SECTION 319 NONPOINT SOURCE POLLUTION CONTROL PROGRAM

WATERSHED PROJECT FINAL REPORT

Northeast Glacial Lakes Watershed Improvement and Protection Project

Segment 4

By

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Day Conservation District

October 2021

This project was conducted in cooperation with the State of South Dakota and the United States Environmental Protection Agency, Region 8

Grant # C9-998185-17, C9-998185-19

EXECUTIVE SUMMARY

PROJECT TITLE:	Northeast Glacial Lakes Watershed Improvement and Protection Project Segment 4

PROJECT START DATE:	July 24, 2017
PROJECT COMPLETION DATE:	August 31, 2021

FUNDING:	TOTAL BUDGET	$880,539.41
	TOTAL EPA BUDGET	$500,000.00
	TOTAL EXPENDITURES OF EPA FUNDS	**$364,483.71**
	TOTAL SECTION 319 MATCH ACCRUED	$209,118.09
	OTHER FEDERAL FUNDS	$160,054.03
	TOTAL EXPENDITURES	$733,655.83

SUMMARY ACCOMPLISHMENTS

The project has exceeded its goal for implementing riparian buffers utilizing the Continuous Conservation Reserve Program (CCRP) by 781 acres. The project milestone was 350 acres; to date a total of 1,131 acres of CCRP have been implemented. A total of 261 acres of riparian buffers utilizing EPA 319 funds have been implemented, the projects goal was 260 acres.

Stabilization of 3,226 lineal feet of shoreline and streambank has been completed utilizing rock rip-rap, exceeding the projects goal of 1,700 lineal feet. An additional 694 lf. of streambank was stabilized with the construction of nineteen stream crossings placed where livestock had degraded streambank vegetation and erosion was occurring. The projects goal was to construct twenty-three stream crossings.

The implementation of CCRP, CRP, stream crossings and streambank stabilization protected and improved 104,3332 lineal feet or 19 miles of streambank and shoreline in the project area.

The projects goal of implementing grazing management improvements on 4,000 acres was not attained. Grazing management improvements were implemented on only 1,136 acres.

A total of 456 acres of cropland deemed critical for water quality was planted to grass or a combination of grass and forbs. The projects milestone was 728 acres.

The project fell short by forty feet, it's goal of 5,000 lineal feet of grassed waterways to be constructed. A total of 4,960 lineal feet were completed.

Implementation of best management practices resulted in a total calculated reduction of 20,277 lbs. per year of nitrogen; 6,361 lbs. per year of phosphorus; and 6,703 tons per year of sediment in the watersheds included in Segment 4 (Table 7).

Milestones for information and education activities have been completed. An audience of 7,025 youth and adults attended presentations by project personnel at workshops, water festivals, environmental education programs, farm and home shows. A website provided project information to the public at *www.neglwatersheds.org*. Information available from the website includes information on cost share available for implementing agricultural best management practices, best management practices for lakeshore property owners, natural history, information and educational opportunities, and attributes of project lakes and watersheds. Due to the Covid-19 pandemic a majority of information and education activities planned for the years 2020 and 2021 were cancelled.

The Covid-19 Pandemic also limited producer contacts during the last eighteen months of this project. Local Conservation District/USDA offices were closed to the general public during this period and had limits on the number of employees and partners that could be working in the office at any given time.

Segment 4 of the Northeast Glacial Lakes Watershed Improvement and Protection Project was amended in 2019. All changes in project activities and milestones are reflected in this report.

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1.0 Introduction

The Northeast Glacial Lakes Watershed Protection and Improvement Project encompass four northeast South Dakota counties: Day, Grant, Marshall, and Roberts a portion of Deuel County, and portions of four major river basins; Big Sioux, James, Minnesota, and Red Rivers. Locations of project lakes and reservoirs are shown in Figure 1. The locations of project streams and rivers are shown in Figure 2.

Figure 1.

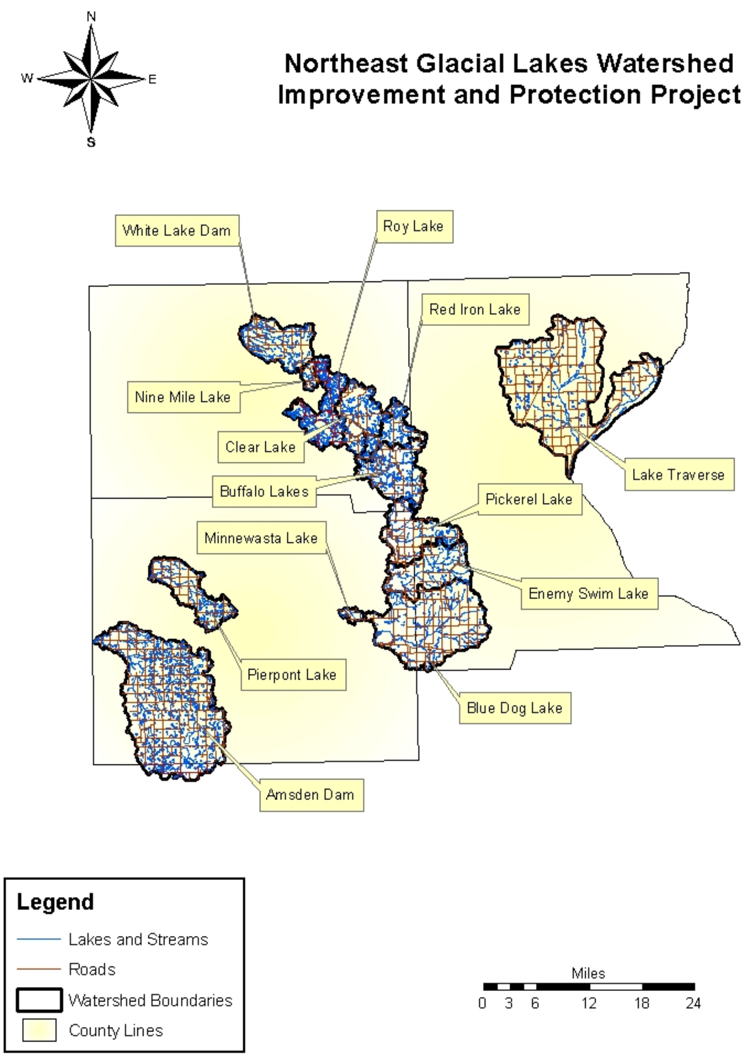
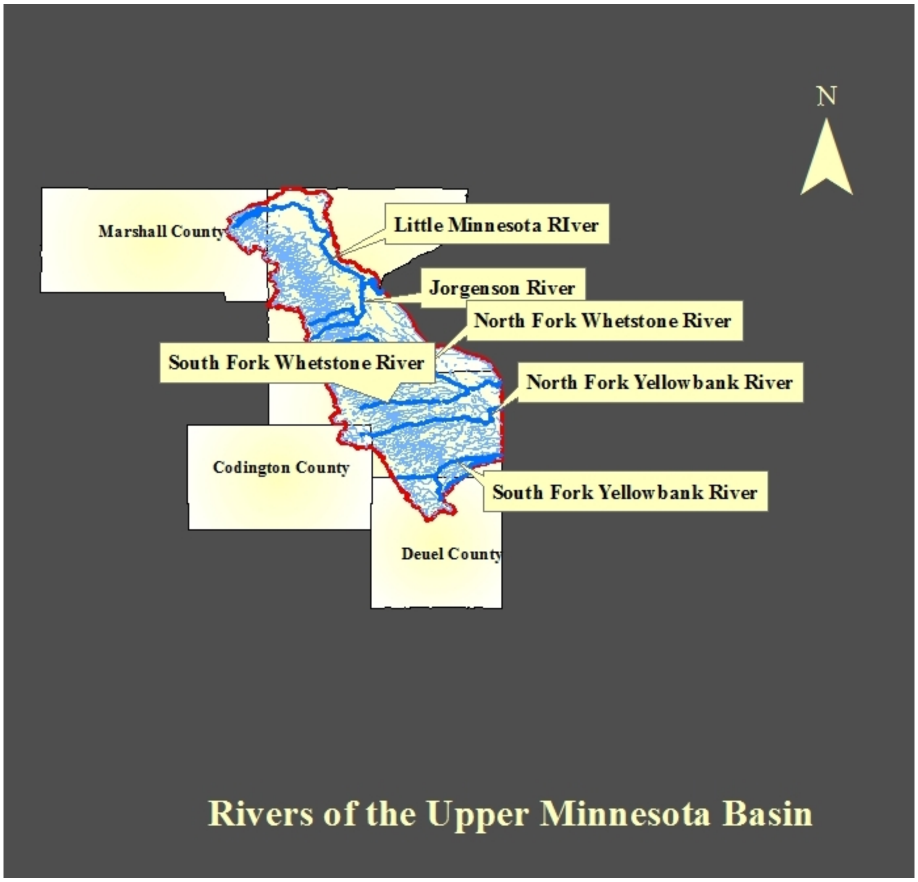


Figure 2.



The majority of the water bodies located in Day and Marshall County portions of the project area lie atop high tableland early French explorers named the Coteau Des Prairie or Hill of the Prairies. The topography of the Coteau was formed by the stagnation of glacial ice during the Late Wisconsin Glaciations that occurred approximately 12,000 years ago. As the glacier stagnated and began to fragment and melt, large blocks of ice were buried in melt water outwash. Melting of the ice blocks left depressions in the outwash of various size and depth. These depressions are the thousands of potholes, sloughs, and lakes characteristic of the modern day topography of the Coteau Des Prairie.

Melt water flowing from the top of the Coteau cut several deep channels along the eastern and western slopes. Along the eastern slope of the Coteau, these channels, called coulees, are deep enough to expose groundwater that lays above the Pierre shale bedrock. The groundwater flowing above the bedrock forms dozens of small perennial streams that are the headwaters of the Red River that flows north and the Minnesota River that flows east. East facing coulees provide cool-wet conditions that support remnants of the eastern deciduous forest community once prevalent approximately 6,000 years ago.

The much drier western slope of the Coteau supports fewer perennial streams. The few wooded coulees that exist are dominated by bur oak. Many of the perennial streams that flow from the western slope have been dammed to form reservoirs. Among these are Amsden Dam and Pierpont Lake. These two reservoirs discharge to the James River.

Many of the lakes perched atop the Coteau are situated in closed basins. The largest closed basin is called the Eastern Lakes Subsystem, or more recently the Waubay Lakes Chain. The Eastern Lakes Subsystem is comprised of eleven major lakes that include Blue Dog, Enemy Swim, and Pickerel Lakes; and several minor lakes including Minnewasta. A group of aquifers and several surface drainages surround and connect these lakes. While the Eastern Lakes Subsystem is closed, the potential exists for these lakes to eventually drain to the Big Sioux River. This potential was realized in the 1990's when greater than normal precipitation, and less than normal evaporation caused many of the lower lakes in the subsystem to rise twenty feet above historical lake level elevations.

Buffalo Lakes, Clear Lake, Roy Lake, and South Red Iron Lake lie in the Coteau Lakes Outwash Deposit. Like the Eastern Lakes Subsystem, aquifers and surface drainages connect these Marshall County lakes.

The watershed of White Lake is located at the northwest base of the Coteau. This reservoir is located on the Wild Rice River that drains into the Red River.

Lake Traverse lies in the main channel of what remains of Glacial River Warren, the major outflow channel of pro-glacial Lake Agassiz formed approximately 10,000 years ago. The South Dakota portion of Lake Traverse's watershed is relatively small with only one tributary, Jim Creek. The majority of Lake Traverse's watershed (90%) lies in Minnesota. Lake Traverse drains into the Bois De Sioux River, a tributary of the Red River that drains north to Lake Winnipeg.

Table 1 lists the locations and attributes of the thirteen project lakes and reservoirs that were included in Segment 4. This data was retrieved from various SD Dept. DANR publications.

The South Dakota portion of the Minnesota River Basin (Figure 2) includes three major stream systems; the Little Minnesota River, Whetstone River (North and South Forks), and Yellowbank River (North and South Forks). These three rivers are the headwaters for the Minnesota River which begins near the South Dakota/Minnesota Border below Big Stone City, SD.

The Little Minnesota River, beginning near Veblen, SD and flowing into Big Stone Lake south of Browns Valley, MN, drains the majority of Roberts County and a portion of east central Marshall County. The drainage includes hundreds of small named and unnamed tributaries that begin as small cold-water spring fed streams in the forested coulees located along the east escarpment of the Coteau des Prairie, and flow into bottomlands known as the Whetstone Valley. One of the larger headwater tributaries Big Coulee Creek flows from the escarpment into the Jorgenson River, the largest tributary of the Little Minnesota River in Roberts County. Pasture and range make up the major land use along the escarpment where these small headwater tributaries begin. The major land use changes to row crops as these headwaters enter the Whetstone Valley. Tile drainage of cropland in the Whetstone Valley is becoming a common practice.

<u>Table 1.</u> Attributes of Targeted Project Lakes and Reservoirs

River Basin and Waterbody	County	Longitude Latitude	Watershed Area (acres)	Max. Depth (feet)	Surface Area (acres)	Shoreline Length (miles)	Watershed to Lake Ratio	Waterbody Type
<u>Upper Big Sioux River Basin</u> HUC # 10160010								
Blue Dog Lake	Day	45° 21'06'N 97° 17'48"W	73,811	8	1,502	8.7	49/1	Natural
Enemy Swim Lake	Day	45° 26'24"N 97° 16'00"W	22,310	26	2,146	11.8	10/1	Natural
Minnewasta Lake	Day	45° 23'24"N 97° 21'42"W	2,564	14	601	5.5	4/1	Natural
Pickerel Lake	Day	45° 30'24"N 97° 16'24"W	17,165	43	931	9.7	18/1	Natural
<u>Upper James River Basin</u> HUC # 10160005								
Amsden Dam	Day	45° 21'30"N 97° 58'06"W	31,961	27	235	5.9	136/1	Reservoir
Buffalo Lake	Marshall	45° 37'00"N 97° 16'48"W	16,781	12	1,780	27.8	9/1	Natural
Clear Lake	Marshall	45° 41'36"N 97° 21'36"W	11,682	20	1,087	7.6	11/1	Natural
Nine Mile Lake	Marshall	45° 46'04"N 97° 29'26"W	2,722	10	282	4.5	NA	Natural
Pierpont Lake	Day	45° 27'42"N 97° 49'48"W	5,885	16	77	2.2	76/1	Reservoir
Red Iron Lake	Marshall	45° 40'12"N 97° 19'06"W	9,862	15	610	7.5	16/1	Natural
Roy Lake	Marshall	45°42'06"N 97°26'06"W	9,614	21	2,054	14.5	6/1	Natural
<u>Red River Basin</u> HUC # 09020101								
Lake Traverse	Roberts	45° 42'12"N 97° 44'06"W	153,836	12	11,530	40.3	63/1	Natural
White Lake Dam	Marshall	45° 51'36"N 97° 36'54"W	21,184	20	187	6.3	113/1	Reservoir

The Whetstone River starts at the confluence of its major tributaries named the North and South Forks northeast of Milbank, South Dakota; and flows a short distance east where it joins the Minnesota River near the South Dakota/Minnesota border. The North Fork of the Whetstone River drains the southern third of Roberts County. The South Fork of the Whetstone River drains the north half of Grant County and begins as several small spring fed streams located along the east escarpment of the Prairie Coteau. Lake Farley located in Milbank South Dakota is a small dammed reservoir located on the South Fork of the Whetstone River.

The North Fork of the Yellowbank River drains central Grant County and is the confluence of several small springs located along the east escarpment of the Prairie Coteau. The South Fork of the Yellowbank River begins in Deuel County and flows through the southeast corner of Grant County. The North and South Forks of the Yellowbank River join to form the Yellowbank River northwest of Bellingham, Minnesota.

These streams and rivers support a number of wildlife species. Forty-three species of fish occur in the rivers and streams of the Upper Minnesota River Basin, including one state endangered species the blacknose shiner, and one state threatened species the Northern redbelly dace. Several fish found in the Upper Minnesota River Basin are considered rare. These include the carmine shiner, hornyhead chub, central mudminnow, blackside darter, and the only known South Dakota population of the slenderhead darter, found only in a small segment of the Whetstone River. Twelve species of freshwater mussels occur in the Upper Minnesota River Basin. Seven of these species are considered rare.

The climate of the project area is classified as Sub-humid Continental. Mean climatic conditions of the area are:

- Winter Average Daily Minimum Temperature - 4 degrees F
- Summer Average Daily Maximum Temperature - 82 degrees F
- Total Annual Precipitation - 21 inches
- Average Seasonal Snowfall - 31 inches

Approximately 75 percent (=16 inches) of the annual precipitation falls between the months of April to September. Tornadoes and severe thunderstorms occasionally strike. These storms, usually local and of short duration, occasionally produce heavy rainfall. (Data from Webster, SD reporting station)

Agriculture is the major land-use in northeast South Dakota. Ownership and agricultural data for each county in the project area are given in Table 2.

Table 3 lists the beneficial uses for the lakes and reservoirs in the project area. Table 5 lists 303 (d) listing, impaired beneficial uses and reasons for impairment for each of the thirteen lakes and reservoirs in Segment 4.

Table 4 list beneficial uses for project streams and rivers. Table 6 lists 303 (d) status, impaired uses, and reason for impairment.

The most recent integrated report at the time the original project implementation plan was written "***The 2018 South Dakota Integrated Report for Surface Water Quality Assessment"***, prepared by the South Dakota Department of Environment and Natural Resources provides the basis for the values in Tables 5 and 6.

Table 2. Land Ownership and Agricultural Data

		County		
*Data from South Dakota Agricultural 2012 Bulletin No. 72	**Day**	**Grant**	**Marshall**	**Roberts**
Population (2010 census)*	5,710	7,356	4,656	10,149
Land Area* (Acres)	658,329	436,818	536,888	704,856
Land Ownership				
Private (Acres)	626,319		483,944	627,087
Tribal (Acres)	10,033 acres		26,363	66,448
Federal (Acres)	10,679 acres		11,180	5,117
State (Acres)	11,298 acres		15,401	6,204
Agricultural Data				
Number of Farms* (2007)	675	555	523	887
Total Cropland Acres* (2007)	386,994	263,680	328,243	412,361
Corn/Soybeans Acres* (2011)	230,000	193,000	167,500	297,500
Small Grain Acres* (2011)	52,500	30,900	1,000	39,000
CRP (Acres)	38,720	12,233	50,386	34,488
Hay Acres* (2011)	18,000	20,000	34,000	52,000
Range/Pasture (Acres)	155,900	173,138	101,661	139,000
Livestock Numbers* (2007 census)				
Cattle	46,488	60,000	76,918	54,487
Swine	1,581	3,117	2,725	21,460
Sheep	732	2,659	1,177	5,377

Table 3. **Beneficial Uses Designated for Targeted Project Waterbodies**

Beneficial Use:	Amsden Dam	Blue Dog Lake	No. Buffalo Lake	So. Buffalo Lake	Clear Lake	Enemy Swim Lake	Minnewasta Lake	Nine Mile Lake	Pickerel Lake	Pierpont Lake	Roy Lake	So. Red Iron Lake	Lake Traverse	White Lake Dam
(4) Warmwater permanent fish life propagation	X	X	X		X	X			X	X	X	X	X	X
(5) Warmwater semipermanent fish life propagation				X			X	X						
(7) Immersion recreation	X	X	X	X	X	X	X	X	X	X	X	X	X	X
(8) Limited contact recreation	X	X	X	X	X	X	X	X	X	X	X	X	X	X
(9) Fish & wildlife propagation, Recreation and stock watering	X	X	X	X	X	X	X	X	X	X	X	X	X	X
(10) Irrigation Waters													X	

Table 4: **Beneficial Uses Designated for Targeted Project Streams and Rivers**

Beneficial Use:	Lt Minnesota River	Big Coulee Creek	Whetstone River	Whetstone River South Fork	Yellowbank River North Fork	Yellowbank River South Fork
(3) Coldwater marginal fish life propagation						X
(4) Warmwater permanent fish life propagation					X	
(5) Warmwater semipermanent fish life propagation	X		X			
(6) Warmwater marginal fish life propagation				X		
(8) Limited contact recreation	X		X	X	X	X
(9) Fish & wildlife propagation, Recreation and stock watering	X	X	X	X	X	X
(10) Irrigation waters	X	X	X	X	X	X

Table 5. **Water Quality Data and Impaired Beneficial Uses for Priority and Targeted Lakes and Reservoirs**

		Impaired Beneficial Use and Cause*					
Waterbody	**303 (d) Listed (2018**)**	**4**	**5**	**7**	**8**	**9**	**10**
Amsden Dam	Yes	Non (Hg)	NA	Full	Full	Non (Hg)	NA
Blue Dog Lake	Yes	Non (pH)	NA	Full	Full	Full	NA
Clear Lake	No	Full	NA	Full	Full	Full	NA
Enemy Swim Lake	Yes	Non (Hg)	NA	Full	Full	Non (Hg)	NA
Lake Traverse	Yes	Non (Temp)	NA	Full	Full	Full	Full
Minnewasta Lake	Yes	NA	Non (Hg) (chlor-a)	Non (chlor-a)	Non (chlor-a)	Non (Hg)	NA
Nine Mile Lake	Yes	NA	Non (pH)	Full	Non (pH)	Full	NA
No. Buffalo Lake	No	Full	NA	Full	Full	Full	NA
Pierpont Lake	Yes	Non (temp)	NA	Ins	Ins	Full	NA
Pickerel Lake	No	Full	NA	Full	Full	Full	NA
Roy Lake	Yes	Non (Hg)	NA	Full	Full	Non (Hg)	NA
So. Buffalo Lake	Yes	NA	Non (DO/Hg)	Full	Full	Non (Hg)	NA
So. Red Iron Lake	Yes	Non (temp)	NA	Full	Full	Full	NA
White Lake Dam	Yes	Non (chlor-a)	NA	Non (chlor-a)	Non (chlor-a)	Full	NA

* Number corresponds to beneficial uses listed in Table 1
** Source: *The 2018 South Dakota Integrated Report for Surface Water Quality Assessment – SD Dept. of Environment and Natural Resources*
Ins – insufficient data, NA – not applicable, Hg – mercury, DO – dissolved oxygen, chlor-a – chlorophyll a, temp – surface water temperature

Table 6: **Water Quality Data and Impaired Beneficial Uses for Priority and Targeted Streams and Rivers**

		Impaired Beneficial Use and Cause*					
Waterbody	**303 (d) Listed (2018**)**	**3**	**4**	**5**	**6**	**8**	**9**	**10**
Little Minnesota River	No	NA	NA	Full	NA	Full	Full	Full
Whetstone River	No	NA	NA	Full	NA	Full	Full	Full
South Fork Whetstone River	Yes	NA	NA	NA	Full	Non (Bacteria)	Full	Full
North Fork Yellowbank River	Yes	NA	Full	NA	NA	Non (Bacteria)	Full	Full
South Fork Yellowbank River	Yes	Full	NA	NA	NA	Non (Bacteria)	Full	Full
Mud Creek	Yes	NA	NA	NA	Non (DO)	Non (DO)	Full	Full

* Number corresponds to beneficial uses listed in Table 1
** Source: *The 2018 South Dakota Integrated Report for Surface Water Quality Assessment – SD Dept. of Environment and Natural Resources*
Ins – insufficient data, NA – not applicable, DO – dissolved oxygen

Several EPA 319 funded watershed assessment and improvement projects have been completed for lakes and reservoirs located in the project area (Figure 1). Watershed assessments have been completed and published for Amsden Dam, Blue Dog Lake, Enemy Swim Lake, Lake Traverse, Minnewasta Lake, Nine Mile Lake, North and South Buffalo Lakes, Roy Lake, South Red Iron Lake, and White Lake reservoir. Watershed implementation projects were completed for Pickerel Lake in 1996, Enemy Swim Lake in 2005, and Blue Dog Lake in 2006. The town of Pierpont, South Dakota funded a two year study of Pierpont Dam Reservoir's water quality that was completed in 2009. The Clear Lake Betterment Association paid for in-lake water quality testing on Clear Lake from 2009 thru 2010. The James River Water Development District funded water quality testing of Clear and Roy Lakes in 2018 and 2019. Since 2002, water quality studies of Enemy Swim Lake and Pickerel Lake have been funded by the Greater Pickerel Lake Association/Pickerel Lake Conservancy and the Enemy Swim Sanitary Sewer District. These continued thru Segment 4. Final reports for most of these projects can be viewed at www.neglwatersheds.org.

The main non-point pollutants impairing the water quality of project lakes, reservoirs, streams and rivers are fecal coliform bacteria, nutrients, and sediments carried by runoff from agricultural lands located in their watersheds. The goal of this project is to continue protecting and improving water quality of northeast South Dakota glacial lakes by implementing best management practices (BMPs). BMPs reduce the amount of non-point source pollutants entering project water bodies, thus maintaining their assigned beneficial uses.

This was the fourth segment of a multi-year locally led effort to implement best management practices recommended by completed watershed assessments, to build on previous efforts, and protect water quality improvements realized from previous implementation projects. The project was sponsored by the Day Conservation District, with the Grant, Marshall, and Roberts Conservations Districts as co-sponsors. This report will describe the activities completed for Segment 4.

2.0 Project Goals, Objectives, and Activities

This project was the fourth segment of an area wide water quality improvement/protection strategy that began in 2007. The project goal is:

"Restore and protect the water quality of northeast South Dakota glacial lakes."

To attain the goal, the following actions were completed:

- Establish an advisory council made up of local, state, tribal, and federal partners to oversee project activities.
- Develop a strategy that will guide activities in subsequent project segments by providing the tools needed to implement the strategy.
- Implement BMPs that reduce nutrient, fecal coliform bacteria, and sediment loads to targeted waterbodies.
- Implement a public outreach program to inform project area stakeholders about the opportunities for involvement in and progress of the project.
- Track project milestones and progress toward reducing nutrient, fecal coliform bacteria and sediment loadings to targeted waterbodies.

Objective 1: Complete activities that will lead to successful protection and restoration of the beneficial uses of lakes and reservoirs in northeast South Dakota.

Task 1: Institute the project management structure developed during Segment 1 to guide successful protection and restoration of lakes and reservoirs in northeast South Dakota.

An advisory council made-up of local, state, tribal, and federal partners will continue to manage the Northeast Glacial Lakes Watershed Improvement and Protection Project. The council was formed during the first segment of the project in 2007, and will oversee the implementation of the strategic plan completed during Segment 1, annually review the practice manual that establishes priorities for BMP implementation, and develop a work plan for subsequent project segments. Revised memoranda of understanding (MOU) that define the responsibilities and obligations of each district in the support and execution of Segment 4 will be entered into between the Day, Deuel, Grant, Marshall, and Roberts Conservation Districts. A Project Coordinator and seasonally hired Conservation Technicians employed by the project sponsor will aid in the implementation of project activities within the five county project area.

Product:

1. Project management structure.

Milestones:	Planned	Total Completed
Advisory council	1	1
Memoranda's of Understanding	5	5

Resource agencies and organizations represented on the advisory council include:

Natural Resources Conservation Service (NRCS)
South Dakota Dept. of Agriculture and Natural Resources (DANR)
United States Fish and Wildlife Service (USFWS)
South Dakota Dept. of Game, Fish, and Parks (SDGFP)
East Dakota Water Development District (EDWDD)
James River Water Development District (JRWDD)
Day, Deuel, Grant, Marshall and Roberts Conservation Districts
Sisseton Wahpeton Oyate
Clear Lake Betterment Association
Roy Lake Associations
Nine Mile Lake Home Owners Association
Pickerel Lake Sanitary Sewer District
Pickerel Lake Conservancy
Enemy Swim Sanitary Sewer District

Objective 2: Install best management practices (BMPs) in critical areas to protect and restore the beneficial uses of lakes and reservoirs in northeast South Dakota.

The BMPs planned are based on those recommended in the assessments and TMDLs, and identified during implementation of the project work plan(s). It is anticipated that as additional studies and TMDLs are completed for water bodies in the project area, the suite of BMPs offered will change accordingly.

Task 1: Install BMPs that reduce nutrient, sediment, and fecal coliform bacteria nonpoint source pollution originating from livestock operations.

Technical and financial assistance will be provided to livestock producers to reduce nonpoint source pollution associated with livestock grazing operations.

