Nine- Element Nonpoint Source Implementation Strategic Plan (NPS- IS plan)

Grand Lake St. Marys:
Grand Lake St. Marys HUC- 12 (05120101-0204)
Version 1.0: May 13, 2019
Approved: June 12, 2019

Created by:
Mercer County Soil and Water Conservation District
220 W. Livingston St., Suite 1
Celina, OH 45822

This page intentionally left blank

Table of Contents

Acknowledgements

Mercer County Soil and Water Conservation District would like to thank the many partners who helped compile the information, maps and projects needed to create this document. This NPS-IS plan will help focus on projects to address the nonpoint source impairments in the Grand Lake St. Marys HUC- 12 of the Grand Lake St. Marys Watershed.

Chapter 1: Introduction

The Grand Lake St. Marys HUC-12 (05120101-0204) drains a large portion of the Grand Lake St. Marys drainage basin, both north and south sides of the lake in Mercer and Auglaize Counties in Ohio. Grand Lake St. Marys is the source for drinking water in the City of Celina, Ohio. It includes Prairie Creek, Grassy Creek, Monroe Creek, Little Chickasaw Creek, Barnes Creek, North Shore and the lake itself. The Grand Lake St. Marys watershed is 54.16 square miles in size, and is the largest of the four 12 digit HUC watersheds within the Grand Lake St. Marys (GLSM) watershed. (WAP 2015) Excluding the open water of the lake, the watershed is made up of primarily intensive row cropping, livestock agriculture, and residential development along the lake, including parts of the City of Celina and the City of St. Marys.

This NPS-IS for the Grand Lake St. Marys HUC-12 will meet the U.S. EPA's nine minimum elements of a watershed plan for impaired waters.

1.1 Report Background

The Grand Lake St. Marys HUC-12, located in the GLSM watershed, was designated as distressed beginning January 18, 2011 due to severe algal blooms associated with phosphorus and nitrate loading into the lake, which is a public drinking water source. This created a primary interest for focusing on agricultural and residential run-off. Having nonpoint source management projects identified, when implemented, will have measureable impacts on water quality in the GLSM HUC-12 and the lake itself.

The City of Celina has made significant investments and advancements in its drinking water treatment system due to the poor water quality of the lake. Activated carbon treatment has been used for many years. The City is currently in process of installing an advanced pre-treatment process to reduce the need for chemical pre-treatment, which will ultimately save on consumable costs throughout the year. While a significant up-front capital investment is needed, the system will pay for itself in less than five years due to reduced chemical costs.

