Five Island Lake
Watershed Management Plan

January 4, 2022

The Five Island Lake Community is dedicated to water quality improvements through the conservation and preservation of the lake and its natural resources.

Prepared By: Palo Alto County Soil and Water Conservation District, FYRA Engineering, and Iowa Department of Natural Resources

Financial support provided by EPA -Section 319 Program, Iowa DNR, City of Emmetsburg, Iowa Trust and Savings Bank, Natural Resource Conservation Service, and Five Island Lake Association

Plan Timeframe: 2022-2052

Plan implementation will be led by the Palo Alto Soil and Water Conservation District

Plan Revisions: 2027, 2032, 2037, 2042, 2047

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Introduction

The community around Five Island Lake has a long history of working toward water quality improvement. According to an Economic Research Associates study conducted in 1974 "If it hadn't been for community action, this lake lying on the north edge of Emmetsburg, IA might today be a corn field." In 1913 when the lake was still known as Medium Lake, a petition was filed to drain the lake. The community of Emmetsburg banded together to preserve their lake and began the first of many attempts to stabilize the lake shore and begin dredging.

In 1974 a cost benefit analysis was prepared for the Iowa Conservation Commission to determine if dredging would be a cost-effective tool to improve water quality and lake usability. By this time many areas previously dredged had silted in. It was also noted in the 1974 report that almost all the waterfowl habitat and rushes had disappeared from the north end of the lake after a dry period in 1954. It wasn't until 1992 that an application was submitted to the Clean Lake Program to help fund dredging and a diagnostic study. The lake was then dredged almost yearly until the project concluded in 2015. In 1994 another study was done to examine alternatives and supplements to dredging. This inquiry lead to a TMDL being completed in 2006, a Watershed Planning Grant in 2012, and a private study by FYRA Engineering in 2018.

Watershed Planning Process

Public outreach is beneficial to any project to gain insight from stakeholders, receive guidance from local experts, and help establish goals to produce a product that is acceptable to the public. Community-based planning efforts for the lake included the formation of two committees, coordination meetings with each committee, and one public meeting. The two committees formed were the Watershed Advisory Council (WAC) and Technical Advisory Team (TAT).

The WAC consists of interested local citizens that will be informed on lake and watershed processes and concepts. They will help develop goals and provide insight on historical and current lake issues and the local perception of different management strategies. The WAC will spread the knowledge they gain to the community and help build consensus and public support. They focused their role on identifying nutrient reduction opportunities and developing public educational tools. A technical advisory team is usually comprised of subject matter experts (like fisheries biologists, regional Basin Coordinators, water quality and watershed professionals, NRCS staff, etc.) that may or may not be stakeholders in the watershed. The technical advisory team works closely with the watershed advisory council, providing technical information on the local watershed conditions and the feasibility and effectiveness of potential solutions.

Table 1. Five Island Lake Watershed Group Members

Name	Affiliation/Title	Committee
Jeremy Thilges	NRCS	TAT
Craig Merrill	Palo Alto Board of Supervisors	WAC
Dan Cooper	Five Island Lake Association	WAC
Jerry Joyce	Palo Alto SWCD	WAC
Kim Kibbie	City of Emmetsburg	WAC
Kathy Mehan	Resident	WAC
Joel Horsley	Palo Alto SWCD	TAT
Lucas Straw	DNR - Wildlife	TAT
Michael Gunderson	Palo Alto SWCD	WAC
Jim George	Five Island Lake Association	WAC
Mike Hawkins	DNR - Fisheries	TAT
Mary Barrick	Palo Alto County Conservation Board	TAT
Kyle Ament	DNR – Water Quality	TAT
Jeff Stillman	Farmer	WAC
George Antoniou	DNR – Lake Restoration	TAT
Michelle Balmer	DNR – Lake Restoration	TAT
Dave Rouse	Resident	WAC
Linus Solberg	Palo Alto Board of Supervisors	WAC
Dean Gronemeyer	Natural Resource Conservation Service	TAT
Warren Jennings	Watershed Coordinator	TAT

Public Knowledge and Willingness to Participate

Public input and participation are crucial to the success of a watershed project. Watershed residents were surveyed in 2020 to better understand their positions on water quality and gauge interest in participating in water quality improvement projects. Two surveys were distributed, one for urban residents one for rural residents. Of rural residents 15 responded. There were 21 responses from urban residents. The results are summarized below.

Rural residents were first asked to describe themselves.

Landowner not farming land - 5
Landowner farming - 3
Tennant farming rented land – 7

Rural survey participants were then asked to indicate their level of agreement or disagreement with the following statements.

Table 2: Perceptions of water quality

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
Water quality in Five Island Lake needs Improvement		1	3	8	3
Ag fertilizers have impacted water quality in Five Island Lake	1	1	4	7	2
Eroded soil and sediments have impacted water quality in Five Island Lake	1	1	3	10	1
Improperly functioning septic systems have impacted water quality in Five Island Lake		1	11	2	1
Urban issues have impacted water quality in Five Island Lake	1	2	5	6	1
Poor water quality effects economic development in the area	1	1	7	5	1
I know what steps to take to better conserve soil and water on my land		1	1	11	2
I would be willing to work with others to develop strategies that protect our watershed		2	3	9	1

Survey participants were also asked which sources of information they use or would use to make decisions about their farming operation or land management strategy. Participants could select as many options as applied to them, their answers are as follows.

Face -to-face contacts - 14
Information meetings -12
Field days - 7
Demonstration projects - 9
Newsletters - 2
Newspapers - 5
Internet - 3
Farm Magazines - 1
Other - 1 NRCS / FSA Office

Survey participants were then asked their opinions on current use and interest in future use of conservation practices if they were offered at 75% cot share rate. The practices in question were selected based on their effectiveness improving water quality and applicability to the watershed's land scape.

Table 3. BMP Interest

	Would not work on my land	Not at all Interested	Somewhat interested	Very interested	Already adopted
No-till / Strip Till	3	2	6	1	3
Mulch-Till	2		7	1	5
Buffers / Filter Strips / Prairie Strips	8	2	4		1
Livestock Exclusion from Streams	14	1			
Streambank Stabilization	12	1	2		
Cover Crops	1	1	7	3	3
Grass Waterways	2	2	2	1	8
Wetlands	5	9	1		
Pasture Management	13	1	1		
Variable Rate Fertilizer Application	1		5	6	3
Livestock Waste Systems	12	1	1		1
CRP	1	1	6	4	3

Urban respondents were first asked to describe where their property was located.

On the water, lake front - 15
In the watershed but not directly on the lake - 4
Unsure – 2

They were then asked about the condition of the lake and describe the water quality they observed over the past 10-15 years.

Worse – 1
Unchanged – 13
Improved – 3
Unsure – 4

Next, they were asked if they felt the need for continued water quality improvements for Five Island Lake.

Yes – 14
No – 2
Unsure – 5

Finally, people were asked which conservation practices they would be interested in adopting or learning more about. Participants were allowed to select as many options as they wished.

Phosphate free fertilizer voucher - 17
Information and cost share on rain gardens - 6
Free or reduced cost rain barrels - 15
Information and cost share on pervious pavers - 2
Information and cost share on native turf grass - 4
Information and cost share on native shoreline – 12
Informational meeting and Q&A with an urban conservationist – 1
I'm not sure what any of these practices are - 2

Public Meeting and outreach (as of publication)

The COVID – 19 pandemic has serious impaired efforts to hold meetings of any sort.

On 12/16/2019 a WAC/TAT meeting was held at the Palo Alto County Nature Center. This meeting was the first time all the partners were assembled. The main focus of the meeting was to introduce both the coordinator and the current project and define partner roles in the project.

Previous meetings were held during the development of the FYRA engineering study published a few years ago. Meetings that were held for the development of the water quality management plan are summarized in Table 5

Through these meetings the committees identified issues and concerns, and are listed in no particular order:

- Limited lake level monitoring
- Need locally driven, not model driven project
- Rough fish spawning in shallow areas
- Lack of storm event sampling
- Drainage districts trying to implement a wetland restoration project; encountering land rights issues
- No watershed coordinator
- Storm sewer outlets into the lake
- Sediment and cornstalk wash into southwest portion of lake
- Septic systems around lake – need inspections and potential repairs
- Slight erosion on Fifth Island
- Enforcing boating restrictions
- Aeration system attracting geese in winter
- Need for public outreach and education
- Tile drainage in watershed
- Vegetation in lake is sparse

The main objective identified for this project is to reduce algae and experience better water quality. Approaches to setting goals were discussed and three standards to quantify water quality were provided:

- Reduce measured algae concentrations to meet the criteria for delisting from impaired waters list (chl-a concentration ≤ 27 μg/L = TSI ≤ 63)
- Increase water clarity to meet the criteria for delisting from impaired waters list (Secchi depth ≥ 2.6 ft = TSI ≤ 63)
- Increase water clarity to Iowa DNR Lake Restoration Program standards (Secchi depth ≤ 4.5 ft from April to September)

After the CBP and public meetings were held and potential improvement alternatives were presented, several general themes/issues became apparent. First, there is sincere commitment to improving and protecting Five Island Lake, and the community appears to recognize the economic value and recreational opportunities it affords the people of Emmetsburg and the surrounding areas. Members of the WAC and public meeting attendees understood and largely supported the need for a two-pronged approach that addresses both watershed and in-lake sources of phosphorus. There is much enthusiasm and interest in improving the fishery in Five Island Lake, as many anglers were present at the public meeting and asked a lot of questions and provided valuable feedback. Finally, there appears to be a broad support for hiring a watershed coordinator that can work with Natural Resource Conservation Service (NRCS) and local landowners to encourage and increase the adoption rate of agricultural BMPs that would help improve and protect the lake while also improving soil health.

Second, common questions or concerns included potential methods and impacts of in-lake alternatives. For example, the potential for increased aquatic vegetation in shallow areas was noted, which raised questions about impacts to boating and potential vegetation management activities. Third, concerns were also raised about the potential impacts of creating a large, in-lake wetland complex in the north end of the lake and acceptance/resistance of property owners in that vicinity. Fourth, there were many questions about proposed water level management, and it was clear that additional outreach and education would be needed in advance of a potential temporary drawdown for fish renovation, vegetation management, and/or construction purposes. Drawdown concerns also included questions about impacts on property and landowners along the drainage course downstream of the outlet structure, as well as questions related to the time required to refill the lake after drawdown. Finally, some stakeholders were curious about the need and/or benefits of further dredging north of the railroad trestle bridge near the outlet structure.

Watershed information

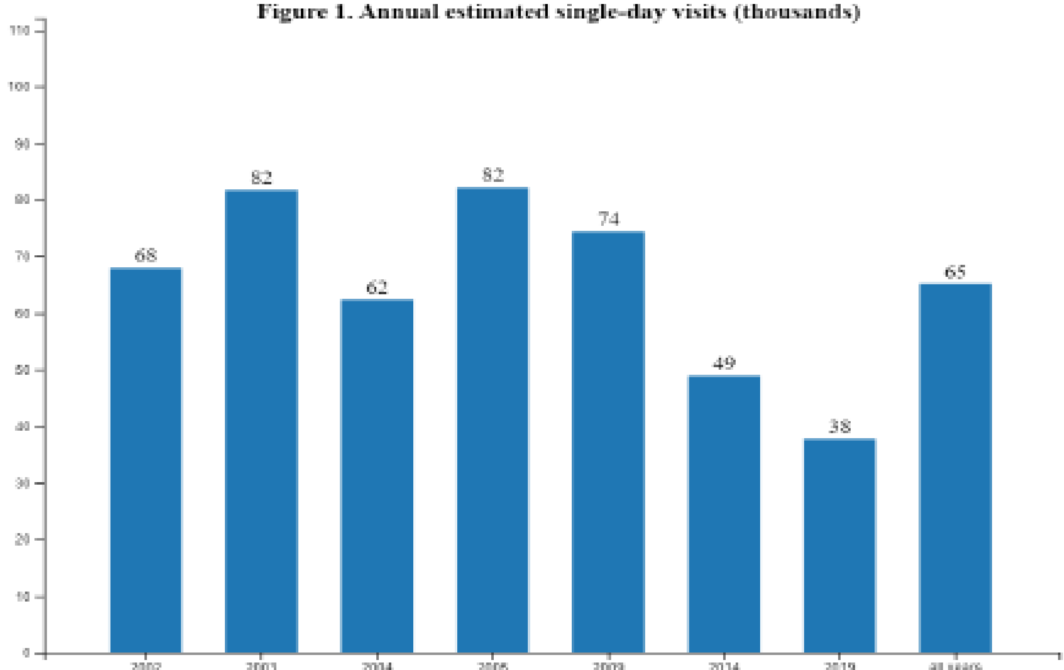
Figure 1. Five Island Lake Watershed:

The south end of the lake is home to Kearny State Park, Soper City Park, and a campground run by the city of Emmetsburg. The Emmetsburg Golf and Country Club and The Shores event centers also border the lake on the south end. The northern shallower end of the lake contains the Five Island Wildlife Management Area and Duhigg County Park.

Five Island Lake is a 1,002-acre natural lake located north of the town of Emmetsburg and extends almost five miles to the north east (Fig. 1). Land use primarily consists of agricultural land in the north, west and eastern portions of the watershed, with the urbanized area of Emmetsburg to the south.

Five Island Lake was enhanced with a man-made embankment and outlet structure to increase water volume and control the surface water outflow. The drainage area delineated during this study is 7,657 acres which yields a relatively low watershed to lake ratio of 8:1. Low ratios are favorable to successful restoration efforts because the watershed generates lower pollutant exports relative to the lake's capacity to receive and process nutrients. These pollutants can be mitigated with the implementation of targeted Best Management Practices, (BMP) and restoration alternatives.

Figure 1. Annual estimated single-day visits (thousands)



Notes
1. "all year" is the average annual estimated visits across all available survey years.
2. The estimated visits are rounded to the nearest thousand.

Economic Impacts

	2009	2014	2019
Direct Spending (thousands)	$10,687	$4,735	$4,927
Total Spending (thousands)	$16,917	$7,496	N.A.
Total Income Impact (thousands)	$2,669	$1,183	N.A.
Jobs	130	58	N.A.

Notes
The 2009 data is from "Economic Value of Outdoor Recreation Activities in Iowa"
The 2014 data is from "A Report to the Iowa Department of Natural Resources"
The 2019 data is from "A Report to the Iowa Department of Natural Resources on 2019 Lake Survey"

Table 4. Watershed Characteristics

IDNR Waterbody ID	IA 04-UDM-03850-L_0
12- Digit Hydrologic Unit Code (HUC)	71000020501

12- Digit HUC Name	Drainage Ditch 80
Location	Palo Alto County R-32W-T-96N
Latitude	43° 7' 56" N
Longitude	94° 40' 56" W
Designated Uses	A1 - Primary Contact Recreation B(LW) - Aquatic Life HH - Human Health
Tributaries	Unnamed intermittent creek
Receiving Waterbody	West Fork of the Des Moines by way of Drainage Ditch and Cylinder Creek
Lake Surface Area	1,002 acres
Max. Depth	24.9 feet
Mean Depth	5
Lake Volume	4,820 acre-feet
Length of Shoreline	14.2 miles
Watershed Area	7,657 acres
Watershed: Lake Ratio	8:1
Lake Retention Time	.92 year

Waterbody to be addressed:

In 2006 a TMDL was completed for Five Island Lake (ID# IA 04-UDM-03850-L) to address the water quality impairment of excessive Algae Growth/Chlorophyll-a and Turbidity. The TMDL indicates that the water quality impairment is due to excessive phosphorus loading from the watershed and internal resuspension of sediment. The TMDL which focused on external loading, called for a 17% reduction to meet water quality standards. No other waterbodies in the watershed have assigned ID numbers due to the nature of the landscape.

