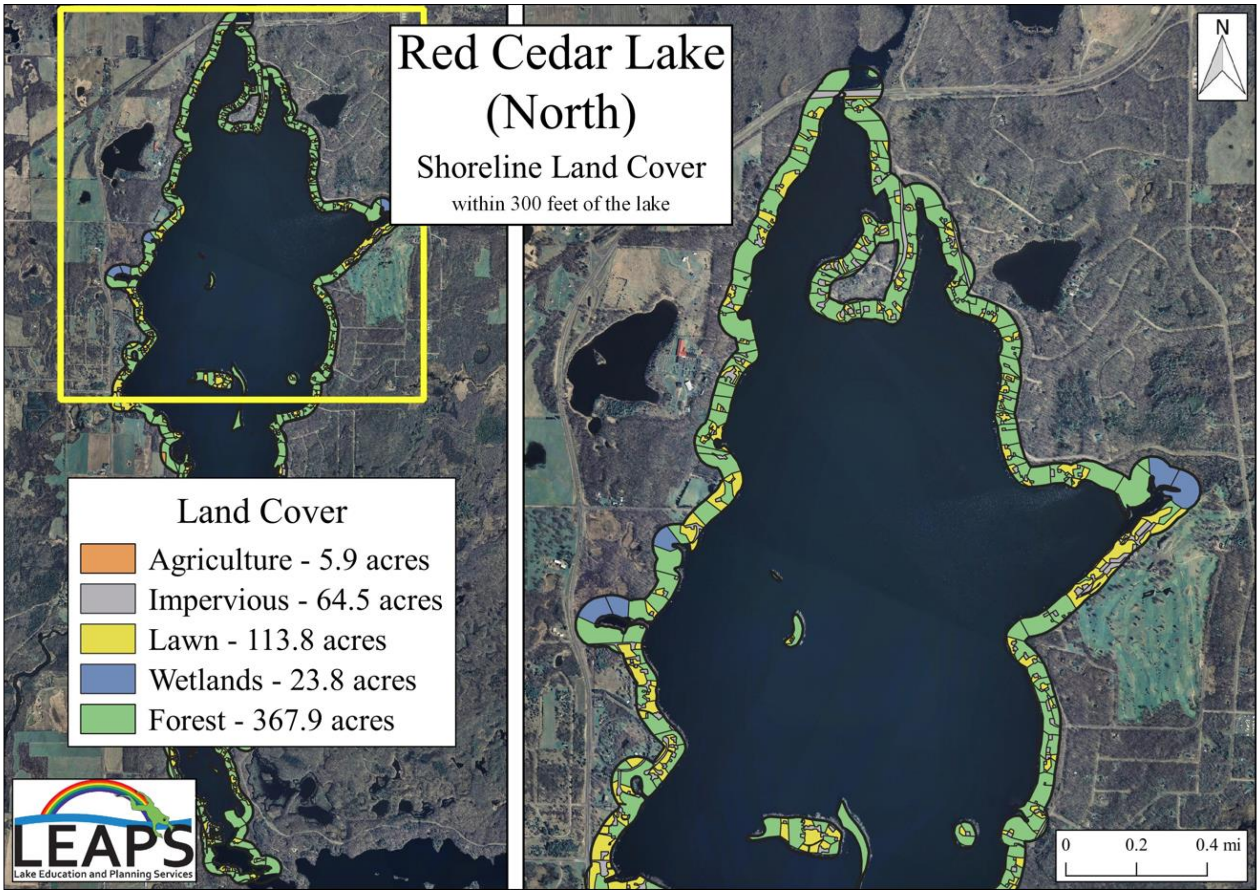


Figure 60: Red Cedar Lake, North nearshore/riparian land use (land cover legend is for all three sections of the lake)

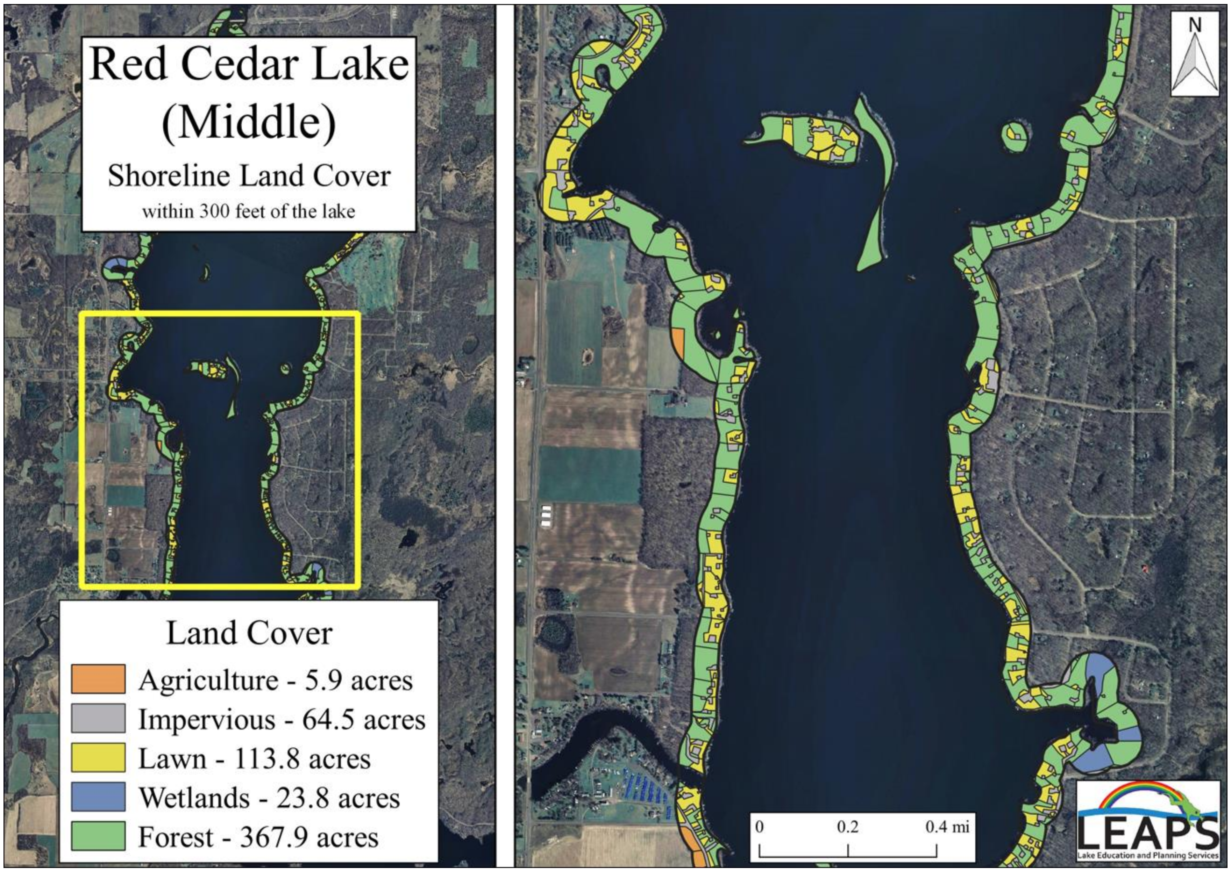


Figure 61: Red Cedar Lake, Middle nearshore/riparian land use (land cover legend is for all three sections of the lake)

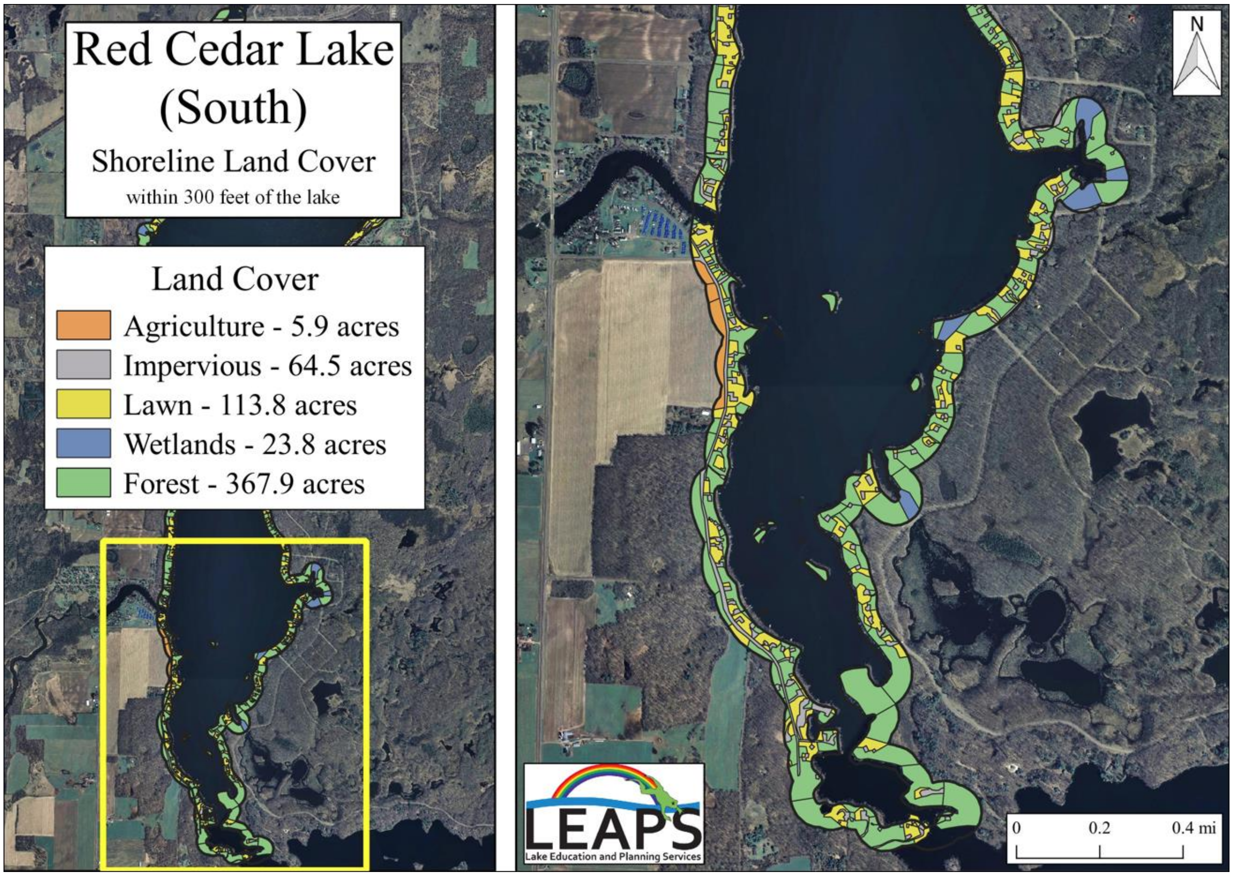


Figure 62: Red Cedar Lake, South nearshore/riparian land use (land cover legend is for all three sections of the lake)

Red Cedar Lake has the most developed shoreline of all five lakes. It has the most agriculture, impervious surface, and lawn by percent of the nearshore area of all five lakes. The least developed is Mud Lake, followed by Balsam Lake. Bass Lake is the second most developed lake of the five related to agriculture, impervious surface, and lawn, but Hemlock is a close third (Figure 63). All five lakes have a lot of natural area including wetlands and forests, the least amount being Red Cedar with 68%. Bass Lake is 86% natural, Hemlock 87% natural, Balsam 90% natural, and Mud Lake is 99.8% natural.

Land use digitizing of the developed area around the lake showed almost 23% of the total acreage as lawn or impervious surface (rooftops, driveways, roads, etc.), most of which was around Red Cedar Lake.