Product:

1. Grazing Management Improvements

Through conservation planning, pasture health and rangeland condition will be improved on 4,000 acres of pasture/rangeland. Resource technicians will work with landowners to promote and implement basic grazing management principles such as rotation, rest, grass banking, and other BMPs that sustain quality grasslands. If needed, financial assistance for implementing conservation practices like perimeter exclusion fence and water development (ponds, pipelines, tanks, wells, solar systems, nose pumps) will come from the EPA 319 Clean Water Grant. Additional funding may be available from the Natural Resource Conservation Service's Environmental Quality Incentive Program (EQIP), US Fish &Wildlife Service's "Partners for Wildlife" and S.D. Game, Fish, and Parks "Private Lands Programs.

Milestones:	Planned	Total Completed
Improved Pasture/Rangeland	4,000 acres	1,136 acres

The project did not meet its goal for this product.

Task 2: Install BMPs that reduce sediment loads entering project water bodies by reducing wind and water erosion from upland and riparian areas, shorelines and streambanks.

Technical and financial assistance will be provided to producers to reduce nonpoint source pollution associated with riparian areas.

Product:

1. **Riparian buffers**

To reduce nutrient, fecal coliform bacteria, and sediment loads entering project water bodies from lakeshore and stream bank segments degraded by livestock, or riparian areas currently being cropped, vegetative buffers will be established. Establishment of riparian buffers may require the installation of fence and the development of alternative watering sources. The Continuous Conservation Reserve Program (CCRP) CP21 Filter Strips, CP23 and CP30 Marginal Pastureland-Wetland Buffer administered by USDA will be the preferred options for providing financial assistance for this product. If a site does not qualify for CCRP, riparian BMPs will be funded using EPA 319 funds. The financial assistance from EPA 319 will follow the docket established by USDA for CCRP and requirements listed in the project's practice manual.

Milestones:	Planned	Total Completed
319 Riparian Area Management	260 acres	261 acres
Continuous CRP	350 acres	1,131 acres

The majority of riparian buffers implemented during this project were located in the Minnesota River watershed in Grant and Roberts Counties, South Dakota (Figure 6). During this project 1,131 acres of CCRP were enrolled. Of these acres EPA 319 grant funds were utilized to pay an additional incentive payment on 158 acres. EPA 319 grant funds were used to fund 90 acres of buffers beyond the CCRP 120 foot maximum buffer width, 21 acres of buffers that did not qualify for CRP. The majority of these buffers were Marginal Pastureland Wetland Buffers (CP-30) placed on pasture and rangeland adjoining perennial streams in the Minnesota River watershed. A total of 62,457 lineal feet of streambank and shoreline have been protected with riparian buffers. 117 acres of wetlands were also restored with these contracts.

The project met its goals for these products.

Product:

2. Critical Area Planting

To reduce runoff from cropland adjacent to riparian areas where CRP and RAM are not applicable or established, plantings of tame grass and legumes or native grass and forbs will be established for haying or grazing purposes on critical areas adjacent to lakes and streams or other conveyances. Priority was given to land deemed by NRCS as highly erodible.

Milestones:	**Planned**	**Total Completed**
Critical Area Planting	728 acres	456 acres

The project did not meet its goal for this product.

Product:

3. Grassed Waterways

To reduce water erosion on cropland located on land where CRP is not applicable, plantings of tame and/or exotic grasses and legumes will be established and eroded gullies will be reshaped.

Milestones:	**Planned**	**Total Completed**
Grassed Waterways	5,000 feet	4,960 feet

The project did not meet its goal for this product.

Product:

4. Shoreline and Streambank Stabilization

Eroding shorelines and streambanks will be stabilized using hard (rip-rap) and/or soft (vegetative) practices, and livestock stream crossings will be constructed to provide a stabilized trail for livestock to reduce streambank erosion and promote better grazing distribution.

Milestones:	**Planned**	**Total Completed**
Shoreline/Streambank Stabilized	1,700 feet	3,920 feet
Stream Crossings	23	19

A total of 3,326 feet of streambank was stabilized utilizing rock rip-rap. An additional 594 feet of stream bank were stabilized by the implementation of stream crossings. Stream crossings reduced the impact of cattle crossing 88,394 lf. of stream bank. Designs for an additional 11 stream crossings were completed but these crossings were not constructed during this segment.

The project exceeded its goal for shoreline and streambank stabilization.

Objective 3: Implement a public outreach program to inform project area stakeholders about the opportunities for involvement in, and progress of the project.

Task 1: Develop and implement a multimedia outreach program to promote the project, offer opportunities for involvement, and inform the public of project progress.

Product:

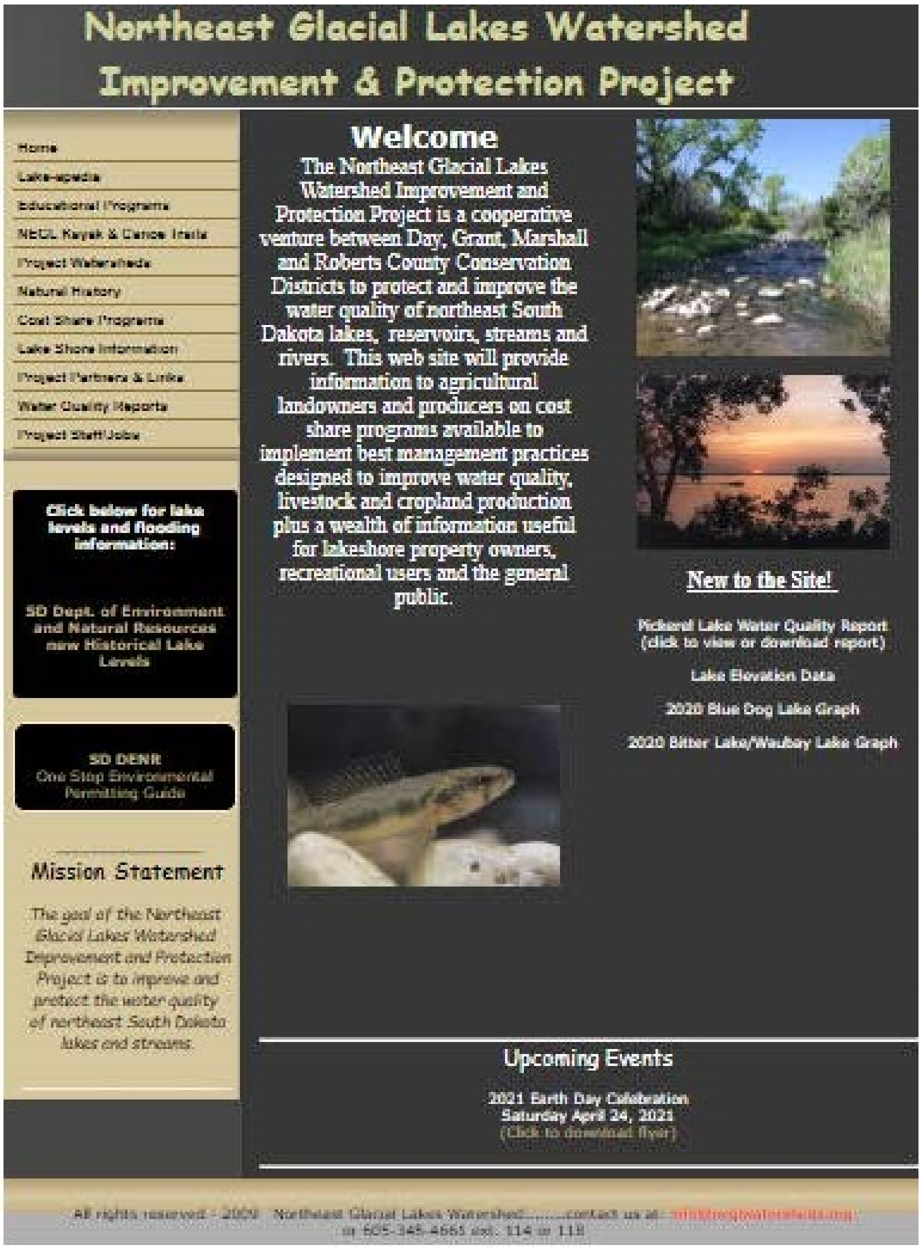
1. Project web site

A project web site developed during Segment 1 will be maintained and updated to inform and educate the public on project opportunities and activities. The web site will contain information on each water body, downloadable fact sheets, calendar of events, workshops and meetings, information on BMPs available to landowners, photo gallery, project articles and news releases, and direct links to other websites useful to agricultural producers (weather, USDA, extension).

Milestones:	**Total Completed**
Number time’s site accessed	4,688

Number above indicates visitors to the website from August 2017 thru December 2019. The website: www.neglwatersheds.org was updated as needed.

Figure 3. Home Page of the NEGL Project Website



Product:

2. News Releases

Local radio, television, and print media will be used to inform the public about project opportunities and activities.

Milestones:	Planned	Total Completed
New Articles	8	11
Radio/Television Interviews	4	2

The Project Coordinator appeared on radio station KBWS "Conservation Report" program on two separate dates to promote project activities and discuss conservation issues. The radio station is located in Sisseton, South Dakota and broadcast coverage includes the entire project area. The radio program ended in 2019. Articles and announcements about the project were published in the Day, Marshall, and Robert's conservation district newsletters that are mailed to local producers, and Pickerel Lake Conservancy and Enemy Swim Sanitary District newsletters. Announcements of upcoming project activities were posted on the NEGL website.

Product:

3. Direct personal contact with and involvement in project opportunities

Information and educational displays, programs, public meetings, and workshops will provide project area residents a direct personal contact with the project and project involvement opportunities, and students of all ages an opportunity to learn about natural resources and resource conservation in the project area. Print material will be developed and distributed at these public events.

Milestones:	Total Completed
Farm, Home and Sports Show	1
Water Festivals (Aberdeen, Brookings, Huron, Pierre)	7
123 to the Refuge	3
Step Outside Programs	4
EcoEd Day Program	4
Northeast Range and Land Contest	4
South Dakota Envirothon	1
Lake and Stream Ecology Workshops	2
Environmental/Outdoor Education Camps (NeSoDak)	16

Additional informational meetings and educational programs project personnel presented or participated in:

8/1/2017 Leopold Award Tour, Blue Bell Ranch – Deuel County, Stream Ecology

9/13/2017 Stream Ecology Field Trip, Abbey of the Hills Campground – Grant County, Waverly/South Shore High School/Sisseton Wahpeton Community College Environmental Science Class

12/1/2017 SD Envirothon Roadshow, NeSoDak Bible Camp – Day County, Milbank and Waubay High School

2/26/2018 South Dakota Wildlife Society Annual Meeting – Oacoma, SD, presentation on northeast South Dakota streams and rivers

5/17/2018 Webster Preschool Class – Webster, SD, presentation on aquatic invertebrates

8/23/2018 Native American Fish and Wildlife Conference, Hankinson, ND, presentation on NEGL Project

2/21/2019 Enemy Swim Day School, Waubay, SD, Math and Science Night, aquatic activities

4/22/2019 Earth Day, Bramble Park Zoo, Watertown, SD, booth aquatic animals

5/10/2019 Stream Ecology Field Trip, Hartford Beach State Park – Grant Co. SD, Milbank High School Science Class

2/26/2020 South Dakota Wildlife Society Annual Meeting – Oacoma, SD, presentation on northeast South Dakota streams and rivers invertebrate study

10/3/2020 Sica Hollow State Park, Roberts Co. SD, Fall Walk-About, booth aquatic animals

4/24/21 – Earth Day Celebration, Fort Sisseton State Park, booth aquatic animals

<u>Figure 4</u>. 4th Grade Students View an Aquatic Food Chain at the Aberdeen Water Festival

A total of 7,025 persons attended the programs and presentations by NEGL personnel listed above during Segment 4 of the project. Programs were presented to a variety of age groups from 1st through 3rd grade students (123 to the Refuge), 4th grade students Northern Prairie (Aberdeen, SD) and Big Sioux (Brookings, SD), Pierre and Huron water festivals), 5th & 6th grade students (NeSoDak Lake Ecology Classes), 7th and 8th grade students (EcoEd Day), high school and college age students and adults (Lake and Stream Ecology and Water Quality Workshops and field trips). Lake and Stream Ecology and Water Quality Workshop college graduate and undergraduate students could earn 1 college credit hour for completing the workshop, elementary and secondary teaches can earn 1 college credit hour or 2 Continuing Education Credits (CEUs) for completing the workshop. Project personnel also judged several science fairs during this segment at the Waubay and Waverly/South Shore High Schools and Enemy Swim Day School, and the Northeast South Dakota Regional Science Fair at Northern State University. Due to the Covid-19 pandemic a majority of information and education activities planned for the years 2020 and 2021 were cancelled

Figure 5. Participants of the 2018 Lake and Stream Ecology Workshop collecting aquatic invertebrates from Chekapa Creek, Pickerel Lake, Day County

Objective 4: Monitor, Evaluate, and Report Project Progress

Task 1: Evaluate the effectiveness of selected past watershed efforts to determine if any BMP implementation needs to be made in future segments of this project to protect or improve water quality of selected lakes and reservoirs.

Product:

1. Water quality data

Comprehensive in-lake water quality sampling will be conducted on Clear, Enemy Swim, Pickerel, and Roy Lakes. Composite surface and bottom water samples will be taken during May, June, July, August, and September from two to three sites each water body. Laboratory analysis will be conducted by RMB Laboratories located in Detroit Lakes, MN. Data from these monitoring programs is used to evaluate the effectiveness of past watershed efforts and determine if any BMP implementation needs to be made in this and future segments of the project to protect or improve water quality of these lakes.

Milestones:	**Total Sample Sets Collected**
Blue Dog Lake	1
Clear Lake	8
Enemy Swim Lake	14
Pickerel Lake	19
Pickerel Lake Tributary	42
Roy Lake	8
South Buffalo Lake	1
South Red Iron Lake	1

Water quality samples were collected from Blue Dog Lake, Clear Lake, Enemy Swim Lake, Pickerel Lake and its tributaries, Roy Lake, South Buffalo Lake, and South Red Iron Lake during this Segment. Water quality testing on Enemy Swim and Pickerel Lakes has been on-going since 2002, with surface and bottom samples collected from June thru August on Enemy Swim Lake, and May thru September on Pickerel Lake. Monthly tributary samples were collected from seven sites located in Pickerel Lake's watershed from April thru September 2019. Lab fees are paid for by the Pickerel Lake Conservancy and the Enemy Swim Sanitary Sewer District. Clear Lake and Roy Lake were sampled during the summer of 2018 (June, July, and August) and 2019 (June). Funding for water quality testing of these two lakes was provided by the James River Water Development District. RMB Laboratories of Detroit Lakes, Minnesota completed the analysis of these samples. The Dakota WaterWatch program sponsored by the East Dakota Water Development District provided funding and equipment for surface samples from Blue Dog, South Buffalo and South Red Iron Lakes during the month of August in 2018, however this program was discontinued in 2019. Further discussion on water quality testing results can be found beginning on page 39.

Task 2: Reports detailing project activities as required by the U.S. Environmental Protection Agency, South Dakota Department of Environment and Natural Resources; and participating agencies and associations will be prepared and submitted

Product:

1. **Project reports**

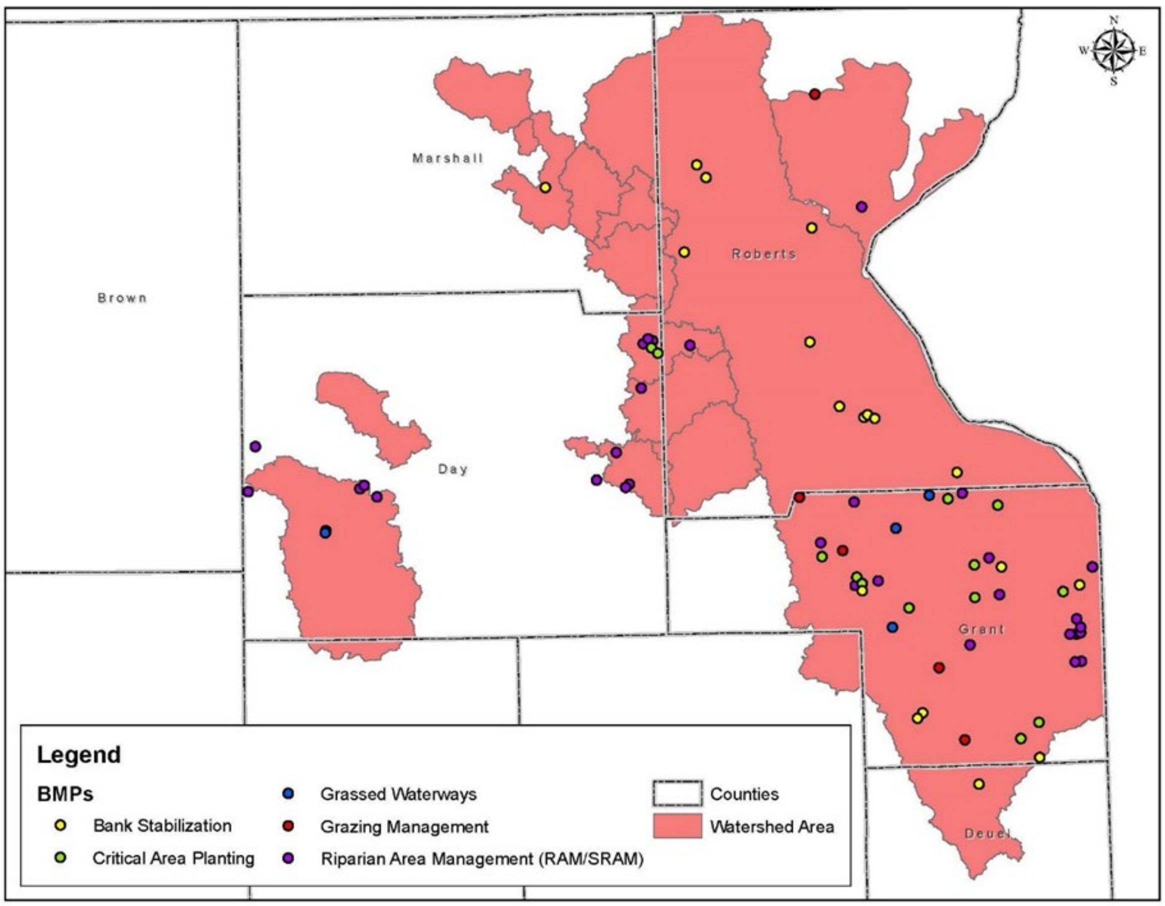
Milestones:	**Total Completed**
Annual Reports (GRTS)	3
Sponsor/Partner Reports	60
Final Report	1

Reports are given to the project sponsors and co-sponsors that include the Day, Grant, Marshall, and Roberts Conservation Districts during monthly Board of Supervisor meetings, and to other project partners including East Dakota Water Development District, Enemy Swim Sanitary Sewer District, Pickerel Lake Conservancy and the Sisseton Wahpeton Oyate.

3.0 Best Management Practices Implemented

Best management practices (BMP) developed and implemented during Segment 4 include riparian buffers on marginal pastureland and cropland, improved grazing management, streambank and shoreline stabilization, grass waterways and critical area plantings. BMP program descriptions follow. Figure 6 shows the locations of all BMPs implemented during this segment.

Figure 6. Location of Best Management Practices Implemented During Segment 4



Riparian Area Management Program (RAM)

Funding Source

The EPA 319 Clean Water Grant was utilized to increase rental rates for Conservation Reserve Program (CRP) acres and pay for additional buffer (120+) acres or ineligible CRP acres as described below. Payments for eligible CRP acres were made through the USDA Conservation Reserve Program administered by the Farm Service Agency (FSA).

Purpose

The Riparian Area Management Program was designed to reduce non-point source pollutants from entering surface waters from adjoining cropland, pastures, and animal feeding operations.

Eligibility

Eligible land must be located in a project watershed and must be adjacent to a stream or wetland draining to a project lake, or shoreline adjacent to a project lake. Priority was given to lands located along streams deemed impaired by the South Dakota Dept. of Environment and Natural Resources (See Table 6). This program was for agricultural land only and not available for residential or commercial properties. EPA 319 Clean Water grant funds for RAM were utilized to increase the soil rental rate for acres enrolled in the CRP program, and for land not eligible under USDA's Conservation Reserve Program (CRP) under the following conditions.

- Landowner has applied for and accepted into USDA CRP program; however, a small portion of land does not qualify and would leave this portion isolated from the main operation for cropping, haying, or grazing utilization (field corners etc.).

- Land that does not qualify for a USDA CRP program because of current land use (or allocation on USDA CRP funds have been reached) that would however, be beneficial to water quality if utilized as a riparian buffer will be eligible for RAM funding.

Lands that are currently grazed or cropped up to the lake shore or stream bank will be a high priority. Lands that are currently maintained as a riparian area will have a lower priority.

Requirements

Proof of ownership was required for landowners. If the applicant did not own the land, a written affidavit defining the relationship between the landowner and applicant must be provided to the Conservation District covering the entire length of the contract period. The landowner must sign a contract and conservation plan with the Day, Deuel, Grant, Marshall, or Roberts Conservation

Districts for the RAM program that will equal the length of time of the CRP contract with USDA (10 to 15 years). As defined in the contract, failure to implement all of the required practices or maintain the buffer for the length of the contract, will require repayment of all funds and liquidated damages of twenty-five percent (25%) of the total payments disbursed to the participant. If the status of agricultural land enrolled into the RAM program changes to residential or commercial lakeshore property, all funds dispersed to the participant must be repaid to the Conservation District unless a minimum of seventy-five percent (75%) of the buffer zone along the lakeshore is maintained under the new land-use.

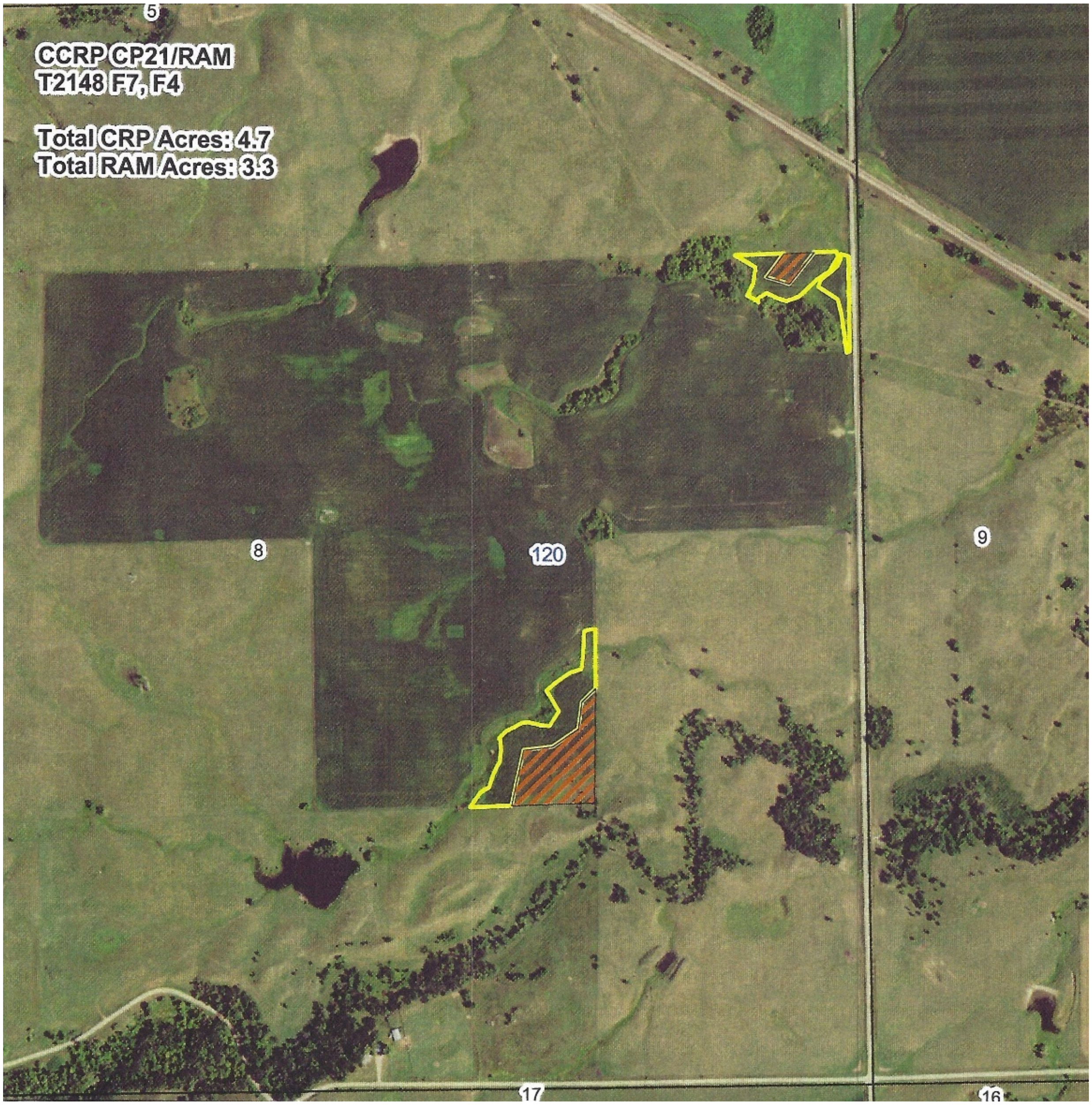
Cost Share Payments

RAM soil rental rates were the same as those available for CRP programs including; CP21 – Filter Strips, CP22-Riparian Buffers, CP29-Marginal Pastureland Wildlife Habitat Buffer, CP30 Marginal Pastureland Wetland Buffer. RAM funds were used to increase the CRP soil rental rate by $5 per acre. If the RAM program was used to add adjacent acres to a USDA CRP contract, total RAM acres could not exceed thirty-five percent (35%) of the total acres enrolled in CRP.

RAM funds were used to pay seventy-five percent (75%) of the eligible CRP soil rental rates. The remaining twenty-five percent (25%) were considered landowner matching funds. All RAM payments were made lump sum to the landowner upon completion of required practices and approval of all contracts; including completion of all contract requirements of adjoining CRP acres.

Eligible conservation practices for implementing riparian buffers included buffer fencing, in-stream livestock crossings, alternative water sources (nose pumps, solar, stock dams, wells, pipelines, and stock tanks).

<u>Figure 7.</u> Example of a CRP/RAM buffer implemented during this Segment



Streambank and Shoreline Stabilization

Funding

Funds for stabilizing eroding streambank and shoreline were available from EPA 319 Clean Water Grant and the Environmental Quality Incentive Program (EQIP).

Purpose

Streambank and shoreline stabilization was available for producers who wanted to implement rock rip-rap or vegetative practices to protect and restore eroding areas or construct livestock stream crossings to improve streambank health and also improve grazing distribution.

Eligibility

Eligible land had to be located in a project watershed. High priority was given to lands adjacent to major streams and rivers. Funding was available for protecting and restoring lake shorelines but only on agricultural or public lands. Funding was not available for private lake lots.

Requirements

Proof of ownership was required for landowners. If the applicant did not own the land, a written affidavit defining the relationship between the landowner and applicant must be provided to the Conservation District covering the entire length of the contract period. The landowner must sign a contract and conservation plan with the Day, Deuel, Grant, Marshall, or Roberts Conservation Districts stating he will implement the conservation practices as described in the conservation plan in the location shown on the conservation plan map for the life span of the practice (typically 10 to 20 years). As defined in the contract, failure to implement all of the required practices or maintain the practice for the length of the contract, will require repayment of all funds and liquidated damages of twenty-five percent (25%) of the total payments disbursed to the participant.

Cost Share Payments

EPA 319 Clean Water grant funds were available to pay up to 60% of the total cost of construction of both stream crossings and streambank stabilization. The most current NRCS docket was used to determine cost of streambank stabilization and crossings that utilized EQIP funds.

<u>Figure 8.</u> Stream crossing Roy Lake Watershed Marshall County.

<u>Figure 9.</u> Large grass waterway with rip rap Grant County.

Grassed Waterways

Funding

Funds for constructing grassed waterways were available from EPA 319 Clean Water Grant, South Dakota Department of Agriculture's Commission Grant, and the Environmental Quality Incentive Program (EQIP).