Due to further degradation of the lake and interest from the local community to improve the water quality in Five Island, FYRA engineering completed a water quality management plan (WQMP). The plan was completed in 2018 with assistance of the City of Emmetsburg and Iowa DNR. This document provided an in-depth analysis of both internal and external sources of phosphorus loading. The WQMP developed in 2018 utilized more recent data and models to reach un updated phosphorus reduction goal of 60% reduction. For the purpose of this document, we will use the 60% reduction of phosphorus as our target to reach the TSI levels set to water quality standards. The TMDL and WQMP both identified row crops as the largest portion of the phosphorus loading in the watershed.

Explanation of differences between TMDL and FYRA modeling:

1. Utilized 2010-2014 data when “calibrating the models. The 2006 TMDL was based on 2000-2005 data.
2. A much more detailed modeling approach that considered tile drainage and internal loading.
3. The TMDL itself had a wide range of potential loading rates and “settled” on the rate developed using the Vollenweider equation. Our watershed load of 6,617 is closer to the average of the 3

watershed loads included in the TMDL (14,250, 8,143, and 5,614). However, the TMDL used a variation of the Vollenweider model to come up with a TMDL load of 4,408.

<u>Hydrology</u>

Five Island Lake is located in Palo Alto County, within the Upper Des Moines River watershed. The lake is fed by an unnamed intermittent tributary as well as ground water and tile runoff. Five Island Lake's current outlet structure is a circular weir approximately five feet in height and around twelve inches thick. The weir is approximately 34 feet long and conveys flows to a 5'H x 8'W reinforced concrete box (RCB) culvert that passes under the lake circulation road. The RCB empties into an open channel area that is then blocked by North Huron Road. There are two metal pipe culverts (36" and 24" in diameter) that pass through North Huron Road. The water then flows 10.5 miles via Drainage Ditch 80 and Cylinder Creek to the West Fork of the Des Moines River.

There is very little historical water level information available for Five Island Lake. During a study published in 2018 some lake level data was taken and combined with information from the public to create an accurate historical model of lake level. (Figure 3)

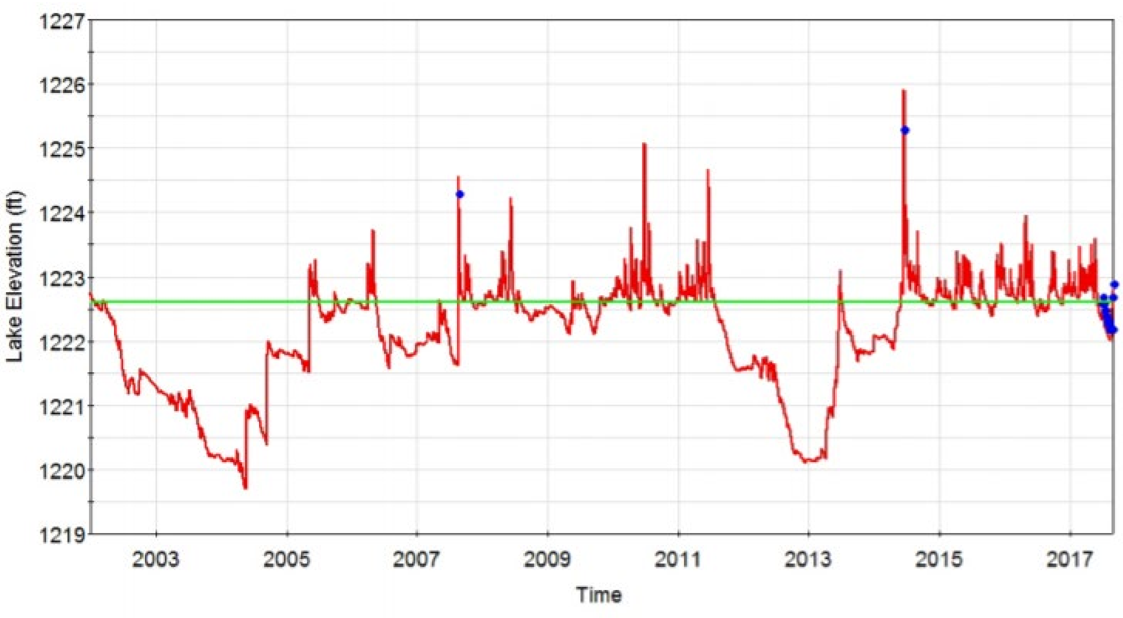


Figure 3. Five Island Lake Elevations (FYRA): Observed and Simulated lake levels over time. Green line represents Crest Elevation

Soils, Climate, Topography

Five Island Lake is within the Des Moines Lobe ecoregion. This region of Iowa was formed 12,000 to 14,000 years ago when the last glaciers receded from the state. These massive ice sheets left behind fertile glacial till soil profiles with generally poor drainage. The Des Moines Lobe is also known for being dotted with many small wetlands, and a few larger lakes, scoured out by the glaciers. Today this portion of the state is known as the Prairie Pothole Region. Many of the historical wetlands have been drained with tiles and converted to row crop production.

Table 5. Five Island Watershed Soils Report

Soil Name	Watershed Area (%)	Description	Typical Slopes (%)
Nicollet	25	Clay loam, somewhat poorly drained	1-3
Canisteo	22	Clay loam, poorly drained	0-2
Clarion	15	Loam, moderately well drained	6-10
Webster	12	Clay loam, poorly drained	0-2
Okoboji	4	Silty clay loam, very poorly drained	0-1

Dominate soil association within the watershed include Nicollet-Canisteo-Clarion, Nicollet-Canisteo-Webster, and Canisteo-Webster-Okoboji. Of the associations the Nicollet-Canisteo-Clarion makes up the bulk of the watershed (Table 5). This association is defined by nearly level to gently rolling slopes but tends to be somewhat poorly drained with pothole wetlands being a common feature, especially in pre-settlement times. Conversely, the Nicollet-Canisteo-Webster association comprises most upland areas, ranges from nearly level to steep, and can be well drained to poorly drained. Finally, the Canisteo-Webster-Okoboji association makes up the low-lying portions of the watershed. It is a nearly level to gently rolling association and poorly drained to very poorly drained.

The watershed has a typical Midwestern climate with most of the annual precipitation occurring from late spring through early fall. The town of Emmetsburg receives on average 30.6 inches of rain per year. Rainfall can be heavy during late spring and early summer. This leads to flooding and increased soil erosion concerns. Emmetsburg also has an average wind speed of 21.17 mph, because of this, wind erosion is also a factor in sediment particle movement. Because of the flat topography (table 7), placement of structural practices will be limited.

Table 6. Topography

Slope (%)		Watershed Area (%)
0-2	Level to nearly level	53.9
2-5	Gently sloping	42
5-9	Modernly sloping	3.2
>9	Strongly sloping to very steep	.9

Land Use

A land use assessment was conducted for by Palo Alto Soil and Water Conservation District (SWCD) and Iowa Department of Natural Resources (IDNR) staff in the spring of 2020 (Fig. 4). This windshield survey collected land cover data and tillage type at a field level. A prior land use survey was done as part of the FYRA report published in 2018. Little to no difference was found between the two surveys. As expected, most of the watershed is used for row crop production of corn and soybeans. Because of the soil types present and most slopes being below 5% much of the watershed is drained by tile. There are six drainage district associations located in the watershed which are responsible for draining 4357.6 acres or 50.3% of the watershed with numerous private tiles also present. There are no point sources or confined animal feeding operations (CAFO) within the Five Island Lake Watershed.

Figure 4. Land Use Coverage

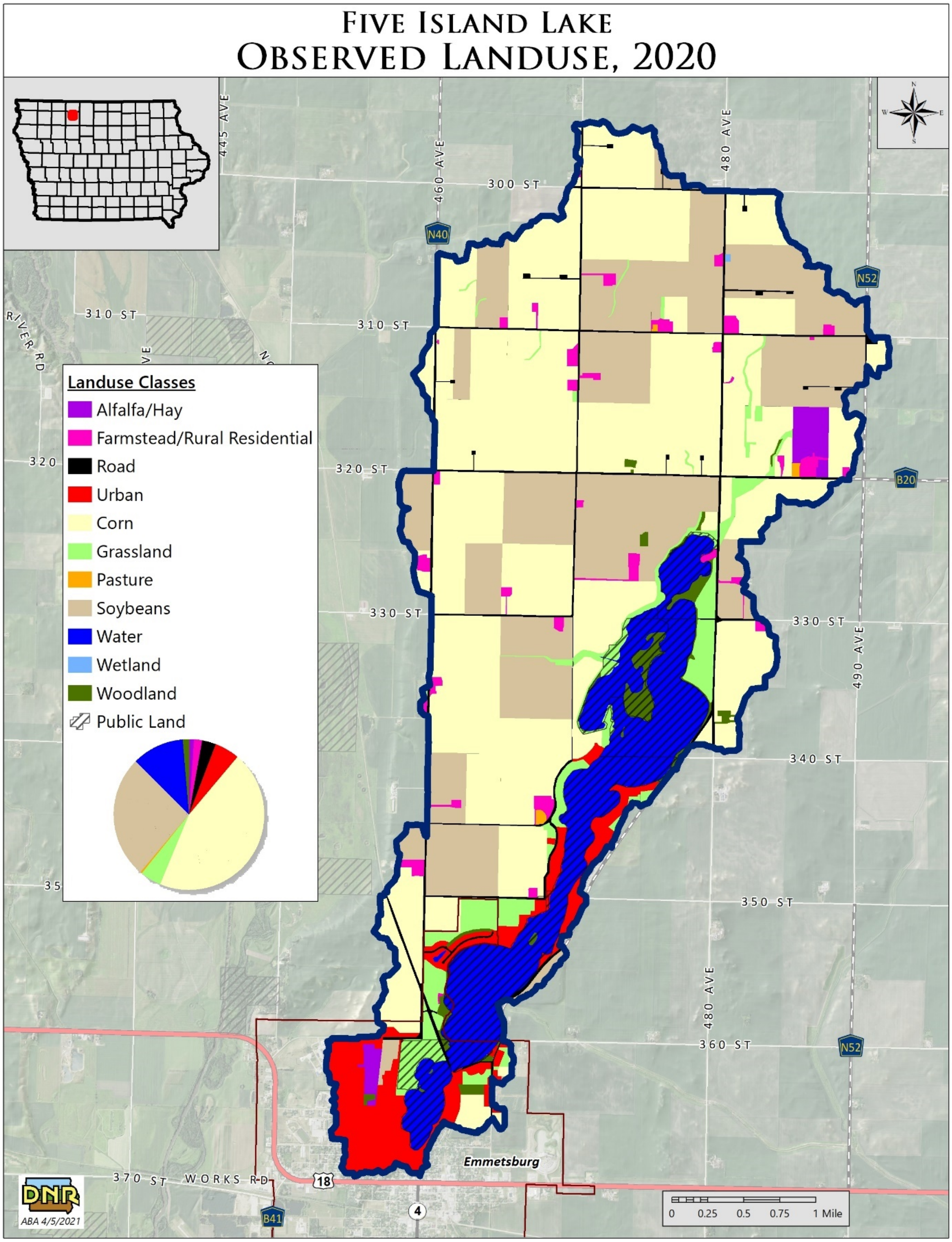


Table 7. 2020 Land Use

2020 Land Use	Description	Area (acres)	% Watershed
Corn	--	2,207.6	25.2%
Soybeans	--	4,083.8	46.6%
Grass, Hay, Pasture	Grassland, pasture, alfalfa, parks	217.90	2.5%
Woodland	Timber, timber savannah	128.46	1.5%
Wetland	Wetlands, ponds (excludes lake)	1.2	.1%
Urban	Residences, Roads, Parking lots	751.64	8.6%
Other	Farm lots, Farmstead	370.20	1.5%

Water Quality Findings

Five Island Lake has monitoring data going back to the 1990's. Additional monitoring was done during the FYRA study in 2017 and 2018, and the IDNR has conducted in lake monitoring since 2000.

Watershed Monitoring

Watershed monitoring conducted during the FYRA study resulted in the division of the lake and watershed into sub sections to better understand where pollutant loads were coming from (Fig. 5).

Since the majority of the watershed is row crop it is not surprising that the highest loads come from the north. Sub watershed's one and two account for 60 percent of the phosphorus load coming in from the watershed. Due to the large amount of phosphorus loading in these two sub watersheds, landowner outreach in these areas will be top priority.