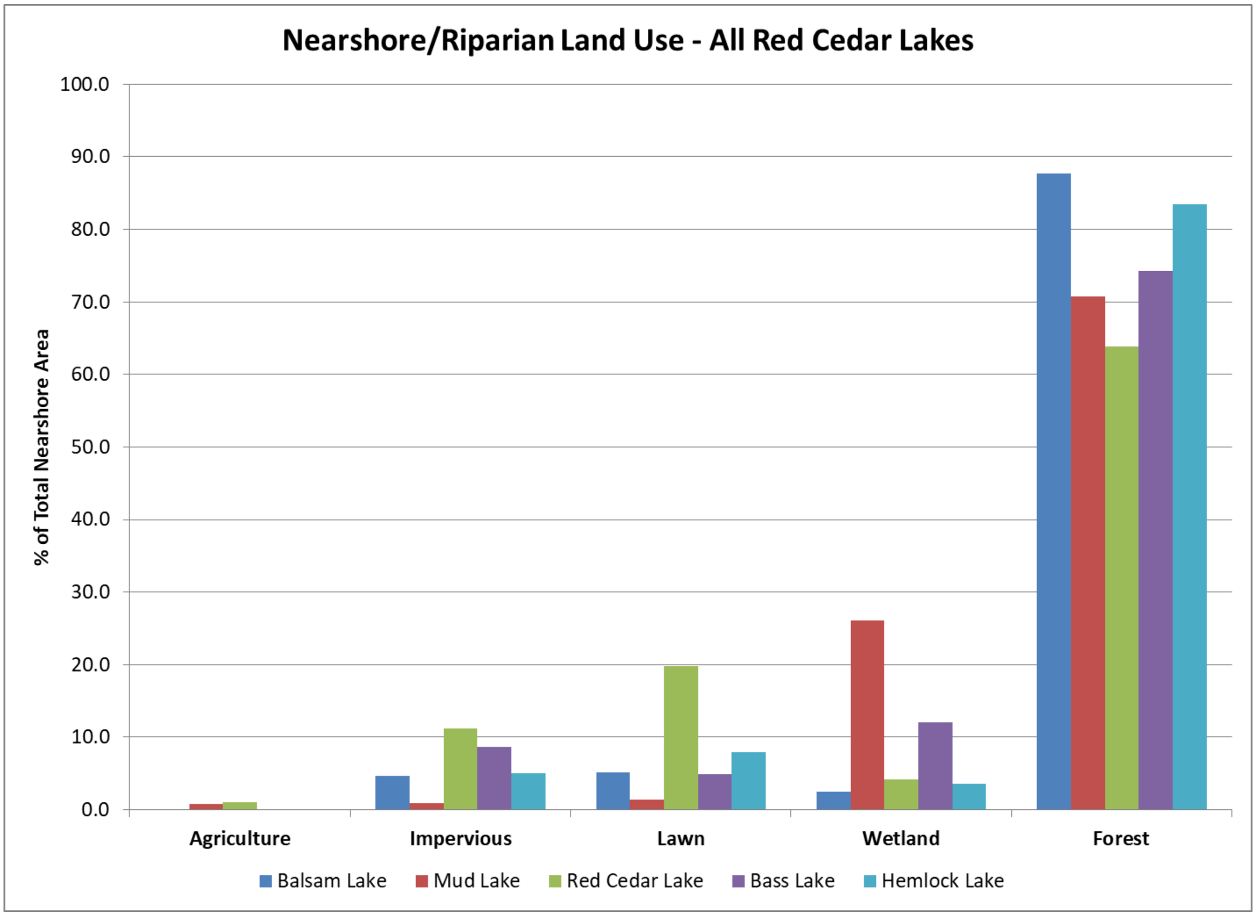


Figure 63: Nearshore area/riparian area land use in a 300-ft band around each lake

4.3.4 Resorts, Campgrounds, RV Parks, and Other Tourism Businesses

There are several tourism-focused entities along the shores of the Red Cedar Lakes including a county-owned campground and boat launch, several resorts, golf course, beach club, and a popular island retreat. Additional public and private boat landings exist that are associated with these entities. These areas are popular with tourists and locals alike. Each represents a different way to enjoy the fantastic resource that is the Red Cedar Lakes. Along with bringing people to the lakes, they also present an opportunity to potentially reduce phosphorus and sediment loading into the lakes. Best management practices including runoff retention areas, rain gardens, restoring native shoreland, infiltration trenches, diversions, and altering/removing impervious surfaces can all help reduce pollution to the lakes. Some of these projects may be small and only cost a few hundred dollars, while others may be large and cost thousands of dollars which can be offset by applications for grant support.

Given the popularity of most of these sites, they are also great places to install practices to improve the lakes that will be seen by many people.

The RCLA and its partners will start and/or maintain a common discourse with these entities about current and future projects that can reduce runoff and limit sediment and nutrient loading. Working in partner with these entities, the RCLA will support the design and implementation of projects to help improve the lakes.

4.3.5 Villages of Birchwood and Mikana

The Village of Mikana is a community in northeast Barron County, situated along the western shore of Red Cedar Lake in the Town of Cedar Lake southwest of Birchwood. There are several resorts, a post office, gas station, restaurant, community hall, and several parks within the village. Mikana is known in the region for its 4th of July celebration, in particular its parade which is colloquially referred to as "The Biggest Littlest Fourth of July Parade". A large portion of the developed area of the village is located east of Hwy 48 along the shores of the channel that leads from the larger Red Cedar Lake to the Mikana Dam, the outlet of the Red Cedar River. Urban runoff into the Red Cedar Rivers is likely an issue within the village.

The Village of Birchwood is located on the shores of Birch Lake in southeastern Washburn County. Birchwood supports its own school district - home of the Bobcats, an RV park, a business district, a village park and beach, and includes the Birchwood Dam that is the outlet of Birch Lake into the Red Cedar River and into Balsam Lake. It is located on the Tuscobia ATV and Snowmobile trail and hikers enjoy access to the Ice Age Trail. Masonite, manufacturer and importer of fine hardwood plywood and one of Washburn County's largest employers is located in Birchwood. The village has its own water treatment facility. Urban runoff into Birch Lake and to some degree, into the Red Cedar River below the Birchwood Dam, is likely an issue within the village.

4.4 Private Onsite Wastewater Treatment (Septic) Systems

A common source of nutrients to a lake is from private onsite wastewater treatment systems (POWTS), more commonly known as septic systems. Failing septic systems can seep raw sewage heavily laden with phosphorus, nitrogen, bacteria, and many other pollutants directly into a lake. This can cause issues for human health if pollutants get into drinking water wells through groundwater and for a lake when the nutrient-rich water enters a lake either through direct overland flow or by the flow of groundwater. Even properly functioning septic systems can contribute nutrients to a lake or groundwater depending on the type of system it is and where it is placed.

When calculating the impact of phosphorus loading from septic systems a "capita-years" use value is used. This value is the average number of days a property is in use, multiplied by the number of people using that property at any given time. Further a default export coefficient and a soil phosphorus retention value is also needed.

From the 2003 USGS Report an export coefficient value of 1.5lbs per capita per year. A soil retention value of 0.7 was used indicating about 70% of the phosphorus released is retained in the soil. Based on these numbers the USGS estimated a total phosphorus load from septic systems at 245lbs. They used a capita year value of 530. Responses from a survey sent to all property owners on the lakes in 2020 were used to update that value, now 510.5 years. This only changed the value from the 2003 USGS report slightly from 245lbs to 236lbs with a possible range from 79 to 393lbs. This equates to 0.4% of the total load in Red Cedar Lake, much less when considering the total phosphorus load in all three main stem lakes.

5.0 Management Measures

Best management practices (BMPs) include soil and water conservation practices, other management techniques, and social actions that are developed for a particular region as effective and practical tools for environmental protection. Rarely does one single practice or action solve the pollutant concern, but often it is a combination of measures that is used. For the purpose of this plan, BMPs will be recommended in each of the three main areas of concern: watershed/agriculture, riparian area, and in-lake.

5.1 Watershed Management

Watershed management measures discussed in this section include agricultural best management practices (BMPs), conservation buffers, forestry BMPs, and ATV/recreational trail management.

5.1.1 Agricultural BMPs

Agricultural BMPs range from measures that involve a change in farming operations, like conservation tillage and crop rotation, to simple actions such as not applying manure before forecasted rainfall[14]. 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. Agricultural BMPs including conservation tillage or no-till field preparation; buffers along wetlands and waterways adjacent to farm fields, grassed waterways, barnyard (feedlot) improvements, and fencing to keep livestock out of waterways can reduce the amount of agricultural runoff in the watershed.

5.1.1.1 Estimated Phosphorus Load Reductions from Various Agricultural BMPs

Based on data from the Tainter and Menomin Lakes TMDL Implementation Plan (A River Runs Through Us), the following phosphorus reductions associated with specific BMPs can be extrapolated for the Red Cedar Lakes watershed by sub-basin (HUC 12's).

5.1.1.1.1 Conservation Tillage - No Till

The Implementation Plan estimated that if no-till was randomly applied to 33% of the total crop acres across the watershed, it would yield an average 64% reduction in watershed phosphorus loading. The total amount of phosphorus coming from each of the sub-basins was estimated based on the results of tributary monitoring completed between 2018 and 2021. Since no actual tributary monitoring was done on Knutson Creek where it enters Big Chetac Lake, phosphorus loading calculations for these two sub-basins are based on what was measured leaving Birch Lake into Balsam. Land use in these two sub-basins was also combined to give one estimated load reduction. The results were as follows:

- Knutson Creek/Big Chetac (469 acres) – Estimated Load = 5,511lbs/yr; Potential Reduction = 99lbs/yr
- Sucker Creek (292 acres) – Estimated Load = 1,861lbs/yr; Potential Reduction = 62lbs/yr
- Hemlock Creek (113 acres) – Estimated Load = 3,540lbs/yr; Potential Reduction = 24lbs/yr
- Pigeon Creek (193 acres) – Estimated Load = 2,117lbs/yr; Potential Reduction = 41lbs/yr.
- Red Cedar Lake (477 acres) – Estimated Load = Not calculated; Potential Reduction = 101lbs/yr

Overall, No Till on 33% of the agricultural crop land in the watershed reduces phosphorus loading by 327lbs/yr or 2.5% of the total 13,029lb annual load.

[14] https://www.ars.usda.gov/is/np/bestmgmtpractices/best%20management%20practices.pdf

5.1.1.1.2 Cover Crops

The Implementation Plan estimated that if cover crops were randomly applied to 40% of the agricultural land in the watershed, it would yield a 15% reduction in watershed phosphorus loading. Using the same numbers from 6.1.1.1.1, the results were as follows:

- Knutson Creek/Big Chetac (469 acres) – Estimated Load = 5,511lbs/yr; Potential Reduction = 28lbs/yr
- Sucker Creek (293 acres) – Estimated Load = 1,861lbs/yr; Potential Reduction = 18lbs/yr
- Hemlock Creek (113 acres) – Estimated Load = 3,540lbs/yr; Potential Reduction = 7lbs/yr
- Pigeon Creek (193 acres) – Estimated Load = 2,117lbs/yr; Potential Reduction = 12lbs/yr.
- Red Cedar Lake (477) – Estimated Load = Not calculated; Potential Reduction = 29lbs/yr

Overall, cover crops on 40% of the agricultural crop land in the watershed, reduces phosphorus loading by 94lbs/yr or 0.7% of the total 13,029lb annual load.

5.1.1.1.3 Barnyard Runoff Management Systems

The Tainter and Menomin Lakes TMDL Implementation Plan identified 62 barnyards in whole Red Cedar River watershed that had the highest phosphorus loading. Their phosphorus inputs were estimated at 4,179lbs/yr. If all of those barnyards received “treatments”, 93% (down to only 310lbs/yr) of the phosphorus would be removed. Within the Sucker and Pigeon Creek sub-basins at least 4 “barnyards” have already been identified through analysis of aerial images. In addition to this, an ATV trail crossing within the Hemlock Creek sub-basin was identified which is likely causing as much phosphorus loading as one of the barnyards. Assuming these five sites are part of the 62 identified for the entire watershed, they would contribute 362lb/yr of phosphorus. If they are “treated”, then another 337lbs/yr or 2.5% of the 13,029lbs/yr of phosphorus can potentially be removed.

5.1.1.1.4 Improvements in Traditional Soil Erosion Practices

For many years, the use of “traditional” practices like crop rotations, contour farming, strips, grassed waterways and terraces have been promoted and implemented across the Red Cedar Basin. Reduction of cropland erosion through “traditional” practices and through conservation tillage has been estimated and reported in the Barron and Dunn County Land and Water Resource Management Plans. These plans estimate that about 50% of the cropland soil erosion control accomplished is due to “traditional” soil erosion control practices.

The Tainter and Menomin Lakes TMDL Implementation Plan modeled what would happen if 10% of the total crop land acreage had improved traditional soil erosion practices implemented. At the field level, it was estimated that improved traditional soil erosion practices could reduce soil loss from 5 tons/ac to 4 tons/ac. It was further estimated that one ton of soil would hold 4lbs of phosphorus.

There are 1,543 acres of crop land across the five sub-basins of the Red Cedar Lakes watershed. If 10% (154 acres) have improved traditional soil erosion practices implemented, then the amount of soil eroded from the fields would be reduced by 154 tons (5tons – 4tons = 1 ton x 154 acres). The amount of phosphorus would be reduced by 616lbs/yr (154 tons x 4lbs/ton). The Tainter and Menomin Lakes TMDL Implementation Plan however, also suggests that only 10% of the erosion from the fields actually makes it to the waterways. So 10% of 616lbs/yr = 62lbs/yr or another 0.5% reduction in the 13,029lbs/yr of phosphorus, as a result of traditional conservation practices.