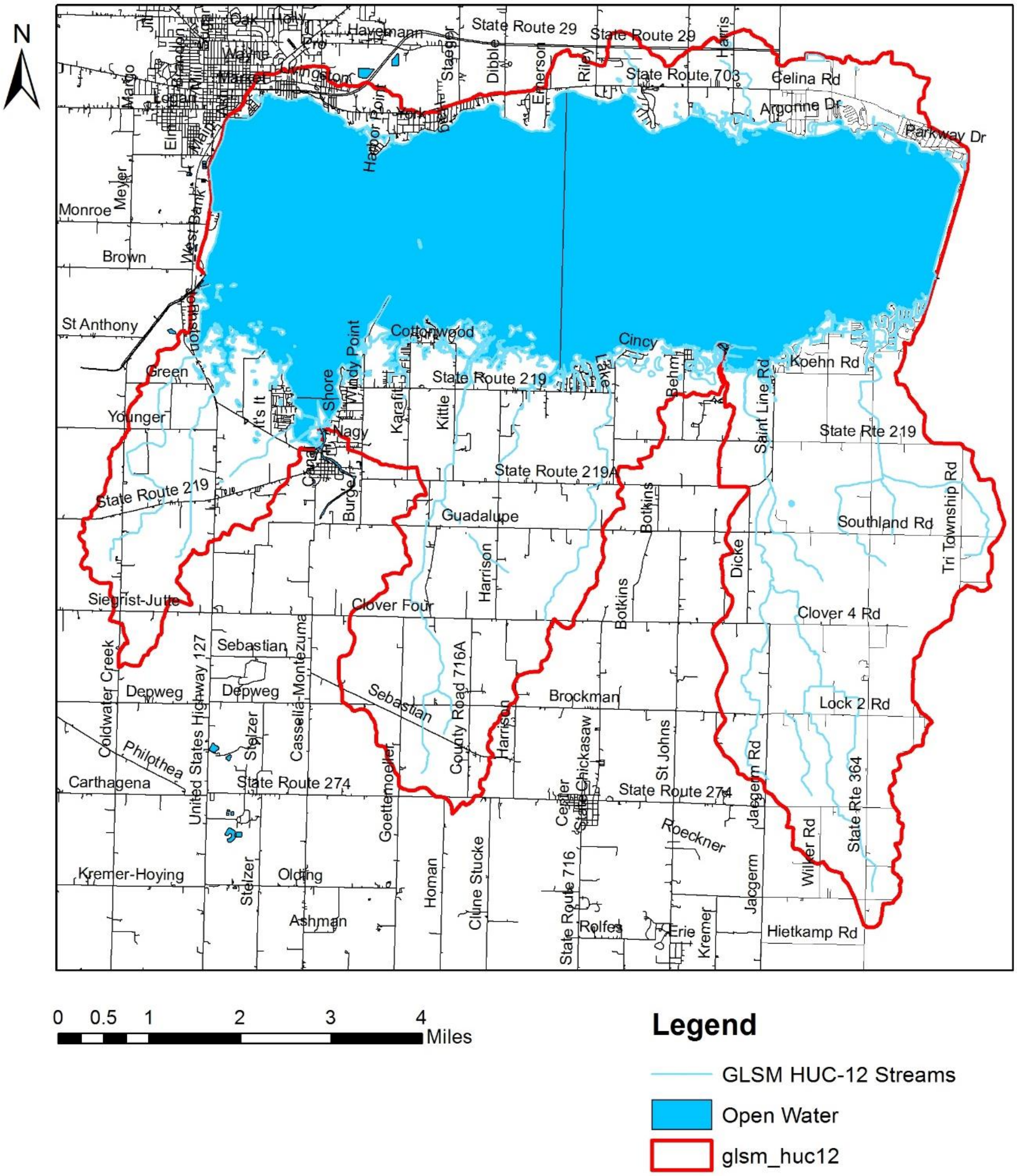

Figure 1: River Mile Map of GLSM HUC-12

The GLSM HUC-12 is a part of the Watershed Action Plan for Grand Lake St. Marys and the Wabash River, which was fully endorsed on May 14, 2008 by ODNR and Ohio EPA. This action plan was developed to promote stewardship of the natural resources in the Grand Lake/Wabash River Watersheds as more land and water resources were being used by humans. With the change of program focus, this NPS-IS is created to guide a more specific region in addressing nonpoint source pollution issues for the Grand Lake St. Marys watershed.

1.2 Watershed Profile and History

The distressed watershed of GLSM consists of nearly 13,500 acres of lake and 58,880 acres of land. The GLSM HUC-12, which is a portion of the entire GLSM watershed, is 34,662 acres in size. The watershed includes Grassy, Monroe, Prairie, Barnes, and Little Chickasaw Creeks, the north lake shore and GLSM itself. There is a total of 165.2 miles of stream network as mapped in Figure 1, which includes the perimeter of the lake and lake channels. There are 40.4 miles of stream within the watershed of the GLSM HUC-12. A portion of the east half of the GLSM watershed, which includes Little Chickasaw Creek and Barnes Creek, is in Auglaize County, Ohio. The remaining portion of the distressed watershed is located in Mercer County, Ohio. (WAP 2015)

The GLSM HUC-12 land use is mixed due to the open waters of the lake. Approximately 47 percent is in agriculture production, 36.9 percent is open water, 8.6 percent urban/residential, 7.5 percent forested, wetlands or shrubs. There has been a significant increase in residential use since the original land use GIS layers were developed in 1994 by the Ohio Department of Natural Resources. These percentages are based on the 1994 data, but modified to reflect what is shown on 2015 aerial imagery.

There has been a long history of livestock farms in the area being composed of dairy, growing steers, swine, and poultry. Many small farms have been maintained in their own family for several decades with their kids and grandkids taking over the farm. This has kept a strong community of livestock farmers in the GLSM watershed. Farm expansion has also continued, to allow for the support of these growing families' needs.

Recreational activities in the GLSM HUC-12 include many opportunities of camping, fishing, boating, and hunting on or in the vicinity. Grand Lake St. Marys State Park, numerous campgrounds, residential developments, the City of Celina and the City of St. Marys allow for a wide range of recreational opportunity within this watershed.

Figure 2: Monitoring a Creek in Grand Lake St. Marys

1.3 Public Participation and Involvement

It is important to have diverse involvement in developing restoration plans for a watershed. This should not only include farmers, but businesses, non-profit groups, organizations and the general public. In recent years, there have been many water quality improvement projects completed within the GLSM HUC-12. These projects include many in-lake improvements and watershed improvements, listed below.

- The Prairie Creek treatment train was first constructed in 2012, utilizing wetlands to filter nutrients and a littoral wetland in-lake for additional filtration. It was expanded in 2015 to allow for additional wetland area for filtering.
- Channel aeration has become widely popular, with the local Lake Improvement Association providing some funding to individuals to help offset the cost. Approximately 23% of the channels currently have aeration installed.
- Alum treatments of lake water were completed in 2010, 2011 and 2012.
- Dredging efforts have greatly increased since 2010. Beginning in 2011, dredging efforts have removed nearly or over 300,000 cubic yards of sediment slurry per year.
- Rough fish removal has been extensively investigated beginning in 2011 and continues.
- Nutrient management plans were completed for all livestock farms generating over 350 tons or 100,000 gallons of manure per year.

- Numerous on-farm best management practices were established utilizing federal, state and local dollars, as shown in Chapter 2.2.
- Distressed watershed rules have been implemented and monitored.

The attention on Grand Lake St. Marys has increased greatly since the watershed was declared distressed on January 18, 2011. The lake has long been a point of interest in western Ohio. Tourism and job creation are of great significance to the community. Due to the presence of microcystin toxin, warnings were first posted at the lake in May of 2009. Tourism dropped significantly from 2009 to 2011. However, there has been a steady increase in tourism since, with the 2015 tourism totals surpassing the totals of 2008, the year prior to the public notification system of microcystin toxin. These warnings have put a spotlight on agriculture, with a focus on manure and fertilizer management along with maintaining soil test phosphorus levels within acceptable levels.

Mercer County Soil and Water Conservation District (SWCD) has long been working closely with livestock farmers in developing Comprehensive Nutrient Management Plans (CNMP). With these plans, livestock operations producing 350 tons or 100,000 gallons of manure annually are required to keep an updated plan. The development of a CNMP requires a comprehensive engineering and conservation planning resource assessment of current site conditions. Management options and structural alternatives are developed to address resource concerns identified during the assessment. All CNMPs are approved by a certified conservation planner. Each CNMP must include Environmental Compliance for the planned system and may be comprised of six possible elements:

1. Manure and Wastewater Handling and Storage - a technical element
2. Land Treatment Practices - a technical element
3. Nutrient Management (planned for three future years) a technical element
4. Record Keeping (non-technical element)
5. Feed Management – a technical element (optional, as needed)
6. Other Utilization Options – a technical element for manure not applied to land (optional, as needed)

The Lake Improvement Association (LIA) is an organization that has worked to promote lake tourism and participation from the community in order to improve water quality in the GLSM watershed. The LIA has been in existence since 1947 and has strong membership support. They have partnered with several other agencies on many projects throughout the years and were significantly involved in the development of this plan.