Purpose

Grassed waterways were available for producers to restore gullies and washouts on cropland, and protect these areas by reshaping and planting a permanent vegetative cover of grass.

Eligibility

Eligible land had to be located in a project watershed.

Requirements

Proof of ownership was required for landowners. If the applicant did not own the land, a written affidavit defining the relationship between the landowner and applicant must be provided to the Conservation District covering the entire length of the contract period. The landowner must sign a contract and conservation plan with the Day, Deuel, Grant, Marshall, or Roberts Conservation Districts stating he will implement the conservation practices as described in the conservation plan in the location shown on the conservation plan map for the life span of the practice (typically 10 to 20 years). As defined in the contract, failure to implement all of the required practices or maintain the practice for the length of the contract, will require repayment of all funds and liquidated damages of twenty-five percent (25%) of the total payments disbursed to the participant.

Cost Share Payments

Project grant funds were available to pay up to 60% of the total cost of construction of grassed waterways. The most current NRCS docket was used to determine cost of streambank stabilization and crossings that utilized EQIP funds.

Critical Area Planting

Funding

Funds for planting areas deemed critical were available from EPA 319 Clean Water Grant and the South Dakota Department of Agriculture's Commission Grant.

Purpose

To reduce runoff from cropland adjacent to riparian areas where CRP and RAM are not applicable or established, plantings of tame grass and legumes or native grass and forbs will be established for haying or grazing purposes on critical areas adjacent to lakes and streams or other conveyances. Priority was given to land deemed by NRCS as highly erodible.

Eligibility

Eligible land had to be located in a project watershed.

Requirements

Proof of ownership was required for landowners. If the applicant did not own the land, a written affidavit defining the relationship between the landowner and applicant must be provided to the Conservation District covering the entire length of the contract period. The landowner must sign a contract and conservation plan with the Day, Deuel, Grant, Marshall, or Roberts Conservation Districts stating he will implement the conservation practices as described in the conservation plan in the location shown on the conservation plan map for the life span of the practice (typically 10 to 20 years). As defined in the contract, failure to implement all of the required practices or maintain the practice for the length of the contract, will require repayment of all funds and liquidated damages of twenty-five percent (25%) of the total payments disbursed to the participant.

Cost Share Payments

Project grant funds were available to pay up to 60% of the total cost of construction of grassed waterways. The Commission Grant docket from the South Dakota Dept. of Agriculture was used to determine cost of streambank stabilization and crossings that utilized EQIP funds.

Range and Pastureland Improvement and Grazing Management

Funding

Funds for improving range and pastureland management were available from the EPA 319 Clean Water Grant.

Purpose

To improve the management of range and pastureland by utilizing practices like cross fencing, alternate water sources, and rotational grazing.

Eligibility

Eligible land had to be located in a project watershed.

Requirements

Proof of ownership was required for landowners. If the applicant did not own the land, a written affidavit defining the relationship between the landowner and applicant must be provided to the Conservation District covering the entire length of the contract period. The landowner must sign a contract and conservation plan with the Day, Grant, Marshall, or Roberts Conservation Districts stating he will implement the conservation practices as described in the conservation plan in the location shown on the conservation plan map for the life span of the practice (typically 10 to 20 years). As defined in the contract, failure to implement all of the required practices or maintain the practice for the length of the contract, will require repayment of all funds and liquidated damages of twenty-five percent (25%) of the total payments disbursed to the participant.

Cost Share Payments

Project grant funds were available to pay up to 60% of the total cost of practices implemented to improve range and pastureland use.

Pickerel Lake Shoreline Restoration

While not part of the original Segment 4 project implementation plan, lake shore restoration was implemented on Pickerel Lake after a 2016 survey was completed to determine the extent of shoreline alteration along the lake (Figure 10).

The full survey report can be viewed at;
http://neglwatersheds.org/images/Revised_Pickerel_Shoreline_Report.pdf

The South Dakota Dept. of Game, Fish and Parks and Pickerel Lake Conservancy applied for and were awarded a $20,000 grant from the Midwest Glacial Lakes Partnership. Both the SD GFP and PLC each contributed $5,000 toward the grant as match. The grant funds were used to purchase planting equipment and native grasses and forbs to be planted along the lakes shoreline. To date, buffers have been planted on twenty-six properties equaling around 2,000 feet of shoreline. Buffers range in width from 10 to 15 feet wide (Figure 12). Grasses and forbs are grown at the Big Sioux Nursery, Watertown, SD, from seeds collected from northeast South Dakota. NEGL project personnel, lake property owners, and GFP officials prepped sites and planted the buffers (Figure 11).

Figure 10. Pickerel Shoreline Survey Map

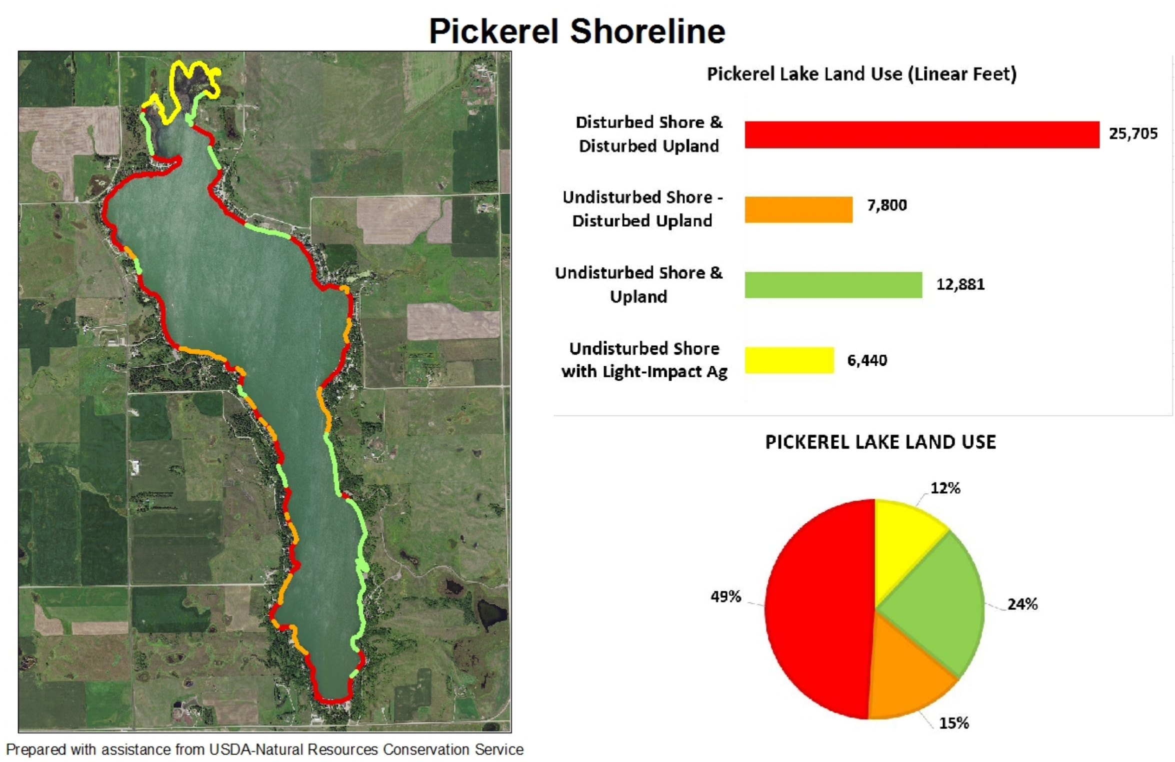


Figure 11. **Project personnel planting shoreline buffer site.**

Figure 12. **Completed shoreline buffer**

4.0 Monitoring Results

4.2 BMP Effectiveness Evaluations

The effectiveness of Best Management Practices (BMPs) installed and load reductions achieved relative to improvement in water quality were evaluated using tools available from SD Dept. of Environment and Natural Resources and Natural Resources Conservation Service. Reductions for BMPs implemented during this segment are given in Table 7 and were calculated using the StepL Model.

Table 7. Load Reductions from Implemented BMPs

	Load Reductions		
	Nitrogen	Phosphorus	Sediment
Watershed	**(lbs/yr)**	**(lbs/yr)**	**(tons)**
Upper James River Basin HUC #10160005			
Amsden Dam	4994	1724	2387
Roy Lake	83	32	52
Total:	**5077**	**1756**	**2439**
Upper Big Sioux River Basin HUC #10160010			
Blue Dog Lake	636	166	86
Enemy Swim Lake	65	21	13
Pickerel Lake	523	177	110
Total:	**1224**	**364**	**209**
Red River Basin HUC #09020101			
Lake Traverse	267	41	21
Total:	**267**	**41**	**21**
Upper Minnesota River Basin HUC #07020001			
Little Minnesota River	420	161	261
North Fork Whetstone River	4535	1244	1414
South Fork Whetstone River	1258	421	357
North Fork Yellowbank River	6797	2129	1739
South Fork Yellowbank River	699	245	263
Total:	**13709**	**4200**	**4034**

Implementation of best management practices resulted in a total calculated reduction of 20,277 lbs. per year of nitrogen; 6,361 lbs. per year of phosphorus; and 6,703 tons per year of sediment in the hydrologic units listed above.

4.3 Surface Water Improvements

In-lake sampling of several project lakes continued from Segment 3. Water quality monitoring will provide data to track changes due to the implementation of best management practices in these lakes watersheds and major changes in land-use like the expiration of Conservation Reserve Program contracts, and conversion of pasture and native range to row crops.

Water quality parameters, that were monitored included:

Total Kjeldahl - N	Total Suspended Solids
Ammonia - N	Chlorophyll a
Total Phosphorus	Total Dissolved Phosphorus

Analysis was completed at RMB Laboratories located in Detroit Lakes, MN.

Water quality parameters that were monitored by the local sampler included:

Dissolved Oxygen	Field pH	Water Temperature
Air Temperature	Field Observations	Seechi Depth

During this segment water sampling procedures were modified to consider aquatic invasive species. Sampling equipment including carboys used to hold sample water and VanDorn Bottles were rinsed immediately after use with distilled water before being used in the next lake. Boat plugs were pulled to follow state law, and trailers inspected at each lake for macrophytes. Two invasive species, the curly-leaf pondweed and zebra mussels, now occur in two lakes sampled during this segment.

Clear Lake

In-lake sampling of Clear Lake occurred during the months of June, July and August in 2018 and June 2019. Composite surface and bottom samples were collected from three sites located on the lake. Water quality samples and field data collected from Clear Lake during this segment showed the lake meeting all state water quality standards for its assigned beneficial uses.

Funding for sampling of Clear Lake during this segment was provided by the James River Water Development District. RMB Laboratories of Detroit Lake, MN analyzed the water quality samples.

Enemy Swim Lake

In-lake sampling of Enemy Swim Lake occurred during the months of August 2017; June, July and August 2018; and June, July and August 2019. Composite surface and bottom samples were collected from three sites located on the lake. Water quality samples and field data collected from Enemy Swim Lake during this segment showed the lake meeting all state water quality standards for its assigned beneficial uses (Table 3).

The Enemy Swim Sanitary Sewer District provided funding to pay for in-lake water quality sample lab fees. A comprehensive water quality report on Enemy Swim Lake was completed by RMB Laboratories, Detroit Lakes, MN, for the Enemy Swim Sanitary Sewer District utilizing data from several former projects and Segments 1 through 4 of this project beginning in 1991 through 2019. This report is given in Appendix A. During 2020, the South Dakota Dept. of Environment and Natural Resources collected surface samples as part of their "Rotating Lake Basins Project".

Pickerel Lake

In-lake sampling of Pickerel Lake occurred during the month of August 2017; June, July and August 2018; June, July and August 2019. Composite surface and bottom samples were collected from three sites located on the lake except for 2020 when only bottom samples were collected during June, July and August. During 2020, the South Dakota Dept. of Environment and Natural Resources collected surface samples as part of their "Rotating Lake Basins Project". Tributary samples were collected from seven sites in Pickerel Lake's watershed from April thru September 2019 (Figure 15). In 2019, the Pickerel Lake Conservancy hired RMB Laboratories of Detroit Lakes, MN to compile and report on water quality data collected during this and previous segments of the project. This report is given in Appendix B.

In 2018, project personnel discovered curly-leaf pondweed growing in Pickerel Lake (Figure 13), and in 2020 project personnel found the first zebra mussels in Pickerel Lake (Figure 14), the first confirmed occurrence of this invasive species in northeast South Dakota. The project has had to change its water sampling protocol due to the occurrence of these aquatic invasive species.

<u>Figure 13.</u> Curly-leaf pondweed, Pickerel Lake

<u>Figure 14.</u> Zebra mussel covered rock from Pickerel Lake's shoreline, July 2021

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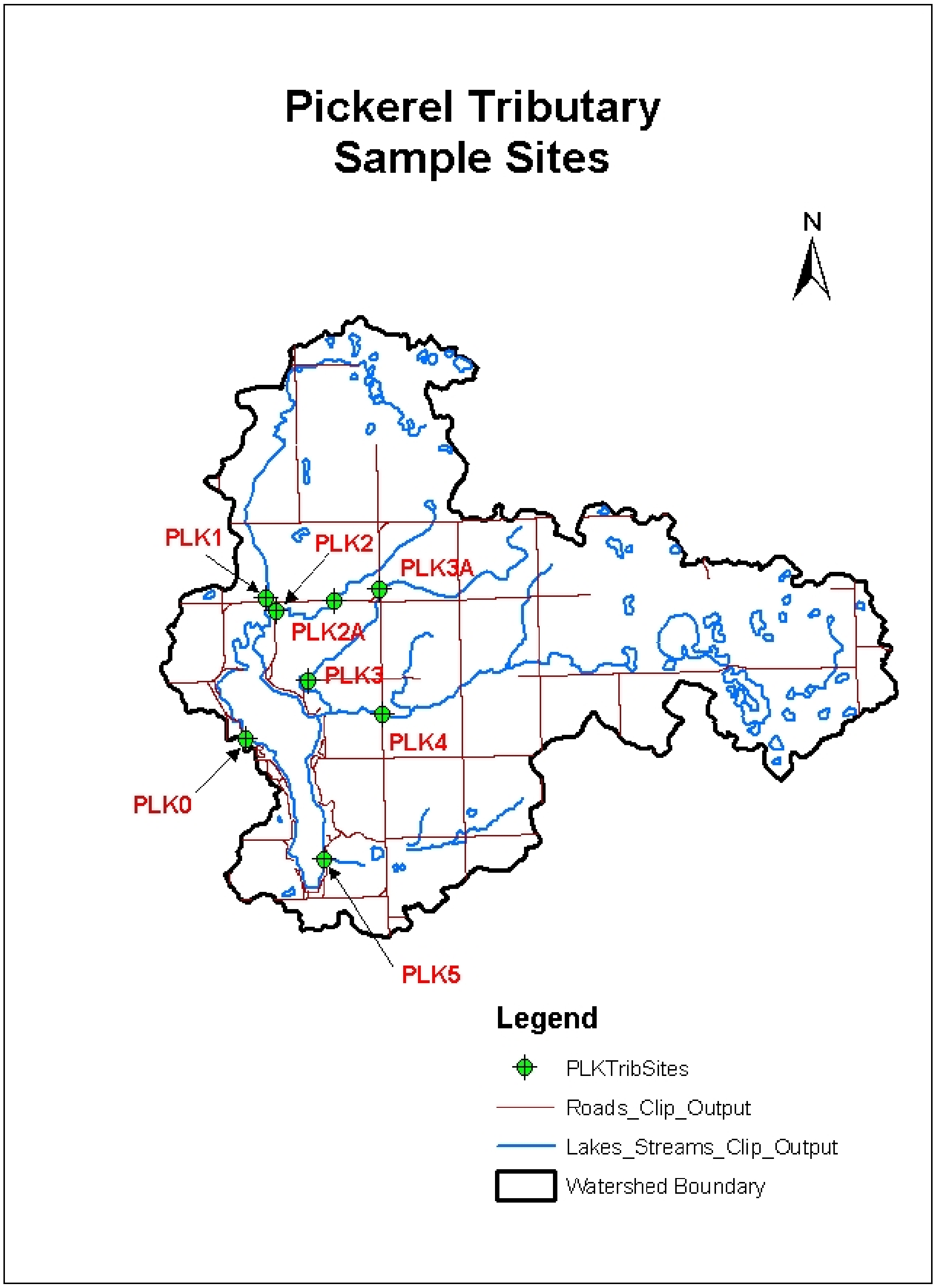
<u>Figure 15.</u> **Pickerel Lake Tributary Sampling Sites**



Roy Lake

In-lake sampling of Roy Lake occurred during the months of June, July and August in 2018 and June 2019. Composite surface and bottom samples were collected from three sites located on the lake. Water quality samples and field data collected from Roy Lake during this segment showed the lake meeting all state water quality standards for its assigned beneficial uses.
Funding for sampling of Roy Lake during this segment was provided by the James River Water Development District. RMB Laboratories of Detroit Lake, MN analyzed the water quality samples.

4.7 Best Management Practice Operation and Maintenance

Producers receiving cost share are required to sign a contract with the co-sponsoring Conservation District, and project sponsor. The contract lists the practices being cost shared, the life span of each practice, and whether the EPA 319 funded practice is contingent upon the successful implementation of a USDA practice like the Conservation Reserve Program. The length of the contract is based upon the longest lifespan of the implemented practices. The lengths of most contracts are ten to twenty years. Field checks to ensure the practice was properly implemented are made by project sponsor, or NRCS personnel before cost share payments are made to the producer. Producers who do not maintain practices funded by EPA 319 grant funds for the full length of the contact are required to repay the sponsoring Conservation District cost share funds, plus liquidated damages of twenty-five percent.

5.0 Coordination Efforts

The lead sponsor for this project was the Day County Conservation District. The district hired a Project Coordinator who administered grant funds and coordinated day-to-day work plan activities, and a seasonal Resource Conservation Technician who worked one-on-one with watershed producers in planning and implementing best management practices. An advisory council with representatives from the resource agencies and organizations listed below and in Sections 5.3 and 6.0 advised the project sponsor, and developed priorities, practice manuals, work plans, and strategies for this and future project segments.

5.1 Coordination from Other State Agencies

The following state agencies provided or administered funds utilized to implement this project.

- **South Dakota Department of Environment and Natural Resources (SD DENR)** – Administered EPA Section 319 grant funds. SD DENR personnel provided oversight of all project activities through on-site office visits, watershed tours, review/approval of reports, and approval of payment requests for 319 funds.

- **South Dakota Department of Agriculture Division of Resource Conservation and Forestry** – Funding through the South Dakota Coordinated Soil and Water Conservation Commission Grant for project personnel wages and benefits, administrative costs, and cost share for implementation of conservation practices.

  (The above two agencies were combined in 2021 and are now called the South Dakota Department of Agriculture and Natural Resources – DANR)

- **South Dakota Game, Fish, and Parks (GFP)** – Technical advice and cost-share funds through the Department's "Private Lands Programs" for grazing improvements, wetland restoration, grass seeding. Funding for shoreline restoration on Pickerel Lake.

5.3 Federal Coordination

The following federal agencies provided or administered funds utilized to implement this project.

- **USDA Natural Resources Conservation Service (NRCS)** – Provided technical assistance for BMPs through District Conservationists, Soil and Range Conservationists, and Tribal Liaison. Provided program funds for the Environmental Quality Incentive Program (EQIP) and Conservation Collaboration Grant (CCG).

- **USDA Farm Service Agency (FSA)** – Provided program funds for the Conservation Reserve Program (CRP).

- **U.S. Fish and Wildlife Service (FWS)** – Technical advice and cost-share funds through the "Partners for Fish and Wildlife" program for grazing improvements, small dams, wetland restoration, and grass seeding.

5.4 USDA Programs

Two USDA program were utilized during this segment. The Conservation Reserve Program (CRP) administered by the Farm Service Agency paid producers to implement buffers along marginal pastureland (CP-30 Marginal Pastureland Wetland Buffer) and cropland (CP-22 Riparian Buffer), or convert cropland to grass and restore farmed wetlands (CP-37 Duck Nesting Habitat), and (CP-23 Wetland Restoration). CRP practices would be implemented for a period of ten to fifteen years. Producers received an annual rental rate dependent on soil type, or whether the buffer was adjacent to a permanent or seasonal water body. Additional incentive payments for maintenance and implementation of conservation practices like fencing and alternate livestock watering sources were also available. The Environmental Quality Incentive Program (EQIP) was also used to fund implementation of best management practices in project watersheds.

5.7 Other Sources of Funds

The project received or utilized additional federal and state funding, local cash, and in-kind contributions from a number of sources to fund project activities and generate funds to match state and federal grants as shown in Table 8. Table 9 shows expenditures per product and overall project match.

The project applied for and received four Conservation Commission Grants from the South Dakota Department of Agriculture's Division of Resource Conservation and Forestry. These funds were utilized to pay project personnel wages and benefits, administrative costs, and cost share for implementation of conservation practices.

United States Department of Agriculture's Conservation Reserve Program (CRP) was utilized to protect riparian areas along project water bodies. CRP enrollment was often in conjunction with the projects Riparian Area Management (RAM) program. CRP provided a yearly rental rate for the length of the contract and signing, maintenance, and practice implementation incentive payments. USDA also provided a Conservation Collaboration Grant to the project to help provide technical assistance for implementing project and NRCS programs by providing wages for the project coordinator and project technician.

The James River Water Development District funded water quality testing of Clear and Roy Lakes located in Marshall County, which is part of the water development district.

The Pickerel Lake Conservancy and Enemy Swim Sanitary Sewer District provided local cash for water quality studies of Enemy Swim and Pickerel lakes.

The Day, Grant, Marshall, and Roberts Conservation Districts provided both cash and in-kind match for the project. Cash match included stipends paid by the Conservation Districts for District Supervisors who attended project workgroup meetings and attended monthly board meetings where project reports and updates were given. In-kind match included the use of the project coordinators boat and other equipment utilized for lake water quality monitoring, and rental for storage of equipment utilized by the project.

Producer cash and in-kind match includes the producer's share of implemented practice costs and in-kind match for their labor and personnel equipment used to implement a conservation practice. Material costs over and above grant docket costs were also calculated from invoices provided by the producer and counted as cash match. Producer cash match ranged from 50% to 75% depending on the funding source used.

Table 8. Other Sources of Funds

Funding Source	Other Federal	State	Local Cash	Local In-Kind
USDA Natural Resources Conservation Service (EQIP)	$ 160,054.03	$ -	$ -	$ -
South Dakota Dept. of Ag. Conservation Commisssion Grant	$ -	$ 51,263.67	$ -	$ -
South Dakota Dept. of Game, Fish and Parks		$ 5,000.00		
James River Water Development District			$ 1,340.00	
Pickerel Lake Conservancy	$ -	$ -	$ 16,661.41	$ -
Enemy Swim Sanitary Sewer District	$ -	$ -	$ 2,687.50	$ -
Day County Conservation District	$ -	$ -	$ 5,963.86	$ 3,000.00
Producer Cost Share Match	$ -	$ -	$ 123,201.65	$ -
Totals:	$ 160,054.03	$ 56,263.67	$ 149,854.42	$ 3,000.00

6.0 Summary of Public Participation

Development of the project was supported by several local entities. The Day, Deuel, Grant, Marshall, and Roberts Conservation District Board of Supervisors composed of local landowners and agricultural producers passed resolutions and signed Memorandum of Understandings with the Project Sponsor supporting the Northeast Glacial Lakes Watershed Improvement and Protection Project. These same Boards provided input on priority water quality issues identified by resource agencies and assessment projects in their respective counties as part of the project advisory council. The Pickerel Lake Conservancy, and Enemy Swim Sanitary Sewer District supported the watershed improvement and protection activities that were planned. The activities planned would protect their investments and infrastructures. Conservation District board meetings, farm and home shows, lake ecology workshops, lake association and sanitary sewer district meetings, all gave the general public a chance to participate in the development and monitor the progress of the watershed project. Local entities that participated in the planning and with monetary support of the watershed project are listed below.

- **South Dakota Association of Conservation Districts** – Provided technical assistance to local conservation districts.

- **Deuel County Conservation District** – Project partner/co-sponsor by MOU, local support and funding.
- **Grant County Conservation District –** Project partner/co-sponsor by MOU, local support and funding.
- **Marshall County Conservation District** – Project partner/co-sponsor by MOU, local support and funding.
- **Roberts County Conservation District** – Project partner/co-sponsor by MOU, local support and funding.
- **East Dakota Water Development District (EDWDD)** – Local support and funding for Grant County activities.
- **James River Water Development District (JRWDD) -** Local support and funding for Marshall County activities.
- **Enemy Swim Lake Sanitary Sewer District** – Local support and funding for water quality testing.
- **Pickerel Lake Conservancy** – Local support and funding for water quality monitoring, purchasing of easements, implementing shoreline buffers.
- **Ne-So-Dak Environmental Learning Center –** Local support, campus and staff for workshops, fishing and kayak camps, and other environmental education programs.
- **South Dakota Discovery Center** –Provided grants from the South Dakota 319 Information and Education Project that funded the Lake and Stream Ecology and Water Quality Workshops held by the Northeast Glacial Lakes Watershed Improvement and Protection Project during Segment 4.

7.0 Aspects of the Project That Did Not Work Well

The majority of project goals, objectives, and activities were completed in an acceptable fashion without problems or delays. However, the Covid-19 Pandemic limited producer contacts during the last eighteen months of this project. Local Conservation District/USDA offices were closed to the general public during this period and had limits on the number of employees and partners that could be working in the office at any given time.

8.0 Future Activity Recommendations

Segment 5 will continue the efforts brought about by this project. While some of the waterbodies listed as impaired during the writing of this Project's Implementation Plan in 2017 are no longer listed as so, efforts will continue to preserve the water quality of these lakes. Future project segments will continue to implement riparian buffers along pastures and cropland to reduce nutrient loading to project waterbodies.