If 20% (308 acres) have improved traditional soil erosion practices implemented, then the amount of soil eroded from the fields would be reduced by 308 tons (5tons – 4tons = 1 ton x 308 acres). The amount of phosphorus would be reduced by 1,232lbs/yr (308 tons x 4lbs/ton). If only 10% of that erosion actually makes it to the waterways, then the phosphorus load would be reduced by 123lbs/yr or 1.0%.

5.1.2 Conservation Buffers (Bentrup, 2008)

Conservation buffers are strips of vegetation placed in the landscape to influence ecological processes and provide a variety of goods and services to us. They are called by many names, including wildlife corridors, greenways, windbreaks, and filter strips to name just a few. Benefits that conservation buffers provide include protecting soil resources, improving air and water quality, enhancing fish and wildlife habitat, and beautifying the landscape. In addition, buffers offer landowners an array of economic opportunities including protection and enhancement of existing enterprises.

Conservation buffers improve resource conditions by enhancing certain landscape functions. Major issues that buffers can be designed to address and their associated functions are listed in Table 23. Most buffers will perform more than one function, even if designed with only one function in mind. For the purposes of this Plan, conservation buffers that may help to improve water quality are discussed.

The main objectives of conservation buffers to improve water quality are to reduce erosion and runoff of sediment, nutrients, and other potential pollutants; and to remove pollutants from water runoff and wind. Conservation buffers serve to slow water runoff and enhance infiltration, trap pollutants in surface runoff, trap pollutants in subsurface flow, stabilize soil, and reduce bank erosion (Bentrup, 2008).

Water quality goals may not be achievable with conservation buffers unless the adjacent land uses are also managed for better water quality. By combining the BMPs from the previous section and conservation buffers, better results can be expected.

Table 23: Buffer functions related to issues and objectives (Bentrup, 2008)

Issue and Objectives	Buffer Functions
Water Quality	
Reduce erosion and runoff of sediment, nutrients, and other potential pollutants Remove pollutants from water runoff and wind	Slow water runoff and enhance infiltration Trap pollutants in surface runoff Trap pollutants in subsurface flow Stabilize soil Reduce bank erosion
Biodiversity	
Enhance terrestrial habitat Enhance aquatic habitat	Increase habitat area Protect sensitive habitats Restore connectivity Increase access to resources Shade stream to maintain temperature
Productive Soils	
Reduce soil erosion Increase soil productivity	Reduce water runoff energy Reduce wind energy Stabilize soil Improve soil quality Remove soil pollutants
Economic Opportunities	
Provide income sources Increase economic diversity Increase economic value	Produce marketable products Reduce energy consumption Increase property values Provide alternative energy sources Provide ecosystem services
Protection and Safety	
Protect from wind or snow Increase biological control of pests Protect from flood waters Create a safe enviroment	Reduce wind energy Modify microclimate Enhance habitat for predators of pests Reduce flood water levels and erosion Reduce hazards
Aesthetics and Visual Quality	
Enhance visual quality Control noise levels Control air pollutants and odor	Enhance visual interest Screen undesirable views Screen undesirable noise Filter air pollutants and odors Separate human activities
Outdoor Recreation	
Promote nature-based recreation Use buffers as recreational trails	Increase natural area Protect natural areas Protect soil and plant resources Provide a corridor for movement Enhance recreational experience

5.1.3 Forestry BMPs

Through an extensive review of land management impacts on water quality in North America, research complied by the EPA found that there is the potential for forestry operations to adversely affect water quality if BMPs are poorly implemented. Sediment concentrations can increase due to accelerated erosion; water temperatures can increase due to removal of over story riparian shade; slash and other organic debris can accumulate in water bodies depleting dissolved oxygen; and organic and inorganic chemical concentrations can increase due to harvesting and fertilizer/pesticide applications. These potential increases in contaminants are usually proportional to the severity of site disturbance. Impacts of nonpoint source pollution from forestry activities depend on site characteristics, climatic conditions, and the forest practices employed (Fulton & West, 2002).

If BMPs are properly designed and implemented, the adverse effects of forestry activities on hydrologic response, sediment delivery, stream temperature, dissolved oxygen, and concentrations of nutrients and pesticides can be minimized. The following specific management measures should be considered by all forest managers as they develop comprehensive forest management plans.

- Planning of the timber harvest to ensure water-quality protection will minimize nonpoint-source pollution and increase operational efficiency.
- Streamside management areas of sufficient width and extent are crucial because they can greatly reduce pollutant delivery.
- Identification and avoidance of high hazard areas can greatly reduce the risk of landslides and mass erosion.
- Careful planning of roads and skid trails will reduce the amount of land disturbed by them, thereby reducing erosion and sedimentation.
- Proper design of drainage systems and stream crossings can prevent system destruction by storms, thereby preventing severe erosion, sedimentation, and channel scouring.
- Road system planning is a critical part of pre-harvest planning. Good road location and design can greatly reduce the sources and transport of sediment. Road systems should generally be designed to minimize the number of road miles per acre, the size and number of landings, the number of skid trail miles, and the number of watercourse crossings, especially in sensitive watersheds.
- Timing operations to take advantage of favorable seasons or conditions and avoiding wet seasons prone to severe erosion or spawning periods for fish reduce impacts to water quality and aquatic organisms.
- Drainage problems can be minimized when locating roads by avoiding clay beds, seeps, springs, concave slopes, ravines, draws, and stream bottoms.

5.1.3.1 Phosphorus Loading Increases or Decreases During Forestry Operations

In a study related to how forest harvesting BMPs affect surface water quality (Wynn, et al., 2000) the authors concluded that "forest clearcutting and site preparation without BMPs can cause significant increases in sediment and nutrient concentrations and loadings in the Virginia Coastal Plain. However, these impacts can be greatly reduced by implementing a system of BMPs on the watershed during harvesting activities." In their study, they compared sediment and nutrient loading from a forest harvest without BMPs, a forest harvest with BMPs, and a control forest with no harvest.

When looking at the average and median annual TP yields per watershed, they found that, following harvest, TP yields increased by a factor of 3.4 in the No-BMP watershed. At the same time, TP yields from the BMP watershed decreased, and TP yields from the Control watershed increased by a factor of 1.4. After site preparation, average annual TP yields remained high for the No-BMP watershed, while they decreased below pre-harvest levels in the BMP and Control watersheds. Similar changes were observed with median annual TP yields. These data indicate forest clearcutting and site preparation without the implementation of BMPs greatly increased the loss of phosphorus. The practices utilized on the BMP watershed were highly effective at reducing phosphorus loss (Wynn, et al., 2000).

Evaluating Barron, Rusk, Sawyer, Washburn County, and private land timber harvests and how BMPs were incorporated, was not a part of the information collected to develop this plan, however, expressing concern to each of the counties and possibly following up on some of the harvests would be worthwhile.

5.1.4 ATV Trails and Water Crossings[15]

Many trail users highly value proximity or access to lakes, streams and wetlands. These resources are easily degraded, however, and a comprehensive set of federal, state, county, and local requirements must be taken into consideration when considering trail development. Water access is a magnet for trail users. Access points should be carefully identified and designed to prevent erosion and sedimentation problems and unauthorized off-trail operation on banks or beds of waterways and wetlands. Where any of these potential impacts are likely, the trail should be routed away from water features. DNR Water Management Specialists should be consulted regarding water law issues related to trail development.

In Wisconsin, permits are needed if recreational trails will cross any navigable waterbodies and wetlands including marshes, ponds, lakes, streams, rivers, some intermittent streams, and even some drainage ditches that may be navigable only part of the year. The permit requires a detailed review of alternatives and may require rerouting the trail if an alternative can be found that would not impact water features. If the permit process indicates that no suitable alternatives exist and that a water feature must be crossed, the crossing should be designed to minimize impacts on the water feature. Bridges are recommended for open water crossings. Culverts are less desirable but may be acceptable in certain circumstances. Water fords are the least desirable type of water crossing and should only be used in limited circumstances. Trail managers and designers should anticipate that trail users may be tempted to go off-trail at water crossings. Techniques such as additional signs, design considerations such as boulders or brush next to a bridge for example and law enforcement will be needed to prevent damage.

At least one trail crossing in the Hemlock Creek sub-basin is a source of major concern (see Section 4.2.5).

5.2 Nearshore/Riparian Area Management

Nearshore/riparian are management measures discussed in this section include protecting and maintaining existing natural shoreland, implementing shoreland habitat improvement and runoff reduction projects, preserving and where necessary, repairing island shoreland, maintaining septic systems in good working order, and determining if sediment and phosphorus loading from the numerous unmeasured gullies, washes, and intermittent streams can be reduced.

5.2.1 Protect and Maintain Existing Natural Shoreland

From a UW-Extension Lakes document entitled Lakeshore Development . . . It All Adds Up![16] – While the impacts from each individual lot that is developed may be minor, water and habitat quality will be adversely affected by the collective impact of shoreland development over time. Densely developed shorelines are more likely than undeveloped shorelines to result in substantial phosphorus inputs entering the adjacent waterway. This is the result of more hard surface area and a high degree of shoreline vegetation removal. Several studies show that sediment and nutrient inputs increase as shoreland lots are developed and cleared. Two are referenced here.

Case study #1: A study on phosphorus loading to a Wisconsin lake showed that a 1940s style home with a narrow grass corridor did not result in an increase in phosphorus loading over an undeveloped shoreline. However, with a 1990s style

[15] https://dnr.wi.gov/Aid/documents/atv/BuildATVTrail.pdf
[16] https://www3.uwsp.edu/cnr-ap/UWEXLakes/Documents/people/lakeclassification/fs_12.pdf

development with the entire property converted to lawn, phosphorus inputs increased 700% compared to an undeveloped shoreline (Panuska 1994).

Case study #2: A study in Maine showed that a developed watershed with 40% forest cover and a subdivision of one acre lots resulted in an increase of 720% in phosphorus delivery over an undeveloped watershed (Dennis 1986).

Owning sensitive shorelands outright or securing agreements with property owners to keep their shorelands in a natural state in perpetuity are increasingly popular tools to protect water quality and habitat along lakes and rivers. The WI-DNR buys property and makes agreements to hold such land; it also provides grant funding to local government and groups to do the same. Many groups are doing so with great results for lakes and rivers. The following are several examples of shoreland protection programs offered by the WI-DNR.

5.2.1.1 Conservation Easements

In its basic form, an easement is a way to convey some of the land rights associated with ownership to another party. Utility, highway and driveway easements are examples of how both parties use the land in a specific way. Similarly, a conservation easement is a voluntary legal agreement between a private landowner and a government agency, a non-profit conservation organization, or a land trust that permanently limits specified current and future uses.

As with other easements, landowners retain ownership and many uses of their property such as agriculture, hunting and fishing. However, a conservation easement will also help protect water quality, habitat and natural resources. Although each conservation easement is unique, some examples of land rights purchased by state or local agencies include the right to improve streams, fence livestock out of the stream corridor, permit public access and prohibit development. Land ownership stays with the landowner while easement rights "run with the land," that is, the agency retains the easement rights if the landowner sells the land and the new landowner must abide by the easement.[17]

5.2.1.2 Knowles-Nelson Stewardship Program

In 1989, Governor Tommy Thompson and the Wisconsin Legislature created the Knowles-Nelson Stewardship Program (or Stewardship Fund) to preserve valuable natural areas and wildlife habitat, protect water quality and fisheries and expand opportunities for outdoor recreation.

The Stewardship fund gives WI-DNR spending authority to purchase land and easement additions to state properties. Stewardship dollars also support recreational infrastructure on state properties, including campsite, restroom and trail improvements. Most annual Stewardship spending takes the form of grants to local governments and nonprofits. Stewardship grants fund local park infrastructure, boat ramp facilities, recreational trails and land purchases for parks and nature preserves statewide.[18]

5.2.2 Shoreland Habitat Improvement and Runoff Reduction

The riparian area of the Red Cedar Lakes offers many opportunities to implement reduction projects that will benefit the lakes. The results of individual projects may be difficult to measure, but the cumulative impact may be significant. Converting mowed lawns to native vegetation buffers particularly along the shore; installing storm water diversions and infiltration trenches to reduce runoff into the lakes 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 lakes.