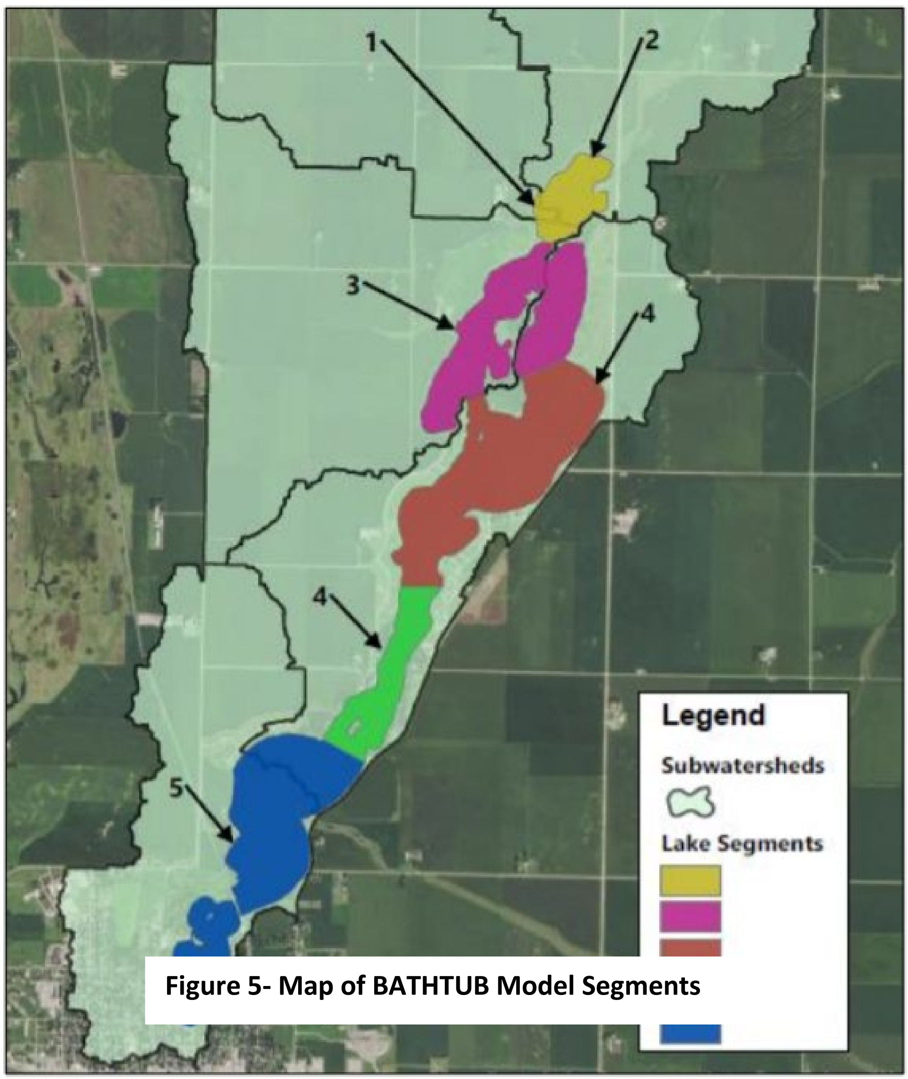


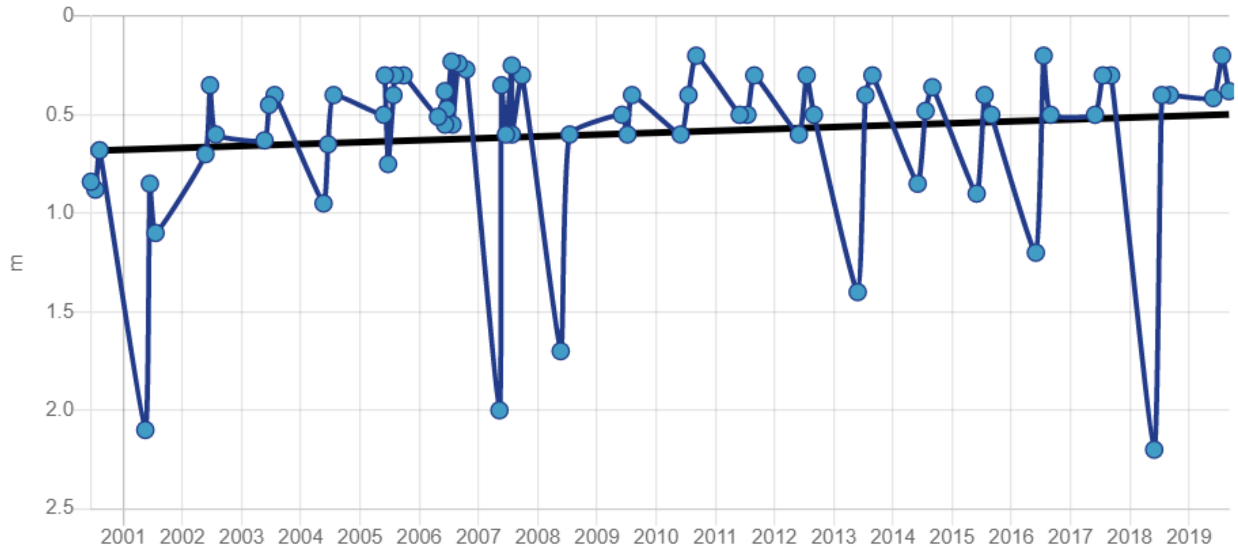
Figure 5- Map of BATHTUB Model Segments

Table 8 Total Annual Watershed Phosphorus Load by Sub Watershed (FYRA)

Subwatershed	TP Load (lbs/year)	% of total load
1	2,031	31%
2	1,869	28%
3	1,020	15%
4	651	10%
5	1,045	16%
Total	6,617	100%

In-Lake Monitoring

Five Island Lake has IDNR ambient lake monitoring date dating back to 2000. Based on this data, Five Island Lake was added to the Iowa 303(d) Impaired Waterways list in 2002. Five Island Lake was listed because the Class A1 designated uses like swimming, boating, and fishing were not being met, due to turbidity and algal growth. Carlson’s Trophic State Index (TSI) factors measurements such as phosphorus (the limiting food source for algae in most freshwater lakes), chlorophyll-a (a green pigment in algae which indicates algal abundance), and Secchi disk depths (a physical measurement of water clarity). The Trophic Status Index (TSI) is a classification system designed to rate waterbodies on the amount of biological productivity occurring in the water. Higher TSI values indicate higher productivity, and hence, higher eutrophic conditions. The TSI identifies Five Island Lake as a hypereutrophic lake. This means it often experiences algal scums or excessive vegetation. Additionally, the lake has an excessive population of rough fish such as common carp which can affect water clarity and algal growth by pulling up rooted, aquatic vegetation. As of 2016 the lake has also had issues with Cyanobacteria which can be toxic to both animals and humans. Secchi depth (Fig. 6) and total phosphorus (Fig. 7) data show that the water quality has been decreasing since 2000.



Secchi disk depth (m)

Figure 6. Secchi Depth Readings

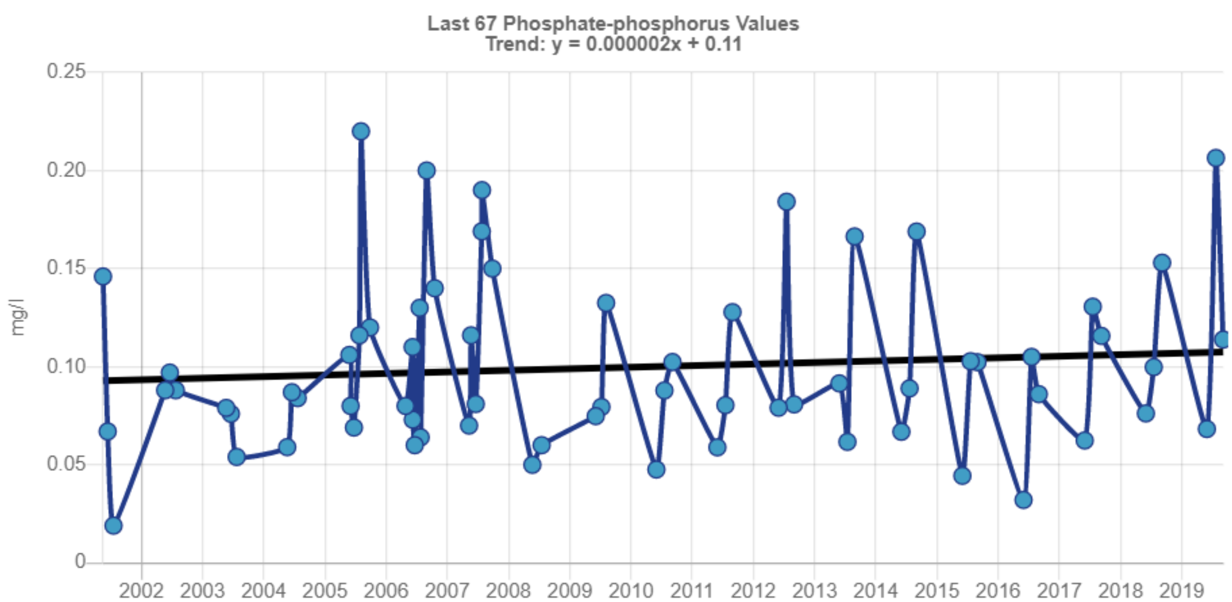


Figure 7. Phosphorus values since 2001

Poor water quality in Five Island Lake is not a recent phenomenon. One study reported phosphorus concentrations up to 147 μg/L in 1979 (ISU Paleolimnology Report). Additional issues with fish kills and an overabundance of vegetation were reported prior to the installation of an aerator and the commencement of the dredging efforts. Currently, the primary concerns include algal blooms, overabundance of rough fish species (e.g., carp and big mouth buffalo) and lack of rooted, aquatic vegetation.

Water quality sampling data, collected 3 times between Memorial Day and Labor Day each year as part of IDNR's ambient lake monitoring program, is used to calculate the TSI values for Five Island Lake (Table 9).

Table 9. Five Island Lake Water Quality Summary

Parameter	2002-2016 Average	TSI
Total Phosphorus (μg/L)	94.4	69
Chlorophyll-a (μg/L)	50.4	67
Secchi Disk Depth (ft)	1.9	69

The average total phosphorus concentration is 94.4 μg/L, but the values have ranged from 32 μg/L up to 220 μg/L since 2002 (Fig. 8). Concentration will also vary throughout the year, and it is important to understand what the levels are during the warm growing season when algal blooms occur. The samples were primarily taken during the warmer months, and the average concentration reported above is representative of the growing season.

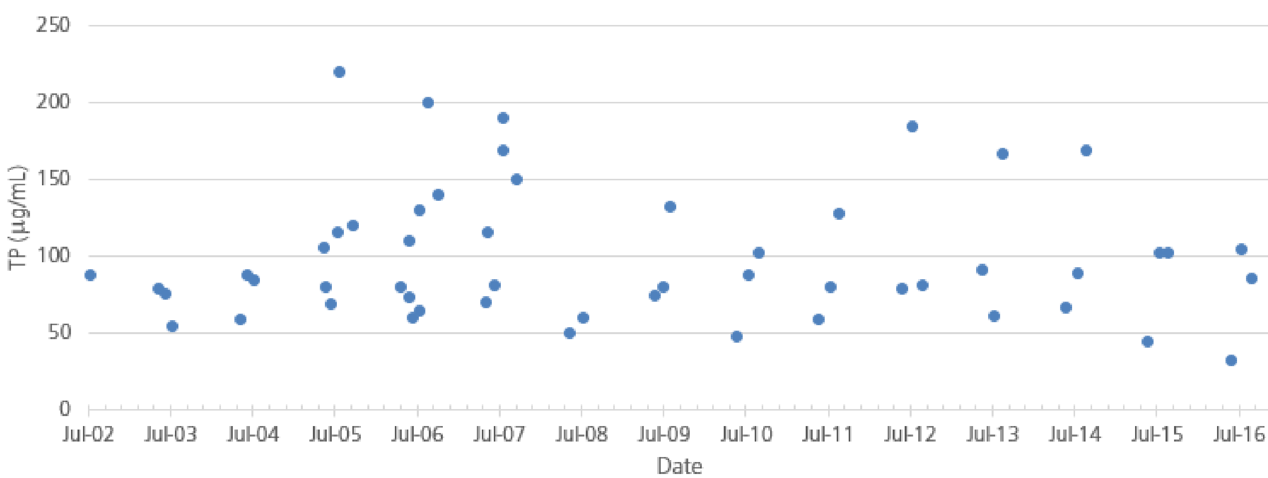


Figure 8. Total Phosphorus Concentrations from 2002-2016

Pollutant Source Assessment

<u>Primary Source of Pollutants:</u> Internal resuspension of sediment attached phosphorus and sediment attached phosphorus runoff from agricultural landscape.

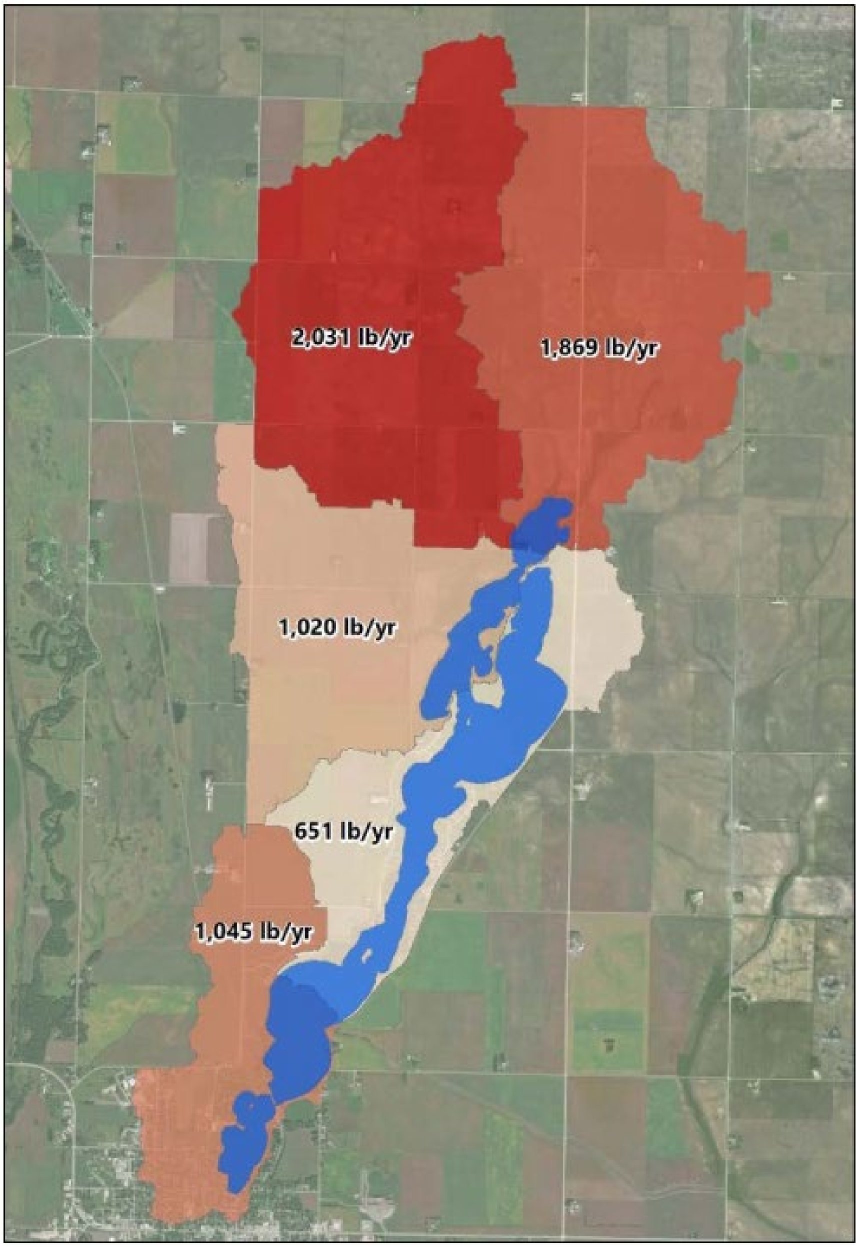


Figure 9. Phosphorus Loading using BATHTUB model (FYRA):

For the 2020 assessment/listing cycle, which covers 2016-2018, the Class A1 (primary contact recreation) uses of Five Island Lake are assessed (monitored) as “not supported” due to poor water transparency and objectionable conditions caused by algae blooms based on information from the ISU lake survey. Using the median values from these surveys from 2010-2014 (approximately 15 samples), Carlson’s (1997) trophic state indices for Secchi depth, chlorophyll a, and total phosphorus were 71,69, and 69 respectively for Five Island Lake. According to Carlson (1977) the Secchi depth, chlorophyll a, and total phosphorus values all place Five Island Lake in between the Eutrophic and Hypereutrophic categories. There values suggest high levels of chlorophyll a and suspended algae in the water, very poor water transparency, and high levels of phosphorus in the water column. However, the data show no violations of the Class A1 criterion for pH in the 15 samples. (From Palo Alto Shallow Lakes Planning Grant)

Existing Load

Thanks to a partnership between the IDNR and the City of Emmetsburg, Five Island Lake underwent an extensive monitoring and modeling process in 2017 and 2018 by FYRA Engineering. FYRA used the BATHTUB model identify and predict phosphorus loading to the lake. BATHTUB is a steady-state lake response model that simulates eutrophication-related water quality conditions. Pollutant load outputs from STEPL and GoldSim were incorporated into BATHTUB along with lake characteristics. BATHTUB computes the lake's response to predict total phosphorus, chlorophyll-a, transparency i.e., Secchi depth, and associated TSI values using empirical relationships. The BATHTUB model of Five Island Lake utilizes the Canfield-Bachman equation to simulate total phosphorus, predicts chlorophyll-a based on phosphorus using a relationship established by Jones and Bachman, and simulates Secchi depth using an algorithm that considers both chlorophyll-a and non-algal turbidity. The model was segmented as illustrated in Figure 5 but was calibrated only to the segment in which ambient water quality data is collected by the DNR (green segment in Figure 5). The model required very little calibration for any simulated parameter and predicted phosphorus, chlorophyll-a, and Secchi depth very well (Table 8). The calibrated BATHTUB model was used to predict lake's water quality response (algae and transparency) to simulated phosphorus reductions, which helps identify the extent of reductions needed to meet project water quality goals.