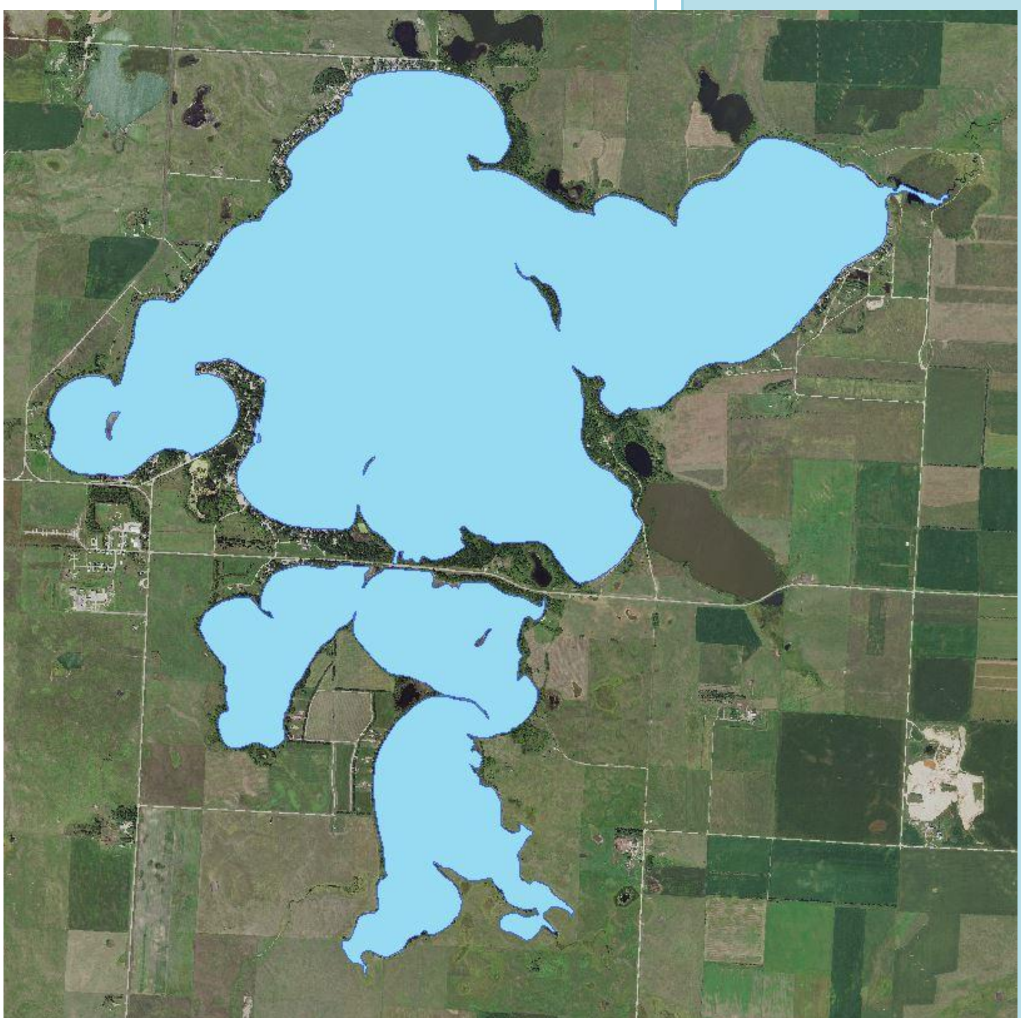
Table 9. Segment 4 Budget Expenditures

ITEM	EPA 319	USDA CCG	State	USDA EQIP/CRP	CONSERVATION DISTRICT	LOCAL	TOTAL
Objective 1: Personnel Support							
Project Coordinator	$ 126,620.50	$ 28,558.74	$ 46,390.16	$ -	$ 3,114.90	$ -	$ 204,684.30
Conservation Technician	$ 16,691.70	$ 5,638.12	$ 1,074.32	$ -	$ -	$ -	$ 23,404.14
Administrative Support	$ 2,052.90	$ -	$ 1,368.60	$ -	$ 2,012.98	$ -	$ 5,434.48
Travel	$ 8,341.30	$ -	$ -	$ -	$ -	$ -	$ 8,341.30
Subtotal Personnel Support	$ 153,706.40	$ 34,196.86	$ 48,833.08	$ -	$ 5,127.88	$ -	**$ 241,864.22**
Objective 2: BMP Installation							
Grazing Mgt. Improvements	$ 11,365.60	$ -	$ -	$ 43,076.14	$ -	$ 15,077.93	$ 69,519.67
Riparian Buffers	$ 115,611.25	$ -	$ -	$ -	$ -	$ 51,126.79	$ 166,738.04
Critical Area Planting	$ 17,674.51	$ -	$ 2,430.59	$ -	$ -	$ 16,662.33	$ 36,767.43
Grass Waterway	$ 14,290.00	$ -	$ -	$ 65,263.36	$ -	$ 18,529.80	$ 98,083.16
Shoreline/Streambank Stabilization	$ 45,205.45	$ -	$ -	$ 17,517.67	$ -	$ 29,534.80	$ 92,257.92
Subtotal BMP Installations	$ 204,146.81	$ -	$ 2,430.59	$ 125,857.17	$ -	$ 130,931.65	**$ 463,366.22**
Objective 3: Information and Education							
Pickerel Shoreline Study Report	$ -	$ -	$ -	$ -	$ -	$ 1,919.41	$ 1,919.41
Project Website	$ -	$ -	$ -	$ -	$ 835.98	$ -	
Subtotal Information and Education	$ -	$ -	$ -	$ -	$ 835.98	$ 1,919.41	**$ 1,919.41**
Objective 4: Water Quality Monitoring							
Water Quality Sampling	$ 6,630.50	$ -	$ 5,000.00	$ -	$ 3,000.00	$ 11,039.50	$ 25,670.00
Subtotal Water Quality Monitoring	$ 6,630.50	$ -	$ -	$ -	$ 3,000.00	$ 11,039.50	**$ 25,670.00**
TOTAL PROJECT COST:	*$ 364,483.71*	*$ 34,196.86*	*$ 56,263.67*	*$ 125,857.17*	*$ 8,963.86*	*$ 143,890.56*	**$ 733,655.83**
MATCH							
Federal to Match	$ 364,483.71	$ -	$ -	$ -	$ -	$ -	$ 364,483.71
Eligible Match - Local and State		$ -	$ 56,263.67	$ -	$ 8,963.86	$ 143,890.56	$ 209,118.09
Percent Match:	64%	0%	10%	0%	1%	25%	100%

Appendix A

2020

Enemy Swim Lake



Analysis and preparation by:

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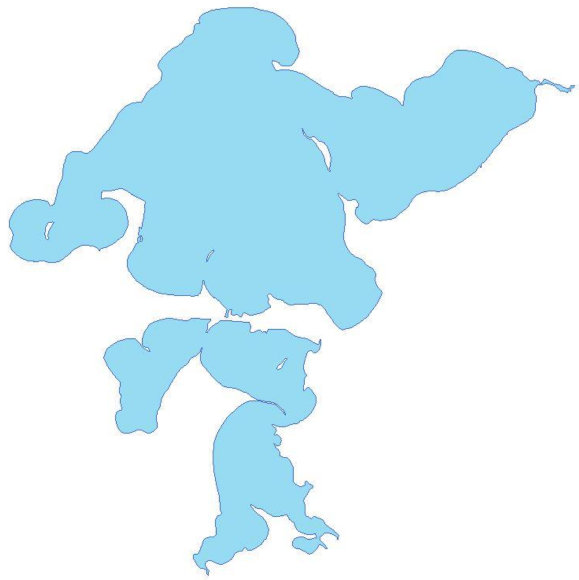
Enemy Swim Lake 22-0006-00 Day County



Introduction

Enemy Swim Lake is located 1 ½ miles east and 6 ½ miles north of Waubay, South Dakota in Day County. It is a large lake covering 2,146 acres (Table 1) with an outlet weir that prevents dramatic water level changes as seen in other local lakes. Enemy Swim Lake is one of the only lakes in South Dakota that is mesotrophic which indicates a moderate level of nutrients, generally clear water, and excellent recreational potential.

Enemy Swim Lake has one inlet and one outlet, which classify it as a drainage lake. Water flows into Enemy Swim Lake through Lewandowski Creek that enters from the northeast and drains Lewandowski Slough. Water exits the lake to the south through Campbell's Slough and the outlet weir running south to Blue Dog Lake.

Water quality data has been collected on Enemy Swim Lake from 1991 to 1998 and 2002 to 2019. The data shows that the lake is mesotrophic (TSI = 47) with consistent clear water conditions throughout the summer and into fall when lake turnover may release stored nutrients from the lake bottom causing an algae bloom. Recreational and fishing opportunities are very good. Enemy Swim Lake is one of the cleanest lakes in South Dakota and is very comparable with lakes in south central Minnesota for clarity, algae, and nutrient levels.

The Day County Conservation District, Enemy Swim Sanitation District, Sisseton-Wahpeton Oyate, Roberts County Conservation District, and the Northeast Glacial Lakes Project are actively involved in lake monitoring, education, and protection activities.

Table 1. Enemy Swim Lake location and key physical characteristics

Location Data	
SD Lake WDN:	**22-0002-00**
County:	**Day and Roberts Counties**
Ecoregion:	**Northern Glaciated Plains**
Major Watershed:	**Big Sioux River**
Latitude/Longitude:	**45.4393°N 97.2662°W**
Invasive Species:	**none**

Physical Characteristics	
Surface area (acres):	**2,146**
Littoral area (acres):	**Data unavailable**
% Littoral area:	**Data unavailable**
Max depth ft, (m):	**26, (7.9)**
Inlets:	**1**
Outlets:	**1**
Public Accesses:	**2**

Table 2. Availability of primary data types for Enemy Swim Lake

Data Availability	
Transparency data	**Good, enough for trend analysis**
Chemical data	**Moderate, enough phosphorus data for trend analysis**
Inlet/Outlet data	**The inlet has not been accessible for monitoring.**
Recommendations	**For recommendations refer to page 19.**

Lake Map

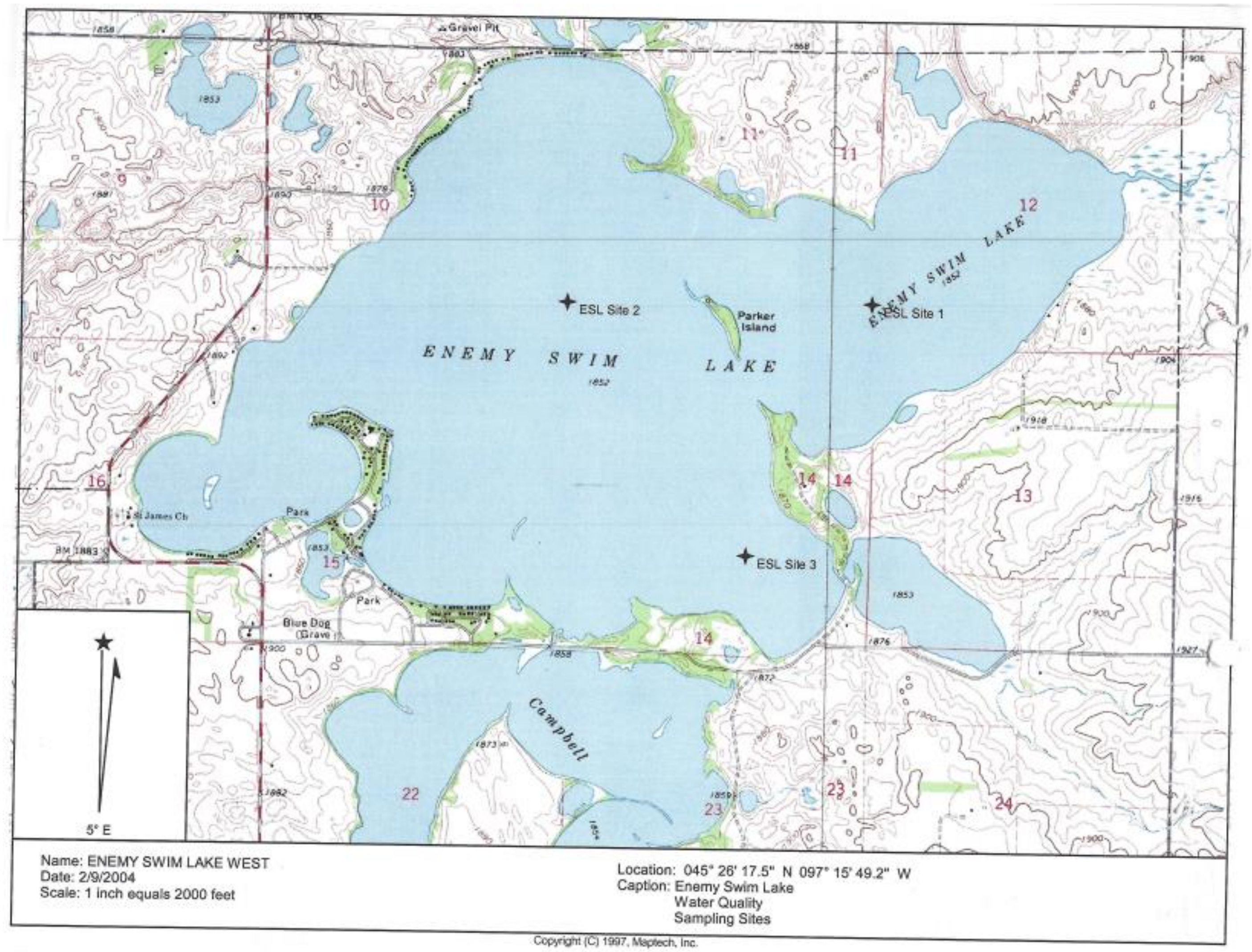


Figure 1. Map of Enemy Swim Lake with sample site locations

Average Water Quality Statistics & Comparisons

The information below describes available chemical data for Enemy Swim Lake through 2019 (Table 3).

Areas of the United States are divided into ecoregions based on land use, vegetation, precipitation and geology. Based on other lakes located within an ecoregion, lake data can be compared to the "average range" of water quality expected in each ecoregion[1] (Table 3). Enemy Swim Lake is in the Northern Glaciated Plains ecoregion.

Table 3. Water quality means compared to ecoregion ranges

Parameter	Mean	Ecoregion Range[1]	Interpretation
Total phosphorus (ug/L)	22.3	130 – 250	Phosphorus and chlorophyll *a* results are lower than the expected range for lakes in the Northern Glaciated Plains Ecoregion. Enemy Swim Lake's results are similar to lakes in south central Minnesota
[3]Chlorophyll *a* (ug/L)	4.9	30 – 55	
Chlorophyll *a* max (ug/L)	8.9		
Secchi depth (ft)	7.8	1 – 4	
Oxygen	*See page 12* *>5 mg/l*		Dissolved oxygen depth profiles show that the lake typically mixes throughout the summer then stratifies in early fall. Staying well oxygenated.
Total Kjeldahl Nitrogen (mg/L)	0.728	1.8 – 2.3	Indicates low levels of nitrogen to support summer algae blooms
pH	8.4	8.3 – 8.6	Within the expected range for the ecoregion
Chloride (mg/L)	ND	0.6 – 1.2	Data not available
Total Suspended Solids (mg/L)	5.9	10 - 30	Lower than the expected range for the ecoregion
Specific Conductance (umhos/cm)	ND	50 – 250	Data not available
TN:TP Ratio	21:1	7 - 14	Above the expected range for the ecoregion indicating nitrogen sources in the watershed. This ratio shows the lake is phosphorus limited. Additional phosphorous, especially ortho-phosphorous the dissolved plant-available form, will cause rapid plant and algae growth.

Hat 1The ecoregion range is the 25th-75th percentile of summer means from ecoregion reference lakes: https://www.pca.state.mn.us/quick-links/edaguide-typical-minnesota-water-quality-conditions
2For further information regarding the Impaired Waters Assessment program, refer to http://www.pca.state.mn.us/water/tmdl/index.html
3Chlorophyll *a* measurements have been corrected for pheophytin
Units: 1 mg/L (ppm) = 1,000 ug/L (ppb)

Water Quality Characteristics - Historical Means and Ranges

Table 4. Water quality means and ranges for Enemy Swim Lake

Parameters	Composite Site
Total Phosphorus Mean (ug/L):	22.3
Total Phosphorus Min:	6
Total Phosphorus Max:	50
Number of Observations:	87
Chlorophyll *a* Mean (ug/L):	4.9
Chlorophyll-a Min:	1.5
Chlorophyll-a Max:	8.9
Number of Observations:	36
Secchi Depth Mean (ft):	7.8
Secchi Depth Min:	4
Secchi Depth Max:	17.8
Number of Observations:	90

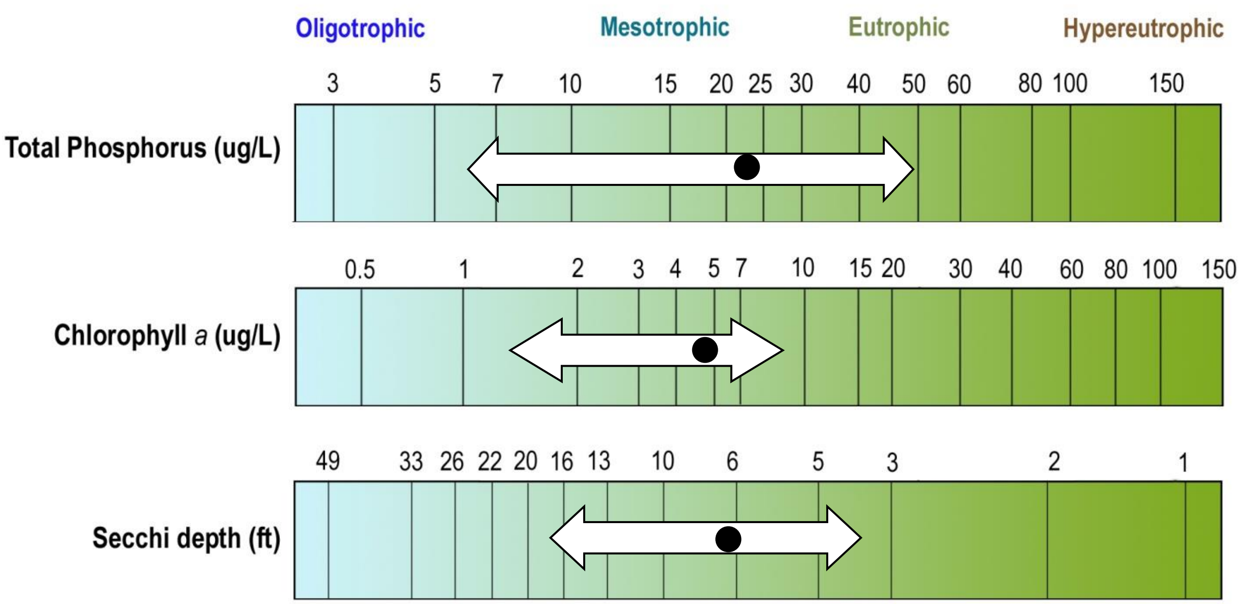


Figure 2. Enemy Swim Lake total phosphorus, chlorophyll a, and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean of the three sites composited. Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. No. EPA 440/5-88-002)

Transparency (Secchi Depth)

Transparency is how easily light can pass through a substance. In lakes, it is how deep sunlight penetrates through the water. Plants and algae need sunlight to grow, so they are only able to grow in areas of lakes where the sun penetrates. Water transparency depends on the number of particles in the water. An increase in particulates results in a decrease in transparency. The transparency varies year to year due to changes in weather, precipitation, lake use, flooding, temperature, lake levels, etc.

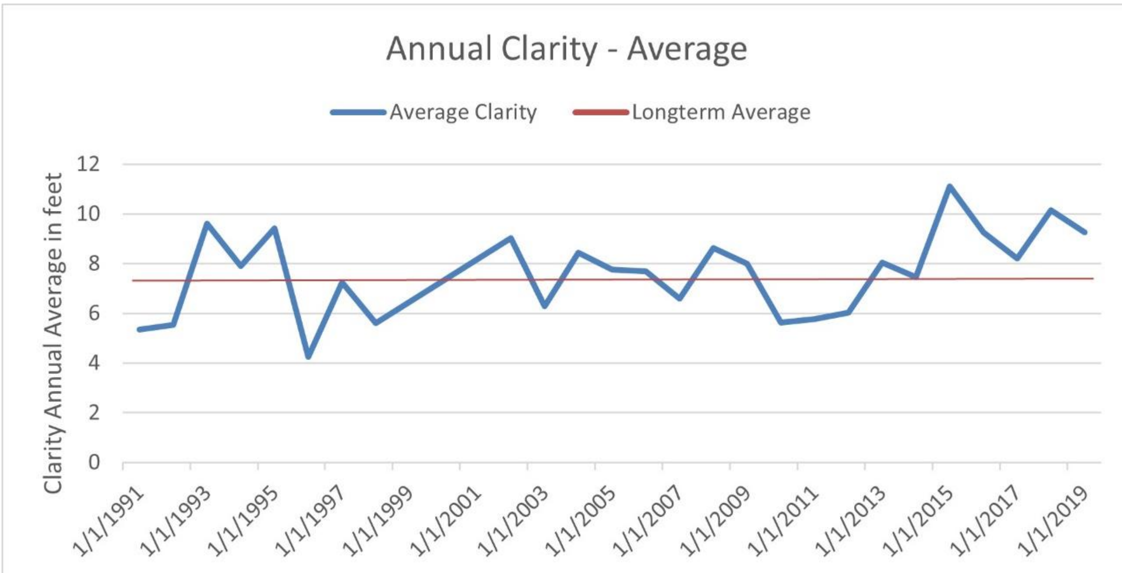


Figure 3. Annual average transparency with long-term mean from 1991 to 2019

Enemy Swim Lake's transparency was monitored annually from 1991 to 1998 and 2002 to 2019 at three sites. The annual average transparency in Enemy Swim Lake ranges from 4 to 10.5 feet. The long term mean transparency is 7.75 feet (Figure 3) which indicates good recreational quality. For the last five years the transparency has been better than the long term mean. For trend analysis, see page 14. Transparency monitoring should be continued at least monthly every summer in order to track water quality changes.

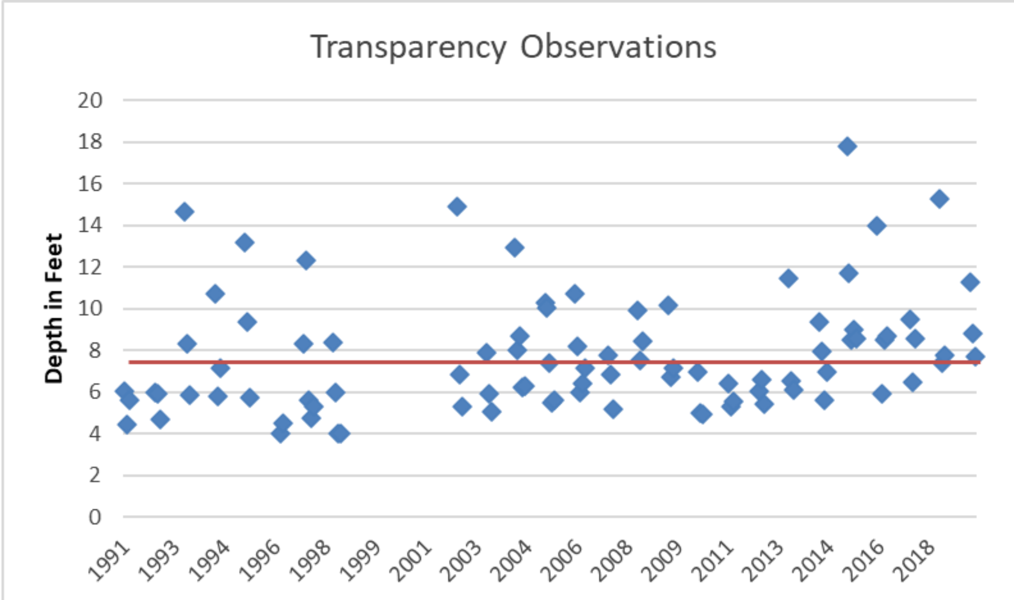


Figure 4: Historical transparency for Enemy Swim Lake from 1991 to 2019

The water clarity in Enemy Swim Lake follows a typical seasonal pattern. Water clarity dynamics have to do with algae population dynamics and lake turnover. It is important for lake residents to understand the seasonal transparency dynamics where transparency can be lower in August than it is in June. Enemy Swim Lake is consistently clear in May and June with slightly lower transparency levels in July and August.

Algae – Chlorophyll *a*

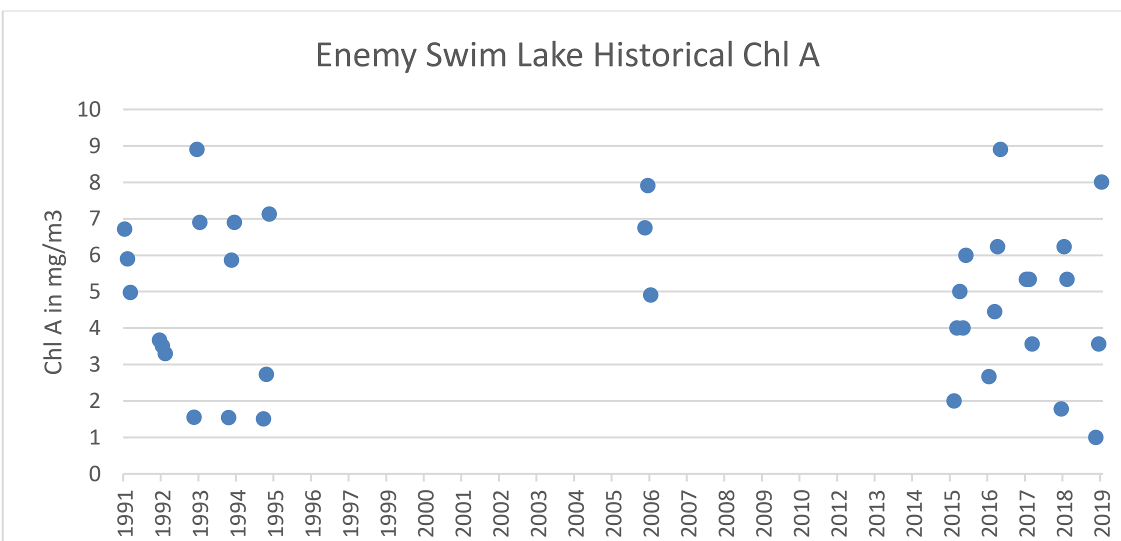


Figure 5. Historical chlorophyll a concentrations (mg/m3) for Enemy Swim Lake from 1991 to 2019

Chlorophyll *a* is the pigment that makes plants and algae green. Chlorophyll *a* is tested in lakes to determine the algae concentration or how "green" the water is. Concentrations greater than 10 mg/m3 are perceived as a significant algae bloom, while concentrations greater than 20 mg/m3 are perceived as a nuisance.

Chlorophyll *a* was evaluated occasionally in Enemy Swim Lake since 1991 (Figure 5). All of the samples were below the 10 mg/m3 significant algae bloom level. Over the period of observation chlorophyll a levels have remained consistent. The range observed is typical for a mesotrophic lake with excellent recreational quality.

Phosphorus

Enemy Swim Lake is phosphorus limited, which means that algae and aquatic plant growth is dependent upon available phosphorus. Total phosphorus was evaluated in Enemy Swim Lake from 1991 to 2019 (Figure 6). A majority of data points fall into the mesotrophic range which is below 0.025 mg/l of phosphorous. During early summer months when the lake is stratified, the phosphorus is at the lowest concentration, and it increases in late summer when lake turnover begins.

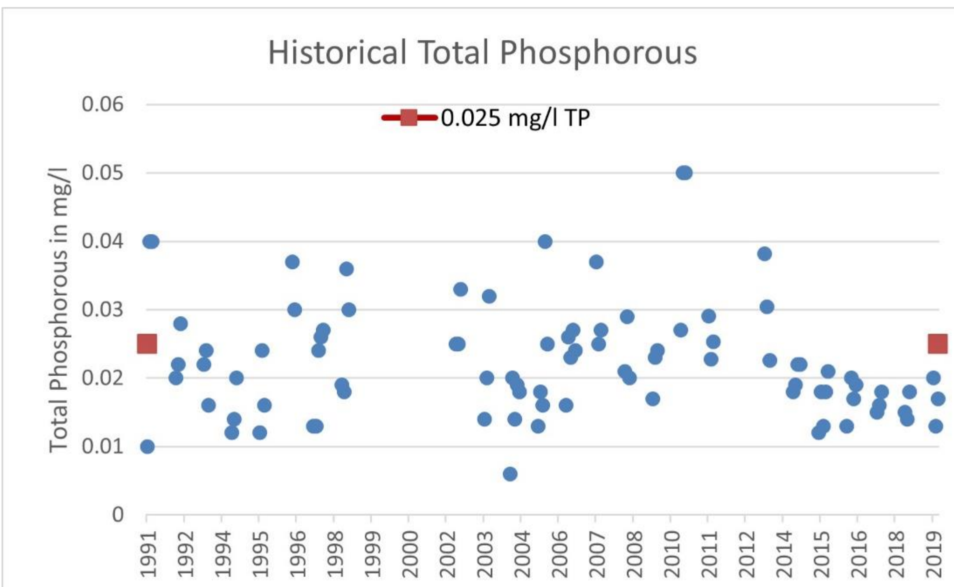


Figure 6. Historical total phosphorus concentrations in surface samples from 1991 to 2019

Similar results are being seen at the lake bottom where levels of phosphorous have remained quite stable (Figure 7). Accumulated nutrients are stored in a lake by binding to bottom sediments. The measure of phosphorous close to the lake bottom is a good indicator of how well a lake is storing nutrients and how much is being released into the water. Levels of phosphorous at the lake bottom also reflect how much oxygen is available in the water. High loads of nutrients can deplete oxygen levels and alter the lake's nutrient storage process. This can make additional phosphorous available to plants and algae that was previously stored in the bottom sediments. This process, known as internal loading, causes elevated levels of dissolved phosphorous near the lake bottom that can cause weed growth and algae blooms if it mixes into the water column.