[17] https://dnr.wisconsin.gov/topic/fl/RealEstate/easements
[18] https://dnr.wisconsin.gov/topic/Stewardship/About

The SHA completed on all five lakes as a part of this project suggested projects that could be implemented to improve habitat and reduce runoff through 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. Nearly every property owner who has shoreland property, or that are adjacent or near the lakes can take action to reduce runoff and/or improve habitat. This includes the local villages, townships and county governments. How these municipalities take care of their roads and right-of-ways, parks, boat landings, and campgrounds can reduce runoff and improve habitat. Local resorts and other businesses can also support a healthy riparian area around the lake – from real estate agents who encourage new buyers to implement BMPs and understand that a natural landscape around a home is better for the lake than a mowed lawn – to bars, restaurants, lodges, bait and boat dealers, landscapers, dock and lift installers, etc. who service those who live on and around or use the lake. Getting "buy-in" from all of these stakeholders and others is imperative to improving the lake and then maintaining those improvements.

5.2.2.1 Runoff Control in Incorporated Areas and Rural Roads

In the Tainter and Menomin TMDL Implementation Plan, development within the watershed that was not in the larger cities was estimated to contribute 0.65lbs/ac/yr of phosphorus. Multiplying this by the 4,551 developed acres within the communities of Birchwood, Edgewood, and Mikana, and the along the shorelines of each lake, the total amount of phosphorus contributed is 2,958lbs/yr. By implementing BMPs that can help reduce runoff on just 15% of these areas (683 acres), another 444lbs/yr of phosphorus (683 x .65) or 3.4% of the 13,029lbs/yr total can be removed.

5.2.3 Island Preservation and Restoration

Similar to working with shoreland property owners to improve habitat and reduce runoff, preservation and restoration of the many islands in the Red Cedar Lakes should be continued (Figure 64). The RCLA has worked to protect several of the publicly-owned islands in the past. The islands contribute to the character of the lakes, and the waters around them provide some of the best walleye spawning areas anywhere in the lakes.

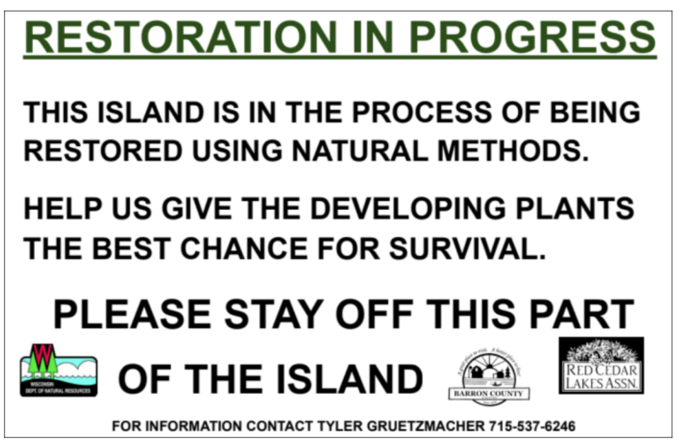


Figure 64: Public signs posted at island restoration projects in the Red Cedar Lakes

5.2.4 Septic 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[19]. The amount of phosphorus contributed by septic systems around the Red Cedar Lakes is extremely small. This is not however, an excuse to ignore it outright. Table 24 reflects many things property owners can do to minimize the impacts of their septic systems on the lakes.

Table 24: Septic System Improvements to Protect Nearby Water Sources (EPA)

Toilets	Any chemicals or medicines that you flush down the toilet could end up in surface water, so don't use your toilet as a trashcan. Contact your local hazardous waste disposal facility to ask about how to correctly dispose of these materials. Using a composting or urine diverting toilet prevents most nitrogen and phosphorus from entering your septic system.
Cleaning Products	Using household cleaning products that are phosphate-free reduces the total amount of phosphorus in wastewater.
Garbage Disposal	Throwing out or composting food waste instead of putting it through a garbage disposal reduces the amount of nitrogen and phosphorus in wastewater. It also helps extend the life of a septic system.
Proper Septic System Maintenance	Regularly inspecting and pumping your septic tank protects your system and minimizes the risk of failure.
Septic System Upgrade	Installation of an advanced treatment system that removes nitrogen or phosphorus can help protect nearby surface waters. Newer technology is being developed for increased nitrogen or phosphorus removal in the drainfield. Shallow, pressurized wastewater flow or specialized drainage material can increase removal.
Setback Distance	When installing a new septic system or upgrading an existing one, consider the setback distance between the drainfield and any bodies of water around your home. Contamination is less likely the farther away your septic system is from a body of water.

5.2.5 Unmeasured Gullies, Washes, and Streams

Although not specifically identified or quantified in the project leading to the development of this plan, there are several unmeasured gullies, washes, and intermittent streams that during periods of snowmelt and heavy rainfall, carry soil and other pollutants into the lakes. A study could be completed that identifies these areas and then makes recommendations on what can be done to reduce their impact to the lakes. One place to start would be using the PRESTO Lite GIS application on the WI-DNR Watershed Restoration and Protection Viewer.[20]

The Pollutant Load Ratio Estimation Tool (PRESTO) is a statewide GIS-based tool that compares the average annual phosphorus loads originating from point and nonpoint sources within a watershed. 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.[21] Figure 65 shows an example of a small, unmeasured, intermittent tributary delineated by PRESTO. Figure 66 is the output that accompanies the

[19] https://www.epa.gov/septic/septic-system-improvements-protect-nearby-water-sources
[20] https://dnrmaps.wi.gov/H5/?Viewer=SWDV
[21] https://dnr.wisconsin.gov/topic/SurfaceWater/PRESTO.html

delineation. An example of a PRESTO Lite report for a small unmeasured, intermittent tributary to Red Cedar Lake (Figure 65) is included in Figure 68.

No calculations of the independent phosphorus loading from these unmeasured gullies, washes, and intermittent streams have been completed, but it stands to reason, that some level of phosphorus reduction could be achieved if "issues" in these areas were identified and addressed.

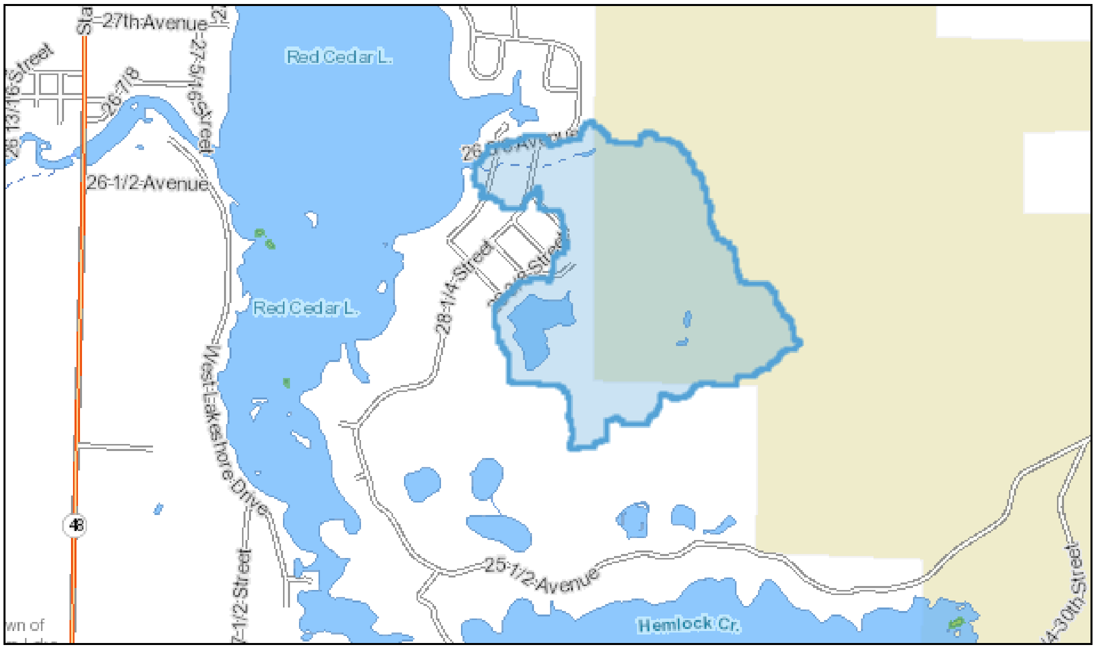
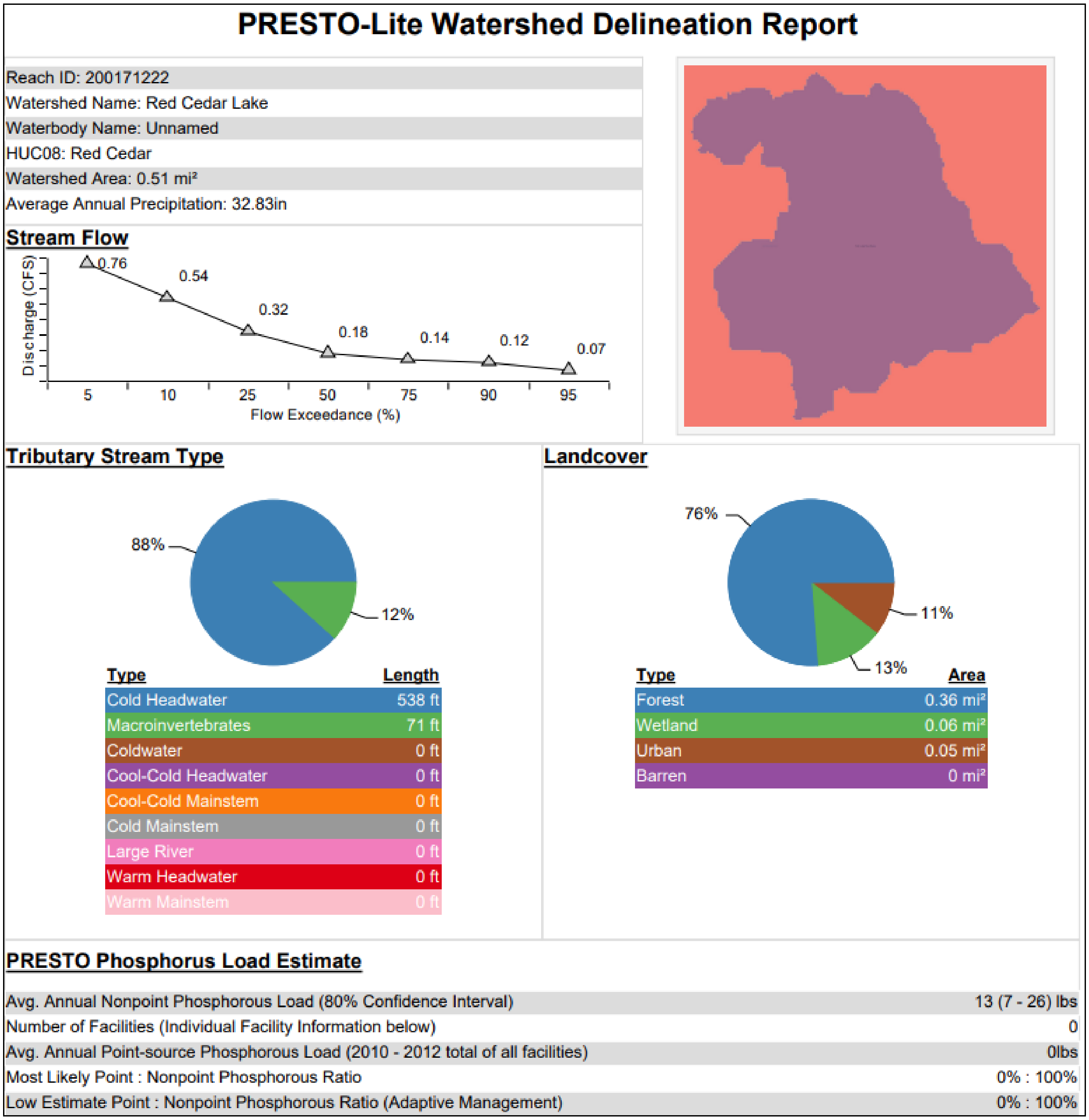


Figure 65: Example of a small, unmeasured tributary to Red Cedar Lake (WDNR Watershed Restoration and Protection Viewer and PRESTO Lite Delineation Tool)



PRESTO-Lite Watershed Delineation Report

Reach ID: 200171222
Watershed Name: Red Cedar Lake
Waterbody Name: Unnamed
HUC08: Red Cedar
Watershed Area: 0.51 mi²
Average Annual Precipitation: 32.83in

Tributary Stream Type

Type	Length
Cold Headwater	538 ft
Macroinvertebrates	71 ft
Coldwater	0 ft
Cool-Cold Headwater	0 ft
Cool-Cold Mainstem	0 ft
Cold Mainstem	0 ft
Large River	0 ft
Warm Headwater	0 ft
Warm Mainstem	0 ft

Landcover

Type	Area
Forest	0.36 mi²
Wetland	0.06 mi²
Urban	0.05 mi²
Barren	0 mi²

PRESTO Phosphorus Load Estimate

Avg. Annual Nonpoint Phosphorous Load (80% Confidence Interval)	13 (7 - 26) lbs
Number of Facilities (Individual Facility Information below)	0
Avg. Annual Point-source Phosphorous Load (2010 - 2012 total of all facilities)	0lbs
Most Likely Point : Nonpoint Phosphorous Ratio	0% : 100%
Low Estimate Point : Nonpoint Phosphorous Ratio (Adaptive Management)	0% : 100%

Figure 66: PRESTO Lite Report from a small, unmeasured tributary to Red Cedar Lake

5.3 In-lake Management

In-lake management measures discussed in this section include aquatic plant management, reducing the impact of waves and watercraft, changing the makeup of the aquatic environment through biomanipulation, and applying binding agents to control phosphorus inputs.