The load assessment concluded that Five Island Lake receives on average 12,586 lbs. of phosphorus over the course of a growing season (Table 10). This study focused on the growing season since that is when models and observed conditions are most likely to match. Additionally, impairments, like algal blooms are most noticeable during this period.

Table 10. Total Annual Phosphorus Load

Origin		TP Load (lbs)	%
Watershed	Surface	3,314	53%
	Subsurface	3,303	
Internal (Growing Season)		5,969	47%
Total		12,586	100%

Identification of Pollutant Sources

Almost all of the existing TP load in Five Island Lake comes from nonpoint sources of pollution. The external load for the watershed was found to be 6,617 lbs. with surface and subsurface loads being nearly equal (Table 10). Of this row crop agriculture is the biggest contributor at 78% of the external load or 5,167 lbs. (Table 11). This isn't surprising since row crop is by far the most prevalent land use in the watershed. Because phosphorus is transferred via runoff, external loads are typically higher in the spring and during wetter growing seasons.

Table 11. Annual External Phosphorus Loading

Source	Surface (lbs)	Subsurface (lbs)	Total (lbs)	%
Urban	783	108	891	14%
Cropland	2,023	3,144	5,167	78%
Pastureland	77	47	125	2%
Forest	14	4	18	0%
Feedlots	346	0	346	5%
Septic	71	0	71	1%
Total	3,313	3,303	6,617	100%

Internal loading of phosphorus from the bottom of the lake is also a significant contributor to water quality problems in Five Island Lake (Table 10). This phenomenon is driven by several factors, including sediment chemistry, temperature/seasonality, mechanical disturbance due wind or boat-induced mixing, rough fish (e.g., carp and big mouth buffalo) and sometimes a lack of dissolved oxygen at the sediment/water interface. Because these factors are always changing, growing season internal loads vary with time, and even vary from year to year. The ratio of internal to external loading spikes towards internal during dry years due to the decreased runoff from the watershed Internal loading becomes the driving factor of algal growth during these years. Additionally, internal loading can also be exacerbated during dry years due to low lake levels and new areas being susceptible to resuspension from boat traffic, rough fish, and wave action.

Total Phosphorus Load

While urban land use contributes only 14 percent of the external load, it could have a disproportionate impact on water quality due to the proximity of the urbanized areas to the lake. Special consideration should be given to urban inflows like the Emmetsburg storm sewer, golf course main tile, and Rockport Pond outlet when planning conservation projects. Other smaller contributions of phosphorus loading such as wild life and atmospheric deposition are present but not at a significant enough level to be used in the model.

Five Island Lake Watershed Goals and Objectives

Statement of Goals

This Water Quality Management Plan and subsequent projects seek to improve the water quality in Five Island Lake to the point where it can be removed from the Iowa Impaired Waterways List. These goals will be accomplished using a comprehensive plan of Best Management Practices in the watershed and in-lake improvements. These goals have been created with the help of the Watershed Action Group, watershed residents, and partner organizations. As of this writing these goals are set to be completed within 30 years.

Goal 1: Educate the public on the water quality issues facing Five Island Lake

Objective 1: Continue to inform landowners of water quality issues by hosting educational meetings, sending mailers, publishing news articles and developing online resources, and by making personal contacts with key stakeholders.

Objective 2: Educate urban landowners and city government by holding events like a "Water Quality Festival or Day on the Lake" use Okoboji's Blue Water Festival as a guide.

Objective 3: Inform visitors with an online presence, handouts, inclusion of educational material in chamber of commerce visitor information, and signage.

Objective 4: Encourage the implementation of BMP's through demonstration projects, field days, online resources, news articles, and one-on-one contacts.

Goal 2: Use targeted best management practices in the watershed and the lake to improve water quality while targeting TSI scores. Achieve TSI scores under the threshold of impairment for chlorophyll-a, turbidity, and algal growth and cyanobacteria

Objective 1: Implement conservation practices on priority agriculture acres. Focus on areas in the north of the watershed that were identified as having a high erosion rate and P load. Also give special attention to areas in close proximity to the lake that could have high P loads during storm events

Objective 2: Install conservation practices in urban landscapes. Inform and encourage landowners to better understand their role in phosphorus delivery to the lake and the practices they can install on their property.

Objective 3: Enhance public land within the watershed.

Objective 4: Create an in-lake wetland complex in the north end of the lake to capture sediments and allow for the uptake of phosphorus by wetland vegetation.

Water Quality Milestones

Water quality goals based on models and TSI scores form the baseline for assessing improvement in water quality projects like this one. The following goals have been established based off the target TSI values.

The Five Island Lake BATHTUB model was used to simulate the improvements in water clarity and algae levels to phosphorus load reductions. The load reduction required to reach the two goals discussed were interpreted from the BATHTUB output reported in Table 12.

1. Reduce measured algae concentrations to delisting from impaired water's list criteria (chlorophyll-a TSI ≤ 65 = concentration ≤ 27 ug/L)
2. Increase water clarity to delisting from impaired water's list criteria (Secchi depth TSI ≤ 65 = Secchi depth ≥ 2.6 ft)

The end goal of this project is to improve water quality by meeting Trophic State Index scores required for delisting of the lake. Five Island Lake is listed as impaired by algal growth and turbidity. Both impairments stem from an overabundance of phosphorus inputs, therefore, goals will be based on the phosphorus reduction needed to meet TSI values sufficient for delisting. A target load reduction for internal and external sources is **60% reduction in phosphorus loading** (Tables 12 and 13).

Table 12. Lake Response to Annual Load Reductions

% P Load Reduction	TP		Secchi		Chl-a	
	µg/L	TSI	ft	TSI	µg/L	TSI
0%	101.7	71	2.0	69	69.1	72
20%	89.5	69	2.3	66	57.3	70
30%	82.9	68	2.3	65	51.2	69
40%	75.8	67	2.6	63	44.9	68
50%	68.2	65	3.3	61	38.4	66
60%	59.8	63	3.6	58	31.7	64

Table 13. Annual Load Reductions Goals

Origin	Annual Load (lbs)	Load Reduction Target	% Reduction
External	6,617	3,970	60%
Internal	5,969	3,581	60%
Total	12,586	7,551	60%

Table 14. Annual Phosphorus Load Reduction Goals for each phase of the WQMP:

Phosphorus Loading					
Scenarios	Watershed TP Load (lbs.)	Internal TP Load (lbs.)	Total TP Load (lbs.)	Reduction (%)	Reduction (lbs.)
Baseline Conditions	6617	5969	12586	-	0
End of Phase 1	5473	5969	11442	18	1198
End of Phase 2	4059	2388	6770	53	4995
End of Phase 3	2701	2388	5635	60	1358

The Best Management Practices

The effectiveness of BMPs were calculated by FYRA Engineering using the BATHTUB model. This combination of practices will reduce Five Island Lake's TSI to 64 for chlorophyll-a, 58 for Secchi, and 63 for TP. These scores fall below the TSI threshold of 65 and would allow Five Island Lake to be delisted from the impaired waterways list. Model results and an understanding of the sources and the nature of the pollutants in this landscape were used to identify and assess a suite of water quality improvement strategies. The general placement for the practices is broken down in the following categories: Watershed-Based, Near-Lake, and In-Lake. A detailed description of these practices and the strategies for their placement can be found in the appendix.

<u>Ag BMPs</u>

See Appendix for detailed information

No-Till
Phosphorus Reduction Potential: 90%
Goal: 3,300 acres of row crop
Target: Row crop land with highest erosion rates and close proximity to the lake
Payment Rate/Incentive: EQIP Payment plus per acre one-time sign-up payment, or Section 319

Cover Crops
Phosphorus Reduction Potential: 90%
Goal: 3300 acres
Target: High load areas in the north end of the watershed
Payment Rate/Incentive: State cost share, Section 319, or EQIP plus per acre one-time sign-up payment

Water and Sediment Control Basin (WASCOB)
Phosphorus Reduction Potential: Varies by site
Goal: 1
Target: Identified site
Payment Rate/Incentive: State cost share, or EQIP payment plus up to 90% of project cost

Grassed Waterways

Phosphorus Reduction Potential: Depends on location
Goal: additional 8,800 ft of waterways
Target: Areas showing signs of gully erosion
Payment Rate/Incentive: State cost share, or CRP plus up to 90% of the project cost

Pothole Wetland Restoration
Phosphorus Reduction Potential: 20%
Goal: Add 107 acres of pothole wetlands
Target: historical pothole areas north of the lake
Payment Rate/Incentive: State Cost Share, or CRP Plus up to 90% of restoration cost

CRP/WRP
Phosphorus Reduction Potential: 90%
Goal: Add 1000 acres of grass/water protection
Target: Areas with highest phosphorus loading
Payment Rate/Incentive: CRP/WRP plus per sign-up incentive (Section 319 Funding)

Variable Rate Fertilizer Application
Phosphorus Reduction Potential: 40%
Goal: 100% of applied fertilizer
Target: 100% of row crop acres
Payment Rate/Incentive: NA – Project will provide technical assistance

Phosphorus Removal Bioreactor
Phosphorus Reduction Potential: 16-71%
Goal: Treat dissolved Phosphorus in tile lies
Target: 4
Payment Rate/Incentive: 100% Section 319 funding along with assistance from Iowa State University and Natural Resource Conservation Service

<u>**Urban BMPs**</u>

See appendix for more information

Phosphorus Free Fertilizer Program
Phosphorus Reduction Potential: Medium to High
Goal: 240 vouchers
Target: All residents in Emmetsburg and surrounding developments
Payment Rate/Incentive: voucher toward P-free fertilizer purchase (Section 319 Funding)

Municipal Rain Gardens
Phosphorus Reduction Potential: Depends on location
Goal: 20
Target: Residential Areas
Payment Rate/Incentive: 50% of total cost (Section 319 Funding)

Residential Rain Gardens
Phosphorus Reduction Potential: Depends on location
Goal: 15
Target: Watershed residents, new development
Payment Rate/Incentive: 50% of total cost (Section 319 Funding)

Rain Barrels
Phosphorus Reduction Potential: Variable
Goal: 100 rain barrels
Target: Watershed residents
Payment Rate/Incentive: $50 toward purchase of rain barrel (Section 319 Funding)

Bioswales
Phosphorus Reduction Potential: Depends on location
Goal: 8
Target: residential ditches entering the lake
Payment Rate/Incentive: 75% of project cost (Section 319 Funding)

Septic System Upgrades
Phosphorus Reduction Potential: Variable
Goal: 6 upgrades
Target: Septic Systems in Watershed
Payment Rate: 50% of cost (Potential funding includes casino grant, infrastructure bill funding, Section 319). Since Septic systems are a small component of the total phosphorus loading, Section 319 funding will be limited and must be pre-approved by EPA before funding can be allocated to this practice.

Native Shoreline Restoration / Armoring
Phosphorus Reduction Potential: Depends on location
Goal: 2000 ft.
Target: residential shoreline that are currently manicured turf grass or with steep slopes
Payment Rate/Incentive: up to 50% of the cost (Section 319 Funding)

In Lake BMPs – Additional studies needed to determine cost, location, and public interest

Sediment Forebay
Phosphorus Reduction Potential: Variable
Goal: Increase phosphorus trapping efficiency
Target: Upper Portion of Lake
Payment Rate: Unknown

In-lake wetland
Phosphorus Reduction Potential: Variable
Goal: Increase phosphorus trapping efficiency

Target: Upper portion of lake
Payment Rate: Unknown

Rough Fish Management
Phosphorus Reduction Potential: Variable
Goal: Reduce biomass density to 50-100 lbs./ac
Target: Reduce rough fish
Payment Rate: NA

Shallow Vegetation
Phosphorus Reduction Potential: Variable
Goal: Manage aquatic vegetation
Target: Upper Portion of Lake
Payment Rate: NA