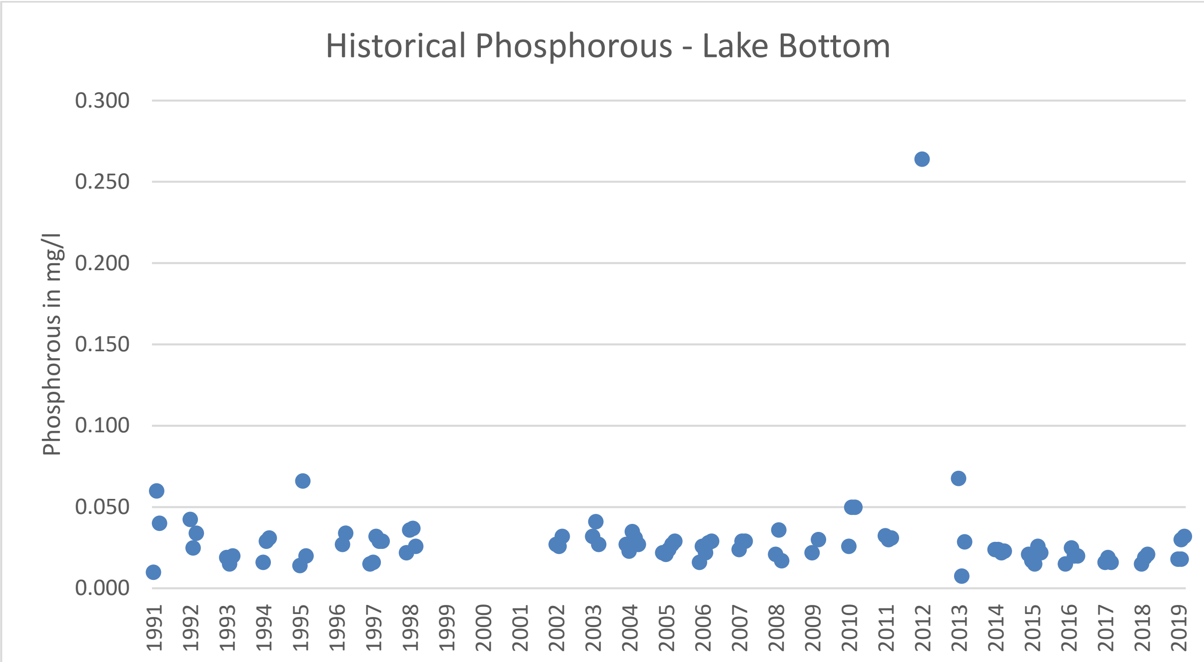


Figure 7: Total phosphorous as measured at the lake bottom from 1991 to 2019

The phosphorous concentrations observed in the samples taken at the bottom of Enemy Swim Lake show almost no indication of an internal loading pattern. The samples show only small increases of phosphorous during periods of low oxygen with levels staying close to the mesotrophic range. Only one sample, from 2012, showed signs of elevated phosphorous levels. Monitoring dissolved oxygen levels and nutrient levels near the lake bottom provides excellent information about the rate of lake aging in Enemy Swim Lake.

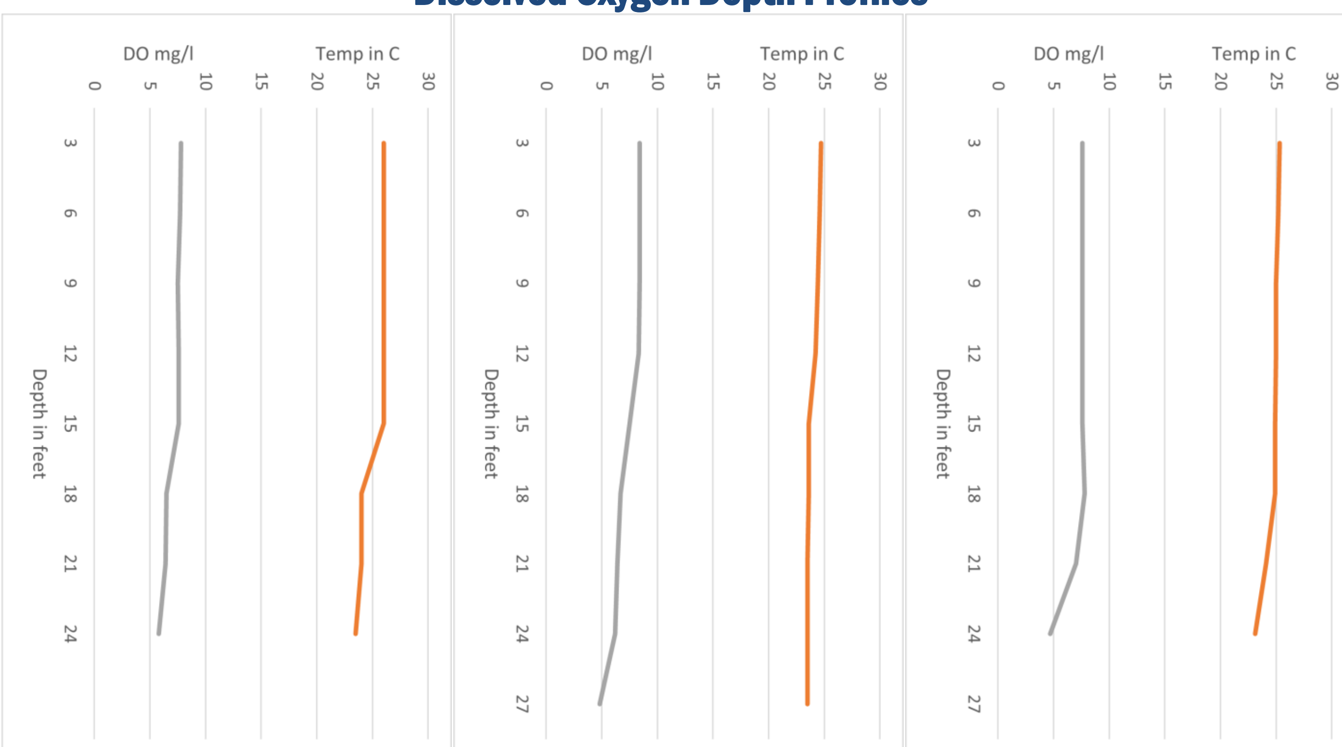
Oxygen

Dissolved Oxygen (DO) is the amount of oxygen available in lake water. Oxygen is necessary for all living organisms to survive except for some bacteria. Dissolved oxygen levels of <5 mg/L are typically avoided by game fisheries. While the surface of the lake stays well oxygenated, the bottom layers can run out.

As organic matter decays, natural iron compounds bind with phosphorus, storing it in lake sediments. The process of decomposition also consumes oxygen, if the supply of dissolved oxygen gets too low then the bottom of a lake can become anoxic – oxygen depleted. These areas of oxygen depletion allow phosphorus to be released from the sediments back into the water as dissolved phosphorus. In very deep lakes, this anoxic layer is often restricted to the lake bottom until fall turnover due to stratification which is the layering of warm light upper water on top of cool dense lower water. In moderately deep lakes the water column can temporarily stratify. While stratified the lower water can become depleted of oxygen and nutrients released from the lake sediments. A windy day can then mix up the water, causing phosphorus from the anoxic lake bottom to resuspend into the water. This process is known as internal nutrient loading and can cause rapid algae blooms. Moderately deep lakes still turnover in fall and spring causing some nutrient recycling. Shallow lakes usually stay well mixed all summer due to wind action and then turnover as water temps cool in the fall.

Sampling in Enemy Swim Lake has indicated the lake only occasionally stratifies and rarely sees oxygen depletion even when stratified. The lake stays well mixed with similar temperature and oxygen levels throughout the water column. Oxygen levels rarely fell to the levels that would affect game fish, 5 mg/l, and when it does occur it is limited to a thin zone of water at the lake bottom.

Dissolved Oxygen Depth Profiles



2005 **2010** **2019**

Trophic State Index (TSI)

TSI is a standard measure or means for calculating the trophic status or productivity of a lake. More specifically, it is the total weight of living algae (algae biomass) in a waterbody at a specific location and time. Three variables, chlorophyll a, Secchi depth, and total phosphorus independently estimate algal biomass.

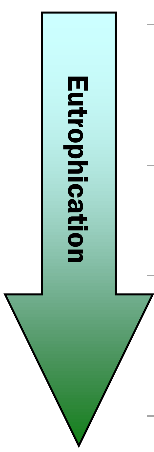
If all three TSI numbers are within a few points of each other, they are strongly related. If they are different, there are other dynamics influencing the lake's productivity, and TSI mean should not be reported for the lake. Enemy Swim Lake falls into the mesotrophic range (Tables 5,6).

Table 5. Trophic State Index for Enemy Swim Lake

Trophic State Index	
TSI Phosphorus	49
TSI Chlorophyll-a	46
TSI Secchi	47
TSI Mean	47
Trophic State:	Mesotrophic

Numbers represent the mean TSI for each parameter.

Enemy Swim Lake



TSI	Attributes	Fisheries & Recreation
<30	**Oligotrophy:** Clear water, oxygen throughout the year at the bottom of the lake, deep cold water.	Trout fisheries dominate.
30-40	Bottom may become anoxic (no oxygen).	Trout fisheries in deep lakes only. Walleye, Cisco present.
40-50	**Mesotrophy:** Water moderately clear most of the summer. May be "greener" in late summer.	No oxygen at the bottom of the lake results in loss of trout. Walleye may predominate.
50-60	**Eutrophy:** Algae and aquatic plant problems possible. "Green" water most of the year.	Warm-water fisheries only. Bass may dominate.
60-70	Blue-green algae dominate, algal scums and aquatic plant problems.	Dense algae and aquatic plants. Low water clarity may discourage swimming and boating.
70-80	**Hypereutrophy:** Dense algae and aquatic plants.	Water is not suitable for recreation.
>80	Algal scums, few aquatic plants.	Rough fish (carp) dominate; summer fish kills possible.

Source: Carlson, R.E. 1997. A trophic state index for lakes. *Limnology and Oceanography*. 22:361-369.

Table 6. Trophic state index attributes and their corresponding fisheries and recreation characteristics

Trend Analysis

For detecting trends, a minimum of 8-10 years of consecutive data with 4 or more readings per season are recommended. Minimum confidence accepted by the Minnesota Pollution Control Agency is 90%. This means that there is a 90% chance that the data are showing a true trend and a 10% chance that the trend is a random result of the data. Only short-term trends can be determined with just a few years of data, because there can be different wet years and dry years, water levels, weather, etc, that affect the water quality naturally.

Enemy Swim Lake had sufficient data to perform a trend analysis for phosphorous and transparency from 2002 to 2019 (Table 7). Chlorophyll *a* data did not have 8 consecutive years of data, so a trend could not be run. Continuing to monitor the chlorophyll *a* in the next few years will allow for future analysis. The data was analyzed using the Mann-Kendall Trend Analysis. No statistically significant trends were detected for total phosphorus or transparency, but there is a trend of increasing levels of dissolved phosphorus which indicates declining water quality.

Table 7. Trend analvsis for Enemv Swim Lake

Parameter	Date Range	Trend	Probability	Significance
Total Phosphorus	2002-2019	Improving - Decreasing Nutrient Levels	95%	Lower levels of nutrients indicate higher recreational quality.
Transparency	2002-2019	Improving – Increasing Water Clarity	90%	Improving clarity enhances recreational quality.

Lakeshed and Land Cover

Understanding a lakeshed requires an understanding of basic hydrology. A watershed is defined as all land and water surface area that contribute excess water to a defined point. The Minnesota DNR has delineated three basic scales of watersheds (from large to small): 1) basins, 2) major watersheds, and 3) minor watersheds.

The Big Sioux River Major Watershed is one of the watersheds that make up the Missouri River Basin, which drains south to the Gulf of Mexico. The Waubay Lakes Basin is part of the Big Sioux River watershed, and Enemy Swim Lake's lakeshed is in the Waubay Lakes Basin. These lakesheds (catchments) are the "building blocks" for the larger scale watersheds. Lakesheds are very useful for displaying the land and water that contribute directly to a lake, but they are not always true watersheds because they may not show the water flowing into a lake from upstream streams or rivers. While some lakes may have only one or two upstream lakesheds draining into them, others may be connected to a large number of lakesheds, reflecting a larger drainage area via stream or river networks.

In an effort to prioritize protection and restoration efforts of fishery lakes, the Minnesota DNR has developed a ranking system by separating lakes into two categories based on their lakeshed: those needing protection and those needing restoration. Modeling by the DNR Fisheries Research Unit suggests that total phosphorus concentrations increase significantly over natural concentrations in lakes that have a watershed with disturbance greater than 25%. Therefore, lakes with watersheds that have less than 25% disturbance need protection and lakes with more than 25% disturbance need restoration (Table 8). Watershed disturbance was defined as having urban, agricultural and mining land uses. Watershed protection is defined as publicly owned land, public water, wetlands, or conservation easement.

Table 8. Suggested approaches for watershed protection and restoration of DNR-managed fish lakes in Minnesota

Watershed Disturbance (%)	Watershed Protected (%)	Management Type	Comments
< 25%	> 75%	Vigilance	Sufficiently protected -- Water quality supports healthy and diverse native fish communities. Keep public lands protected.
	< 75%	Protection	Excellent candidates for protection -- Water quality can be maintained in a range that supports healthy and diverse native fish communities. Disturbed lands should be limited to less than 25%.
25-60%	n/a	Full Restoration	Realistic chance for full restoration of water quality and improve quality of fish communities. Disturbed land percentage should be reduced and BMPs implemented.
> 60%	n/a	Partial Restoration	Restoration will be very expensive and probably will not achieve water quality conditions necessary to sustain healthy fish communities. Restoration opportunities must be critically evaluated to assure feasible positive outcomes.

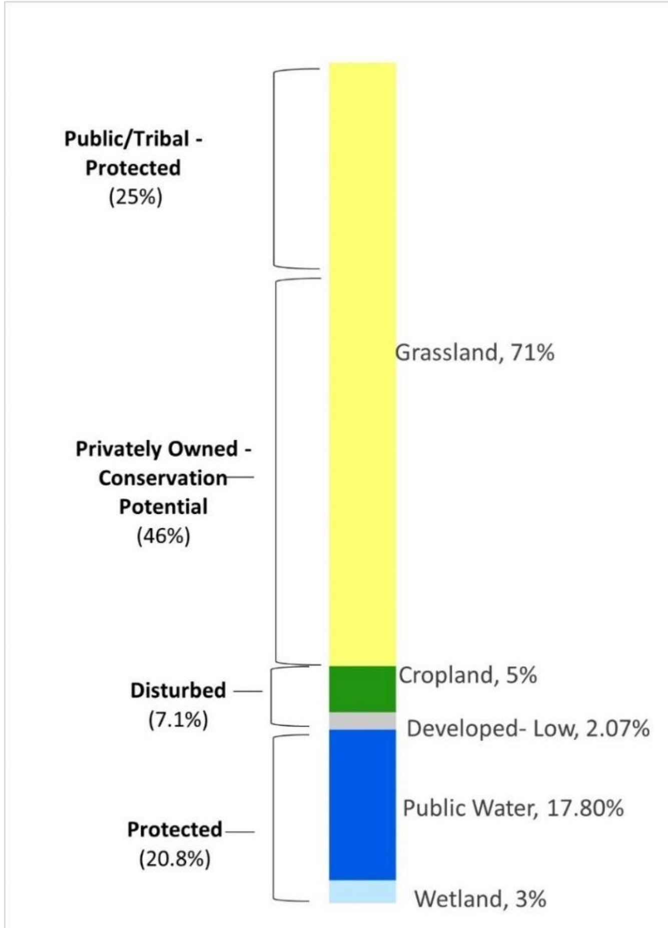


Figure 8. Land use in the Enemy Swim Lake lakeshed

According to the 2011 National Land Cover Data Set Enemy Swim Lake's lakeshed is classified as having 45.8% of the watershed protected and 7.1% of the watershed disturbed (Figure 8). Therefore, this lakeshed should have a protection focus. Goals for the lake should be to limit any increase in developed or agricultural land uses and increase the amount of protected lands. Runoff reduction, cover cropping, and wetland restoration projects are some potential tools for reducing the impacts existing development and intensive land uses have on Enemy Swim Lake's recreational quality.

Land use and Ownership

Activities that occur on the land within the lakeshed can greatly impact a lake. Land use planning helps ensure the use of land resources in an organized fashion so that the needs of the present and future generations can be best addressed. Enemy Swim Lake receives water from the northeast through one perennial stream.

The majority, over 2/3rd's, of the Enemy Swim Lake's watershed is privately owned. Almost half (45%) of the watershed could be considered protected lands. This total includes Public land, Tribal land, open water, and wetlands. Some of the areas mapped as Protected may actually be developed land, roadways, and other intensive uses but the level of protection in this lakeshed is still considered high. Protecting and restoring wetlands in the Enemy Swim lakeshed would provide additional nutrient and water storage. This can reduce the amount of nutrients transported to Enemy Swim Lake if the restored wetlands function properly. This lakeshed vitals table identifies where to focus organizational and management efforts for each lake (Table 9). Criteria were developed using limnological concepts to determine the effect to lake water quality.

KEY

● Possibly detrimental to the lake
◍ Warrants attention
○ Beneficial to the lake

Table 9. Enemy Swim Lake lakeshed vitals

Lakeshed Vitals		Rating
Lake Area	2146 acres	descriptive
Littoral Zone Area	Data unavailable	descriptive
Lake Max Depth	26 ft	descriptive
Lake Mean Depth	16 ft	◍
Water Residence Time	5 years	●
Miles of Stream	Data unavailable	descriptive
Inlets	1	◍
Outlets	1	○
Major Watershed	Big Sioux River	descriptive
Minor Watershed	Waubay Lakes Basin	descriptive
Ecoregion	Northern Glaciated Plains	descriptive
Total Lakeshed to Lake Area Ratio (total lakeshed includes lake area)	10.4:1	◍
Standard Watershed to Lake Basin Ratio (standard watershed includes lake areas)	10.4:1	Not Available
Wetland Coverage	3%	●
Aquatic Invasive Species	None	○
Public Drainage Ditches	Data unavailable	Not Available
Public Lake Accesses	2	◍
Miles of Shoreline	11.8	descriptive
Shoreline Development Index	2.3	●
Public Land to Private Land Ratio	Data unavailable	Not Available
Development Classification	Recreational Development	◍
Miles of Road	52.8	descriptive
Municipalities in lakeshed	None	○
Forestry Practices	None	●
Feedlots	13	●
Percent Disturbed Land Use	7.1%	○
Percent Protected Land	20.8%	◍
Sewage Management	Holding Tanks	○
Lake Management Plan	Several	○
Lake Vegetation Survey/Plan	None	◍

Enemy Swim Lake, 2020 Fisheries Survey Summary from SD G&F

Enemy Swim, located 1.5 miles east and 6.5 miles north of Waubay, is managed as a multiple-species fishery including panfish (i.e., black crappie, bluegill, and yellow perch), black bass (largemouth and smallmouth) and walleye.

• Black crappie. More black crappies were sampled in 2020 than in 2019, but relative abundance remained low (2.2/frame net). Sampled black crappies ranged from 3.9 to 9.1 inches, of those that were at least 5.0 inches, 35% were 8.0 inches or longer.

• Bluegill. Bluegill CPUE declined for the second straight year. At 46.0/frame net, relative abundance was considered low to moderate for Enemy Swim Lake. Sampled bluegills ranged in length from 3.1 to 9.8 inches, 19% were >6.0 inches and 2% were >8.0 inches. Individuals from five consecutive year classes (2014 – 2018) contributed to the catch. Bluegills from the 2016 (age-4) cohort were the most abundant accounting for 50% of fish in the sample, those from the 2017 (age-3) year class made up an additional 34%. Since 2011, mean length at capture values for age-5 bluegills have ranged from 5.4 to 7.8 inches. In 2020, age-5 bluegills had a mean length of 6.2 inches.

• Largemouth/Smallmouth bass. Spring electrofishing was not completed in 2020.

• Walleye. Similar to 2019, walleye numbers were low (1.8/gill net). Sampled walleyes ranged in length from 7.1 to 28.0, more than half (57%) were >15.0 inches. Individuals from 10 year classes produced between 2001 and 2018 contributed to the catch, each was represented by six or fewer fish. The oldest walleye sampled was from the 2005 (age-15) cohort.

• Yellow perch. Yellow perch numbers were higher in 2020 than in 2019. In 2020, the mean gill net CPUE was 13.2 and suggested moderate relative abundance. Those sampled ranged from 5.1 to 7.5 inches, most (75%) were from the 2018 (age-2) cohort. Yellow perch growth tends to be slow with mean length at captures at age 2 from 3.8 to 5.8 inches in surveys conducted since 2011. In 2020, age-2 fish had a mean length of capture of 5.8 inches.

For more detailed results see the computer generated South Dakota Statewide Fisheries Survey for Enemy Swim https://apps.sd.gov/GF56FisheriesReports/ExportPDF.ashx?ReportID=22891

Key Findings and Recommendations

Monitoring Recommendations

Transparency monitoring at the primary sites should be continued every year. It is important to continue transparency monitoring, possibly weekly but at least monthly every summer to enable year-to-year comparisons and trend analyses. Phosphorus, dissolved phosphorous, Total Kjeldhal Nitrogen, and chlorophyll *a* monitoring should continue, as the budget allows, to track future water quality trends. Additional dissolved oxygen data would be helpful in gauging the lake's condition.
Monitoring the aquatic plant communities composition and coverage can be important for tracking lake aging if zebra mussels should infest the lake in the future. By consuming free floating algae and redepositing it onto the shallow lake bottom zebra mussels shift lakes from their current phytoplankton (algae) dominated state to a periphyton (rooted algae and plants) dominated state.

Overall Conclusions

Enemy Swim Lake is a mesotrophic lake (TSI = 47) with improving water quality trends for total phosphorus and transparency. Water quality measures appear to be stable to improving. Nutrients are being effectively stored in the lake bottom with little to no sign of internal loading which occurs when previously stored nutrients recycle back into the lake water.

Phosphorus Loading and Priority Impacts

Enemy Swim Lake is a headwaters lake so very little nutrients or sediment are transported to the lake from far away. Water that enters Enemy Swim Lake takes several years to flow through the system and the lake retains almost all of the nutrients and sediment that wash into it. This means that the land practices immediately around the lake have the greatest impact on the lake's water quality.

Table 10. Watershed characteristics

Lakeshed to Lake Area Ratio (lakeshed includes lake area)	10:1
Watershed to Lake Area Ratio (watershed includes lake areas)	10:1
Number of Upstream Lakes	0
Headwaters Lake?	Yes
Inlets / Outlets	1/ 1
Water Residence Time	~5 years

Enemy Swim Lake is primarily fed by surface inflow and there are some springs discharging groundwater into the lake. The large lake size and reasonable depth gives the water a moderate residence time in the lake, likely 5 or more years. Most lakes permanently retain at least half of the nutrients that flow into the lake in their bottom sediments. Enemy Swim Lake likely retains over 75% of the nutrients that reach the lake.

Only 3% of the lakeshed is covered with wetlands, which does not provide very much water storage and filtration (Figure 8). Protecting and restoring wetlands will help maintain water levels and water storage, reduce flooding, and filter runoff during large storm events. Maintaining existing grassland acres will help preserve the lake's water quality.

Development pressure is increasing around the shorelines and within the watersheds of many lakes. This development can degrade water quality and impact valuable shoreline habitat. Native shoreline vegetation provides habitat for fish and wildlife, filters harmful nutrients, and protects against shoreline erosion. Lakeshore owners can minimize their impact on the shoreline and maintain a more natural setting while reducing annual maintenance. For more information on how to accomplish this, go to the following website: www.dnr.state.mn.us/shorelandmgmt

Best Management Practices Recommendations

The management focus for Enemy Swim Lake should be to preserve and improve the condition of the watershed implementing grassland stewardship and preservation projects. Efforts should also be focused towards managing and/or decreasing the impacts caused by agriculture, current and additional development, nutrient-saturated wetlands, and impervious areas. Project ideas include grazing easements, rotational grazing promotion, cover crops, shoreline restoration, rain gardens, and runoff infiltration systems.

Enemy Swim Lake Goals

1. Protection Focus: minimize disturbed land uses with BMPs and maintain protected lands through stewardship and easement programs.
2. Manage phosphorus loading from the **nearshore.**
3. Restore wetlands where appropriate and functional conditions can be attained.
4. Encourage maintaining a living soil cover including rotational grazing, cover crops, and no till cropping.

Table 11. Best Management Practices specific to Enemy Swim Lake

Category	Land use type	Conservation project ideas	Results	Who	Contact for help
Conservation Potential	Pasture/grassland/CRP 71%	Conservation Reserve Program (CRP), managed grazing, plant trees, conservation/grazing easements, maintain/restore wetlands.	Reduce water runoff and soil erosion, better water storage.	• Individual Property Owners • Sisseton-Whapeton Oyate	Day County Conservation District (605) 345-4661
Disturbed Land	Cultivated crops 5%	Restore wetlands; Conservation Reserve Program (CRP), Cover Crops	Reduce water runoff and soil erosion, better water storage. Maintain a living soil cover.	• Individual Property Owners	Day County Conservation District (605) 345-4661
	Developed, low intensity 2%	Shoreline buffers, tree planting, rain gardens.	Reduce water runoff and shoreline erosion.	• Individual Property Owners	Day County Conservation District (605) 345-4661
	Developed, high intensity (0.01%, 2 acres)	Infiltration trenches, permeable pavements, tree planting, rain gardens, shoreline buffers, stormwater retention.	Reduce water runoff into streams and lakes.	• Individual Property Owners	Day County Conservation District (605) 345-4661

The current lakeshore homeowners can lessen their impacts on water quality and lake health by planting native plants, shoreline buffers, or maintaining the trees on their properties. Suitable tree species can intercept rainfall, loosen the soils, and reduce the movement of nutrients and sediment to the lake. Forested uplands contribute about one tenth as much phosphorus (lbs/acre/year) compared to developed land.

Native aquatic plants stabilize the lake's sediments and tie up phosphorus in their tissues. When aquatic plants are uprooted from a shallow lake, the lake bottom is disturbed, and the phosphorus in the water column gets used by algae instead of plants. Protecting native aquatic plant beds will ensure a healthy lake and healthy fishery. If a swimming area is necessary in front of people's docks, clear only the area of plants necessary and permitted.

Organizational contacts and reference sites

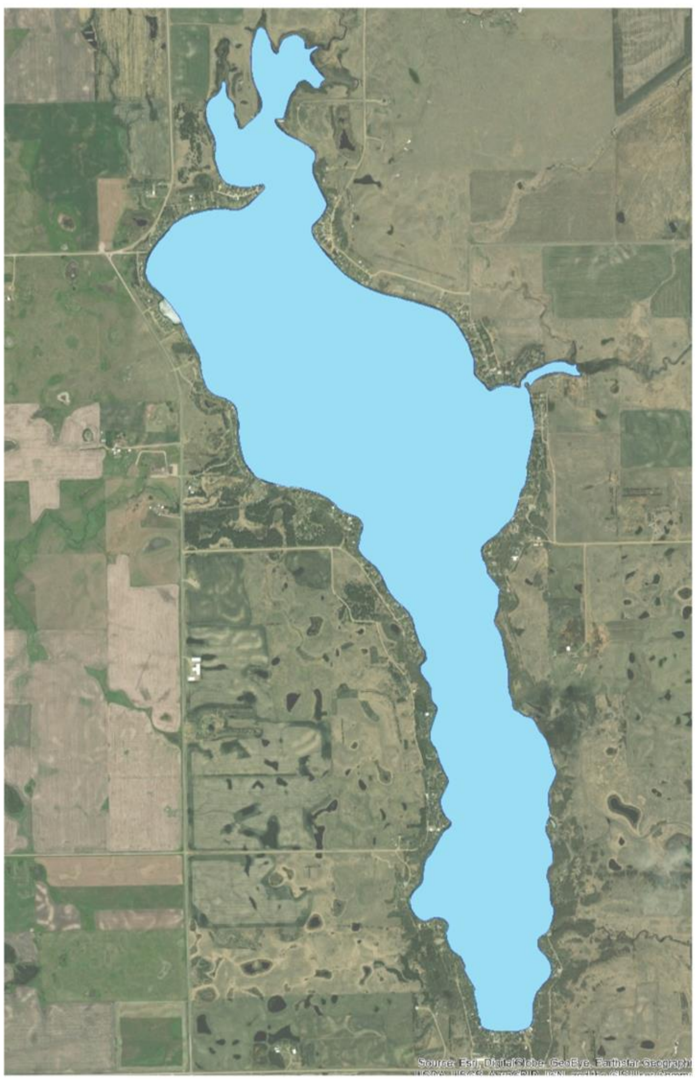
South Dakota Game, Fish & Parks Office	603 East 8th Ave, Webster, SD 57274 605-345-3381
South Dakota Department of Agriculture & Natural Resources	523 E Capitol Ave, Pierre, SD 57501 (605) 773-3151
Northeast Glacial Lakes Watershed Project	info@neglwatersheds.org (605) 345-4661
Enemy Swim Sanitation District	3278 South Bay Drive, Waubay, SD 57273
Sisseton-Wahpeton Oyate	PO Box 509, Sisseton, SD 57262 (605) 698-3911
Day County Conservation District	600 E Highway 12, Ste 1 Webster, Sd 57274 (605) 345-4661
Roberts County Conservation District	2018 SD Highway 10, Sisseton, SD 57262 (605) 698-3923

Table 12. Organizational contacts and reference sites

Appendix B

2019

Pickerel Lake



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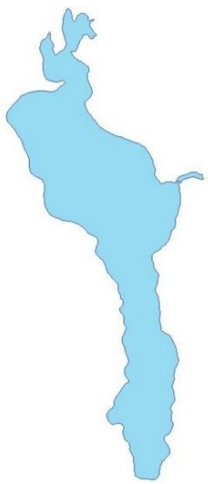
Pickerel Lake

22-0002-00 Day County



Pickerel Lake is located 10 miles northeast of Webster, South Dakota in Day County. It is a large lake covering 981 acres (Table 1) with an outlet dam that prevents dramatic water level changes seen in other local lakes. Pickerel Lake is one of the deepest natural lakes in South Dakota with a maximum depth of 41 feet.