5.3.1 Aquatic Plant Management

The Red Cedar Lakes Aquatic Plant Management Plan covering the years 2020-2024 has the following six aquatic plant management and lake protection goals. Each goal has several objectives to be met and identified management actions to help meet those objectives.

- Prevent the expansion of curly-leaf pondweed in the Red Cedar Lakes.
- Maintain or improve current (2018) measurements of the health of the native aquatic plant community in the Red Cedar Lakes.
- Monitor changes in water quality.
- Reduce the threat that new aquatic invasive species (AIS) will be introduced into and go undetected in the Red Cedar Lakes, and that existing AIS like purple loosestrife will continue to spread.
- Improve shoreland habitat and capability of the shoreland to filter runoff entering the lakes.
- Assess the progress and results of this project annually and report to and involve other stakeholders in planning efforts.

How these management goals and the associated actions to help meet individual objectives are implemented can impact water quality in the lakes. The APM Plan goes into greater detail about how each goal is to be met and how by doing so, the overall health of the system will be maintained or improved. It also makes recommendations on how to prevent new AIS infestations. Implementation of the APM Plan began in 2020 with limited management of CLP in 2020, 2021, and 2022.

5.3.1.1 Aquatic Invasive Species

Aquatic invasive species (AIS) already in the Red Cedar lakes can and likely are having an adverse impact on water quality and overall health of the lake. These species include curly-leaf pondweed, rusty crayfish, purple loosestrife, and Chinese mystery snails. 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 and Eurasian watermilfoil. Most existing and new AIS that could or are impacting the lake are discussed in the 2020-24 Aquatic Plant Management (APM) Plan for the Red Cedar Lakes (Blumer, 2019). 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.

5.3.1.2 Big Chetac and Birch Lakes

The Red Cedar Lakes APM Plan does not include management recommendations for Big Chetac and Birch Lakes, however it does comment on up to 600 acres of dense growth curly-leaf pondweed in Big Chetac and Birch Lakes in any given year. The water coming from Big Chetac and Birch Lakes carries an estimated 30% of the phosphorus load into the Red Cedar system. In one management plan for Big Chetac and Birch Lakes, it was estimated that die back and senescence of CLP contributed up to 15% of the total phosphorus load in the two lakes. Despite an identified need for management of CLP in both Big Chetac and Birch Lakes, this has not happened yet. While there is support for management of CLP, the level of support is not vocal enough to offset the volume of those against implementing any management.

5.3.2 Waves and Watercraft

The use of large watercraft on the Red Cedar Lakes for recreational purposes including fishing, waterskiing, tubing, wake boarding, and wake surfing has an impact. Waves created by these large boats and waves in general stir up bottom sediments and erode shorelines which in turn suspends sediments in the water causing temporary or even long-term changes in water clarity and available nutrients that feed plant and algal growth.

Currently, the only local boating ordinance that exists on the lakes is a No Wake ordinance in the channel between Hemlock Lake and Red Cedar Lake; and in the Red Cedar River from Red Cedar Lake to the dam in Mikana. Barron County also has a “No Power Loading” ordinance at all county-owned landing, including those on the Red Cedar Lakes. Increased enforcement of both the no wake and power loading ordinances is necessary.

5.3.2.1 Motorized Boating in General

Any motorized watercraft, large or small, fishing or other recreation, if driven in the wrong place, in the wrong way, or at the wrong time, can cause lake issues. In a review of existing studies related to boats and how they affect lakes, (Apslund, 2000) concludes that boats in general have been shown to affect water clarity and can be a source of nutrients and algal growth in aquatic ecosystems, and that shallow lakes, and shallows parts of lakes and rivers, and channels connecting lakes are the most susceptible to impacts. In another part of the review, he concludes that waves or wakes produced by boats can influence shoreland erosion. River systems, channels connecting lakes, and small lakes are the most impacted. The type of shoreline also impacts how much these waves erode, with loosely consolidated, steep, un-vegetated banks being the most susceptible.

Apslund, 2000 identifies other boating impacts, but these in general are less studied, and not as conclusive. Boats impact aquatic plants by direct cutting, scouring of sediments in shallow areas preventing aquatic plant growth, uprooting of plants, and increased wave activity. The effects of boating on the fishery is less studied and basically centers around disturbing fish from spawning nests, or in changing fish habitat (water clarity, sediment, aquatic plant beds, etc.). Effects on wildlife are also little studied, but include temporary disturbance (waterfowl, birds of prey) and in some cases more permanent disturbance (loons and loon nesting).

In another part of the Apslund, 2000 study, personal watercraft (PWC) or jetskis are discussed. The conclusions drawn suggest that the issues caused by PWC are similar to those caused by boats in general. Noise and emissions, and how PWC are used by their riders are of generally more concern than the impacts on the ecosystem.

5.3.2.2 Wake Boats

Low-speed power boating is a relatively new phenomenon on Wisconsin lakes. It involves motorized watercraft specifically designed to be driven at slow speeds and to create large wakes for skiing, boarding, and surfing. Specialized "wake boats" are designed to increase wave height in the wake in a number of different ways. These specialized boats are often built with a hull shaped to achieve maximum wake, may have a hydrofoil device that lowers the stern of the boat when under power, and may have built in ballast tanks to increase weight in the back of the boat causing more water to be displaced and larger waves created.

The ultimate impact on lakes from these watercraft is still under much debate between those who support and those who don't support their use. But it is widely asserted by many that their use negatively impacts a lake, more so than other water recreation activities. The Sierra Club for example has this to say[22].

Just one pass of a wake boat can be devastating to the ecosystem. Unfortunately, these boats often make multiple passes in the same area, causing long-lasting damage.

When there isn't enough distance on a lake or river to dissipate these wakes, the boats cause shoreline erosion. They also damage docks, swamp other boats, endanger swimmers, and destroy waterfowl nesting sites.

Additionally, the propwash points downward at such an angle that it can disturb the lake bottom at depths 16' or more. This action reintroduces sequestered contaminates such as phosphorus and nitrates into the water column and results in algae blooms.

[22] https://www.sierraclub.org/minnesota/blog/2021/03/wake-boats-land-10000-lakes

The propwash also increases turbidity, which warms the water and makes the ecosystem less hospitable to native flora and fauna. It uproots native plants and destroys fish nesting sites.

Furthermore, Aquatic Invasive Species (AIS) are often pumped into the tank along with the lake water. A study by the Minnesota Aquatic Invasive Species Research Center shows that Zebra Mussels are difficult to remove from these tanks and therefore easily spread to other lakes. Although the boating industry has acknowledged this problem and is attempting to improve the tank-cleaning process, for now the boats will continue spreading AIS.

The Sierra Club also states that "Legislatures across the country, from New Hampshire to Washington state, are struggling to weigh the impact of wake boats on the environment, public safety, and the economy. We need more peer-reviewed studies to determine the most effective regulations."

In the summer of 2020, the University of Minnesota (UMN) launched a program titled "Healthy Waters Initiative" through the St. Anthony Falls Laboratory, an interdisciplinary research laboratory associated with the College of Science and Engineering. The mission of the initiative is to establish multi-year research efforts focusing on issues that have the potential to adversely affect Minnesota lakes and rivers. The Initiative is an independent research program focused on producing targeted, unbiased, peer-reviewed publications of data and research findings. The initial research performed under the Healthy Waters Initiative was focused on the characterization of boat-generated waves Marr et al. (2022). It has two phases.

The Phase I project began in fall 2020 and focused on characterizing the wake waves of various recreational boats. The report was published February 2022. The Phase II project will focus on characterizing the propeller wash of recreational boats under various usage scenarios and is not yet complete[23].

One finding from Phase 1 of the project was that when operating under typical wake surfing conditions, wake surf boats required distances greater than 500ft to attenuate wake wave characteristics (height, energy, and power) to levels equivalent to non-wake surf boats operating under typical planing conditions Marr et al. (2022).

5.3.2.3 No Wake and Boating Ordinances

No-wake zones are already in place by State Law within 100-ft of shore (200-ft for personal watercraft), in proximity to other boaters and swimming rafts, and where no wake buoys have been deployed. The RCLA could consider ordinances to limit boat use that creates large wakes and/or the times when boating activities like waterskiing and wakeboarding can be done on the lake. The process of developing and implementing ordinances that restrict lake use requires substantial public input, education, and participation in order to balance recreational needs and the protection of water quality.

5.3.3 Biomanipulation

Another management action to promote change from turbid water to clear water is biomanipulation. Biomanipulation aims to prevent the unusual growth of phytoplankton (algae) as a result of eutrophication in a lake. The basic concept of biomanipulation is that if the effective grazing of phytoplankton by zooplankton (small organisms that feed on algae) is achieved in a lake, the unusual phytoplankton growth is suppressed at certain levels of nutrient loadings. To create this ecological structure, the biomass of planktivorous fish (which eat zooplankton) should be suppressed and the biomass of piscivorous fish (which eat planktivorous fish) should be maintained Banerjee et al. (2019).

[23] https://sites.google.com/umn.edu/healthywatersinitiative/welcome

In the Red Cedar Lakes this would mean stocking more predator fish like walleye. This would decrease the population of bluegills and other planktivores (fish that eat zooplankton), allowing the zooplankton to flourish and decrease the amount of algae (Figure 67).

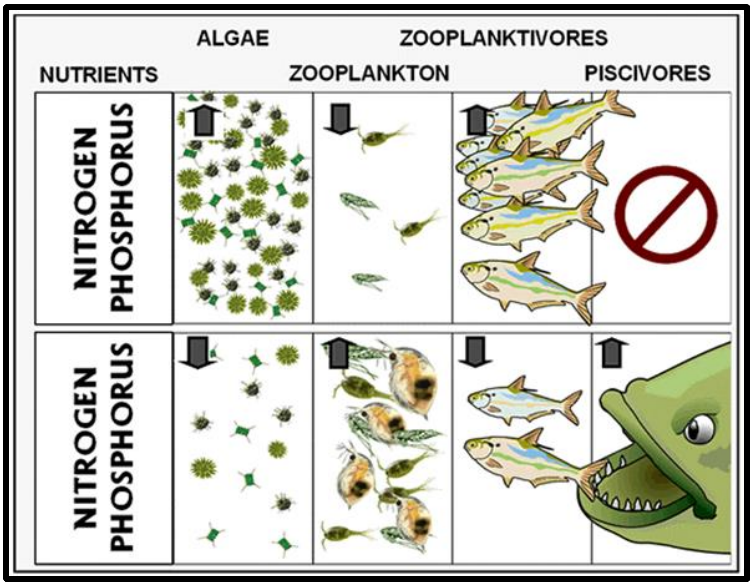


Figure 67: A representation of biomanipulation to reduce the number of zooplankton-feeding fish in a lake. Image: Anthony Thorpe, Lakes of Missouri Volunteer Program.

5.3.4 Alum Application

Alum can be used as a chemical agent to promote nutrient precipitation. This process essentially binds nutrients, like phosphorus, to particles of aluminum and locks them up at the bottom of the lake in the sediment where it cannot be used by algae. This process effectively seals the bottom of the lake and prevents future release of nutrients from the sediment. These actions reduce the overall concentration of nutrients in the water, which results in decreased algae levels and increased water clarity. This method is often used on lakes with significant internal loading where external nutrient loads are already low.

Through a process called flocculation, the chemical agent binds phosphorus, which causes it to form heavier aggregates that sink to the bottom (Figure 68). Aluminum sulfate (alum), or sometimes iron salts, have a high affinity for phosphorus, and due to their molecular make up, are highly attracted to one another. Once they are bound together, the phosphorus is no longer available for organisms like algae to use. Treatments must take into consideration a number of variables such as depth, pH, and the buffering capacity (alkalinity) of the water to reduce impacts to fish and other biota. Additionally, treatments may not compromise environmental safety nor exceed acceptable levels of aluminum and acidity.