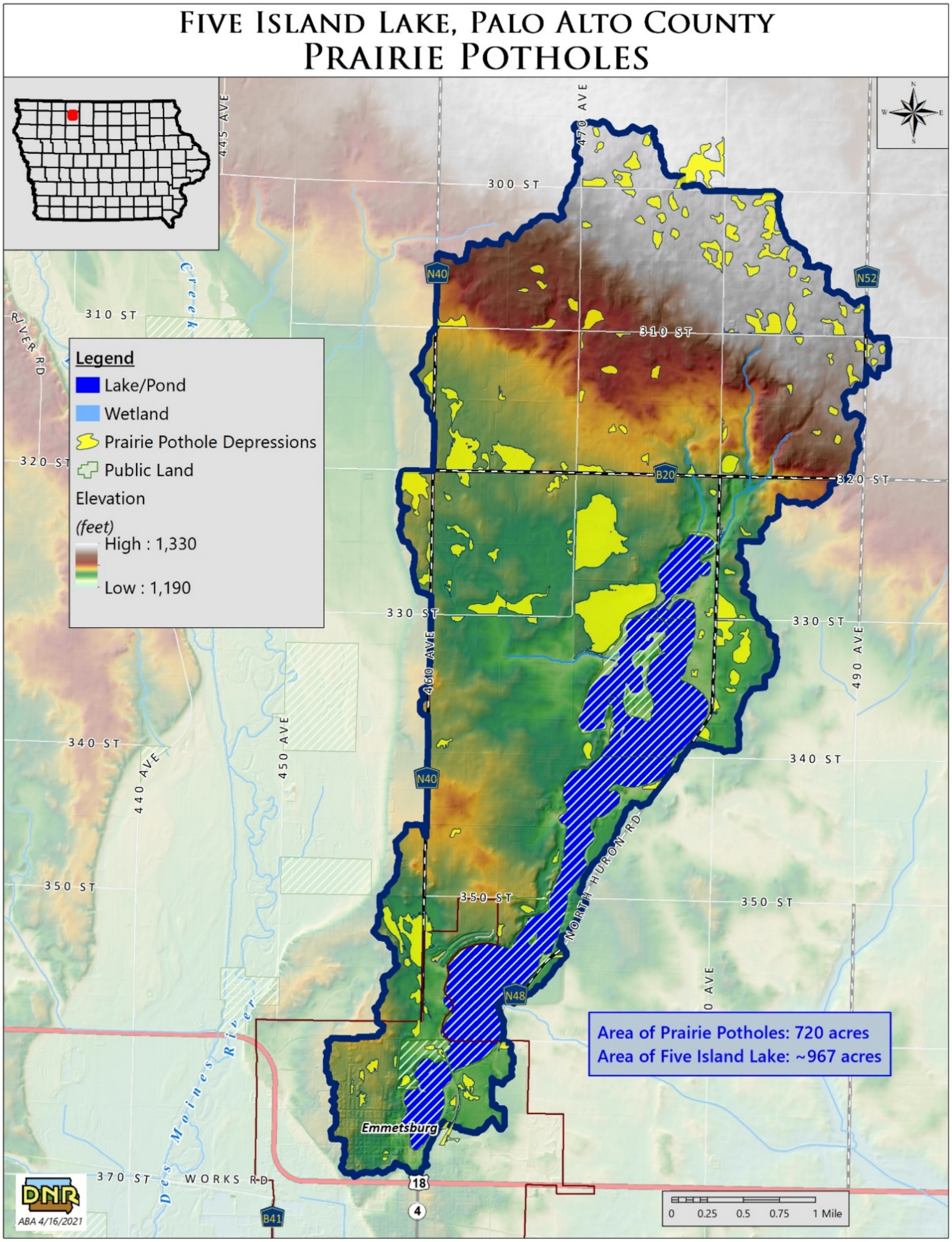


Figure 11. Potential Prairie Pothole Locations

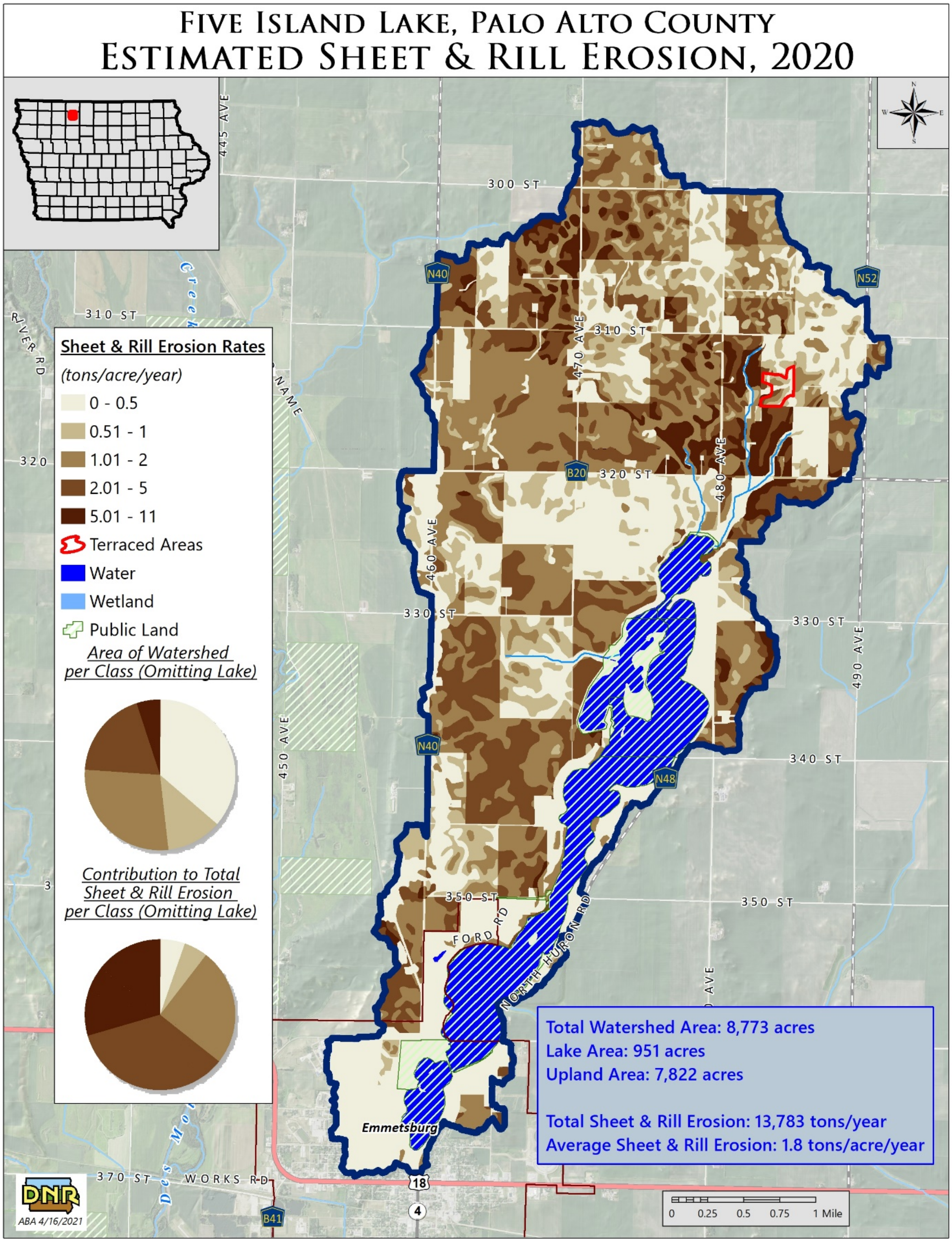


Figure 12. Sheet and Rill Erosion

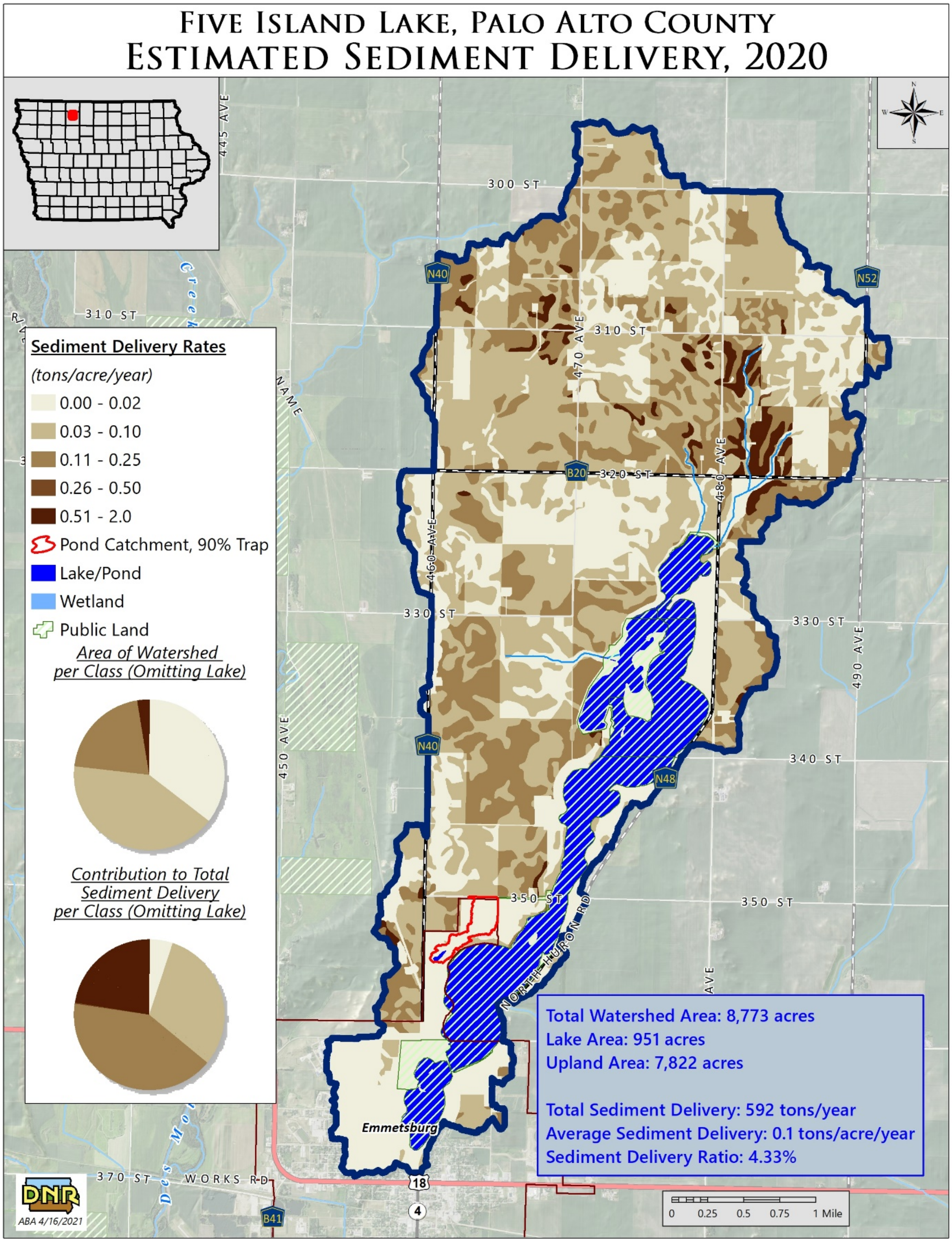


Figure 13. Sediment Delivery

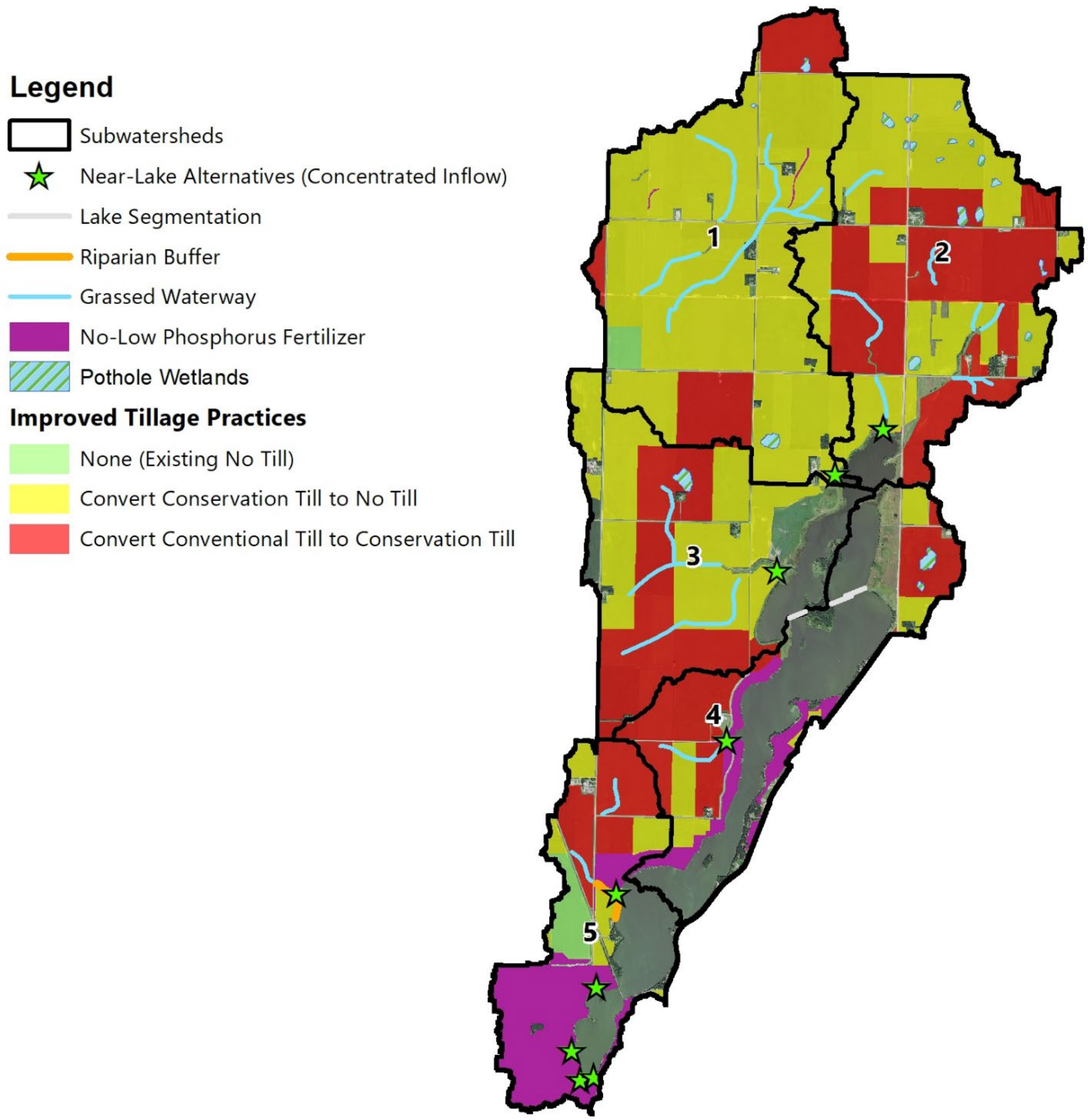


Figure 14. Potential Locations for Management Practices (FYRA)

Water Quality Monitoring

Water monitoring is an important tool in all watershed improvement projects. Monitoring tracks the progress of the project and allows for future changes and improvements. This water monitoring plan will collect data from both from within the watershed and in Five Island Lake.

Site Locations

In-Lake: The ambient lake location will continue to be monitored by Iowa State through the IDNR's ambient lake monitoring program. Additionally, two other sites should be monitored, one in the south bay in town and the other in the northern basin south of fifth island. This will give a clear picture of water quality in all sections of the lake. Given the popularity of beach at Soper Park this site should be enrolled in the IDNR's Beach monitoring program. The Five Island Lake Association has expressed interest in helping with water quality monitoring and would be a good resource.

Watershed Tributaries: Unnamed creek which enters under 480th St. Monitor all drainage district tiles entering the lake especially DD 64. Rockport pond outflow Total of 8 sites

Frequency

In-Lake: Monthly (April through October)

Tributary: Twice per month (April through October) and try to include some samples taken during heavy rain events to better understand high load conditions.

Parameters

In-Lake: chlorophyll-a, total suspended solids, total volatile suspended solids, nitrate and nitrite, total phosphate, orthophosphate, Secchi depth, dissolved oxygen, temperature, pH, .

Tributary: total suspended solids, total volatile suspended solids, nitrite and nitrate, total phosphate, orthophosphate, dissolved oxygen, temperature, pH, and flow.

Entity Performing Monitoring – Potential entities performing monitoring include Iowa State University, Palo Alto Soil and Water Conservation District, and Iowa Department of Natural Resources.

Table 15. Water Sampling Annual Budget

In-lake:

Parameter	Cost per Sample	# of Sites	# of samples	Total Cost
Chlorophyll-a	$43.50	2	7	$609
Total suspended solids	$15	2	7	$210
Total volatile suspended solids		2	7	
Nitrite and nitrate	$15	2	7	$210
Total phosphate and orthophosphate	$30	2	7	$420
			Subtotal	$1449
			Facilities and Administrative Costs @ 8%	$116

			Shipping	$150
			Total	$1715

Tributary

Parameter	Cost per Sample	# of Sites	# of samples	Total Cost
Total suspended solids	$15	8	7	$840
Total volatile suspended solids		8	7	
Nitrite and nitrate	$15	8	7	$840
Total phosphate and orthophosphate	$30	8	7	$1680
			Subtotal	$3360
			Facilities and Administrative Costs @ 8%	$269
			Shipping	$375
			Total	$4004

Public Outreach Plan

Public input and involvement are crucial to the success of watershed projects like this one. Landowners who live in and/or own land in the watershed directly influence the water quality in Five Island through their land management decisions. It is crucial to maintain their involvement in the planning process, even with the additional challenges of COVID-19.