In 2010, a group of farmers within the GLSM watershed came together to look for innovative solutions to improve water quality from an agriculture perspective. This Ag Solutions group met monthly for several years and heard many water quality and manure management technology presentations. They also conducted several trials with different technologies. Participation declined over time; however, the Mercer County Commissioners recognized the importance of keeping agriculture strong in the area and funded a full-time Agriculture Solutions Coordinator position. This position was hired in early 2016, and several projects are currently on-going and many technologies are being researched. The Ag Solutions Coordinator was also significantly involved in the development of this plan.

The Lake Restoration Commission (LRC) was formed in December of 2009 to pioneer the initiative dedicated to fostering the regional cooperation and resources needed for the environmental renewal and sustainability to the lake. The initial efforts primarily focused on identifying the proven scientific strategies and technological solutions able to solve the environmental crisis in GLSM. The LRC developed a strategic plan in 2011 to provide a framework and timeline for restoration of the GLSM ecosystem. This plan was then updated in 2017 as an adaptive management plan. The LRC has developed treatment trains on three of the tributaries to GLSM, including Prairie Creek which resides in the GLSM HUC-12. These "treatment trains" include a series of constructed wetland cells where water from the creek is pumped. Water levels in the constructed wetlands can be varied with differing residence times to affect water quality improvements. After the water is released from the constructed wetlands, it flows into an in-lake littoral area for further treatment prior to entering the lake itself. The LRC intends to construct a treatment train on Big and Little Chickasaw Creeks in 2019 or 2020, which also resides partially in the GLSM HUC-12. The area involves 70 acres of wetland area using natural vegetation to absorb nutrients and an estimated 76 acres of littoral in-lake wetland. Figure 3 below shows an aerial view of the proposed treatment train area for Big and Little Chickasaw Creeks. The site is less than a half mile from GLSM and will be located between Big and Little Chickasaw Creeks.

Wright State University-Lake Campus (WSU-LC) has become a critical partner in the lake improvement effort. WSU-LC has provided the collection and testing of water samples from all treatment trains, the lake, and various areas of the watershed. They have also completed an extensive study of the stream monitoring data to determine the progress made in the watershed since 2011. WSU-LC works closely with the LRC to make this monitoring data collection a reality and ensures that the data is shared with the public in a timely fashion. An Agriculture and Water Quality Center was built on the campus in 2017-2018 and is now open for coursework and research.

Figure 3: Proposed Area of Big/Little Chickasaw Creek Treatment Train

Many agricultural BMP's and projects have been installed as a result of the distressed watershed rules. Livestock operations within the GLSM HUC-12 have been of particular focus. All milk house wastewater is now contained, collected, and/or treated. All livestock operations have a minimum of four months of manure storage, with most having six months to one year of storage. This was done in conjunction with complying with the manure application ban starting in January of 2013. The current distressed watershed rules state that no application of manure or fertilizer shall occur between December 15 and March 1st. During all other times of the year, manure applications must be completed following NRCS Practice Standard 590.

A survey was distributed to GLSM farmers in January 2018 to gauge interest in potential nonpoint source pollution recovery projects. This survey was distributed to an estimated 180 farmers. There was a 57% response rate. Figure 4 shows the results of the survey. Many landowners are engaged in best management practices and on average, 15 to 20 percent are willing to engage in the same practices. Education and performance-based incentives would likely encourage a higher percentage of landowners to engage in these practices as well. On March 11, 2019 a public meeting was held with 20 producers from the area in attendance. Future projects were discussed and the results from the land owners corresponded with figure 4 results.

Farmer Survey Results

	Currently engaged in practice	Unlikely to engage in practice	Likely to engage in practice in near future
Planting cover crops	68.9%	20.0%	11.1%
Incorporation of all manure and/or nutrients within 24 hours	48.3%	31.0%	20.6%
Harvest of two crops in a field per year	38.6%	44.3%	17.1%
Install an edge of field practice	19.2%	66.7%	14.1%
Install and maintain a minimum 20’ wide filter strip along streams	40.4%	48.3%	11.2%
Apply 90% of manure during the growing season (June-September)	21.6%	61.4%	17.0%

Figure 4: Survey Results Received from Farmers for Changing Management Practices.

Chapter 2: GLSM HUC-12 Watershed Characterization and Assessment Summary

2.1 Summary Watershed Characterization for GLSM HUC-12

2.1.1 Physical and Natural Features

The Grand Lake St. Marys HUC-10 watershed is comprised of four 12-digit HUCs. This document is focused on the GLSM HUC-12 which has direct contact of river flow to Grand Lake St. Marys. It includes Grassy, Monroe, Prairie, Little Chickasaw, and Barnes Creeks, the North Shore and GLSM itself. It is surrounded by the remaining three 12-digit HUC's, Coldwater Creek HUC-12(05120101-0203), Beaver Creek HUC-12 (05120101-020), and Chickasaw Creek HUC-12 (05120101-0201), all which also have direct river flows to Grand Lake St. Marys. (WAP 2015)

Agriculture is a significant portion of the GLSM HUC-12 with corn, soybeans, wheat, and alfalfa in rotation. The area has flat topography, fertile soil, and good drainage. The farmers have consistently used these resources to produce crop and livestock yields at or near the top for all Ohio counties. The majority of cropland is subsurface drained with systematically-patterned tiles. (WAP 2015)

Specific landmarks and features of this watershed include:

- Unincorporated area of St. Sebastian
- Western edge of the City of St. Marys
- Numerous campgrounds and residential developments
- Grand Lake St. Marys State Park
- Mercer County Sportsman Club
- Eastern edge of the City of Celina
- A portion of Lakefield Airport
- Montezuma Industrial Park
- A portion of the Village of Montezuma
- Wright State University-Lake Campus

The numerous campgrounds and residential developments are all connected to sanitary sewer. The southern portions of development around the lake are transferred to the Montezuma Club Island wastewater treatment plant. The northern portions of development are connected to the City of Celina and/or the City of St. Marys.