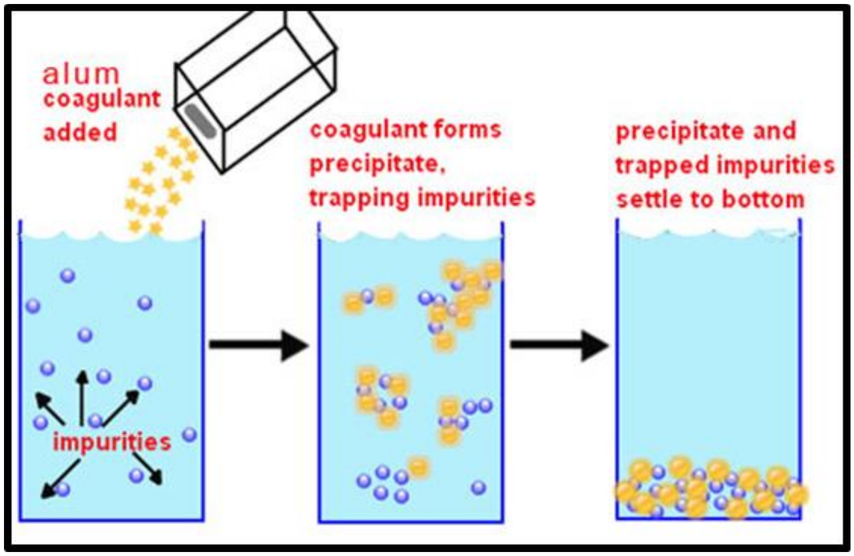


Figure 68: How alum works (http://www.bionicsro.com/water-treatment-chemicals/alum-salt.html)

Given that most of the Red Cedar Lakes watershed is in a natural state, alum application may be a viable management option for the RCLA to strongly consider. It could provide relief from internal loading for several years and allow the group to implement more management strategies while the lake recovers. Treatments cost an average of $450 per acre. The initial cost can be amortized over several years, so the long-term cost may not be as great other treatment options.

The benefits of alum application are as follows:

- Efficiently removes phosphorus for about 10 years
- Seals the bottom sediment to prevent further internal loading
- Increases water clarity
- Increased water clarity can increase plant growth, which provides important habitat and further reduces available phosphorus in the water
- Can be cost effective compared to other methods like dredging
- Works very quickly – effects can often be seen within an hour
- Pre-buffered solutions can be used to reduce free aluminum and negative impacts

The disadvantages of alum application are as follows:

- Other sources of nutrients need to be reduced as much as possible to get the most benefit from the treatment
- Increases the potential for elevated free aluminum and lowered pH (dissolved concentrations of free aluminum above 100ppb can be toxic to many fish species, while other species may show acute or chronic toxicity symptoms at concentrations as low as 50ppb)
- Cost – can be very expensive based on the amount of water to treat and the number of times it is treated

An alum application study would have to be completed, likely with support from one or more University programs to determine the best approach for alum application. From this consultant's perspective, alum application in Balsam Lake or Birch Lake (or both) would make the most sense.

5.3.5 Internal Phosphorus Loading Study in Balsam Lake

According to Ogdahl et al. (2014), three principal approaches are available for quantifying internal P loading to lakes.

1. In situ measurements of changes in hypolimnetic TP over time can be used when monitoring data are available. Internal load estimates based on in situ measurements suffer from high variability associated with the inherent spatial and temporal variability of environmental data and can be affected by inadequate monitoring frequency.
2. Mass balance can be used to estimate internal loading, when complete P budgets can be constructed. However, it is rare that sufficient data are available on P inputs and exports to construct a complete P budget.
3. Experimentally-determined sediment P release rates can be used, in combination with information on areal extent and duration of P release (i.e. anoxic period), to calculate internal P load is the best. This is a direct method of internal P load quantification (Ogdahl et al, 2014).

For Balsam Lake, it is likely that the third approach that would be used.

Laboratory incubations of sediment cores can help determine the relative importance of internal vs. external P loads; however, this approach also has limitations (Ogdahl et al, 2014). Assumptions must be made with respect to: extrapolating results from sediment cores to the entire lake; deciding over what time periods to measure nutrient release; and addressing possible core tube artifacts. A comprehensive dissolved oxygen monitoring strategy to assess temporal and spatial redox status in the lake provides greater confidence in annual P loads estimated from sediment core incubations (Ogdahl et al, 2014).

This Plan recommends that the RCLA work closely with a University entity to complete an internal phosphorus loading study for at least Balsam Lake in the first few years of implementation.

5.4 Management Measures from the 2004 Lake Management Plan

The last Comprehensive Lake Management Plan for the Red Cedar Lakes completed in 2004 had many recommendations for management actions to protect, maintain, and/or improve the lakes. This section lists the main aspects of those actions. Some slight modifications of the verbiage describing these actions may have been made to either shorten or better represent the description of these actions.

1. Exotics Management
    a. Purple Loosestrife Control
    b. EWM Monitoring and Watercraft Inspection
2. Runoff Management
    a. Tagalong and Loch Lomond
        i. Minimal of no use of fertilizers with phosphorus
        ii. Restore native shorelands (35ft)
        iii. Storm water management from impervious surfaces
    b. Shoreland Protection and Restoration
        i. Red Cedar Lakes island protection and restoration
        ii. Stabilize areas of shoreland erosion
        iii. Leave coarse woody debris in the water along the shoreline

        iv. Restore native shorelands (35ft)
        v. Avoid lake shore burning of leaves
        vi. Minimize construction site erosion
    c. Rural Residential and Urban Areas
        i. Divert storm sewers to water quality pre-treatment ponds or similar BMPs
        ii. Sweep leaves and dirt from streets
        iii. Divert parking lot runoff to water quality pre-treatment ponds or similar BMPs
        iv. Local government adoption of erosion control and/or storm water management ordinances

3. Infiltration Management
    a. Impervious Surfaces
        i. Redirect downspouts to grassed areas (swales), rain gardens, or French drains
        ii. Filter storm water by other means including infiltration trenches, alternative/porous surfaces, oil and grit separators, and detention ponds
4. Reduce Fertilizer Usage
    a. Soil test lawns
    b. Support no phosphorus fertilizers
5. Monitoring Programs
    a. Continue annual water quality monitoring
    b. Complete a ground water study
    c. Complete a historic water quality or Paleolimnology study
6. Forest Land Management
    a. Reforestation
    b. Implement forestry BMPs
    c. Leave timber on steep slopes
    d. Build bridges at stream and gully areas
    e. Keep timber harvests to the winter months
7. Agriculture
    a. Encourage minimum tillage
    b. Encourage contour farming
    c. Create diversions around barnyards
    d. Limit soil loss and leave winter cover crops
    e. Minimize fertilizer use
    f. Increase forage crops and reduce corn and soybean crops
    g. Do not apply manure to frozen ground or steep slopes
    h. Improve manure storage tanks
    i. Fence pastured stream banks
    j. Encourage the use of no-till farming, grassed waterways, and nutrient management
        i. Implement cost-share programs in cooperation with Barron County
        ii. RCLA incentive payments to farmers who implement these practices
8. Government Partnership and Policies
    a. Work with State, County, and Town transportation departments to determine the best ways to ensure safe roads, minimal salt usage, and minimal impacts to the Red Cedar Lakes
    b. Utility and Highway Corridors
        i. Minimize road runoff directly to the lakes by encouraging the use of BMPs that trap runoff
        ii. Don't dump sand on the waterfront
        iii. Make docks and boat houses as unobtrusive as possible
        iv. Keep dock lighting to a minimum safe level
    c. Spill Preparedness
        i. Make sure local officials are prepared in the event of a toxic spill near the lakes
        ii. Provide adequate training and equipment, such as booms and spill absorbents

    d. Encourage Comprehensive Plans in the Towns of Birchwood, Cedar Lake, Edgewater, and Wilson focused in part on maintaining and protecting their natural resources
    e. Encourage Storm Water Management Plans in Birchwood and Mikana to reduce sedimentation to the Red Cedar Lakes
    f. Encourage phosphorus monitoring around the Birchwood community wastewater seepage cell for sewage processing
    g. Reduce phosphorus loading from upstream contributors in the Birch and Chetac lakes areas
        i. Work with and build partnerships with other groups in the Red Cedar River watershed to implement BMPs through the watershed
        ii. Develop local ordinances related to a multitude of issues related to degradation of the Red Cedar Lakes from nonpoint source pollution

9. Sensitive Area Recommendations
    a. Follow recommendations in the 1997 WDNR Sensitive Areas Survey Report and Management Guidelines for Balsam, Hemlock, and Red Cedar Lakes
10. Community Education and Information
    a. Septic System Maintenance
        i. Provide education and research on how to tell if septic tanks are in poor or failing condition
        ii. Implement a "Pumping Maintenance Campaign"
        iii. Implement a "Repair/Replacement Campaign"
        iv. Encourage the development of an ordinance where septic systems must be evaluated at the time a property is sold or transferred to another party
    b. Quiet Time (slow no wake) Ordinance Development and Implementation
    c. Lake Clean Up
        i. Organize a group litter pick-up program like Adopt-a-Highway
        ii. Instigate other group clean up days including spring clean-up and fall leaf collection

5.5 Accomplishments from the 2004 Lake Management Plan

The following activities from the 2004 Comprehensive Lake Management Plan identified in Section 5.4 were completed in full or in part.

1. Exotics Management
    a. Purple Loosestrife Control
    b. EWM Monitoring and Watercraft Inspection
2. Runoff Management
    a. Tagalong and Loch Lomond
        i. Storm water management from impervious surfaces
    b. Shoreland Protection and Restoration
        i. Red Cedar Lakes island protection and restoration
        ii. Stabilize areas of shoreland erosion
        iii. Leave coarse woody debris in the water along the shoreline
        iv. Restore native shorelands (35ft)
    c. Rural Residential and Urban Areas
        i. Divert parking lot runoff to water quality pre-treatment ponds or similar BMPs
3. Infiltration Management
    a. Impervious Surfaces
        i. Redirect downspouts to grassed areas (swales), rain gardens, or French drains
        ii. Filter storm water by other means including infiltration trenches, alternative/porous surfaces, oil and grit separators, and detention ponds
4. Reduce Fertilizer Usage
    a. Support no phosphorus fertilizers
5. Monitoring Programs

    a. Continue annual water quality monitoring
    b. Complete a historic water quality or Paleolimnology study
6. Forest Land Management
    a. Implement forestry BMPs
    b. Keep timber harvests to the winter months
7. Agriculture
    a. Create diversions around barnyards
    b. Improve manure storage tanks
8. Government Partnership and Policies
    a. Spill Preparedness
        i. Make sure local officials are prepared in the event of a toxic spill near the lakes
    b. Encourage Comprehensive Plans in the Towns of Birchwood, Cedar Lake, Edgewater, and Wilson focused in part on maintaining and protecting their natural resources
    c. Reduce phosphorus loading from upstream contributors in the Birch and Chetac lakes areas
        i. Work with and build partnerships with other groups in the Red Cedar River watershed to implement BMPs through the watershed
9. Sensitive Area Recommendations
    a. Follow recommendations in the 1997 WDNR Sensitive Areas Survey Report and Management Guidelines for Balsam, Hemlock, and Red Cedar Lakes
10. Community Education and Information
    a. Septic System Maintenance
        i. Provide education and research on how to tell if septic tanks are in poor or failing condition
    b. Lake Clean Up
        i. Organize a group litter pick-up program like Adopt-a-Highway
        ii. Instigate other group clean up days including spring clean-up and fall leaf collection

6.0 Implementation Schedules

Reducing nutrient loading into the Red Cedar Lakes involves both gathering of additional information and the implementation of specific BMPs in all three areas of concern: the watershed, the riparian area, and in the lakes themselves. Gathering additional information will help to identify other sources and, along with monitoring, help evaluate the success of management actions. This Plan is also about implementing management actions in the three areas of concern that do actually reduce nutrient loading and help to maintain or improve the lakes.

Appendix B provides an Implementation Matrix with greater detail about what to do and when, who implements a given action, and how it could be funded.

6.1 Watershed

Reducing phosphorus loading in the watershed is generally focused on changing logging and agricultural land use by implementing recognized BMPs. The following are recommendations for information gathering and management actions to be implemented in the watershed. In some cases, the recommendations assume that none of the stated BMPs are already being implemented. This is likely not the case, which points to the need to gather more data along with plans for implementation.