Goals

- Education: There is a big need to increase the public knowledge of the specific factors impacting water quality in Five Island
- Utilize public input to shape the Best Management Practices Targeting plan

Target Audiences

People directly responsible for implementing practices to improve the land and water

- Ag landowners
- Ag tenants
- Residents of Emmetsburg and surrounding developments
- Year-round residents around Five Island Lake
- Seasonal residents around Five Island Lake
- Rural residents
- Public land managers (Palo Alto County Conservation and IDNR)
- Local business that benefit from the lake (Northland Marine, Restaurants, Grocery Stores, Hotels, Casino)
- City of Emmetsburg

Agencies needed to advance the project

- Palo Alto SWCD
- Palo Alto County Conservation Board
- Iowa DNR
- NRCS
- City of Emmetsburg
- Five Island Lake Association

Target Audience Outreach Strategy and Tactics

All audiences are different and come with their own preconceptions and challenges. This section explores ways to contact and work with the many unique audiences that will be involved with this project. It will address key messaging and contact strategies as well as each group's barriers to participation and ways to overcome them.

Potential Barriers to Participation by Group

Ag Landowners

- Loss of land in production and therefore income from implementing conservation practices
- Cost share rates on conservation practices
- Perception of yield loss when transitioning a new system such as no-till or implementing cover crops
- Absentee landowner contact and education

Ag tenants

- Loss of acres in production and therefore income
- Perception of yield loss when implementing a new practice such as no-till or cover crops
- Convincing absentee landowners to participate in conservation practices
- Cost share rates for conservation practices
- Uncertainty about continuing to farm the land in the future

Urban Property Owners

- Loss of property to install conservation practices
- Cost share to install practices
- Maintenance of conservation practices
- City and HOA codes
- Neighbors
- Seasonal resident availability
- Visual appeal of conservation practices

Potential Solutions, Motivators, Incentives and Benefits to Participate

- Provide or increase cost share rates for conservation practices
- Utilized multi-program funds / stack benefits where possible
- Participation recognition/ awards
- Educational projects and demonstrations

Keeping in mind the potential barriers to participation as well as ways to mitigate them, outreach tactics are being developed to specific audiences preferred methods of communication. These include one-on-one contacts, smaller group meetings (e.g. attending an HOA meeting), direct mail, email, and press (e.g. local papers). Also included are general communication elements that will assist the advancement of all public outreach efforts in the future.

General Communication Elements

- Project Identity: developing an identity for the project that will provide consistency to all public outreach so it can be tied back to the project
- Online presence: Maintain and enhance a web presence to provide basic information about the watershed and project activities. Utilize online platforms that appeal to a

wide range of people. (e.g. Facebook, Town website, YouTube, Zoom etc.) Theses communication methods are becoming increasingly popular and important in the age of COVID-19

- Photography: Take photos of watershed projects that can show progress and be used to educate other interested groups.
- Communication schedule: Create an annual outreach plan that focuses on key seasons / events to reach target audiences and ensure that the project remains relevant (e.g. summer events that target seasonal residents)

One-on-One Personal Contact

- Personal meeting/phone calls: Schedule private meeting or phone calls with individuals to educate them about the project and explain methods and cost share options in detail. Focus on influential landowners and community members.
- Field Days: arrange at least one annual field day to increase awareness of watershed projects and show off project progress. Tours should include representatives from as many partner groups as possible to demonstrate cooperation on the project. Schedule additional field days that showcase specific projects or groups (e.g. spring ag tour by SWCD or Master Gardeners open house)
- Other educational events: Take advantage of any opportunity to expose the technical advisory team or watershed advisory group to the public. Encourage member to build relationships with other agencies and have one-on-one conversations with public (e.g. Summer Water Quality Festival modeled after the Okoboji one)

Direct Mail/Email

- Annual letter: Draft an annual letter or brochure to raise awareness and education. The Five Island Lake Association has already started this process.
- Email newsletter: Create an E-newsletter that can be used for project updates, watershed news, and educational pieces.

Press/Publicity

- News articles: Send quarterly press releases to media outlets (Local newspapers/websites) with project news and updates. Focus on including pictures or other visuals when possible. Additionally write a few columns for the Five Island Lake Association's bimonthly spot.
- Public recognition/awards: Create and present urban and rural watershed awards to publicly recognize participating landowners and partners.
- Publicity Events: Hold events and educational activities that have a "feel good" spin, like field days or watershed tours mentioned previously. Also plan events that include other key audiences (e.g. youth events with local 4-H and FFA, county conservation programs, local high school or college environmental science classes)

Other

- Partnerships: Develop good relationships with local groups and organizations that have platforms that can be utilized to communicate watershed information to the public. (e.g. City of Emmetsburg website, Five Island Lake Association)
- Committee and Public Meetings
  - Hold quarterly watershed advisory committee meetings
  - Hold annual project review meeting
  - Hold annual public meeting

Evaluation/measurement

- Keep track of meeting attendance and participation
- Follow-up surveys (e.g. hand out a survey at the annual meeting and public meeting, post online surveys periodically do gauge public opinion)
- Follow-up phone calls with key partners and landowners
- Follow-up one-on-one interviews
- Conservation practice participation reports
- Press hits/media coverage

Implementation Schedule

Achieving the water quality targets set forth in this plan will be no easy task. Implementation and adoption of these practices must happen across the board to meaningfully impact water quality. These tables are divided the areas where these practices will be implemented, watershed, urban, and in lake.

Table 16. Implementation Schedule

Component	Units	Phase One (Years 1-5)	Phase Two (Years 6-15)	Phase 3 (Years 15-30)	Total
Waterways	Feet	2,800	3,000	3,000	8,800
CRP/WRP	Acres	300	300	400	1,000
No-till	Acres	1000	1150	1150	3,300
Pothole Wetland Restoration	Acres	30	30	47	107
Cover Crops	Acres	1000	1300	1000	3300
Phosphorus Removing Bioreactor	Number	1	2	1	4
Water and Sediment Basin	Number	1			

Residential Practices

No Phosphorus Fertilizer	Number	40	100	100	240
Residential Rain Gardens	Number	5	5	10	20
Native Shoreline	Feet	500	500	1000	2,000
Rain Barrels	Number	25	25	50	100
Bioswales	Feet	2	3	3	8
Septic System Upgrades	Number	2	2	2	6
Bio cell	Number		1		1

In-Lake Practices

Sediment Forebay	Number	0	1	0	1
In-Lake Wetland	Number	0	1	0	1
Rough Fish Management	Number	0	1	0	1
Shallow Vegetation/Lake Level Management	Number	0	1	0	1

Implementation Schedule (Years 1-5)

Goal 1: Educate the public on the water quality issues facing Five Island Lake

		Metric	Total	FY22	FY23	FY24	FY25	FY26
Objective 1	Inform Landowners of WQ Issues							
Task1	Utilize Social Media	Online Postings	60	12	12	12	12	12
Task 2	Draft Annual Letter to Landowners	Mailings	5	1	1	1	1	1
Task 3	Meet one on one with Landowners	Contact	50	20	10	10	10	

Task 4	Kickoff Open House Event	Event	1	1				
Objective 2	Education Landowners by holding WQ Festival							
Task 1	Host event by year 2	Events	4		1	1	1	1
Objective 3	Inform Visitors with Educational information							
Task 1	Create Handout about watershed and cost share	Handout	1	1				
Task 2	Signage at stream crossings and watershed boundaries	Signs	20	20				

Goal 2: Use targeted best management practices in the watershed and the lake to improve water quality while targeting TSI scores. Achieve TSI scores under the threshold of impairment for chlorophyll-a, turbidity, and algal growth and cyanobacteria

		Metric	Total	FY22	FY23	FY24	FY25	FY26
Objective 1	Implement conservation on Agriculture Lan							
Task 1	Grassed Waterways	Feet	2800	400	400	600	600	800
Task 2	No-Till	Acres	1000	100	200	200	200	300
Task 3	Pothole Wetland Restoration	Acres	30	0	5	5	10	10
Task 4	Cover Crops	Acres		100	100	200	300	300
Task 5	Phosphorus Reducing Bioreactor	No.	1	0	0	1	0	0

Task 5	Water and Sediment Basin	No.	1	0	0	1	0	0
Objective 2	Urban Practices							
Task 1	Native Shoreline Vegetation	Feet	500	50	50	100	100	200
Task 2	Rain Barrels	No.	25	0	10	5	5	5
Task 3	Septic Systems	No.	2	0	0	1	1	0
Task 4	Biocell	No.	0	0	0	0	0	0
Objective 3	Public Lands Enhancement							
Task 1	Inventory opportunities and peruse funding options	No	2	0	1	1	0	0
Objective 4	In-lake wetland complex							
Task 1	Conduct additional feasibility Studies/design	X			X	X	X	

Resource Needs

The estimated cost, in 2020 dollars to achieve a 60% reduction in phosphorus loading is $3,919,060 (Table 17). Practices listed below will be adopted on a voluntary basis. Palo Alto Soil and Water Conservation District in Emmetsburg, Iowa will handle the technical and financial assistance associated with the project. In addition, the project coordinator will be located in the district office.

Table 17. Resource Needs

Location	BMP	Unit Cost	Unit	Planned Amount	Total Cost	P Reduction (lbs)
Watershed	No Till	$ 30.00	acre	3300	$ 99,000.00	1279
	Cover Crops	$ 40.00	acre	3300	$ 132,000.00	1205
	CRP/WRP	$ 800.00	acre	1000	$ 800,000.00	632
	Water and Sediment Control Basin	$ 3,000.00	each	1	$ 3,000.00	25
	Native Shoreline Restoration	$ 20.00	feet	2000	$ 40,000.00	10
	Grassed Waterways	$ 6.00	feet	8800	$ 52,800.00	372
	Pothole Wetland Restoration	$ 500.00	acre	107	$ 53,500.00	70
	No Phosphorus Fertilizer	$ 15.00	each	240	$ 3,600.00	140
	Bioswale	$ 1,200.00	each	8	$ 9,600.00	12
	Rain Gardens	$ 400.00	each	20	$ 8,000.00	15
	Rain Barrels	$ 80.00	each	100	$ 8,000.00	5
	Phosphorus Removing Bioreactor	$ 12,000.00	each	4	$ 48,000.00	115
	Septic System Upgrades	$ 6,000.00	each	6	$ 36,000.00	90
	Water Quality Monitoring	$ 5,752.00	year	30	$ 172,560.00	
	Public Outreach	$ 1,500.00	year	30	$ 45,000.00	
	Project Coordinator (1/3 time)*	$30,000	year	30	$ 900,000.00	
In Lake	Sediment Forebay	$92,000	each	1	$ 92,000.00	3581
	In-lake wetland	$940,000	each	1	$ 940,000.00	
	Rough Fish Management	$75,000	each	1	$ 75,000.00	
	Shallow Vegetation/Lake Level Management	$400,000	each	1	$ 400,000.00	
	Total				$ 3,918,060.00	7551
	*Coordinator time will be split between 3 watersheds.					
	** Inlake BMPs modeled together					

The load reductions in Table 17 show the annual load reductions for each BMP type. A total annual load reduction of 7,551 lbs or phosphorus are needed to achieve the water quality goals milestones listed on pages 25-26. Watershed BMP Cost share estimates were based on information provided by USDA Service center/Palo Alto SWCD. In lake practices cost estimates were based on engineering estimates provided by FYRA Engineering. Project coordinator pay is based on the starting wage of a environmental specialist with the state of Iowa.

Funding Sources

In order to obtain the goals/objective of this plan, multiple funding sources will need to be utilized. Below is a list of funding possibilities.

EPA Section 319 Funding, managed by Iowa DNR: The 1987 amendments to the Clean Water Act (CWA) established the Section 319 Nonpoint Source Management Program Section 319 addresses the need for greater federal leadership to help focus state and local nonpoint source efforts. Under Section 319, states, territories and tribes receive grant money that supports a wide variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects and monitoring to assess the success of specific nonpoint source implementation projects.

Iowa DNR – Lake Restoration Funding: The goal is to invest money on projects with multiple benefits such as improved water quality and increased public use, while taking into account feasibility of restoration. Science based prioritization has been our most effective tool in targeting projects of value to the state. Funding for the Lake Restoration Program (LRP) is currently appropriated on an annual basis. We anticipate that at the current annual level of $9.6 million per year the DNR can stay on schedule with implementing restoration efforts at the significant publicly-owned lakes and publicly-owned shallow lakes/wetlands currently prioritized in the five-year plan.

Iowa Department of Agriculture and Land Stewardship:

Conservation Reserve Enhancement Program (CREP) - The Iowa Conservation Reserve Enhancement Program is a state, federal, local, and private partnership that provides incentives to landowners who voluntarily establish wetlands for water quality improvement in the tile-drained regions of Iowa. The goal of the program is to reduce nitrogen loads and movement of other agricultural chemicals from croplands to streams and rivers. In addition to improving water quality, these wetlands will provide wildlife habitat and increase recreational opportunities.

Water Quality Initiative (WQI) -The Iowa Water Quality Initiative (WQI) is the action plan for the Iowa Nutrient Reduction Strategy (NRS) established in 2013. The WQI improves water quality through a collaborative, research-based approach that is evaluated and reported by a team of independent researchers from multiple institutions, led by Iowa State University. This comprehensive approach allows farmers and cities alike to adopt conservation practices that fit their unique needs, lands, and budgets.

Natural Resource Conservation Service (NRCS):

Environmental Quality Incentive Program (EQIP)- The Environmental Quality Incentives Program (EQIP) provides financial and technical assistance to agricultural producers to address natural resource concerns and deliver environmental benefits such as improved water and air quality, conserved ground and surface water, increased soil health and reduced soil erosion and sedimentation, and improved or created wildlife habitat.

Conservation Stewardship Program (CSP) helps agricultural producers maintain and improve their existing conservation systems and adopt additional conservation activities to address priority resources concerns. Participants earn CSP payments for conservation performance—the higher the performance, the higher the payment.

Farm Service Agency (FSA):

Conservation Reserve Program (CRP) - CRP is a land conservation program administered by the Farm Service Agency (FSA). In exchange for a yearly rental payment, farmers enrolled in the program agree to remove environmentally sensitive land from agricultural production and plant species that will improve environmental health and quality. Contracts for land enrolled in CRP are from 10 to15 years in length. The long-term goal of the program is to re-establish valuable land cover to help improve water quality, prevent soil erosion, and reduce loss of wildlife habitat.

Local Partners and Funding Sources: As opportunities present themselves, local partners will contribute funds to the projects.

Appendices

BMP Descriptions and Definitions

Row Crop

Description – Incorporation of additional conservation practices in lands supporting row crop production will improve soil health and water quality. Many nonstructural management practices reduce soil erosion and increase infiltration, which reduces sediment and phosphorus transported to the lake. Structural conservation practices provide the next level of protection that intercept and trap/ treat pollutant loads during transport. In the poorly drained landscape surrounding Five Island Lake, subsurface tile drainage has been used extensively to improve row crop production. This feature alters water and nutrient transport and must be considered when selecting and locating conservation practices.