Pickerel Lake has three inlets and one outlet, which classify it as a drainage lake. Water enters Pickerel Lake from Dry Creek to the north, from Oneroad Lake to the east through perennial Chekepa Creek, and Hatchery Creek in the southeast which is primarily discharge from an old artesian well. Pickerel Creek exits the lake on the west side at the outlet weir and runs south to Waubay Lake.

Water quality data has been collected on Pickerel Lake from 1991-2019 (Table 2). These data show that the lake is eutrophic (TSI = 54) with moderately clear water conditions most of the summer, occasional algae blooms in mid-summer and fall, and good recreational opportunities. Pickerel Lake is one of the cleanest lakes in South Dakota and is very comparable with lakes in south central Minnesota for clarity, algae, and nutrient levels.

The Pickerel Lake Conservancy Association and The Northeast Glacial Lakes Project are actively involved in lake monitoring, education, and protection activities.

Table 1. Pickerel Lake location and key physical characteristics

Location Data	
SD Lake WDN:	**22-0002-00**
County:	**Day County**
Ecoregion:	**Northern Glaciated Plains**
Major Watershed:	**Big Sioux River**
Latitude/Longitude:	**45.5167°N 97.2833°W**
Invasive Species:	**Curly-leaf Pondweed, Zebra Mussels**

Physical Characteristics	
Surface area (acres):	**981**
Littoral area (acres):	**Data unavailable**
% Littoral area:	**Data unavailable**
Max depth (ft), (m):	**41, 12.5**
Inlets:	**3**
Outlets:	**1**
Public Accesses:	**3**

Table 2. Availability of primary data types for Pickerel Lake

Data Availability	
Transparency data	**Good, enough for trend analysis**
Chemical data	**Moderate, enough phosphorus data for trend analysis**
Inlet/Outlet data	**Good, all three inlets are monitored with enough data for analysis**
Recommendations	**For recommendations refer to page 20.**

Lake Map

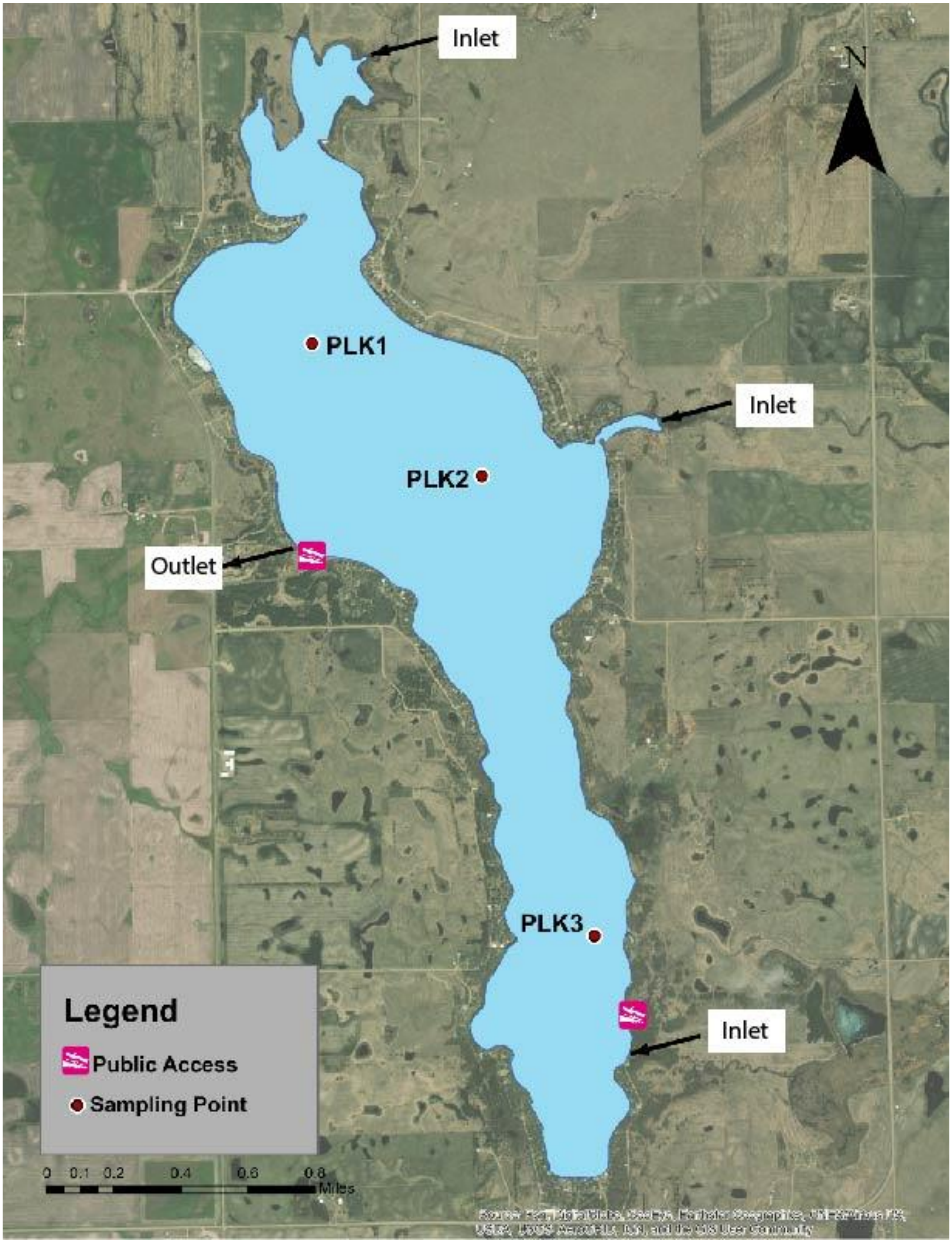


Figure 1. Map of Pickerel Lake with sample site locations and public access points

Average Water Quality Statistics & Comparisons

The information below describes available chemical data for Pickerel Lake through 2019 (Table 3). Data for total phosphorus, chlorophyll *a*, and Secchi depth are from a composite of all three sample sites.

Areas of the United States are divided into ecoregions based on land use, vegetation, precipitation and geology. Based on other lakes located within an ecoregion, lake data can be compared to the "average range" of water quality expected in each ecoregion[1] (Table 3). Pickerel Lake is in the Northern Glaciated Plains ecoregion.

Figure 2. South Dakota ecoregions

Table 3. Water quality means compared to ecoregion ranges

Parameter	Mean	Ecoregion Range[1]	Interpretation
Total phosphorus (ug/L)	41.6	130 – 250	Phosphorus and chlorophyll *a* results are lower than the expected range for lakes in the Northern Glaciated Plains Ecoregion. Pickerel Lake's results are similar to lakes in south central Minnesota
[3]Chlorophyll *a* (ug/L)	10.7	30 – 55	
Chlorophyll *a* max (ug/L)	40		
Secchi depth (ft)	6.4	1 – 4	
Dissolved oxygen	*See page 11*		Dissolved oxygen depth profiles show that the lake typically mixes throughout the summer then stratifies in early fall.
Total Kjeldahl Nitrogen (mg/L)	0.87	1.8 – 2.3	Indicates low levels of nitrogen to support summer algae blooms
pH	8.4	8.3 – 8.6	Within the expected range for the ecoregion
Chloride (mg/L)	ND	0.6 – 1.2	Data not available
Total Suspended Solids (mg/L)	8.5	10 - 30	Lower than the expected range for the ecoregion
Specific Conductance (umhos/cm)	ND	50 – 250	Data not available
TN:TP Ratio	21:1	7 - 14	Above the expected range for the ecoregion indicating nitrogen sources in the watershed. This ration shows the lake is phosphorus limited. Additional phosphorous, especially ortho-phosphorous the dissolved plant-available form, will cause rapid plant and algae growth.

Hat [1]The ecoregion range is the 25th-75th percentile of summer means from ecoregion reference lakes: https://www.pca.state.mn.us/quick-links/edaguide-typical-minnesota-water-quality-conditions
[2]For further information regarding the Impaired Waters Assessment program, refer to http://www.pca.state.mn.us/water/tmdl/index.html
[3]Chlorophyll *a* measurements have been corrected for pheophytin
Units: 1 mg/L (ppm) = 1,000 ug/L (ppb)

Water Quality Characteristics - Historical Means and Ranges

Table 4. Water quality means and ranges for Pickerel Lake

Parameters	Composite Site
Total Phosphorus Mean (ug/L):	41.6
Total Phosphorus Min:	17.0
Total Phosphorus Max:	136.0
Number of Observations:	91
Chlorophyll *a* Mean (ug/L):	10.7
Chlorophyll-a Min:	1.3
Chlorophyll-a Max:	40
Number of Observations:	42
Secchi Depth Mean (ft):	6.4
Secchi Depth Min:	2.4
Secchi Depth Max:	15.3
Number of Observations:	97

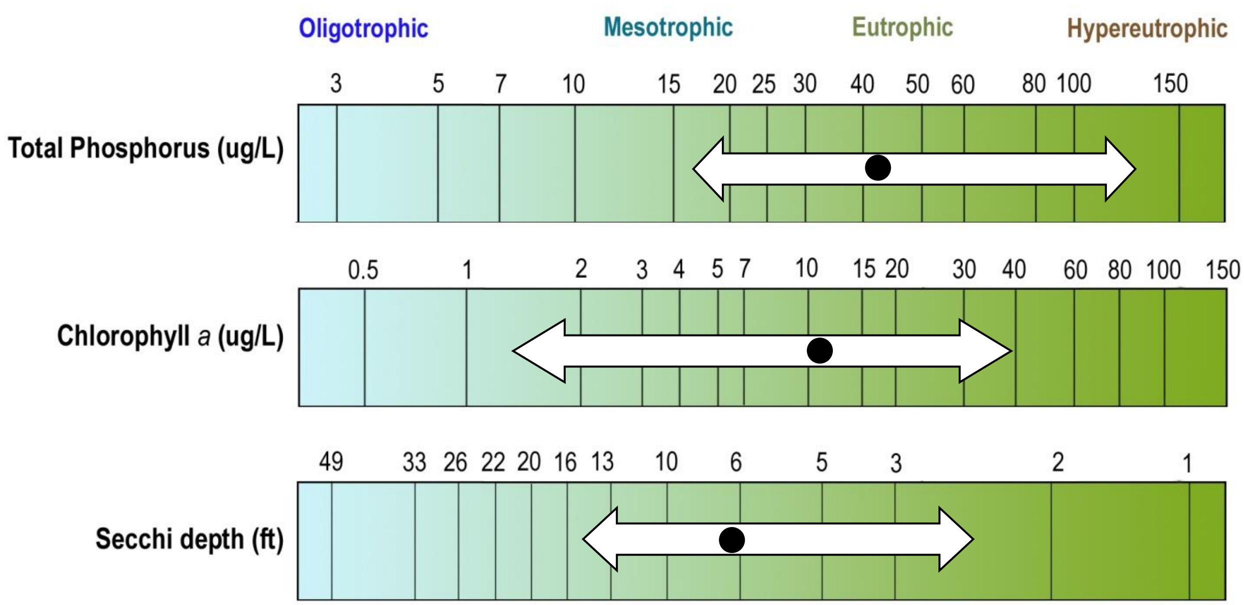


Figure 3. Pickerel Lake total phosphorus, chlorophyll a, and transparency historical ranges. The arrow represents the range and the black dot represents the historical mean of the three sites composited. Figure adapted after Moore and Thornton, [Ed.]. 1988. Lake and Reservoir Restoration Guidance Manual. (Doc. No. EPA 440/5-88-002)

Transparency (Secchi Depth)

Transparency is how easily light can pass through a substance. In lakes, it is how deep sunlight penetrates through the water. Plants and algae need sunlight to grow, so they are only able to grow in areas of lakes where the sun penetrates. Water transparency depends on the number of particles in the water. An increase in particulates results in a decrease in transparency. The transparency varies year to year due to changes in weather, precipitation, lake use, flooding, temperature, lake levels, etc.

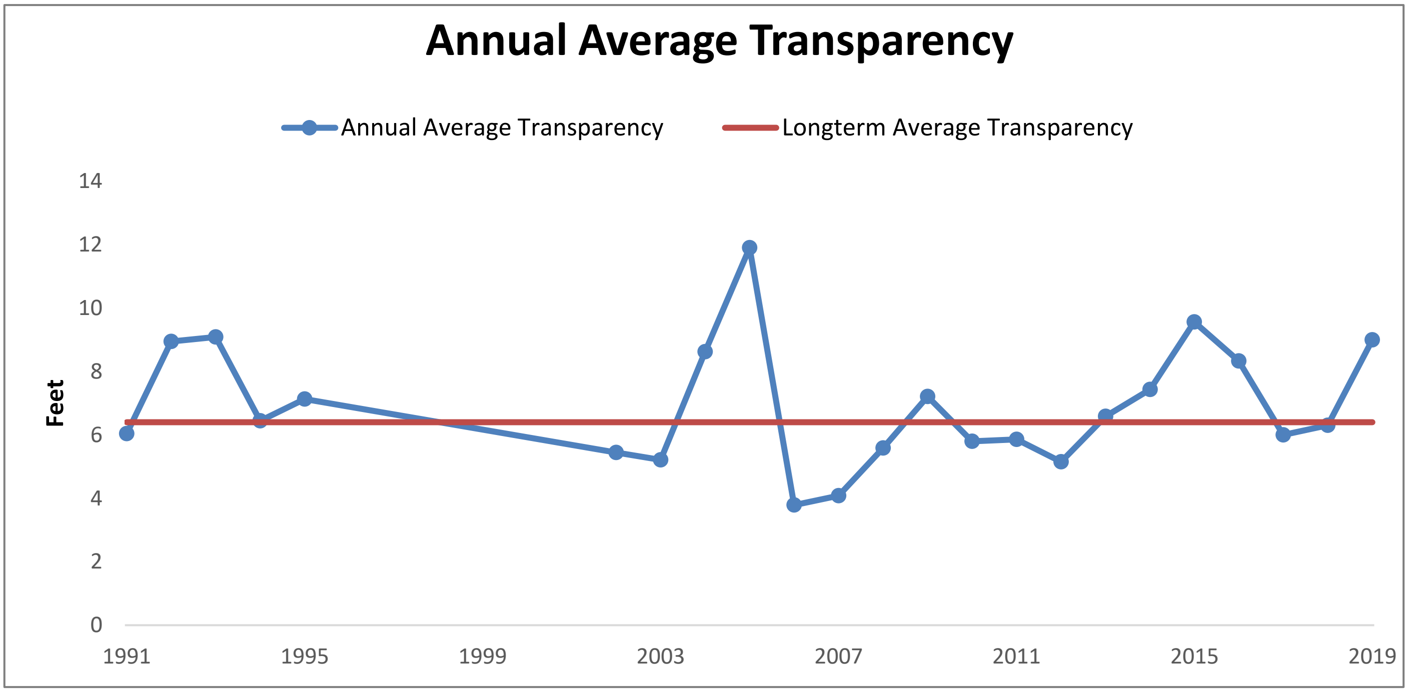
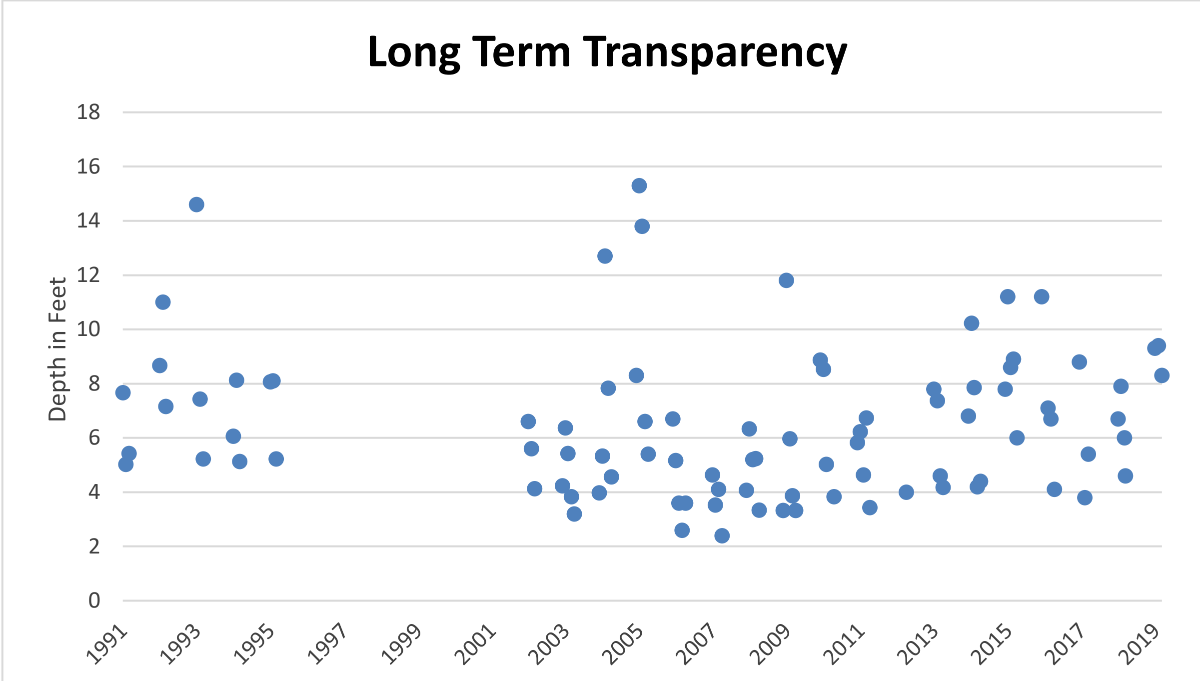


Figure 4. Annual average transparency with long-term mean from 1991 to 2019

Pickerel Lake transparency was monitored annually from 1991 to 2019 at site PLK2. The transparency measurements in Pickerel Lake range from 2.4 to 15.3 feet and hover fairly close to the long-term mean of 6.2 feet (Figure 4). For trend analysis, see page 13. Transparency monitoring should be continued at least monthly every summer in order to track water quality changes. Additional volunteer weekly water clarity monitoring would be useful in documenting the occurrence and persistence of algae blooms.



The water clarity in Pickerel Lake follows a typical seasonal pattern (Figure 5). Water clarity dynamics have to do with algae and zooplankton population dynamics and lake turnover. It is important for lake residents to understand the seasonal transparency dynamics in their lake so that they are not excessively worried when their transparency is lower in August than it is in June. It is typical for a lake to vary in transparency throughout the summer. Pickerel Lake is consistently clear throughout the early summer and prone to algae blooms in later summer and fall, causing lower transparency levels.

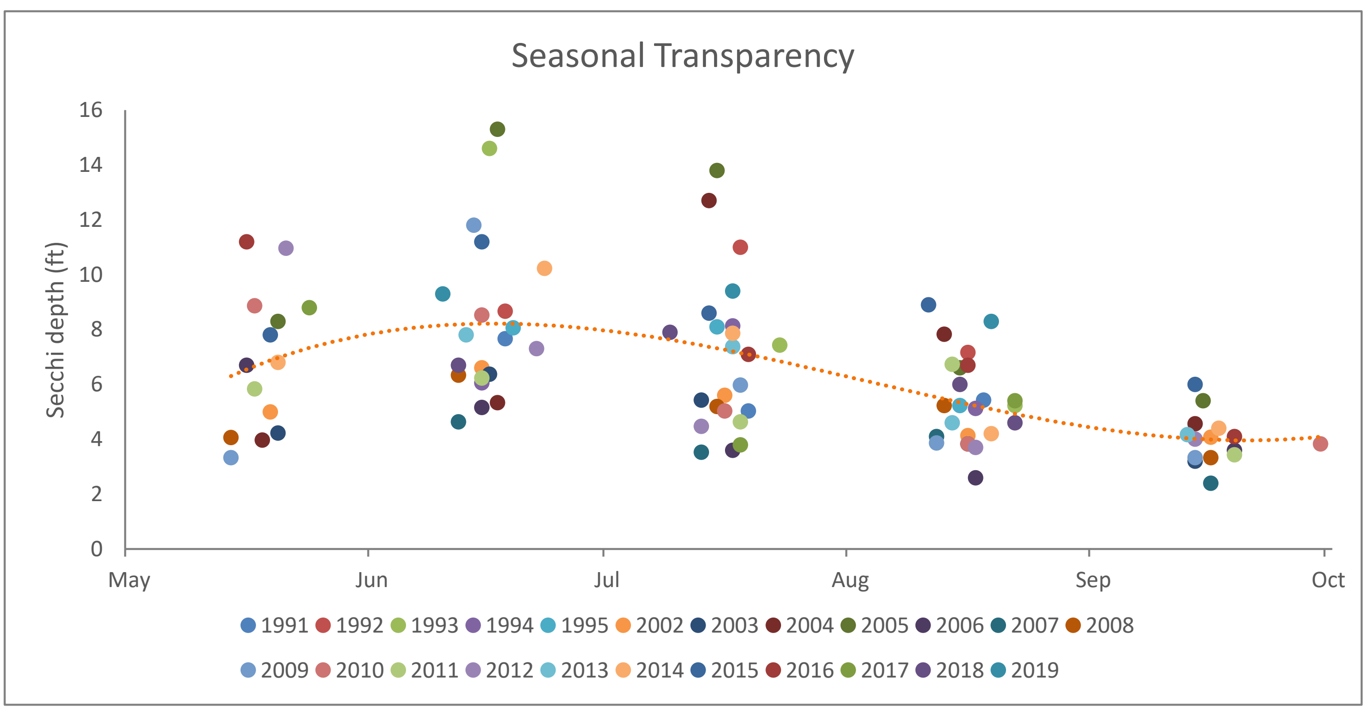


Figure 5: Seasonal transparency for Pickerel Lake from 1991 to 2019

Algae

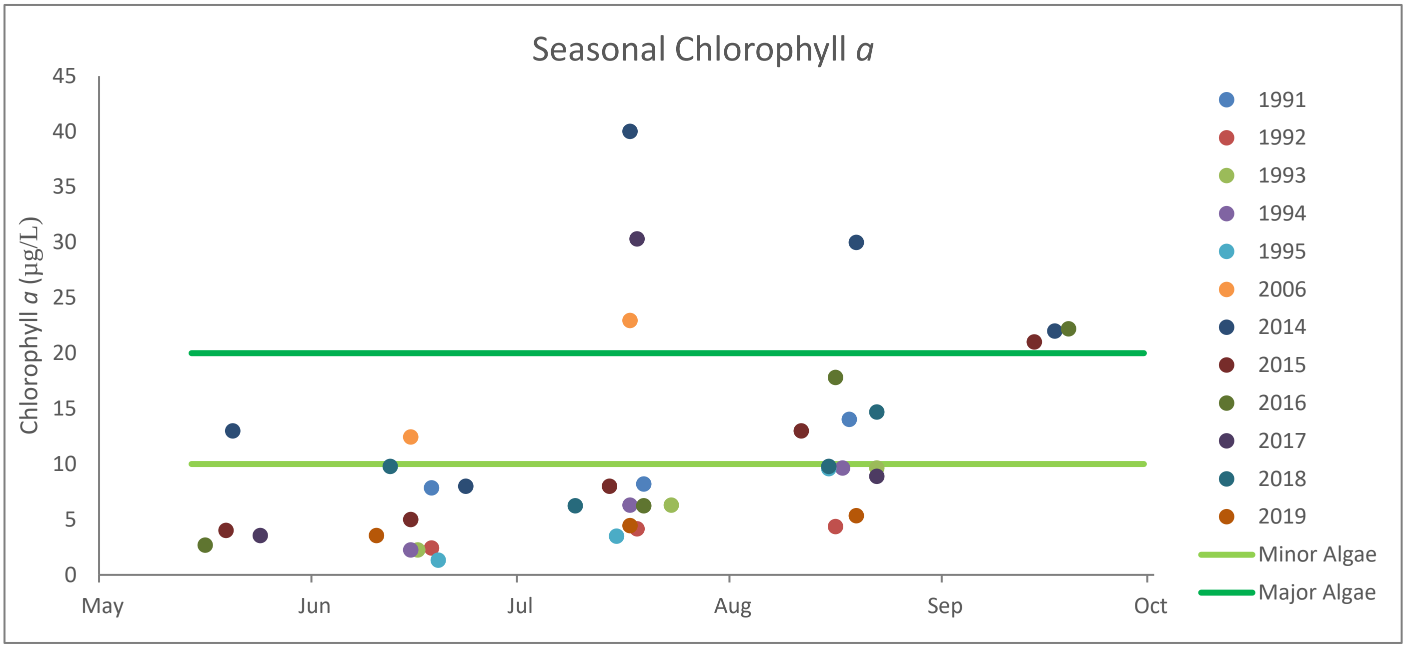
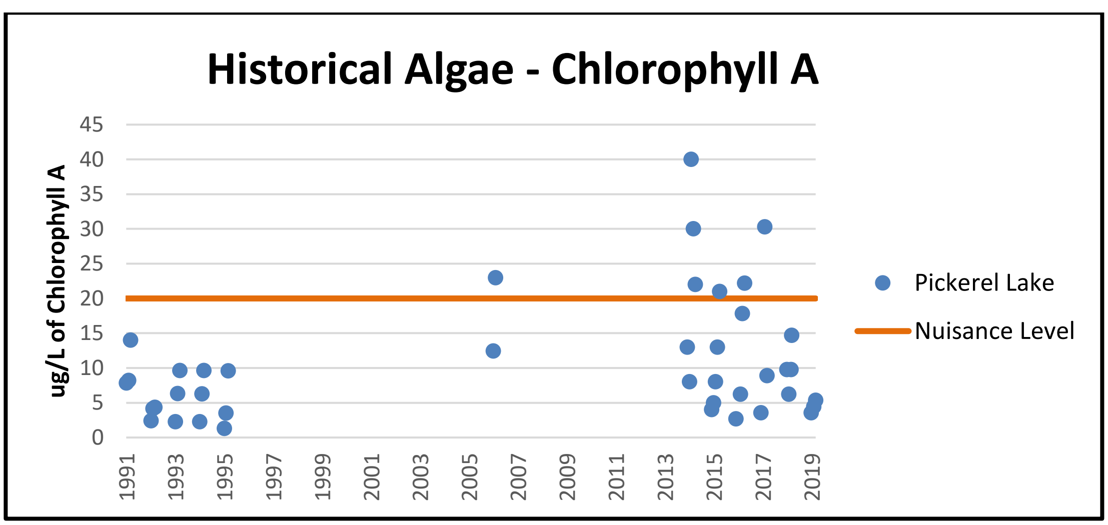


Figure 6. Seasonal chlorophyll a concentrations (ug/L) for Pickerel Lake from 1991 to 2019

Chlorophyll *a* is the pigment that makes plants and algae green. Chlorophyll *a* is tested in lakes to determine the algae concentration or how "green" the water is. Concentrations greater than 10 ug/L are perceived as a mild algae bloom, while concentrations greater than 20 ug/L are perceived as a nuisance.