6.1.1 Gathering Additional Data - Watershed

1. Work with the four County Land and Water Conservation Departments to better evaluate the limited agricultural cropland in the watershed and the BMPs already employed.
    a. Monitor land use changes via satellite imagery and "cropland data layer" at least every two years.
    b. Monitor more local land use changes with boots-on-the-ground surveys of cropland within the watershed at least every two years.
    c. Evaluate manure application throughout the watershed to determine if it is being applied following the appropriate guidelines.
2. Identify areas of the stream corridors that could benefit from the installation of conservation buffers.
3. Work with the four County Forestry Departments to evaluate stream crossings on the ATV trail system.
    a. Using maps of the ATV trail system identify stream crossings with the potential for problems.
    b. Complete on-site visits to identified crossings.
4. Work with the four County Forestry Departments and private land owners to ensure that proper forestry and mining BMPs are being implemented on all timber harvest sites.
    a. Add BMP information to materials that are available to private landowners considering timber harvest on their property.
    b. Actively engage with each County Forestry Department to encourage them to make sure BMPs are being implemented on all timber harvests.

6.1.2 Management Actions - Watershed

1. Convert 33% of existing cropland acres to no-till or non-crop related uses.
    a. 33% is based on the values modeled in the Tainter and Menomin Lakes TMDL Implementation Plan
    b. 33% of 1543 acres of cropland = 509 acres
2. Apply cover crops to 40% of all cropland.
    a. 40% is based on values modeled in the Tainter and Menomin Lakes TMDL Implementation Plan
    b. 40% of 1543 acres of cropland = 617 acres

3. Reduce the number of problem barnyards and animal feedlots by 100%.
4. Apply a wide range of traditional soil erosion practices like crop rotations, contour farming, strips, and grassed waterways to 10% of all remaining cropland.
5. Implement appropriate conservation buffers along streams and waterways in the watershed.
6. Work with county and private foresters to ensure proper BMP implementation on all timber harvest sites.
7. Work with the four counties, State of Wisconsin, and ATV Clubs to address ATV trail system stream crossings with known issues by implementing appropriate and required “fixes”.

6.2 Riparian

Reducing sediment and phosphorus loading in the riparian area is focused primarily on encouraging property owners around the lakes 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.

6.2.1 Gathering Additional Data – Riparian Area

1. Identify individual property owners who are willing to implement habitat improvement and runoff reduction projects.
    a. Use the SHA Results Books as a resource to guide initial contacts.
    b. Redo SHA between Implementation Years 7-10
2. Work with resorts and other tourism-focused entities to evaluate the potential for habitat improvement and runoff reduction projects within these establishments.
    a. Meet in person with the “care takers” of each of these establishments to judge interest
3. Identify smaller, intermittent streams, washes and gullies that may be directly contributing to nutrient loading into the lakes.
    a. Complete an evaluation of intermittent stream, washes, and gullies using PRESTO Lite
    b. Complete on-site visits to verify potential issues.

6.2.2 Management Actions – Riparian Area

1. Protect and preserve undeveloped lands around the Red Cedar Lakes
    a. Apply for grants to set up conservation easements and to purchase properties
2. Implement shoreland habitat and runoff reduction projects
    a. Reduce the number of moderate and high priority property parcels identified by the SHA by 20%
    b. Implement habitat improvement and runoff reduction projects identified during discussions with resorts and other tourism-focused entities.
        i. Annual Shoreland Improvement Workshops
        ii. Project assistance through RCLA and grant programs
3. Continue with island preservation and restoration
    a. Implement projects.
4. Reduce verified field gully/ravine and stream erosion areas
    a. Implement BMPs where possible.
5. Encourage property owners to properly maintain septic systems

6.3 In-lake

Reducing phosphorus loading within the Red Cedar Lakes 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 and waves are addressed either directly in this plan or in the Red Cedar Lakes Aquatic Plant Management Plan. Actions are included that would remove phosphorus from the lake including considering the application of phosphorus binding agents.

6.3.1 Gathering Additional Data – In-lake

1. Evaluation of boating ordinances on one or all of the lakes that may reduce sediment suspension.
2. Complete an internal phosphorus loading study in Balsam Lake.

6.3.2 Management Actions – In-lake

1. Implement the recommendations in the Red Cedar Lakes APM Plan (AIS monitoring and prevention, management planning, survey, permitting, and treatment).
    a. CLP management
    b. Purple loosestrife management
    c. CLMN AIS monitoring
    d. WDNR CBCW watercraft inspection
    e. AIS decontamination and information signage
2. Address watercraft use and issues
    a. Increased enforcement of existing no wake and power loading ordinances
    b. Implementation of new boating ordinances if appropriate.
3. Implement biomanipulation techniques to improve water quality
4. Apply aluminum sulfate (alum) or other phosphorus binding agents to Balsam Lake

7.0 Education and Outreach

Through education and outreach, the RCLA has to increase public awareness of water quality issues and what contributes to them; increase public involvement in lake and watershed stewardship; and increase communication and coordination among the stakeholders and partners that are most able to help implement management actions. To do this the following activities should be continuously implemented over the time frame of this plan.

- Develop and distribute appropriate educational and informational materials for target audiences on and around the lakes and in their watershed
  - Examples: newsletters, brochures, website and Facebook posts.
- Host workshops, meetings, and events that landowners can attend to learn more about BMPs that will help maintain or improve the lakes.
  - Examples: RCLA Annual Education Meeting and Nature Committee events
- Explore what level of professional support various state, county, and local resource agencies can offer to help plan and implement management strategies to improve the lakes.
- Solicit involvement and support from local businesses, schools, clubs, and other organizations.

7.1 Target Audience

Multiple audiences will be targeted with this education and outreach plan. Target audiences include, but are not limited to, property owners on and adjacent to Red Cedar Lakes and in the larger watershed that includes Big Chetac and Birch lakes, lake users, local businesses, local clubs/organizations/schools, RCLA board members, and local government officials (Barron County, Town of Cedar Lake, Washburn County, Town of Birchwood, Rusk County, Town of Wilson).

7.1.1 Property Owners

The first level of education always involves the officers of the various lake organizations, lake constituency or lake property owners. Every lake property owner can do something to help maintain or improve water quality. 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 often help people understand each other's view points and vision for the lake.

7.1.2 Lake Users

Lake users can be anybody with property on the lakes or who come to the lakes for some purpose. The lakes are popular for fishing, power boating, water skiing, tubing, and use of personal watercraft. They are also popular for activities that don't necessarily involve power boats – swimming, kayaking, sailing, paddleboards, wildlife viewing, etc. Continued efforts toward providing education and information regarding transport and introduction of AIS; safe and legal use of watercraft; and use of watercraft in a way that does not harm the

Red Cedar Lakes will help protects the people using the lake and the overall health of the lake. Fishing is a popular activity on the Red Cedar Lakes 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.

7.1.3 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. The RCLA is a voluntary membership organization, but new homeowners/buyers on the lakes should be encouraged to be a part of it. Information should continue to be provided to these new property owners about what the RCLA does, what their membership in the RCLA will get them, and how their dues are used to help protect the lakes may increase support for the RCLA. Generally, home/property values are 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. The RCLA should be actively engaged in property sales around the lake. When a property exchanges hands, representatives of the RCLA should welcome the new owner and pass on materials about how and what that property owner can do to maintain or improve the lakes into the future.

7.2 Red Cedar River Watershed Conference

Since 2012, the RWQP, in cooperation with the Tainter Menomin Lake Improvement Association Inc. and UW-STOUT, has organized an annual conference with the goal of maintaining and sustaining a conversation about what it takes to improve water quality in the whole watershed. The conference, held at UW-STOUT and generally schedule for early March each year focuses on three areas, the land, the people, and the water of the Red Cedar River watershed. This marquee regional event brings together citizens, farmers, lawmakers, academics and others from across the watershed and beyond.

8.0 Monitoring

Watershed restorations and adoption of agricultural best management practices for conservation purposes has become commonplace in recent decades and is one of the avenues for attempting to make positive changes in Red Cedar Lakes. 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. 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. An implementation matrix for monitoring is included in Appendix B.

8.1 Watershed Monitoring

8.1.1 Land Use

As human and natural forces modify the landscape, resource agencies find it increasingly important to monitor and assess these alterations. There are several common methods for monitoring changes in land use. Nation-wide, the National Land Cover Database (NLCD) from the USGS is used to identify basic categories of land cover from agriculture to forests to urban. However, for the Red Cedar Lakes watershed, where agriculture is limited and county forest land covers much of it, this scale is likely not fine enough to be a great use for this project. Remote sensing satellite imagery has increasingly been used as a tool for identifying changes in land use. Related, is satellite/aerial photos from the National Agriculture Imagery Program (NAIP), which may also be of use to document changes.

County "boots-on-the-ground" surveys, also known as cropland roadside transect surveys, can provide a regular assessment of agricultural BMPs in the watershed. These surveys provide a high degree of confidence in the accuracy of the results, but are labor intensive and time consuming, often involving multiple staff and days to complete. The RCLA can work with the individual counties to establish ways to help support these surveys. In addition to boots-on-the-ground surveys to document agricultural BMPs, a similar survey could be developed to monitor timber harvests for BMPs.

8.1.2 Water Quality

The water quality parameters of most concern in tributary flow in the watershed are total phosphorus (TP) and suspended sediment (TSS). 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).

Regular tributary monitoring for at least TP and TSS should be completed at the following sites (Figure 69).

8.1.2.1 Tributaries to Balsam, Red Cedar, and Hemlock Lakes

- Red Cedar River at Co. D (downstream of the Birch Lake Dam)

- Sucker Creek at 29 ½ St. (downstream of the main agricultural areas)
- North Branch of Pigeon Creek at Valley Rd (downstream of main agricultural areas)
- South Branch of Pigeon Creek at Fire Tower or Valley Road (downstream of the main agricultural areas)
- Hemlock Creek at Co. F (downstream of Murphy Flowage Dam)

8.1.2.2 <u>Tributaries to Murphy Flowage</u>

- Louler Creek at North Bucks Lake Rd
- Hemlock Creek at North Bucks Lake Rd
- South Branch of Hemlock Creek at South Bucks Lake Rd

Tributary sampling would follow WI-DNR WisCALM guidelines where samples are collected once a month from May to October. The total number of years this sampling would occur would likely be 3-5 years beginning in 2024 and continuing through 2027 or 2029 depending on when BMPs are actually implemented.

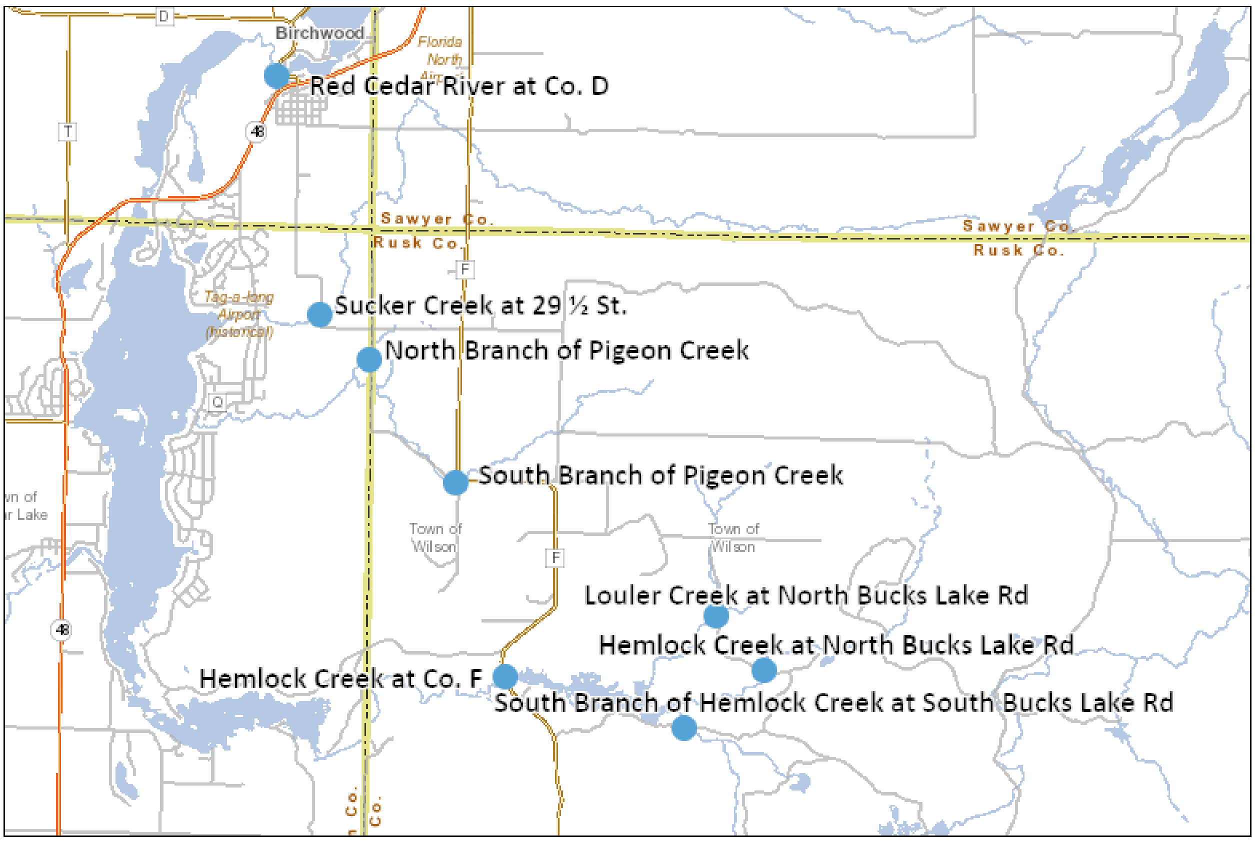


Figure 69: Red Cedar Lakes and Murphy Flowage Watershed Tributary Monitoring Sites

8.2 Riparian Area Monitoring

8.2.1 Nearshore/Developed Area of the Lakes

As the number of shoreland habitat improvement projects that are implemented increases, it will be necessary to repeat the Shoreland Habitat Assessment and the Nearshore Development Survey to track how many acres are impacted. Since it takes time to encourage, plan, and then implement these projects, it is recommended that the Shoreland Habitat Assessment and Nearshore Development Survey be completed sometime late in the implementation of this 10-year plan.