Ability to Assist in Achieving Goals – Because cropland comprises most of the drainage area to the lake, and hence the largest source of phosphorus from the watershed, implementation of agricultural conservation practices provides significant opportunities to reduce phosphorus losses to the lake. Non-structural management practices that are most applicable to the Five Island Lake watershed include (but are not limited to):

- Conservation tillage and no-till farming
- Cover crops
- Extended crop rotations (to include small grains and/or hay)
- Fertilizer and manure management
- Increased perennial vegetation using the Conservation Reserve Program (CRP) or Wetland Reserve Program (WRP)

Structural conservation practices can be implemented by private landowners on fields and waterways on their property. The watershed for Five Island Lake is dominated by gently sloped terrain with many low-lying depressions and a subsurface tile drainage. Consequently, commonly-used structures such as terraces and farm ponds are not suitable in much of the watershed. Practices that focus on filtration and nutrient uptake are more appropriate for this watershed include:

- Grassed waterways
- Riparian buffer strips (traditional and saturated buffers)
- Restoration of pothole wetlands
- Phosphorus removal bioreactor

Qualitative Description of Cost – The cost of implementing non-structural conservation practices varies widely depending by practice type and position in the landscape. There are a wide range of Federal programs available largely through USDA-NRCS that provide cost-share for conservation practices, but the implementation is voluntary through landowner participation. Applications to the NRCS Environmental Quality Incentives Program (EQIP) that are located within the drainage area to Five Island Lake will be given priority points when applications are evaluated. The iron-enhanced sand filter is not an approved practice for cost sharing and is not a traditional practice commonly applied in the watershed. Implementation of this alternative would require additional education and design assistance, which could be a task for a watershed coordinator. A watershed coordinator would also assist USDA-NRCS employees with landowner/operator outreach and education. This focused attention on the drainage area to Five Island Lake should increase the rate of adoption and implementation of voluntary conservation practices.

Phosphorus removal bioreactor –

Information Provided by Ohio State University Extension: https://agbmps.osu.edu/bmp/phosphorus-removal-structure-nrcs-782

A Phosphorus Removal Structure (PRS) is an edge of field practice that removes dissolved phosphorus (DP) from drainage water leaving the field. The practice is best suited to sites where a history of DP concentrations in water leaving the site are measured at 0.2 mg/L DP or greater. These sites are best candidates for the P Removal Structure practice due to efficiency of filtration and the capital cost involved with the installation.

The practice requires the ability to divert concentrated flows of water into a structure containing P absorbent media. The water flows through the media where the DP attaches to a media lowering P levels of the treated water leaving the site.

The structures can take on many styles and forms, but each possesses the following core components:

1. Enough of an unconsolidated Phosphorus Sorption Material (PSMs). PSMs are usually industrial by-products or manufactured materials composed of Fe, Al, or Ca with different P adsorptive characteristics.
2. Water with high DP concentration flow through the PSM in the structure at a suitable flow rate while allowing enough contact time based on the PSM characteristics.
3. Plan for the ability to remove and replace PSM after it is no longer effective at removing P at the minimum desired rate. Some materials are available that allow renewing the adsorptive capacity without removal of the PSM.

Structure placement is site dependent. Structures can generally be placed in non-production spaces such as buffer areas near the field tile outlet or surface concentrated flow. In some cases, field edges may need to be taken out of production to accommodate the structure. There are several media types available with different absorbance efficiencies which allow some design flexibility. This provides options to adjust filter size to conform to the space available. This is an engineered practice, and it is recommended to consult with a Professional Engineer for design and installation recommendations. An online tool P-Trap is available from USDA-ARS to use as a planning tool. Natural Resources Conservation Service has an interim standard 782 Phosphorus Removal System that can be consulted.

Where is it used:

The Phosphorus Removal Structure can be utilized for many situations where DP is a resource concern in receiving waters: urban, agricultural, golf course, horticultural, and wastewater. Much of the early work using P removal structures were done with municipal, domestic, and agricultural wastewater where the structures were often used in conjunction with treatment wetlands. Phosphorus Removal Structures have been placed in line with surface drainage water, in conjunction with drainage tile, or in ditch areas; it is possible to "stack" this practice with nitrogen bioreactors. Placement is only limited by the practicality of directing enough high concentration DP water through the filter material while allowing for a functional drainage system.

In a field setting, it is best to measure water leaving a field site at several different flow conditions to quantify the actual DP concentrations leaving a site. Taking a grab samples under a high, moderate and low flow conditions is a reasonable method to use. The best sites for a PRS have water with DP concentrations greater than 0.2 mg/L which is four times the desired DP concentration target (0.05 mg/L) for many receiving water bodies such a streams, rivers and lakes.

These field sites are often associated with high Soil Test Phosphorus (STP) levels, generally 2-3 times the agronomic STP need of many crops grown. Fields with a STP value of 100 mg/kg Mehlich 3 or greater would be a candidate for water testing to confirm DP concentrations. Fields with high STP will remain high for many years due to the P buffering capacity of soils. In these high STP field situations there are few conservation practice alternatives to reduce DP losses. The long term needs at these sites make the PRS a cost-effective option.

Why install it:

Sites with high concentrations of DP in drainage water are often associated with high STP levels from past field management. Phosphorus removal structures can be installed to trap the lost P while in-field practices to lower STP are implemented for reducing the source of DP. More information on the relationship of soil test level to DRP losses can be found on this site.

The PRS immediately removes DP from drainage water and surface runoff at the edge of a field. The ideal field site is where high levels of DP (>0.2 mg/L) are measured in water and other conservation practices cannot be effectively deployed to reduce DP in sensitive watersheds. The practice will be most cost effective when implemented at sites where long-term DP reduction are needed while infield practices are used to reduce DP sources in the field. The primary in-field practice for reducing the source of DP is reduced or no application of additional P while drawing down STP levels to environmentally acceptable levels.

What do I need to know about it:

Effectiveness

Properly designed P Removal Structures can result in reductions of 16-71% in DP concentration and loading. These results were from a summary of 40 different field scale trials using various designs and PSM materials. (Penn, et al, 2017) Water 2017, 9, 583; doi:10.3390/w9080583

Considerations

Characteristics of the ideal site for construction of a P removal Structure include:

Flow convergence to a point where water can be directed into a structure, or the ability to manipulate the landscape to concentrate water flows.

Dissolved P (DP) in water of at least 0.2 mg/L.

Hydraulic head required to "push" water through structure which is a function of elevation change or drainage ditch depth.

Sufficient space to accommodate PSM chosen.

P removal structures require careful design to reach peak absorption efficiencies and maintain subsurface tile drainage. Design inputs needed to determine size and function for a PRS fall into three categories.

Site hydrology and water quality characteristics

Target removal and Lifetime needs

PSM characteristics.

Site characteristics will determine the amount of water that flows to potential installation locations. Measurements of the DP concentration over several different flow conditions combined with estimates of annual flow volume can be used to estimate the load (mass) of DP that is delivered. Sizing of a P removal structure is a function of the annual P load, the chosen P removal amount and lifetime, and the characteristics of the PSM to be used. The most important PSM characteristic is its ability to remove P, as quantified by a "P removal curve". The P removal curve is simply a mathematical description of P removal under flowing conditions for a given P inflow concentration and retention time (RT), expressed as a function of P loading (i.e., P added per unit mass of PSM). Physical characteristics of the PSM, especially porosity and saturated hydraulic conductivity (i.e. its ability to conduct water) are especially important when it comes to designing PRS to achieve the desired P removal at the chosen flow rate and RT.

An important factor in design is PSM selection. Generally, any product with a high affinity for P, suitable physical characteristics, and is safe for use in waterways can work as a PSM. Types of PSMs available include drinking water treatment residuals, fly ash, mine drainage residuals (Fe oxides), steel slag, metal filings, and manufactured PSM. The most cost effective PSM known at this point, is metal filings/turnings mixed (5-8%) with clean pea-gravel. A graphic of PSM's is found in Figure 2.

Manufactured PSMs tend to absorb P more efficiently but are higher cost products. While manufactured PSMs are higher cost, less material mass is needed to perform the desired P capture, lowering the amount of space needed for the PRS. For example, a subsurface tile drain filter designed to remove 35% of a 5-year Dissolved P load using treated steel slag would require 40 tons while a manufactured Fe-rich PSM would only require 2-5 tons.

When treating subsurface tile drainage water do not use untreated electric arc furnace slag or blast furnace slag. The bicarbonate contained in the tile water will cause premature failure with these PSM options. Aluminum-treated slag can be used for tile drains if properly sieved to removed fines. Regular non-treated sieved slag works well for treating surface water, especially when used as the gravel in blind inlets.

A variety of materials have been evaluated and are included in the P-Trap software database. New materials are always being evaluated at USDA Agricultural Research Service, National Soil Erosion Research Laboratory in West Lafayette, IN. Contact the USDA Erosion Laboratory if your PSM of interest is not found in the P-Trap database.

Urban Land Practices

Description – There are a different set of practices that are suitable for urban area, but like cropland practices, there are non-structural and structural opportunities. Non-structural practices or ordinances can be implemented to reduce the amount of nutrients introduced into the runoff. Structural practices provide the next level of protection that trap and/or treat pollutant loads that are generated from urban land uses and transported with overland runoff.

Ability to Assist in Achieving Goals – Since urban area is a small portion of the land use in the watershed, it is not a major contributor of phosphorus to the lake. However, the phosphorus loading rate (pounds per acre) is high, so efforts to reduce the amount of nutrients generated from urban land have some water quality benefit. Further, cooperation and adoption by urban landowners often increases participation by rural residents and farmers. Non-structural management practices that are most applicable to urban areas in the Five Island Lake watershed include (but are not limited to):

- Use of no-phosphorus fertilizer
- Pet waste management
- Soil quality restoration

Structural conservation practices can be implemented by private landowners to treat runoff from individual properties. Similar to the bioswale implemented in the Five Island Lake Campground, larger properties that have the space and ability to treat concentrated flow are encouraged. The local golf course may have these opportunities and a watershed coordinator could also help identify and orchestrate urban practices. Structural practices that focus on filtration and nutrient uptake that would be highly suitable for this watershed include:

- Rain Gardens
- Bioswales

Qualitative Description of Cost – Costs will vary depending upon the practice. Stormwater ordinances may cost little to implement, with only minor costs required for public outreach and education. Iowa's Resource Enhancement and Protection (REAP) program will provide cost-share for some urban practices. A watershed coordinator would help identify opportunities, coordinate activities, and educate the public on the benefits of urban practices.

Septic System Repairs

Description – Faulty onsite wastewater treatment systems (septic tank and leaching systems) can develop leaks or untreated discharges that contribute pollutants to surface and groundwater. Not only nutrients, but also bacteria that can lead to health concerns. Failing septic systems should be identified and repaired.

Ability to Assist in Achieving Goals – There is limited information on the number of septic systems that are failing, but any system should have routine inspections to ensure proper function. Since the current level of function/failure is unknown, it is difficult to estimate the pollutant load from septic, as well and the load reductions that would be achieved. The relatively small number of systems would not generate a large flux of phosphorus compared to other sources, but would provide overall lake/health benefits. Any site located directly on the lake with an older system is likely to have the biggest impact on the lake from any leaks; these systems should be inspected and repaired as needed.

Qualitative Description of Cost – Dependent upon the problem, repairs to or complete replacement of septic systems can be high for individual property owners. A specific grant opportunity through the Palo Alto Gaming Development Corporation Grant (Casino Grant should benefit landowners in the watershed.

Construction Ordinances

Description – Controlling sediment and erosion on construction sites is important to prevent transport of the sediment and associated pollutants to local waterbodies. Common methods for sediment control include silt fences, erosion control blankets, detention ponds, rock entrances at access points, and hay bales or coir rolls as checks along drainage paths within a construction site.

Ability to Assist in Achieving Goals – Any construction directly along the lakefront should have very strict controls to prevent immediate delivery of sediment to the lake. Any development or construction activity should abide by a set of established rules to help protect Five Island Lake. It is understood that the Emmetsburg currently has a policy, but practices throughout the watershed outside city limits could be improved. Potential methods to implement and enforce runoff from construction sites should be investigated in more detail, which may be another potential activity for a watershed coordinator.

Qualitative Description of Cost – Costs associated with this alternative include implementation and enforcement by the responsible entity and relatively minor increased costs to the party responsible for the construction activity.

Near-Lake Management Practices

Near-lake alternatives, which are capable of treating large drainage areas, provide good opportunities for significant load reductions at improved economies of scale. These features are sometimes installed on private land with potential cost-share dollars, but the City could implement several alternatives by acquiring the necessary land rights. Examples of some near-lake strategies include:

- Constructed/CREP wetlands
- Detention basins or
- Sediment forebays

Constructed Wetlands

Description – Wetlands can provide uptake of dissolved phosphorus via the growth of aquatic vegetation and adsorption to wetland soils. Secondary benefits include aquatic habitat and a more diverse ecosystem around the lake. Wetlands initially have relatively high phosphorus removal rates; however, over time phosphorus-binding decreases as the wetland soils “fill up” with phosphorus. Additionally, phosphorus taken up by plants is released when the plants die and decay. Research suggests the phosphorus removal efficiency in unmanaged wetlands begins to decrease after 5-10 years. During periods of vegetation die-off, nutrients can be released, making the wetland a temporary source of phosphorus to the lake. Ideally, this die-off would occur only after the recreation season has ended, therefore impacts to algal growth and recreational uses should be minimal. With proper management, which may require occasional harvest and removal of wetland vegetation, nutrient uptake can be enhanced and sustained over time.

Ability to Assist in Achieving Goals – Constructing large wetlands at major inlets to the lake could provide substantial phosphorus load reduction. A wetland design that provided treatment of tile drain outlets would have the greatest potential water quality benefits.

Qualitative Description of Cost – Costs associated with constructing wetlands are primarily earthwork and water level control structures. If this is pursued by the City and land rights need to be acquired, that would also be a factor in the cost. If implemented through the Iowa Conservation Reserve Enhancement Program (CREP) and IDALs or the local conservation district, financial incentives are provided to private landowners. Constructed wetlands are also eligible for EQIP funding through USDA-NRCS. If the City pursued a constructed wetland, grant opportunities through REAP, IDALs and/or the Casino Grant should be investigated.

Detention Basin/Sediment Forebay

Description – Detention basins are earth embankment structures installed on tributaries to impound water and help improve water quality by trapping sediment and sediment-attached phosphorus. A sediment forebay is a similar alternative to the detention basin that traps/treats the watershed load, however if there are space/land rights limitations in the uplands, a sediment forebay can be implemented in the lake at a concentrated location of stormwater discharge.

Ability to Assist in Achieving Goals – The design of a detention structure includes impounding a tributary and artificially raising the water level. This is not conducive to intercepting tiling drain outlets that discharge immediately at the lake, however any tile drains that are outlet into overland drainage paths throughout the watershed would be treated. The feasibility of a detention basin at each near-lake outlet should be investigated to ensure that available space and topography allow for proper design, Care would have to be taken to place detention basins at locations where elevated water levels do not inundate tile drainage outlets and prevent proper drainage from the fields they are draining

Qualitative Description of Cost – The primary cost of detention basins is for earthwork, outlet control structures, and land rights. Sediment forebays are generally constructed with rock, which can be expensive and often limits the size (and trapping efficiency) of the structure. EQIP funds will provide cost-share for private land owners that install detention basin/farm ponds. If the City pursued a constructed wetland, grant opportunities through REAP, IDALs and/or the Casino Grant should be investigated.