Chlorophyll *a* was evaluated in Pickerel Lake since 1991 at the composite of the three sites (Figure 6). A majority of the samples were below the 10 µg/L level. Chlorophyll *a* concentrations above 20 ug/L were not recorded in the 1990s, indicating few summer algae blooms. Residents did note fall algae blooms in the 1980s and 1990s, but they were not reflected in the summer water quality samples. In recent years, chlorophyll *a* concentrations have occasionally exceeded nuisance levels, especially in mid to late summer. It is typical for a eutrophic lake to see increased amounts of chlorophyll *a* during the summer months.



Phosphorus

Pickerel Lake is phosphorus limited, which means that algae and aquatic plant growth is dependent upon available phosphorus. Total phosphorus was evaluated in Pickerel Lake from 1991 to 2019 (Figure 7). There is no statistically significant trend for total phosphorus concentrations, so nutrients are stable in the most recent 18 years of consecutive data. Seasonally, phosphorus shows a typical pattern in Pickerel Lake (Figure 8). A majority of data points fall into the eutrophic range which is above 0.025 mg/l of phosphorous. During early summer months when the lake is stratified, the phosphorus is at the lowest concentration, and it increases later in the summer when lake turnover begins.

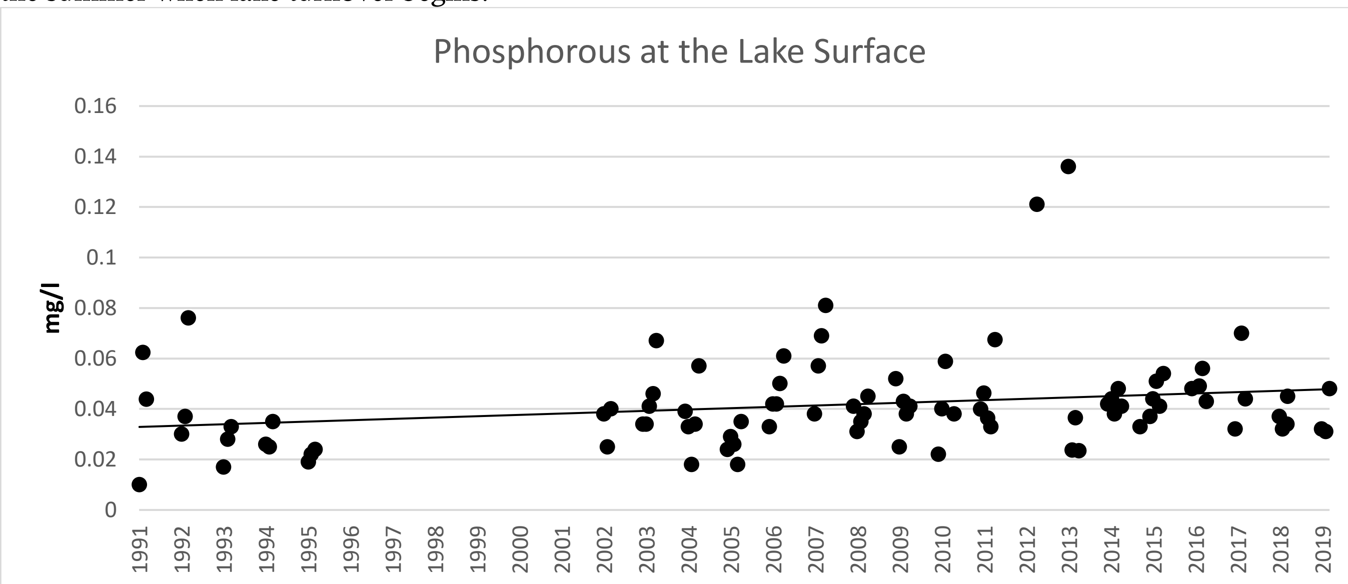


Figure 7. Historical total phosphorus concentrations in surface samples from 1991 to 2019

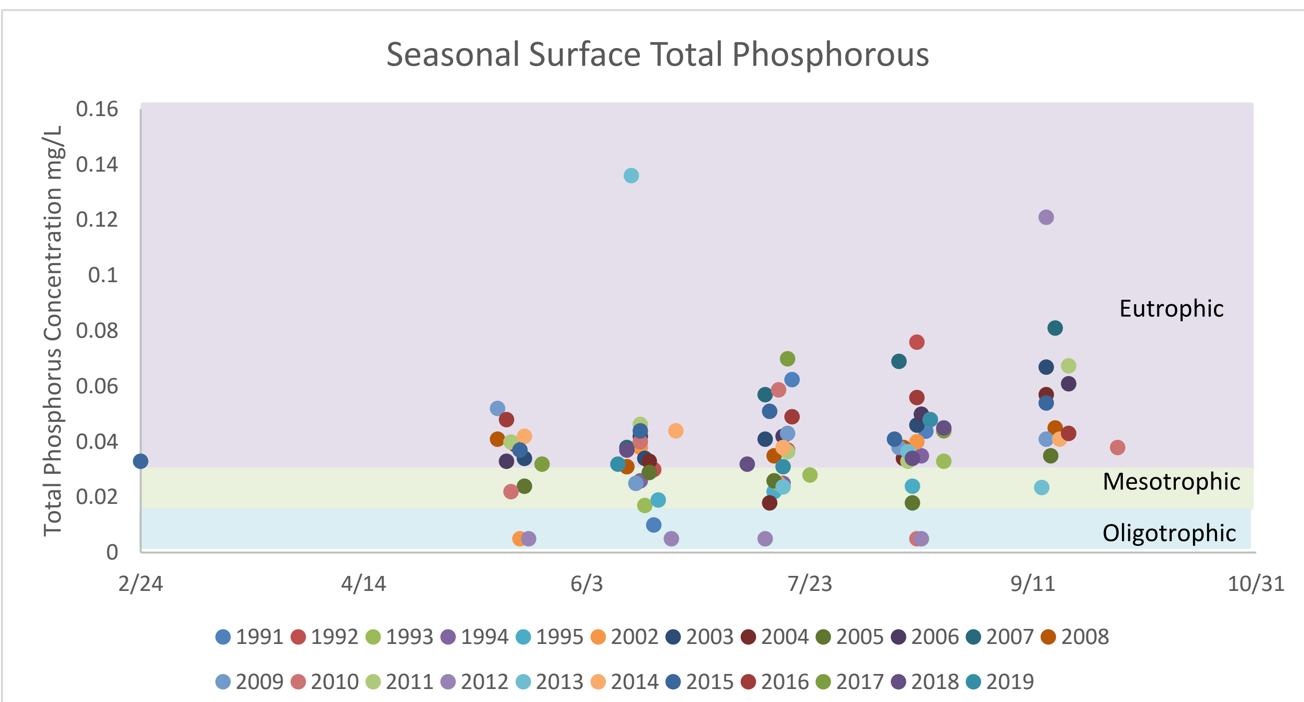


Figure 8. Seasonal phosphorus dynamics in surface samples from 1991 to 2019

The biggest changes are being seen at the lake bottom where levels of plant available dissolved phosphorous have increased with statistical significance (Figure 9). Both total phosphorus and dissolved phosphorus were analyzed using data collected from the bottom of the lake. Using a Mann-Kendall statistical test, there is a statistically significant short-term trend (Table 8) indicating increasing dissolved phosphorus concentrations at the lake bottom.

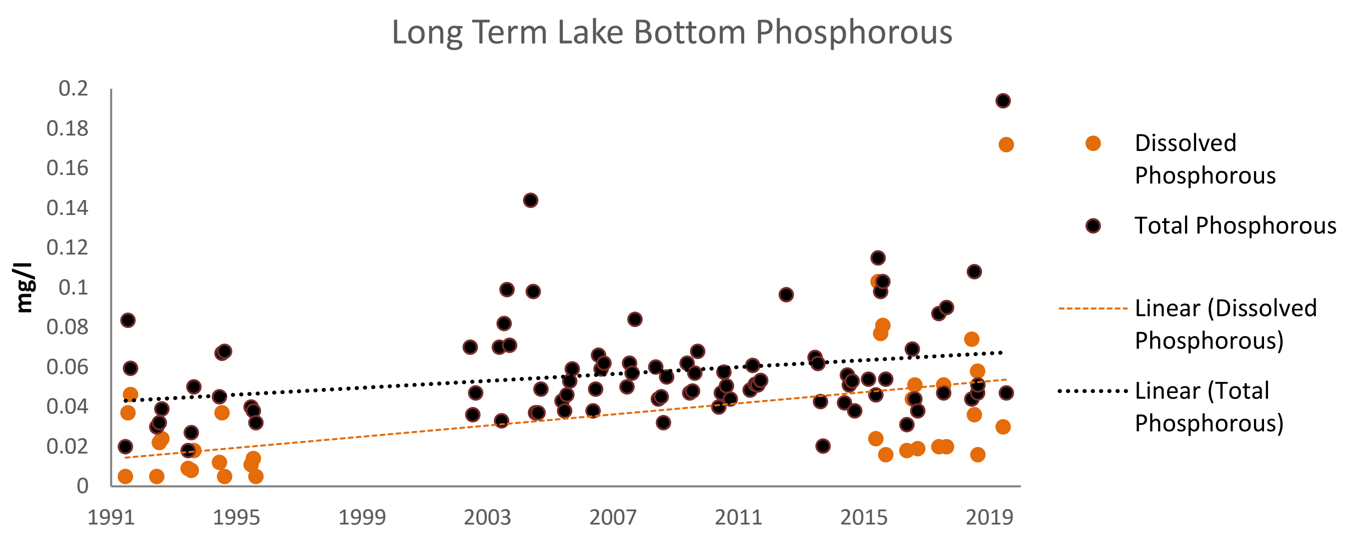


Figure 9: Total phosphorous and dissolved phosphorous as measured at the lake bottom from 1991 to 2019

Accumulated nutrients can be stored in a lake by binding to bottom sediments. The measure of phosphorous at the lake bottom is a good indicator of how well a lake is storing nutrients and how much is being released into the water. Levels of phosphorous at the lake bottom also reflect how much oxygen is available in the water. High loads of nutrients can deplete oxygen levels and alter the lake's nutrient storage process. This can make additional phosphorous available to plants and algae that was previously stored in the bottom sediments. This process, known as internal loading, causes elevated levels of dissolved phosphorous near the lake bottom that can cause weed growth and algae blooms if it mixes into the water column.

The phosphorous concentrations in the samples taken at the bottom of Pickerel Lake have reflected this internal loading pattern. When dissolved oxygen levels have declined, phosphorous has been released from the lake bottom. The samples from the 1990s show only small increases of phosphorous during periods of low oxygen. In more recent years, phosphorous levels when oxygen is depleted are much higher than when oxygen is available. Monitoring available phosphorus through cores of the lake sediments would allow for comparisons with the previously collected samples.

Oxygen

Dissolved Oxygen (DO) is the amount of oxygen available in lake water. Oxygen is necessary for all living organisms to survive except for some bacteria. Dissolved oxygen levels of <5 mg/L are typically avoided by game fisheries. While the surface of the lake stays well oxygenated, the bottom layers can run out.

As organic matter decays, natural iron compounds bind with phosphorus, storing it in lake sediments. The process of decomposition also consumes oxygen, if the supply of dissolved oxygen gets too low then the bottom of a lake can become anoxic – oxygen depleted. These areas of oxygen depletion allow phosphorus to be released from the sediments back into the water as dissolved phosphorus. In very deep lakes, this anoxic layer is often restricted to the lake bottom until fall turnover due to stratification which is the layering of warm light upper water on top of cool dense lower water. In moderately deep lakes the water column can temporarily stratify. While stratified the lower water can become depleted of oxygen and nutrients released from the lake sediments. A windy day can then mix up the water, causing phosphorus from the anoxic lake bottom to resuspend into the water. This process is known as internal nutrient loading and can cause rapid algae blooms. Moderately deep lakes still turnover in fall and spring causing some nutrient recycling. Shallow lakes usually stay well mixed all summer due to wind action and then turnover as water temps cool in the fall.

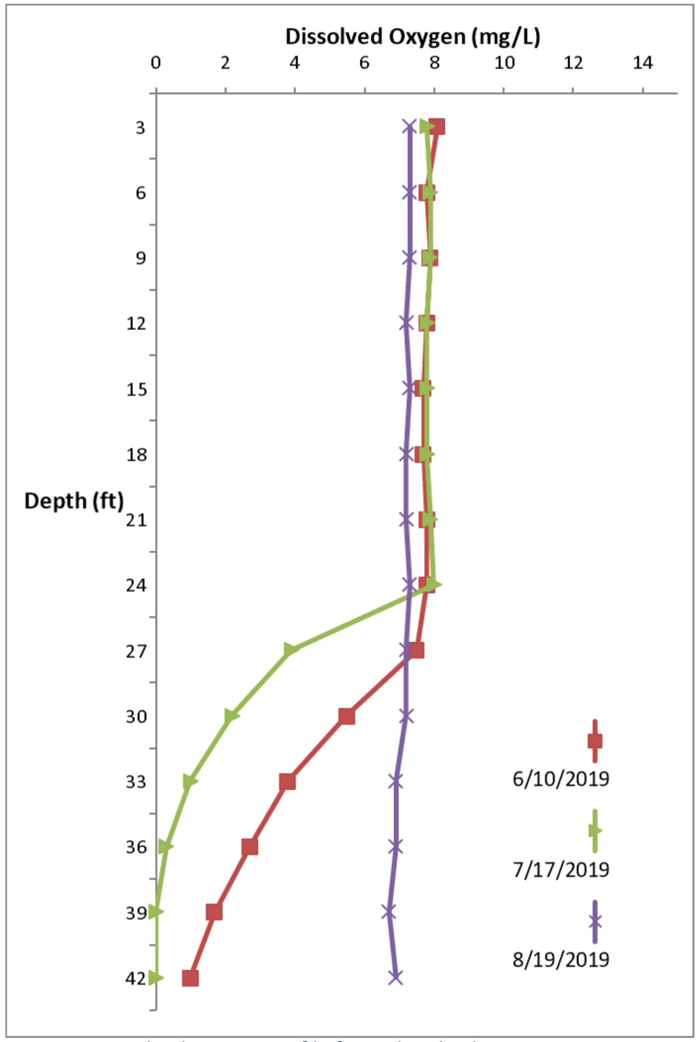


Figure 10. Dissolved oxygen profile for Pickerel Lake in 2019

Pickerel Lake is a moderately deep lake, with a maximum depth of 41 feet. Dissolved oxygen profiles from data collected in 2019 at site PLK2 show stratification in June and July. While a lake is stratified, it is typical for the bottom of a deep lake to become low in oxygen, anoxic. If the lake mixes again oxygen is replenished at the bottom of the lake and nutrient rich water can be cycled through the lake. Many lakes only mix twice a year at spring and fall turnover. Some lakes mix more often due to their shallow nature and wind mixing. Based on the oxygen and temp profile in 2019 Pickerel Lake stratified in early summer and then mixed again around mid-August prior to the actual fall turnover.

From 2002 to 2019, dissolved oxygen readings show mid-summer anoxic periods occurring more frequently. In the 1990s, anoxic conditions were observed in late summer or early fall. From 2002 to 2010, anoxic conditions were only observed on 2 summer sampling trips. In more recent years, oxygen levels have become depleted at the lake bottom by mid-summer with 12 occurrences in the past ten years, including two June anoxia events (Table 5).

Lakes stratify when the upper water warms significantly faster then the water near the bottom. The wind is always mixing the lake water helping to keep temperatures even. Stratification is more likely in years when temperatures warmup quickly and wind speeds are average. In years with a long slow spring and above average wind speeds Pickerel Lake is likely to stay well mixed all summer and only experience internal nutrient release during fall turnover. In recent years Pickerel Lake has been experiencing mid-summer stratification and anoxic conditions followed by wind induced mixing events. This can release plant-available dissolved phosphorous from the lake bottom back into the water, triggering algae blooms, rooted algae, and aquatic plant growth. When this new growth dies additional oxygen is consumed which can contribute to another anoxic period.

	June	July	August
2002			
2003			
2004			
2005		X	
2006			
2007			
2008			
2009			X
2010			
2011		X	
2012		X	
2013		X	X
2014			X
2015	X	X	X
2016			
2017		X	
2018	X		X
2019		X	

Table 5: Anoxic conditions observed in Pickerel Lake from 2002 to 2019

Trophic State Index (TSI)

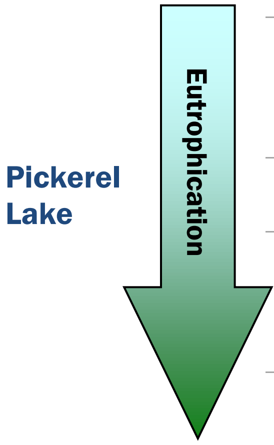
TSI is a standard measure or means for calculating the trophic status or productivity of a lake. More specifically, it is the total weight of living algae (algae biomass) in a waterbody at a specific location and time. Three variables, chlorophyll a, Secchi depth, and total phosphorus, independently estimate algal biomass.

If all three TSI numbers are within a few points of each other, they are strongly related. If they are different, there are other dynamics influencing the lake's productivity, and TSI mean should not be reported for the lake. Pickerel Lake falls into the eutrophic range (Tables 6, 7).

Table 6. Trophic State Index for Pickerel Lake

Trophic State Index	
TSI Phosphorus	58
TSI Chlorophyll-a	54
TSI Secchi	50
TSI Mean	54
Trophic State:	Eutrophic

Numbers represent the mean TSI for each parameter.



TSI	Attributes	Fisheries & Recreation
<30	**Oligotrophy:** Clear water, oxygen throughout the year at the bottom of the lake, deep cold water.	Trout fisheries dominate.
30-40	Bottom may become anoxic (no oxygen).	Trout fisheries in deep lakes only. Walleye, Cisco present.
40-50	**Mesotrophy:** Water moderately clear most of the summer. May be "greener" in late summer.	No oxygen at the bottom of the lake results in loss of trout. Walleye may predominate.
50-60	**Eutrophy:** Algae and aquatic plant problems possible. "Green" water most of the year.	Warm-water fisheries only. Bass may dominate.
60-70	Blue-green algae dominate, algal scums and aquatic plant problems.	Dense algae and aquatic plants. Low water clarity may discourage swimming and boating.
70-80	**Hypereutrophy:** Dense algae and aquatic plants.	Water is not suitable for recreation.
>80	Algal scums, few aquatic plants.	Rough fish (carp) dominate; summer fish kills possible.

Source: Carlson, R.E. 1997. A trophic state index for lakes. *Limnology and Oceanography*. 22:361-369.

Table 7. Trophic state index attributes and their corresponding fisheries and recreation characteristics

Trend Analysis

For detecting trends, a minimum of 8-10 years of consecutive data with 4 or more readings per season are recommended. Minimum confidence accepted by the Minnesota Pollution Control Agency is 90%. This means that there is a 90% chance that the data are showing a true trend and a 10% chance that the trend is a random result of the data. Only short-term trends can be determined with just a few years of data, because there can be different wet years and dry years, water levels, weather, etc, that affect the water quality naturally.

Pickerel Lake had sufficient data to perform a trend analysis for phosphorous and transparency from 2003 to 2019 (Table 8). Chlorophyll *a* data did not have 8 consecutive years of data, so a trend could not be run. Continuing to monitor the chlorophyll *a* in the next few years will allow for future analysis. The data was analyzed using the Mann-Kendall Trend Analysis. No statistically significant trends were detected for total phosphorus or transparency, but there is a trend of increasing levels of dissolved phosphorus which indicates declining water quality.

Parameter	Date Range	Water Quality Trend	Probability	Significance
Total Phosphorus	2002-2019	Stable	-	
Dissolved Phosphorus	2002-2019	Declining	99.9%	Additional fertility feeds algae and plants, leading to nuisance conditions and low oxygen levels.
Transparency	2003-2019	Stable	-	

Table 8. Trend analysis for Pickerel Lake

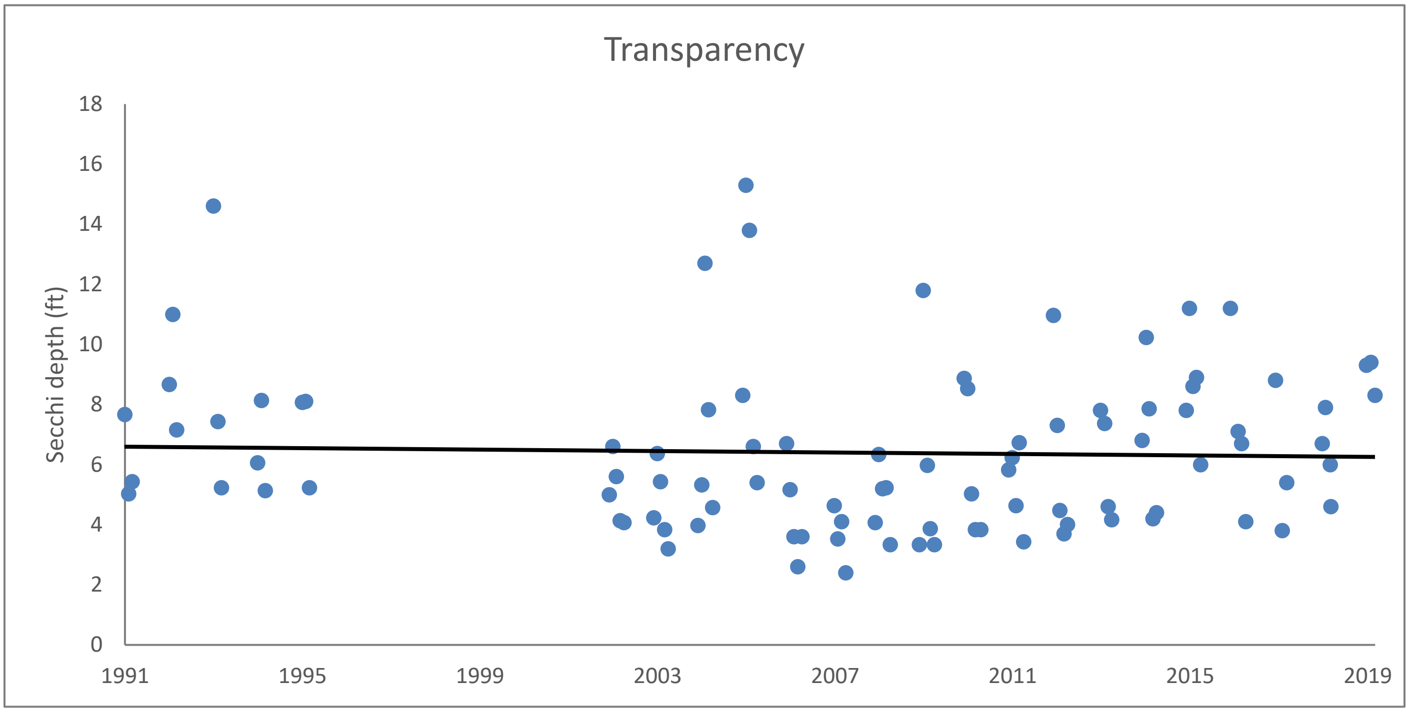


Figure 11: Transparency measurements with long-term mean from 1991 to 2019

Lakeshed

Understanding a lakeshed requires an understanding of basic hydrology. A watershed is defined as all land and water surface area that contribute excess water to a defined point. The Minnesota DNR has delineated three basic scales of watersheds (from large to small): 1) basins, 2) major watersheds, and 3) minor watersheds.

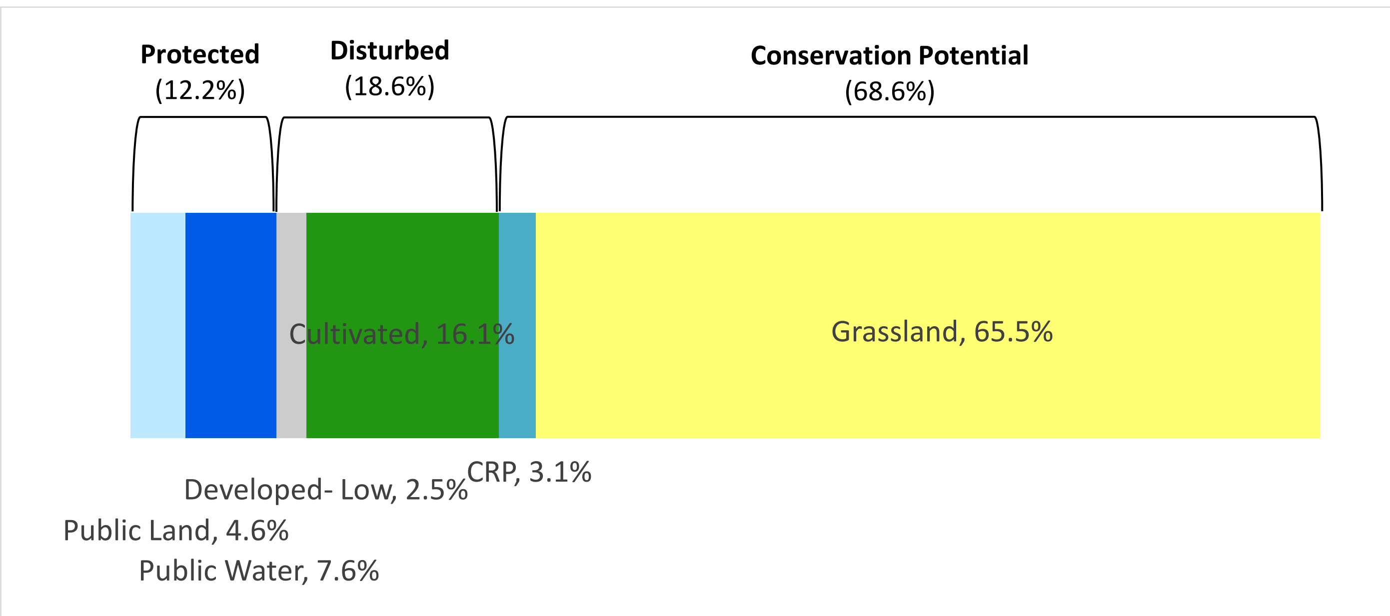
The Big Sioux River Major Watershed is one of the watersheds that make up the Missouri River Basin, which drains south to the Gulf of Mexico. The Waubay Lakes Basin is part of the Big Sioux River watershed, and Pickerel Lake's lakeshed is in the Waubay Lakes Basin. These lakesheds (catchments) are the "building blocks" for the larger scale watersheds. Lakesheds are very useful for displaying the land and water that contribute directly to a lake, but they are not always true watersheds because they may not show the water flowing into a lake from upstream streams or rivers. While some lakes may have only one or two upstream lakesheds draining into them, others may be connected to a large number of lakesheds, reflecting a larger drainage area via stream or river networks.

In an effort to prioritize protection and restoration efforts of fishery lakes, the Minnesota DNR has developed a ranking system by separating lakes into two categories based on their lakeshed: those needing protection and those needing restoration. Modeling by the DNR Fisheries Research Unit suggests that total phosphorus concentrations increase significantly over natural concentrations in lakes that have a watershed with disturbance greater than 25%. Therefore, lakes with watersheds that have less than 25% disturbance need protection and lakes with more than 25% disturbance need restoration (Table 9). Watershed disturbance was defined as having urban, agricultural and mining land uses. Watershed protection is defined as publicly owned land, public water, wetlands, or conservation easement.

Table 9. Suggested approaches for watershed protection and restoration of DNR-managed fish lakes in Minnesota

Watershed Disturbance (%)	Watershed Protected (%)	Management Type	Comments
< 25%	> 75%	Vigilance	Sufficiently protected -- Water quality supports healthy and diverse native fish communities. Keep public lands protected.
	< 75%	Protection	Excellent candidates for protection -- Water quality can be maintained in a range that supports healthy and diverse native fish communities. Disturbed lands should be limited to less than 25%.
25-60%	n/a	Full Restoration	Realistic chance for full restoration of water quality and improve quality of fish communities. Disturbed land percentage should be reduced and BMPs implemented.
> 60%	n/a	Partial Restoration	Restoration will be very expensive and probably will not achieve water quality conditions necessary to sustain healthy fish communities. Restoration opportunities must be critically evaluated to assure feasible positive outcomes.