Many parts of the small streams have become impaired due to stream channelization, drainage tiles, loss of floodplains, and loss of streamside vegetation. GLSM has also lost significant wetland filtration close to the lake due to residential development. These factors have degraded the creeks and GLSM. When streams are widened and deepened, they contribute excess soil to the stream, which destroys habitat for fish and other aquatic life. This has threatened many aquatic species due to habitat degradation.

Causes	Sources
Direct Habitat Alteration	Non-irrigated crop production, residential development
Nitrate/Nitrite	Confined animal feeding operations (NPS), residential development
Phosphorus	Channelization – agriculture, residential development
Sedimentation	Removal of riparian vegetation, streambank and shoreline destabilization
Algae: Cyanobacteria and associated toxins	External and internal nutrient loading and habitat loss

Figure 5: Causes and Sources of NPS in GLSM HUC-12 (05120101-0204)

According to the latest TMDL report, nutrient loading, nitrogen, and total phosphorus are significant nonpoint pollutants that impact the watershed and Grand Lake St. Marys, both economically and environmentally. Because pastureland and row crops are the dominant land cover in the watershed, many of the probable sources of impairment in this watershed are tied to agricultural practices. As these practices encroach on riparian and in-stream habitats, habitat may be altered through stream channelization, riparian vegetation removal, and subsequent stream bank destabilization. Without the natural filtering capabilities of a healthy, vegetated riparian buffer, runoff from pasturelands/row crops carries pathogens and nutrients from recent manure and fertilizer applications directly into streams. There are numerous small Animal Feeding Operations in this watershed that are also noted sources of nutrients and pathogens. Animals grazing near streams can be a direct source, while runoff from these operations' pastures, holding areas, and manure application fields can also be a significant nonpoint source. This is especially true in the absence of effective manure management plans and appropriately sized waste storage facilities. (TMDL, GLSM 2007) While this statement was true in 2007, this is no longer the case within the GLSM HUC-12. All livestock operations generating over 350 tons or 100,000 gallons of manure annually maintain a current Comprehensive Nutrient Management Plan and have a minimum of 120 days of manure storage. This is consistent with the distressed watershed rules for GLSM.

Another source of pathogen and nutrient impairment in the GLSM HUC-12 watershed comes from human waste. Unsewered areas with failing septic systems are of serious concern as untreated sanitary wastewater from residential areas is discharged directly into streams. There is one unsewered, clustered residential area (St. Sebastian) within the GLSM HUC-12.

GLSM receives direct flow from the GLSM HUC-12 through Grassy Creek, Monroe Creek, Prairie Creek, Little Chickasaw Creek and Barnes Creek. With nearly 13,500 acres of lake, GLSM is currently in non-attainment status for drinking water. The GLSM HUC-12 is one of four 12-digit HUC's that deliver water to GLSM, therefore, is not the only source of nutrient impairment. Because GLSM is a source for drinking water, there is a serious need to improve the water quality in GLSM.

Causes	Sources
Direct Habitat Alteration	Residential development
Algae: Cyanobacteria and associated toxins	External and internal nutrient loading
Sedimentation	Shoreline destabilization

Figure 6: Causes and Sources of GLSM Aquatic Life Use (ALU) Attainment Status (HUC 05120101-0204); and contributing factors to non-attainment of Public Drinking Water Supply standards in GLSM

2.1.2 Land Use and Protection

Figure 7 shows the land use is dominantly cropland. Looking at Figure 8 below, the three predominant land uses for the Grand Lake/Wabash Watershed are 1) cropland; 2) developed areas; and 3) Grand Lake St. Marys itself. This table includes areas outside the GLSM HUC-12 watershed. The table sorts the data in several categories such as number of acres per land use, square miles per land use, and percent of the total watershed area (including the lake). These numbers are beneficial in determining potential sources of pollutants in the watershed. They are also valuable at targeting education and implementation of various best management practices. This table is based on information provided by National Land Cover Database updated in 2011. (WAP 2015)