In-Lake Management Practices

- Rough Fish Management
- Wetland Creation
- Shallow Vegetation/Lake Level Management
- Phosphorus Inactivation
- Boating Restrictions
- Dredging

Rough Fish Management

Description – Fish that have bottom feeding habits that disturb lakebed sediments and create turbid conditions are often referred to as 'rough fish'. The most commons species encountered in the Midwest are common carp and bigmouth buffalo. Controlling the rough fish species reduces the amount of sediment resuspension and release of phosphorus that contributes to internal loading. Reduction of the rough fish population would also facilitate establishment of desirable, shallow aquatic vegetation.

Ability to Assist in Achieving Goals – If the biomass density of rough fish at Five Island Lake could be reduced to 50-100 lbs/acres, significant water quality benefits would be achieved though reduced lakebed resuspension/internal loading, and improving the aquatic habitat and fishery. There are several approaches to managing the rough fish described below that together could bring down the population. These include fish removal, reducing access to spawning habitat (via hard barriers or lake level drawdown), fish passage barriers, and public education.

Fish Removal

Commercial harvests of rough fish at Five Island Lake are reported to DNR, but available data has limited utility for estimating the population and understanding recruitment trends. The results of the study by Iowa State will be available in the fall and will be used to evaluate the feasibility of options to meet rough fish population goals.

If commercial harvesting cannot meet goals, chemical applications such as Rotenone or physical removal of the fish may be necessary. Both options would be made easier and more affordable by concentrating fish within smaller areas of the lake. This would be facilitated by the implementation of a fish passage barrier in the northern portion of the lake and/or a lake level management (i.e., drawdown) system.

Reduce Spawning Habitat

Rough fish typically spawn in shallow waters, and preventing access of undesirable species to shallow areas of Five Island Lake will help reduce recruitment. A permanent or temporary fish barrier can be placed in the lake to prevent access to the shallow waters on the north end from the remainder of the lake. Installing this barrier would be facilitated by a lower lake level during construction. Additionally, lowering the lake level may limit rough fish access to some spawning areas without the need for additional barriers. For those reasons, the incorporation of a lake level drawdown system may benefit rough fish removal. Figure 15 depicts the areas that would be exposed with varying levels of drawdown.

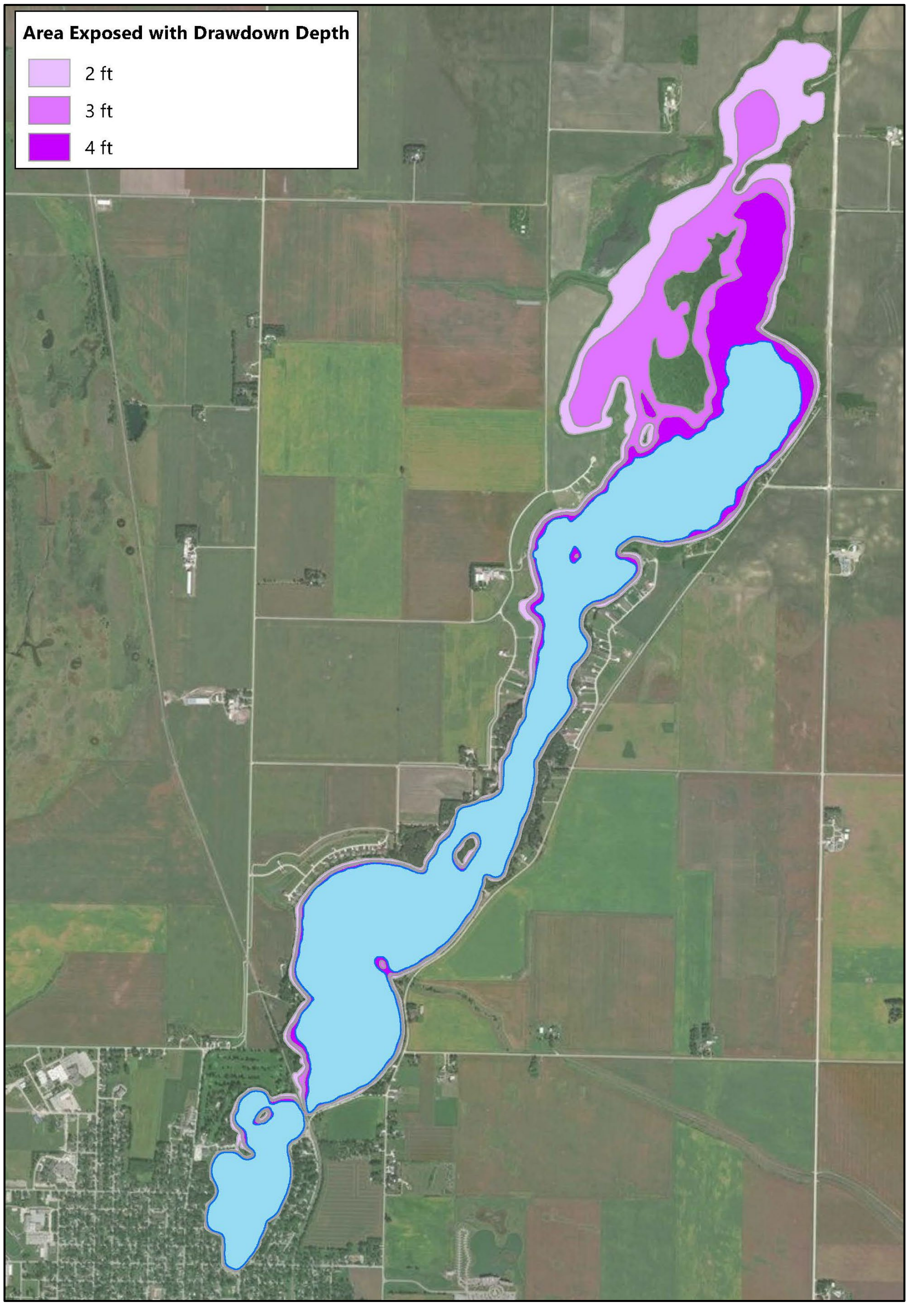


Figure 15. Proposed Drawdown Map

Fish Passage Barrier

Rough fish can enter the lake by swimming upstream and jumping over the weir when there is enough flow in the outlet channel to provide depth for the fish in the approach to the weir. Screens serve as an effective fish barrier and it appears that there is a simple solution to preventing fish from passing into the lake through this route.

A screen can be fabricated to cover the upstream (not downstream) opening of the two culverts under North Huron Road. This screen should have a maximum opening of 2" x 2" to prevent fish in the downstream channel passing through. Screens require maintenance. Debris will eventually block the screen and reduce hydraulic capacity of the culverts. For this reason, a second screen should be placed between the RCB outlet and the North Huron Road culverts to create a larger screened area (which is less likely to be clogged to the point that it reduces hydraulic capacity) and is easier to remove debris and maintain (Figure 16). This screen can have larger openings such as present in a 4" x 4" woven wire mesh panel. This screen can be attached to fence posts that will span the open channel area. Collectively, this inexpensive system should prevent fish passage into the lake and require only minor maintenance.

Fish Barrier Screen Series Concept

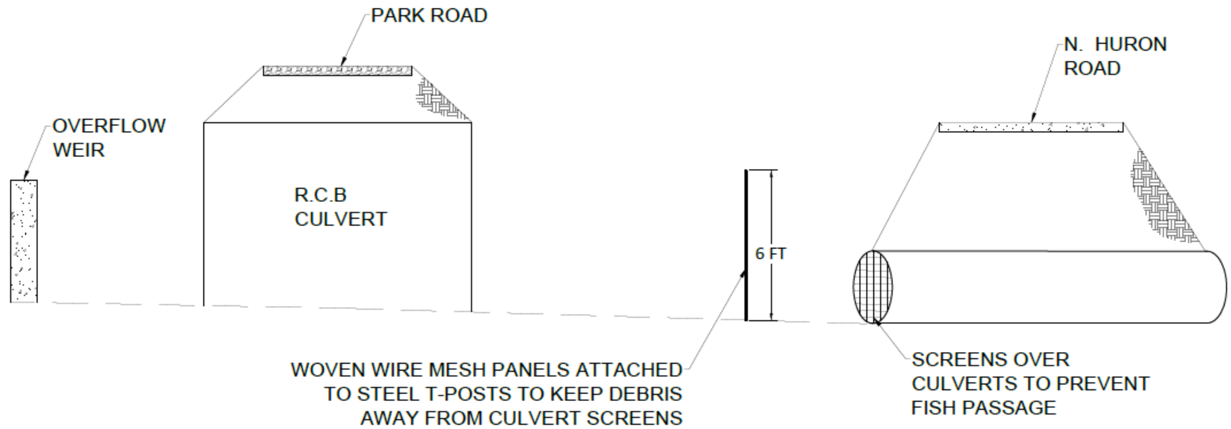


Figure 16. Fish barrier Diagram

Rough Fish Public Education

Because there are no upstream impoundments in the watershed, rough fish are likely entering the system through one of two avenues; they are passing through the downstream channel and jumping over the outlet weir or they are being brought in by fishermen through live bait or in fishing wells in boats and get released into the lake.

Fish passage through the outlet structure is identified within this Plan and a renewed effort with the public on education related to keeping invasive and undesired species of fish, aquatic vegetation and other organisms such as mussels, etc. should accompany the implementable portions of the Plan. Iowa DNR has a wealth of available information and education tools to assist the community in getting the word out.

Qualitative Description of Cost – The rough fish management approach will depend upon the results of the results of the Iowa State study, which will dictate the costs. The fish passage barrier screen costs are estimated at only $4,000, and the major costs associated with this alternative will be function of the fish removal method selected.

Wetland Creation

Description – Establishing a large designated area of wetlands in the lake, often created by separating a portion of the lake with hard structures or buoys, can improve water quality in multiple ways. The wetlands capture sediment, take up nutrients thus competing with algae for their food source. Rooted aquatic vegetation on the bottom of the lake thrives in shallow wetlands, and this can reduce resuspension of lakebed material that contributes to the internal load.

Ability to Assist in Achieving Goals – The geometry of Five Island Lake is conducive to implementing a large, in-lake wetland feature. The north portion of the lake is shallow, with power boating already restricted in portions of this area. The north end of the lake also has three major inflow locations that drain a large portion of the watershed. An in-lake wetland in north portion of the lake would help trap and treat sediment and phosphorus from the watershed, and the rooted vegetation would help reduce resuspension of the shallow lakebed. The establishment of wetland vegetation would be assisted through lake level drawdowns. A hard barrier at the south end of this area would also assist in establishing the wetland. It would protect the area from resuspension and disturbance to help establish aquatic vegetation, limit movement of rough fish into this shallow, ideal spawning habitat, and act as a speed control barrier that help enforce no-wake boating in the wetland area.

Figure 17 – Hard Barrier Structure

The potential hard barrier location identified in Figure 17 was selected to minimize the length (and associated costs) of the structure. The configuration on the east side of the island consists of two parallel structures with a slight overlap. The gap between the structures would be temporarily blocked with a highly durable fabric curtain until the rough fish have been successfully reduced to desired levels. Once the curtain is removed, this configuration will allow boating access to the northern portion of the lake, but the structure will act as a speed control mechanism requiring boats to maneuver between the two structures. It is recommended that only trolling motors be allowed in the area north of the barrier even after access is resumed.

Qualitative Description of Cost – The largest expense for establishing wetlands would be to construct a hard barrier structure in wet conditions. Costs would vary depending on barrier location, size, materials, and methods of construction. For this plan, a rock riprap structure was assumed to rise 2 ft. above the water level with 5 ft. top width and 3:1 slope. The total length of the structure would be approximately 2,000 ft.

Shallow Vegetation/Lake Level Management

Description – Like wetlands discussed above, increasing aquatic vegetation in a lake provides numerous benefits to a waterbody. The management of shallow vegetation in the lake would be enhanced by the ability to vary the water level in the lake during a growing season approximately 2-4 ft. to help establish vegetation in the shallow areas primarily around the perimeter of the lake. This is most commonly achieved by making modifications to the outlet control structures to allow for water level control.

Ability to Assist in Achieving Goals – At Five Island Lake, the ability to temporarily lower lake levels would not only help establish shallow vegetation around the perimeter of the lake, but it would also greatly assist in establishing aquatic vegetation behind the lake segmentation structure and facilitate the harvesting and removal of rough fish from the lake.

Figure 18 - Outlet Structure Modifications

Potential modifications to the outlet structure were assessed. Based on existing geometry, it should be possible to lower lake levels up to four feet. The incorporation of a slide gate or a stop log structure are both potential modification alternatives to consider. The capacity of the modification may determine the most reasonable alternative. A ten-foot wide weir would take approximately 15 days to lower the lake the first two feet with no additional inflow. A gate this wide would be more expensive and more difficult to incorporate into the existing weir and for that reason, incorporating a stop-log system would be proposed. This system would likely require removing the central portion of the weir and incorporating channels into the sides of the removed portion of the weir so that stainless steel panels could be dropped into the channels to control the desired lake depth. A general concept is shown in the image above (Fig. 18).

Qualitative Description of Cost – These modifications are relatively simple, with the primary cost associated with the installation of the stop-log system.

Whole Lake Phosphorus Inactivation

Description – Phosphorus inactivation across the entire lake involves use of a chemical agent to bind with phosphorus in the water column and the lake bed sediments. The most common compound that is used for this treatment is aluminum sulfate (alum). Alum is applied just below the water surface of a waterbody via a barge. As it sinks, it will bind to phosphorus, form a floc, and strip it from the water column. As the floc settles to the lake bottom it creates a thin, unnoticeable layer. To control internal loading, the dose of alum should allow for available binding sites in the floc after stripping phosphorus from the water column and settling to the bottom. The floc will provide reductions in the internal load by binding with any phosphorus released from sediments in anoxic conditions.

Ability to Assist in Achieving Goals – Whole lake treatments provide immediate stripping of water column phosphorus (and other constituents) and can be very effective in reducing lake phosphorus concentrations and increasing clarity to meet water quality goals. The longevity of water quality improvement is a function of proper dosing rate, timing of application, and other factors that increase phosphorus levels to pre-treatment levels (watershed load, organic matter decay, etc.).

Qualitative Description of Cost – The cost of whole lake phosphorus inactivation is dependent upon type and amount of the chemical agent used. Typically, it is most efficient and effective to apply an amount that can strip the quantity of phosphorus in the water column while also addressing the potential release of phosphorus from the sediment layer. The required dose is typically based on the amount of potentially available phosphorus in the sediment or estimated phosphorus release rates over some designated time frame. For planning purposes, dosing costs in this study assumed that alum would be dosed in a quantity sufficient to capture potentially available phosphorus, which is equivalent to a 4-year release rate (estimated from sediment core analysis and mass balance modeling). The proposed dosing rate (and cost) should be refined based on more detailed investigation/study before implementation of this alternative.