According to the 2016 National Land Cover Data Set, Pickerel Lake's lakeshed is classified with having 12.2% of the watershed protected and 18.6% of the watershed disturbed (Figure 13). Therefore, this lakeshed should have a protection focus. Goals for the lake should be to limit any increase in disturbed land use and maintain protected lands. Forest stewardship planning, harvest coordination to reduce hydrology impacts and forest conservation easements are some potential tools that can protect Pickerel Lake for the long term.



Land use and Ownership

Activities that occur on the land within the lakeshed can greatly impact a lake. Land use planning helps ensure the use of land resources in an organized fashion so that the needs of the present and future generations can be best addressed. Pickerel Lake receives water from Dry Creek to the north, Oneroad Lake through Chekepa Creek to the east, and Hatchery Creek to the southeast.

Around one eighth (12.2%) of the Pickerel Lake lakeshed is protected. This total includes open water and wetlands. There are two areas along Dry and Chekepa Creeks just upstream from the lake that could be targeted for potential sedimentation and nutrient removal ponds. There are three animal feedlots in the lakeshed, only one of which is currently in use. Each feedlot has cooperated in the installation of runoff reduction projects starting as early as the 1970's.

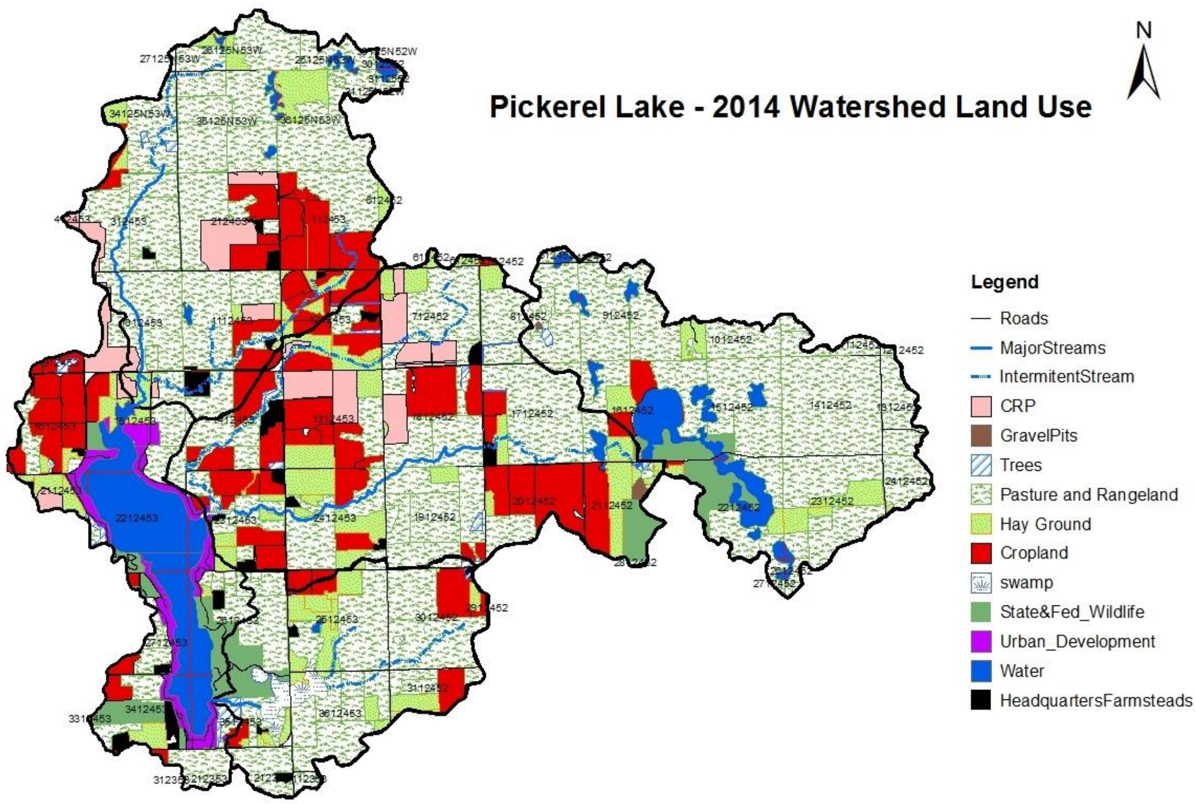


Figure 12. Land use and ownership in the Pickerel Lake lakeshed

The lakeshed vitals table identifies where to focus organizational and management efforts for each lake (Table 10). Criteria were developed using limnological concepts to determine the effect to lake water quality.

KEY

Possibly detrimental to the lake
Warrants attention
Beneficial to the lake

Table 10. Pickerel Lake lakeshed vitals

Lakeshed Vitals		Rating
Lake Area	981 acres	descriptive
Littoral Zone Area	Data unavailable	descriptive
Lake Max Depth	41 ft	descriptive
Lake Mean Depth	16 ft	Warrants attention
Water Residence Time	5 years	Possibly detrimental to the lake
Miles of Stream	53.4	descriptive
Inlets	3	Warrants attention
Outlets	1	Beneficial to the lake
Major Watershed	Big Sioux River	descriptive
Minor Watershed	Waubay Lakes Basin	descriptive
Ecoregion	Northern Glaciated Plains	descriptive
Total Lakeshed to Lake Area Ratio (total lakeshed includes lake area)	23:1	Warrants attention
Standard Watershed to Lake Basin Ratio (standard watershed includes lake areas)	Data unavailable	Not Available
Wetland Coverage	6%	Beneficial to the lake
Aquatic Invasive Species	Curly Leaf Pondweed, Zebra Mussels	Possibly detrimental to the lake
Public Drainage Ditches	Data unavailable	Not Available
Public Lake Accesses	3	Warrants attention
Miles of Shoreline	10.1	descriptive
Shoreline Development Index	2.3	Possibly detrimental to the lake
Public Land to Private Land Ratio	Data unavailable	Not Available
Development Classification	Recreational Development	Warrants attention
Miles of Road	52.8	descriptive
Municipalities in lakeshed	None	Beneficial to the lake
Forestry Practices	None	Beneficial to the lake
Feedlots	3	Possibly detrimental to the lake
Sewage Management	Sanitary Sewer	Beneficial to the lake
Lake Management Plan	None	Warrants attention
Lake Vegetation Survey/Plan	None	Warrants attention

Tributary Monitoring

Pickerel Lake has very good tributary data collected at sites along the streams that feed into the lake. On Dry Creek just north of Pickerel Lake is Site 1. Sampling locations on Chekepa Creek include Site 3 the north branch and Site 4 the east branch from One Road Lake. These three sites represent the primary inlets into the lake. Hatchery Creek at site 5 has very low nutrient levels and is not a significant source of nutrients to the lake. There are not enough consecutive years of data to run statistical trends on the tributary data, but most of the phosphorus and suspended solids values are comparable year to year. The expected ranges for streams in the Northern Glaciated Plains region are 0.09 – 0.25 mg/L for phosphorus and 11 – 63 mg/L for suspended solids.

In all of the samples at Dry Creek Site 1, there are low levels of phosphorus and suspended solids, regardless of the year (Figures 14, 15). The annual average phosphorus concentrations are on the low end of the expected range, and a majority of the suspended solids samples were well below the expected range.

At Site 3 on Chekepa Creek, phosphorus and suspended solids were occasionally slightly elevated in 2008 and 2009 (Figures 16, 17). In more recent years, levels of both parameters have declined and fall within or below the expected regional range.

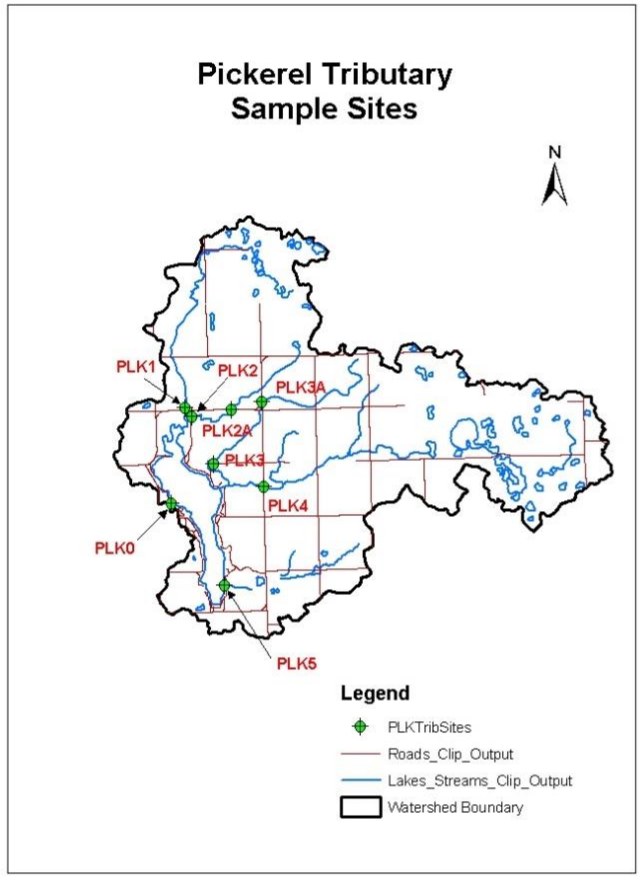


Figure 13: Stream sample sites in tributaries to Pickerel Lake

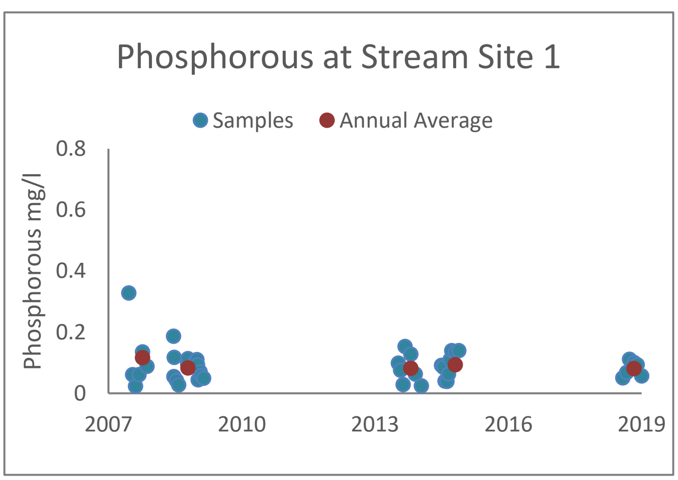


Figure 14: Phosphorus concentrations at Stream Site 1 Dry Creek from 2008 to 2019

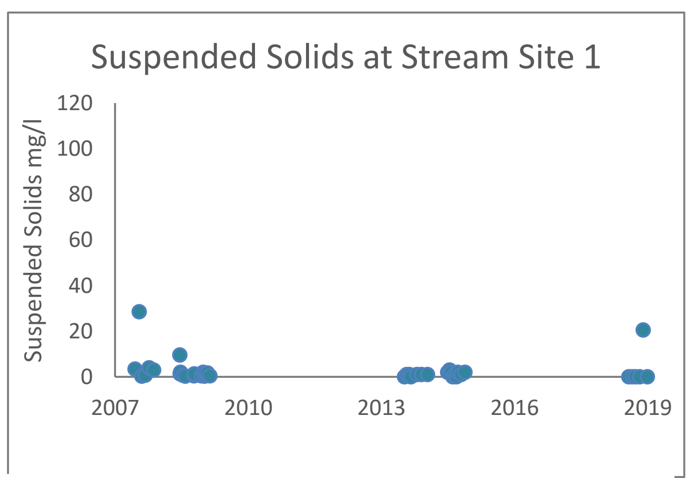


Figure 15: Total suspended solid concentrations for Stream Site 1 Dry Creek from 2008 to 2019

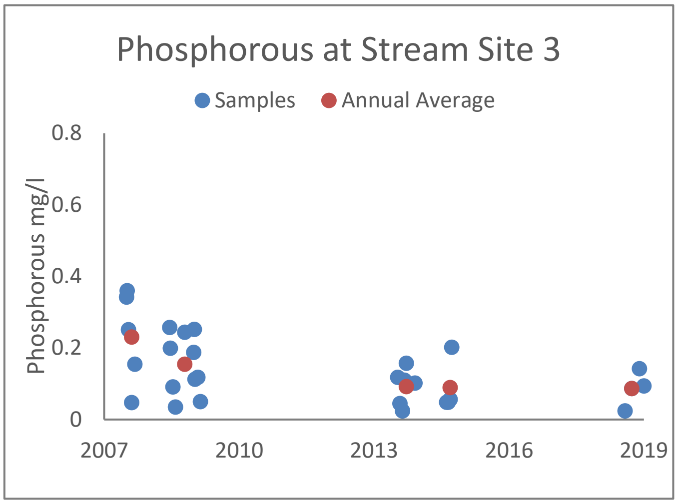


Figure 17: Total Phosphorous concentrations for Stream Site 3 Chekepa Creek from 2008 to 2019

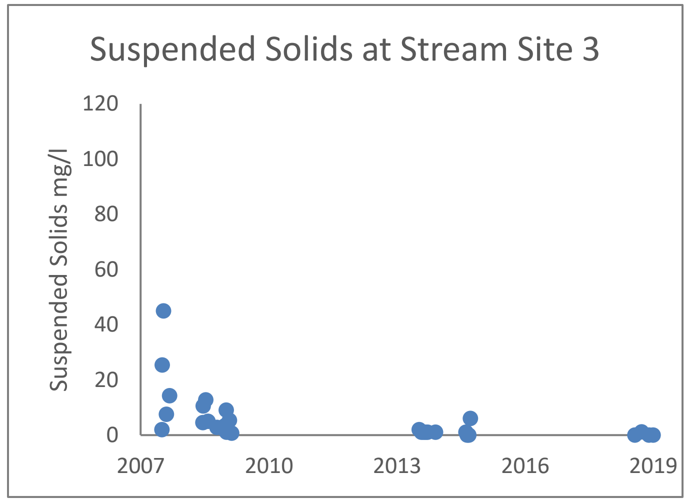


Figure 17: Total suspended solid concentrations for Stream Site 3 Chekepa Creek from 2008 to 2019

Chekepa Creek Site 4 had the highest levels of all three sites for both phosphorous and suspended solids (Figures 18, 19). This input is likely the most influential source of nutrients to Pickerel Lake. In 2008, both parameters had samples with very high values, but the average concentrations were still within the ecoregion range. The levels of phosphorous were much lower in 2014 while the levels of suspended solids remained elevated. By 2019, levels of both phosphorous and suspended solids were low and below the expected range.

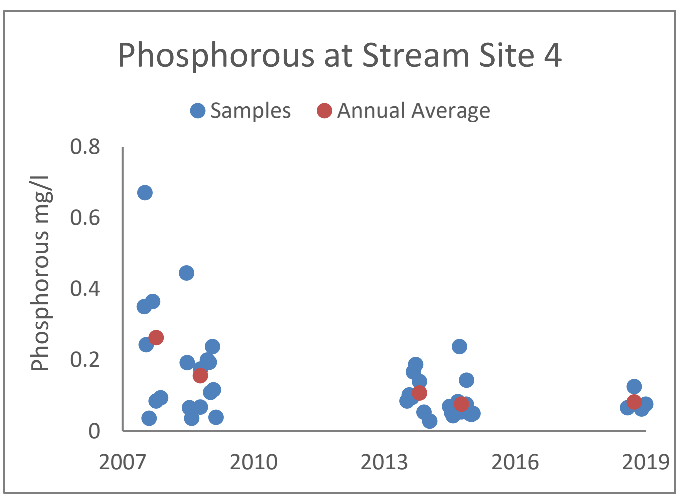


Figure 18: Phosphorus concentrations at Stream Site 4 Chekepa Creek from 2008 to 2019

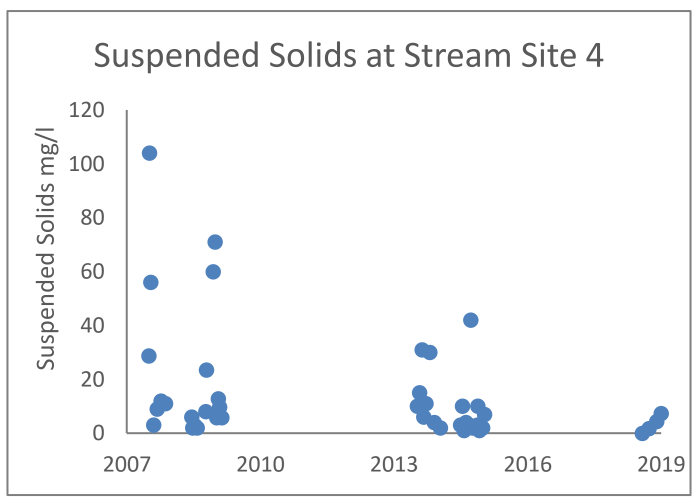


Figure 19: Total suspended solid concentrations for Stream Site 4 Chekepa Creek from 2008 to 2019

Note: Curly leaf pondweed, an invasive species, has been found in Pickerel Lake. Care should be taken by all user groups to prevent its spread. For information regarding curlyleaf pondweed and other aquatic invasive species please visit https://sdleastwanted.sd.gov/

Pickerel Lake, located 6.0 miles northeast of Grenville, is managed as a multi-species fishery including panfish (i.e., black crappie, bluegill, and yellow perch), smallmouth bass and walleye; other fish species (e.g., northern pike, white bass, etc.) also contribute to the fishery.

• Black crappie. Black crappies were not abundant (0.7/frame net) in 2019. Sampled fish ranged in length from 4.7 to 12.2 inches and four cohorts (2004, 2010, 2016, and 2017) were represented, each by eight or fewer individuals.

• Bluegill. The 2019 frame net CPUE was the highest recorded in surveys from 2010 to 2019. At 24.5/frame net, relative abundance was considered moderate to high. Sampled bluegills ranged in length from 3.5 to 8.7 inches; 92% were >6.0 inches and 15% were >8.0 inches. Fish from three consecutive year classes (2015 - 2017) were present; those from the 2016 cohort were the most abundant accounting for 80% of bluegills in the sample. Growth appears to be good with a mean length at capture value of 8.3 inches at age 4.

• Northern pike. Northern pike numbers were higher in 2019 than 2018. At 2.5/gill net, relative abundance was considered moderate to high. Sampled northern pike ranged in length from 18.1 to 29.9 inches, 87% were >21.0 inches and 3% were 28 inches and longer.

• Smallmouth bass. More smallmouth bass were sampled in 2019 (59.0/hour) than 2018 (6.0/hour). The increase was likely not related to population changes but rather improved sampling conditions in 2019. Sampled smallmouth bass ranged in length from 8.7 to 19.3 inches, 83% were >11.0 inches and 37% were 14.0 inches or longer. Of those <14.0 inches nearly 70% (30 of 43 individuals) were from the 2015 (age-4) year class. In 2019, age-4 fish had a mean length at capture of 13.0 inches, which is higher than age-4 mean lengths at capture reported from 2011 to 2015 (11.1 to 12.0 inches).

• Walleye. At 5.2/gill net, relative abundance was considered moderate in 2019. Gill net captured walleyes ranged in length from 10.2 to 28.0 inches, most (74%) were >15.0 inches and 18% were 20.0 inches or longer. Individuals from 10 year classes (2004, 2006, 2008, 2010, 2011, and 2013 – 2017) were present; those from the 2013 (age 6), 2015 (age 4) and 2017 (age 2) cohorts, which coincided with small fingerling stockings, were the most abundant accounting for >70% of fish in the sample. Since 2010, mean length at capture of age-4 fish has ranged from 12.7 to 17.4 inches. In 2019, the mean length at capture for age-4 fish was 16.5 inches.

• Yellow perch. The 2019 mean gill net CPUE of 16.1 suggested moderate relative abundance. Sampled yellow perch ranged in length from 4.7 to 11.8 inches, of those >5.0 inches 32% were >8.0 inches and 4% were 10.0 inches or longer. Individuals from five year classes (2012 and 2014 - 2017) were present, those from the 2016 (age-3) cohort were the most abundant accounting for more than half (51%) of fish in the sample. Growth tends to be slow to moderate as mean length at capture values for age-3 yellow perch have ranged from 7.6 to 8.8 inches since 2010. In 2019, the mean length of age-3 fish was 7.6 inches.

For more detailed results see the computer generated South Dakota Statewide Fisheries Survey for Pickerel Lake at https://apps.sd.gov/GF56FisheriesReports/ExportPDF.ashx?ReportID=17799

Development pressure is increasing around the shorelines and within the watersheds of many lakes. This development can degrade water quality and impact valuable shoreline habitat. Native shoreline vegetation provides habitat for fish and wildlife, filters harmful nutrients, and protects against shoreline erosion. Lakeshore owners can minimize their impact on the shoreline and maintain a more natural setting while actually decreasing annual maintenance. For more information on how to accomplish this, go to the following website: www.dnr.state.mn.us/shorelandmgmt

Key Findings and Recommendations

Monitoring Recommendations
Transparency monitoring at the primary sites should be continued annually. It is important to continue transparency monitoring, possibly weekly but at least monthly every summer to enable year-to-year comparisons and trend analyses. Weekly volunteer secchi disc readings would help identify the occurrence and duration of algae blooms and any trends over time. Phosphorus, dissolved phosphorous, Total Kjeldhal Nitrogen, and chlorophyll *a* monitoring should continue, as the budget allows, to track future water quality trends. Currently the streams sites have fairly low nutrient and sediment levels. Stream site monitoring could be reduced to once every few years or as concerns arise. The good long term data set will allow any new samples to be compared with past observations.

Overall Conclusions
Pickerel Lake is a eutrophic lake (TSI = 54) with stable total phosphorus and transparency trends, in the last 18 years. The total dissolved phosphorus levels have been increasing over time indicating a declining water quality trend with 99.9% confidence. Recent chlorophyll measurements are higher than results observed in the 1990s but may be similar to what was observed in the 1980s based on anecdotal reports.

Approximately one eighth of the lakeshed is protected (12.2%), which includes public land and open water. About 19% of the lakeshed is disturbed, which is mainly cropland, lakeshore development, and low density developed areas like roads (Figure 12). Undisturbed areas in the lakeshed should be protected by paying landowners to maintain the existing habitat and utilizing conservation easements through groups such as Ducks Unlimited or other state, local, or federal groups.

Phosphorus Loading and Priority Impacts
Pickerel Lake is at a disadvantage because it retains much of the nutrients and sediment that wash into it. There is one additional lakeshed that contributes water from upstream areas and several streams flow into Pickerel Lake. This means that the land practices upstream likely impact to the lake's water quality.

Table 11. Watershed characteristics

Lakeshed to Lake Area Ratio (lakeshed includes lake area)	23:1
Watershed to Lake Area Ratio (watershed includes lake areas)	Data unavailable
Number of Upstream Lakes	1
Headwaters Lake?	No
Inlets / Outlets	3 / 1
Water Residence Time	5 years

Only 6% of the lakeshed is covered with wetlands, which does not provide very much water storage and filtration (Figure 12). Protecting and restoring wetlands will help maintain water levels and water storage, reduce flooding, and filter runoff during large storm events.

Pickerel Lake has a moderate amount of surface inflow and some springs discharging groundwater into the lake. The large lake size and deep depths give the water a moderate residence time in the lake, likely 5 or more years. Most lakes retain at least half of the nutrients that flow into the lake in their bottom sediments. Pickerel Lake likely retains 75% of the annual nutrient load into the lake.

Data show that summer algae blooms are now worse than they were in the 1990s. It is likely that phosphorous release from the lake bottom sediments is causing the summer algae blooms that are being observed. The cumulative effects from the large watershed and land practices have aged the lake, resulting in greater oxygen demand in the deep portions of the lake. As the bottom water layers run out of oxygen, dissolved reactive phosphorous is released from the lake sediments. This phosphorous is available for uptake and causes aquatic plant and algae growth. An analysis of the dissolved phosphorous data collected at the lake bottom shows an increase with current levels four times higher than in the 1990s (Figure 9).

Best Management Practices Recommendations

The management focus for Pickerel Lake should be to protect the water quality by implementing nutrient and runoff reduction BMPs in the lakeshed and investigating the possibility for hypolimnetic withdrawal. Efforts should be focused on managing and/or decreasing the impacts caused by agriculture, current and additional development, nutrient-saturated wetlands, and impervious areas. Project ideas include treating runoff in regional nutrient removal ponds, conservation cropping systems, hypolimnetic withdrawal to remove nutrient rich water from the lake bottom when oxygen is absent, shoreline restoration, rain gardens, and infiltration systems.

Pickerel Lake Goals

1. Protection Focus: minimize disturbed land uses and maintain protected lands
2. Manage phosphorus loading from **nearshore** (Table 12)
3. Implement regional sedimentation and nutrient removal ponds
4. Manage phosphorous release from lake sediments by removing bottom water, hypolimnetic withdrawal, or alum application

Table 12. Best Management Practices specific to Pickerel Lake (refer to Figure 12 for locations)

Category	Land use type	Conservation project ideas	Results	Who	Contact for help
Conservation Potential	Pasture/grassland/CRP 68.6%	Conservation Reserve Program (CRP), maintain vegetative cover, plant trees, conservation easements, grassed waterways, ditch buffers, maintain/restore wetlands.	Reduce water runoff and soil erosion, better water storage. Treat runoff with iron enhanced media to remove dissolved phosphorous.	• Individual Property Owners • Regional treatment ponds could be pursued by the Pickerel Lake Conservancy	Day County Conservation District (605) 345-4661
Disturbed Land	Cultivated crops 16.1%	Restore wetlands; Conservation Reserve Program (CRP), Cover Crops	Reduce water runoff and soil erosion, better water storage. Treat runoff in regional ponds that include iron enhanced media to remove dissolved phosphorous.	• Individual Property Owners • Regional treatment ponds could be pursued by the Pickerel Lake Conservancy	Day County Conservation District (605) 345-4661
	Developed, low intensity 2.5%	Shoreline buffers, tree planting, rain gardens.	Reduce water runoff and shoreline erosion.	• Individual Property Owners • Pickerel Lake Conservancy	Day County Conservation District (605) 345-4661
	Developed, high intensity (0.01%, 2 acres)	Infiltration trenches, permeable pavements, tree planting, rain gardens, shoreline buffers, stormwater retention.	Reduce water runoff into streams and lakes.	• Individual Property Owners • Pickerel Lake Conservancy	Day County Conservation District (605) 345-4661

The current lakeshore homeowners can lessen their negative impact on water quality by installing or maintaining the existing trees on their properties. Forested uplands contribute about 10% as much phosphorus (lbs/acre/year) than developed land.

The lakeshed still has a few undeveloped shoreline parcels (Figure 12). There is the great potential for protecting this land with conservation easements or public ownership. Conservation easements can be set up easily and at little cost with help from organizations such as the The Nature Conservancy and Ducks Unlimited. Public land purchases can be pursued through the local Game and Fish office, Pheasants Forever, and other partners.

Native aquatic plants stabilize the lake's sediments and tie up phosphorus in their tissues. When aquatic plants are uprooted from a shallow lake, the lake bottom is disturbed, and the phosphorus in the water column gets used by algae instead of plants. This contributes to "greener" water and more algae blooms. Protecting native aquatic plant beds will ensure a healthy lake and healthy fishery. If a swimming area is necessary in front of people's docks, clear only a small area of plants. Clearing the whole frontage of a lake lot is not necessary and can contribute to additional algae blooms.

Organizational contacts and reference sites

Pickerel Lake Conservancy	Grenville, SD 57239 info@pickerellakeconservancy.org
South Dakota Game & Fish Office	603 East 8th Ave, Webster, SD 57274 605-345-3381
South Dakota Department of Environment & Natural Resources	523 E Capitol Ave, Pierre, SD 57501 605-773-3151
Northeast Glacial Lakes Watershed Project	info@neglwatersheds.org 605-345-4661
Day County Conservation District	600 E Highway 12, Ste 1 Webster, Sd 57274 (605) 345-4661

Table 13. Organizational contacts and reference sites