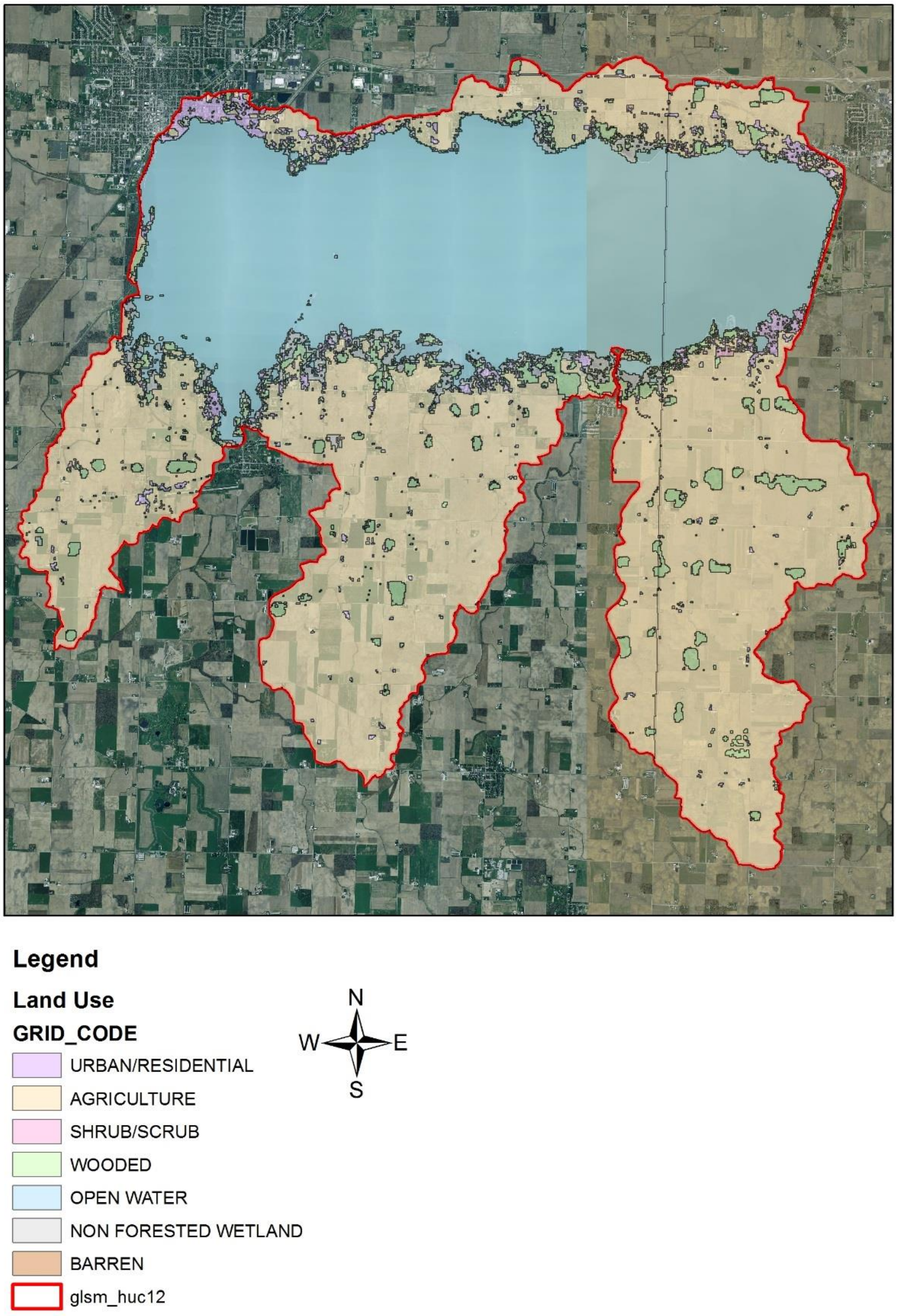

Figure 7: Land Use Map of the GLSM HUC-12

Land Use/Land Cover	Acres	Square Miles	% of Total Watershed
Cropland (Pasture and Cultivated Crops)	144,950	226.49	77.6%
Developed Area	17,929	28.01	9.6%
Forest	7348	11.48	3.9%
Brush/Shrub (Shrub and Grassland)	2343	3.66	1.25%
Undeveloped (Barren)	106	0.17	0.06%
Wetlands (forested & non-forested)	906	1.42	0.49%
Open Surface Water	13096	20.46	7.2%
TOTAL	**186,678**	**291.68**	**100.0%**

Figure 8: Land Use/Cover for GLSM and Wabash Watershed (WAP 2015)

To illustrate the importance of agriculture in Mercer County, the United States Department of Agriculture (USDA) reported the total market value of agricultural products sold in 2012 was $596 million. This statistic ranked Mercer County 1st of the Ohio's 88 counties, and 69th of the 3,079 United States' counties. Approximately 74.3% of the total value of agricultural products sold in 2012 was directly related to sale of livestock, poultry, and their products, also ranking Mercer County 1st in the State and 54th nationally. Net cash farm income of operation was $192.1 million or $159,061 per farm, on average (Mercer Co Comp Plan 2013).

2.2 Summary of HUC-12 Biological Trends

In 2007, Ohio EPA sampled the Beaver Creek and GLSM watersheds. The Beaver Creek and GLSM watersheds drain approximately 171 square miles and include two Assessment Units; Grand Lake St. Marys and tributaries, and Beaver Creek downstream of Grand Lake St. Marys to mouth. The GLSM HUC-12 is included in this assessment. (TMDL GLSM 2007)

The GLSM HUC-12 is currently designated as a warm water habitat, with GLSM itself being designated as exceptional warmwater habitat. A summary of the GLSM HUC-12's biological status are provided in Figures 9, 10, 11 and 12.

RIVER MILE Fish/Invert.	IBI	MIwb	ICI	QHEI	Attainment Status
Little Chickasaw Creek (04-521)					
	Eastern Corn Belt Plains WWH (Existing)/LRW proposed				
2.2	--flow	--	VP*	--	NON/NON
	Eastern Corn Belt Plains MWH (Existing)				
0.2/0.5[A]	27*	8.1[ns]	VP*	46.5	NON
Grand Lake St. Marys (22-999)					
	Eastern Corn Belt Plains EWH (Existing)				
17.7	31	9.2	VP	44.0	No applicable criteria
16.7	32	8.6	VP	46.0	No applicable criteria
15.6	29	6.5	VP	51.5	No applicable criteria
15.1	30	8.5	VP	53.5	No applicable criteria
Barnes Creek (04-535)					
	Eastern Corn Belt Plains WWH (Existing)/MWH proposed				
0.5	--flow	--	P*	--	(NON/NON)
Prairie Creek [Lake] (22-112)					
	Eastern Corn Belt Plains WWH (Existing)/MWH proposed				
1.6[A]	32*	8.9	VP*	46.0	NON/NON

A Boat sampling method
* Indicates significant departure from applicable WWH biocriteria (>4 IBI or ICI units, or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range.
ns Nonsignificant departure from biocriteria (≤4 IBI or ICI units or ≤0.5 MIwb units)
flow Performance limited by lack of water

Notes:

- The Modified Index of Well-Being (MIwb) is not applicable (NA) to headwater site types
- A qualitative narrative evaluation used when quantitative data were not available or unreliable due to current velocities less than 0.3 fps flowing over the artificial substrates (P = Poor, F = Fair, MG = Marginally Good, G = Good, VG = Very Good, E = Exceptional)
- Use attainment status based on one organism group is parenthetically expressed

Narrative ranges and WWH biocriteria (bold) for Ohio ecoregions. Exception (EWH biocriteria), very good (EWH nonsignificant departure), poor and very poor evaluations are common statewide. For WWH, the ranges of marginally good and nonsignificant departure are the same (except in HELP).