8.2.2 Gullies, Washes, and Stream Monitoring

Once an evaluation of the gullies, washes, and streams has been completed, it is expected that a few will exhibit some level of concern. To substantiate that concern, it may be necessary to collect water samples for analysis of TP and TSS concentration, along with some attempt to quantify flow and discharge to help identify the severity of the problem. Water samples would be collected either on a monthly basis or at least during spring snowmelt and/or large rain events for a year or two before the expected implementation of BMPs. Then once BMPs are implemented, it may be necessary to collect water samples for a year or two after.

8.3 In-lake Monitoring

8.3.1 Surface Water Monitoring

Through the Citizen Lake Monitoring Network (CLMN) sponsored by the WI-DNR and UW-Extension Lakes, regular surface water quality testing occurs on the South Basin of Red Cedar Lake and at the Deep Hole in Bass Lake. Expanded water quality testing occurs at the Deep Hole in Balsam Lake, Deep Hole North Basin in Red Cedar Lake, and at the Deep Hole in Hemlock Lake (Figure 70). 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.[24] It is recommended that these locations continue to be monitored for long-term water quality trends.

8.3.1.1 Additional Dissolved Oxygen and Temperature Profiles

Presently, DO and Temp profiles are taken once a month as a part of the CLMN expanded water quality monitoring program using a digital DO meter. At least for a period of 2-3 years, more frequent profiles should be recorded in at least the three main stem lakes. Every 10 days or every two weeks would be OK, weekly profiles throughout the open water season would be ideal. When attempting to calculate internal loading of phosphorus, accurate and frequent DO and temp profiles provide valuable information about when, how deep, and how long stratification lasts in a lake.

[24] 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

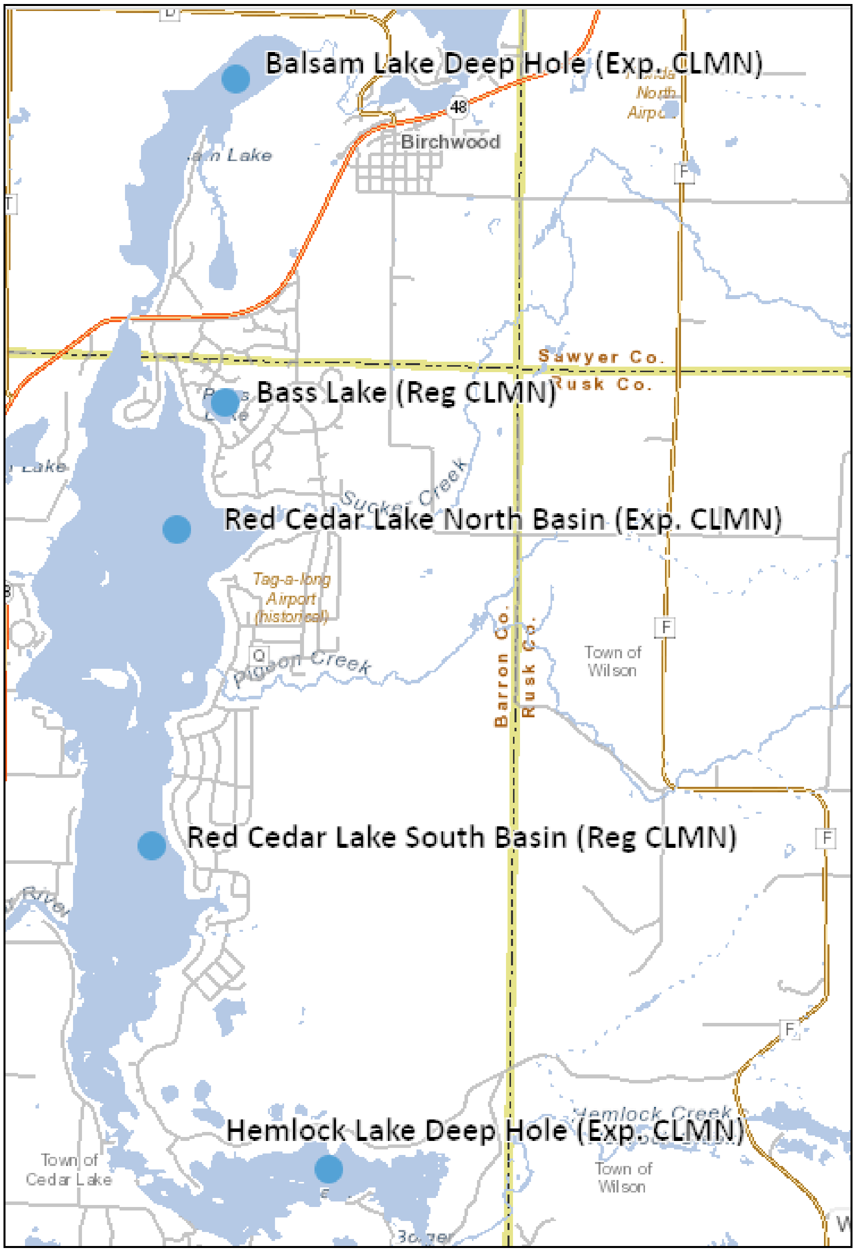


Figure 70: Citizen Lake Monitoring Network water quality monitoring sites

8.3.2 Water Column Sampling of TP

Because there is interest in learning more about how much internal loading of phosphorus impacts the lakes, particularly Balsam Lake, it is recommended that water column sampling for TP and iron be completed up to two times per month from July through October for a period of at least 2 to 3 years. This additional monitoring would likely be included in any internal phosphorus loading study that might be completed on Balsam Lake.

Similar water column sampling could be completed in both basins of Red Cedar Lake and in Hemlock Lake; however, it is not likely that these lakes would receive any sort of phosphorus binding management action.

Water column sampling could make estimates of internal phosphorus loading more accurate and help to improve the accuracy of the total phosphorus load in the lakes.

8.3.3 Surface Water Monitoring in Murphy Flowage

Tributary sampling on Hemlock Creek below the Murphy Flowage dam gives an idea as to what the phosphorus concentration is in Murphy Flowage, however actual water sampling in Murphy Flowage following the same guidelines as the CLMN expanded monitoring program would be beneficial in determining how much phosphorus is being held in Murphy Flowage. In addition to this monitoring in Murphy Flowage, similar monitoring could be done in Bucks Lake a little further up in the watershed. For both of these lakes, three years of monitoring data would provide a baseline for documenting future changes as BMPs are implemented in the watershed of Murphy Flowage.

8.4 Aquatic Plant and Aquatic Invasive Species (AIS) Monitoring

Although aquatic plant and AIS monitoring is covered in the existing Aquatic Plant Management Plan for the Red Cedar Lakes, 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.[25]

Annual mapping of wild rice should also continue, at least in those areas where it has been documented before. During the 5-yr whole-lake, point-intercept survey the presence of wild rice is also documented.

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

9.0 Technical Assistance

Many of the actions recommended in this plan cannot be completed solely by the RCLA. Multiple outside resources and expertise will be needed to guide implementation. A list of outside resources that the RCLA will need to partner with to implement the actions in this plan is included in Appendix D.

10.0 Funding Sources for Plan Implementation

All five of the HUC 12 sub-basins that make up the greater Red Cedar Lakes watershed are already included in the existing TMDL and TMDL Implementation Plan for Tainter and Menomin Lakes focused on the Red Cedar River Watershed. As such, the RCLA is eligible for financial assistance that will help implement BMPs to reduce nonpoint source pollution with or without a WI-DNR approved Comprehensive Lake Management Plan.

10.1 Federal & State Funding

Most of the federal funding is available for agricultural lands through the EPA's Clean Water Act, the Natural Resource Conservation Service (NRCS), and the Farm Service Agency (FSA). State funding comes largely from the Surface Water grants program.

10.1.1 EPA 319 Grant Programs for States and Territories

The 1987 amendments to the Clean Water Act 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.

10.1.2 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 NRCS. A majority of these programs would be administered by the one or more of the four counties that are included in the watershed of the Red Cedar Lakes.

- 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 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.

10.2 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

10.3 WI-DNR Surface Water Grants[26]

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 (see Section 10.3.1)
- Management Plan Implementation
- Clean Boats, Clean Waters
- AIS Supplemental Prevention

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

- 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

10.3.1 Surface Water Management Grants – Surface Water Restoration

Surface water restoration grants help implement protection and restoration actions. Unlike plan implementation grants, these projects don't require a management plan, however, projects shall follow the appropriate NRCS standards.[27]

10.3.1.1 Shoreland Protection Projects

Projects that are aimed at protecting and maintaining the shoreland around a lake include:

- Critical area stabilization
- Diversions
- Filter strips
- Grade stabilization structures on artificial or non-navigable watercourses
- Riparian buffers
- Water bar diversion
- Sediment and water basins
- Pervious pavement
- Rain gardens
- Vegetation planting
- Urban pollution and runoff control
- Streambank or shoreline protection
- Impervious area removal within 35 feet of the ordinary high-water mark

10.3.1.2 In-Water Management Projects

Projects that protect or improve in-water conditions include:

- The installation of department-approved habitat structures, culvert or road crossing removal or modification, and aquatic re-vegetation

10.3.1.3 Wetland Restoration Projects

Projects that will help restore or enhance a prior converted or existing wetland are eligible provided they meet the following criteria:

- Projects must occur on hydric soils and implement the best practices for wetland restoration or enhancement

[27] For more information about Surface Restoration Grants specifically go to: https://dnr.wisconsin.gov/sites/default/files/topic/Aid/grants/surfacewater/ManagementGrantFactSheet.pdf

- Eligible activities included drainage tile disablement, ditch plugs and fills, water level manipulation or vegetation enhancement
- Projects cannot be necessary or required to achieve mitigation standards

10.3.1.4 Ordinance Development Projects

Projects that create local regulations to benefit surface waters including topics like boating, AIS prevention, wetlands, shorelands, erosion control and others can be awarded grant funding. Eligible activities include:

- Development
- Legal work
- Facility rental
- Training for compliance and enforcement
- Outreach
- Assessment of administrative and enforcement capacity

Applications must include a letter of support from the unit of government most likely to implement the ordinance.

11.0 Tracking, Assessment, and Depreciation

Tracking and assessment is a critical component to meeting the 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.

11.1 Tracking Conservation Best Management Practices

Annual updates related to the implementation of conservation practices 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
- 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.

11.1.1 BMP Depreciation

With this Plan, the causes and sources of water resource impairment have been explored. Greater information will be needed to assess existing, and recommend new BMPs to address the identified problems including the identifying the best locations for these BMPs and the pollutant load reductions likely to be achieved by implementing them. However, existing or new, the question always remains as to whether or not these BMPs will actually do what they are supposed to for the expected amount of time.

All too often, watershed managers and agency staff assume 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 nonpoint source 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. 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" should be used when evaluating BMP effectiveness and identifying factors that may affect BMP performance levels and implementation.[28]

11.2 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.

11.3 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 Red Cedar Lakes Comprehensive Lake Management Plan to incorporate emerging practices into the implementation strategy and model pollutant load reductions.

11.4 Water Quality Improvements in the Red Cedar Lakes

The purpose of this entire document is to maintain or make improvements in water quality in the Red Cedar Lakes. 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 WDNR 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. 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.
- Changes in growing season, soil conditions and water quality resulting from changes in climate, weather patterns, and precipitation events.

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

- 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 time frames.
- Keeping up with the changes that occur to accurately represent their impacts.

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