IBI			MIwb		ICI	Narrative Evaluation
Headwater	Wading	Boat	Wading	Boat	All	
50-60	50-60	48-60	≥9.4	≥9.6	46-60	Exceptional
46-49	46-49	44-47	8.9-9.3	9.1-9.5	42-44	Very Good
Eastern Corn Belt Plains						
40-45	**40**-45	**42**-43	**8.3**-8.8	**8.5**-9.0	**36**-40	Good
36-39	36-39	38-41	7.8-8.2	8.0-8.4	32-34	Marginally Good
28-35	28-35	26-37	5.9-7.7	6.4-7.9	14-30	Fair
18-27	18-27	16-25	4.5-5.8	5.0-6.3	2-12	Poor
12-17	12-17	12-15	0-4.4	0-4.9	<2	Very Poor

Figure 9: Attainment of Biological Criteria for Sites Sampled in the Wabash River and GLSM Basin (TMDL GLSM 2007)

In a warm water habitat, the following scores are needed to meet attainment status:

- IBI: 40
- ICI: 36
- MIwb: 8.3
- QHEI: 60

Prairie Creek (300043) TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**23.67 cfs**	**3.68 cfs**	**1.30 cfs**	**0.42 cfs**	**0.12 cfs**
Total Phosphorus (kg/day)	Current Load	84.91	5.49	2.76	5.57	3.51
	TMDL= LA+WLA+MOS	**4.63**	**0.72**	**0.26**	**0.08**	**0.02**
	LA	4.40	0.68	0.25	0.076	0.019
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	0.23	0.04	0.01	0.004	0.001
	TMDL Reduction (%)	**95%**	**88%**	**91%**	**99%**	**99%**
Nitrate Nitrogen (kg/day)	Current Load	5,484	170	57	No Data	No Data
	TMDL= LA+WLA+MOS	**58**	**9**	**3**	**1**	**0.30**
	LA	55	8.55	2.84	0.95	0.28
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	3	0.45	0.16	0.05	0.02
	TMDL Reduction (%)	**99%**	**95%**	**95%**	No Data	No Data

Figure 10: Loading Statistics for Prairie Creek, part of GLSM HUC-12 (TMDL GLSM 2007)

Little Chickasaw Creek (Z01B13/CAFO15) TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**23.32 cfs**	**3.63 cfs**	**1.29 cfs**	**0.42 cfs**	**0.12 cfs**
Total Phosphorus (kg/day)	Current Load	74.8	2.22	0.52	0.73	No Data
	TMDL= LA+WLA+MOS	**4.56**	**0.71**	**0.25**	**0.08**	**0.02**
	LA	4.33	0.67	0.24	0.076	0.019
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	0.23	0.04	0.01	0.004	0.001
	TMDL Reduction (%)	**94%**	**70%**	**54%**	**89%**	No Data
Nitrate Nitrogen (kg/day)	Current Load	2,857	116	34	No Data	No Data
	TMDL= LA+WLA+MOS	**57**	**9**	**3**	**1**	**0.30**
	LA	54	8.56	2.84	0.95	0.29
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	3	0.44	0.16	0.05	0.01
	TMDL Reduction (%)	**98%**	**93%**	**91%**	No Data	No Data

Figure 11: Loading Statistics for Little Chickasaw Creek, part of GLSM HUC-12 (TMDL GLSM 2007)

Barnes Creek (300040) TMDL		High Flows 14.31 cfs	Moist Conditions 2.23 cfs	Mid-Range Flows 0.79 cfs	Dry Conditions 0.26 cfs	Low Flows 0.07 cfs
Pollutant	TMDL Component					
Total Phosphorus (kg/day)	Current Load	29.34	1.89	0.8	1.28	0.17
	TMDL= LA+WLA+MOS	**2.80**	**0.44**	**0.15**	**0.05**	**0.01**
	LA	2.66	0.42	0.14	0.048	0.0093
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	0.14	0.02	0.01	0.002	0.0007
	TMDL Reduction (%)	**91%**	**78%**	**82%**	**96%**	**92%**
Nitrate Nitrogen (kg/day)	Current Load	1,780	50	16	No Data	No Data
	TMDL= LA+WLA+MOS	**35**	**5**	**2**	**1**	**0.18**
	LA	33	4.73	1.90	0.97	0.17
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	2	0.27	0.10	0.03	0.01
	TMDL Reduction (%)	**98%**	**90%**	**89%**	No Data	No Data

Figure 12: Loading Statistics for Barnes Creek, part of GLSM HUC-12 (TMDL GLSM 2007)

The TMDL study shows there is a significant improvement needed to meet the TMDL. Data from 2007 TMDL indicates total phosphorus and nitrate reductions are to be 78% or greater across all flow regimes. It has been several years since this data has been collected. With the large amount of agricultural best management practices that have been implemented over the last several years, it is assumed that levels have improved. There has been some expansion of livestock operations; however these expansions are required to have a current nutrient management plans and manure storage. There has also been depopulation of livestock facilities and conversions of livestock species. With these changes, and future nonpoint source pollution restoration projects, a future assessment will be carried out to determine more current water quality before and after a project will take place.

Since the last TMDL was completed in 2007, many BMP's and projects have been installed due to the distressed watershed rules and conservation planning efforts. A summary of the practices installed since 2007 are listed below:

- 27 Dry Manure Storages
- 24 Feedlot Covers or Abandonments
- 8 Silage Leachate Collection Systems
- 8 Pump out Ports

- 6 Liquid Manure Storages
- 4 Mortality Composters
- Runoff Treatment Wetlands
- 1 Milkhouse Irrigation System
- 1 Catch Basin Abandonment

All milk house waste water is now contained, collected, and/or treated on all 10 dairy operations located in the GLSM HUC-12. All 51 livestock operations have a minimum of four months of manure storage, with most having six months to one year of storage. These storages were completed in conjunction with complying with the manure application ban starting in January of 2013. The current distressed watershed rules state that no application of manure or fertilizer shall occur between December 15 and March 1st. During all other times of the year, manure applications must be completed following NRCS Practice Standard 590. Several household septic systems were also improved and inspected since the completion of the TMDL in 2007.

2.3 Summary of NPS Pollution Causes and Associated Sources for GLSM HUC-12

Causes	Sources
Direct Habitat Alteration	Non-irrigated crop production, residential development
Nitrate/Nitrite	Confined animal feeding operations (NPS), residential development
Phosphorus	Channelization – agriculture, residential development
Sedimentation	Removal of riparian vegetation, streambank and shoreline destabilization
Algae: Cyanobacteria and associated toxins	External and internal nutrient loading and habitat loss

Figure 13: Causes and Sources of NPS pollution in GLSM HUC-12

The 2007 TMDL data for the GLSM HUC-12 determines that biological impairments are tied to agricultural practices. Figure 13 above illustrates the sources being related to agriculture and residential development around the lake. As these practices encroach on riparian and in-stream habitats, habitat may be altered through stream channelization, riparian vegetation removal, and subsequent stream bank destabilization. Without the natural filtering capabilities of a healthy, vegetated riparian buffer, runoff from row crops carries pathogens and nutrients from recent manure and fertilizer applications directly into streams. Residential developments have removed wetlands and vegetation, and add additional channels, which creates more stagnant lake water.

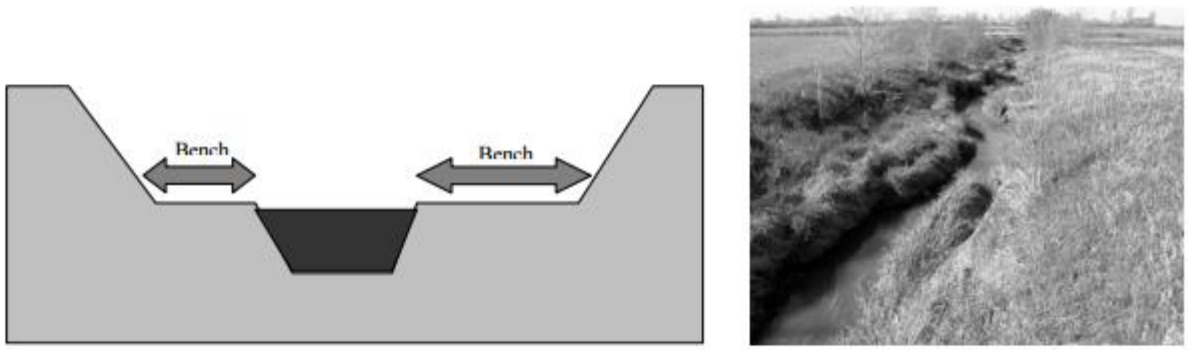

Figure 14: Graphical depiction of a two-stage ditch (left) and photo (right) that was taken in Wood County, Ohio. Notice the slight meander pattern along the ditch bottom in the picture.

There are numerous small Animal Feeding Operations (AFOs) in this watershed that are also noted sources of nutrients and pathogens. Livestock farm holding areas and manure application fields can also be a significant nonpoint source. Over many years of manure production, the soil test phosphorus levels have been built up in some areas to levels over 200 pounds per acre. This is especially true in the absence of effective manure management plans and appropriately sized waste storage facilities. (WAP 2015) However, since the inception of the distressed watershed rules, all livestock operations generating more than 350 tons or 100,000 gallons of manure per year are maintaining a current comprehensive nutrient management plan and have a minimum of 120 days of manure storage. The implementation of these practices, along with farmers doing a better job to lower manure application rates, incorporate manure, follow setbacks, apply at the right time, etc. has had an impact on water quality within the GLSM watershed. A study completed by Dr. Stephen Jacquemin, et al evaluated the effectiveness of the distressed watershed rules package, and noted significant improvements in nutrient concentrations being delivered to the lake after implementation of the distressed watershed rules. The significant number of best management practices, farmer education programs, and nutrient management planning all contributed to this reduction of nutrients being delivered to GLSM.

Pathogen and nutrient loading from failed home sewage treatment systems and nutrient loading from point sources are also contributing to the non-attainment status of the GLSM HUC-12. Within the watershed, St. Sebastian is one clustered residential area that remains unsewered.

2.4 Additional Information for Determining Critical Areas and Developing Implementation Strategies for GLSM HUC-12

There are several groups and agencies that work in the GLSM HUC-12 to improve water quality. The Lake Improvement Association and the Lake Restoration Commission have played active roles in promoting activities on and around GLSM. There have been partners on many water quality improvement projects that will promote a cleaner GLSM HUC-12 (05120101-0204) which ultimately generates tourism. The Mercer County Ag Solutions Coordinator has been working; and continues to work to develop plans by creating ways to restore streams and watercourses by lowering nutrient and sediment loading into GLSM.

2.4.1 Phosphorus Levels Assessment Data

Prior to the 1990's, animal manure was viewed as a waste, not a fertilizer, and the nutrient value of the manure was not counted when devising a field's nutrient budget. A portion of the nutrients are moved out of the watershed; however, years of over-application of manure have created a concern of high legacy soil test levels on some fields within the GLSM HUC-12. Based on Figure 15 below, it would appear that there is enough acreage to apply all nutrients generated within this watershed. However, this does not account of manure applied that is generated in other areas of the entire GLSM watershed, nor does it account for manure being moved out of this HUC-12. It also does not account for fields with legacy soil test phosphorus levels.

GLSM HUC-12						
		Lbs. N per Year	Lbs. K_2O per Year	Lbs. P_2O_5 per Year	Acres Cropland	Lbs. P_2O_5 per Crop Acre
Manure Production-Tons	141,486	1,145,152	1,177,863	536,409	16,566	32
Less 90% Poultry Manure**	140,835	1,114,912	1,158,153	509,859	16,566	31
Approximate $ Value Per Year		$423,706	$353,359	$150,195		
Total Nutrient Value Per Year =		$927,260				

** Based on conversations with poultry manure brokers, it is estimated that at least 90% of the poultry manure is brokered out of the watershed.

Figure 15: Manure and Nutrient Production in the GLSM HUC-12

The amount of manure produced in the GLSM HUC-12, shown in Figure 15, is estimated based on current nutrient management plans. These figures have been updated since the initial watershed action plan figures were calculated. Based on this current production information, manure production in the GLSM HUC-12 is approximately 9% lower now than in 2007. Manure nutrient production book values were used to determine nutrients produced in 2007. By utilizing actual manure characteristics from farm level data, the updated nutrient production values show that 41% less nitrogen, 57% less P_2O_5, and 21% less K_2O is being produced currently than in 2007. More efficient animal diets, more accurate manure production information, and less animals in the watershed are also factors in these reductions.

The dollar values associated with each nutrient were obtained from local commercial fertilizer costs in 2018. The value for nitrogen is estimated at $0.37 per pound, the value for P_2O_5 is $0.28 per pound, and the value of K_2O is $0.30 per pound.

Chapter 3: Critical Area Conditions and Restoration Strategies for GLSM HUC-12

3.1 Overview of Critical Areas

The entire GLSM HUC-12 is in non-attainment of its warm water habitat aquatic life use designation and it includes the public drinking water source for the City of Celina. The GLSM HUC-12 watershed has issues related to both agricultural use and urban uses. The stream alterations in this watershed have been modified to remove the majority of riparian vegetation. The stream bank destabilization has been an impairment related to agriculture as farmers have modified water courses to create row cropping close to the edge of the stream. The increase in residential areas directly surrounding the lake have added many channels, creating additional stagnant water, and the removal of filtering areas. The highly concentrated area of animal facilities within the critical areas also causes impairments of nitrate/nitrite, phosphorus, and sediment loading. There are four critical areas defined in this watershed to improve these impairments.

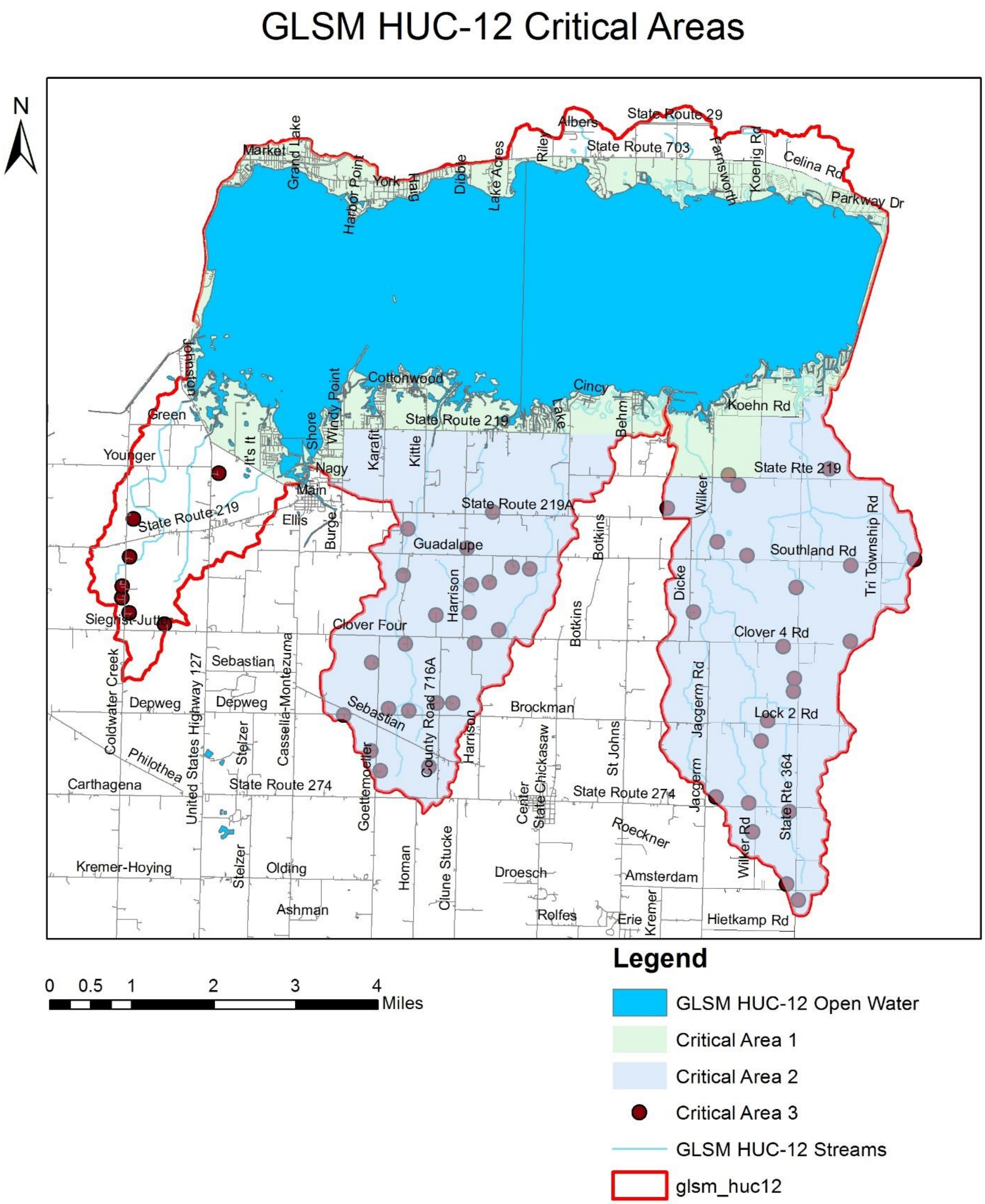

Figure 16: GLSM HUC-12 Critical Areas

3.2 Critical Area 1: Conditions, goals and objectives for GLSM HUC-12

3.2.1 Detailed Characterization

The area defined in the GLSM HUC-12 as Critical Area 1 is the lake itself and land directly adjacent to the lake. The focus of this critical area will be on lake water quality management, residential contributions to water quality degradation and areas directly surrounding the lake that could be utilized to improve water quality, enhance wildlife habitat, and provide a place to install best management practices. The focus will be on wetland restoration and creation, channel aeration, and in-lake wetland creations.

3.2.2 Detailed Biological Conditions

Figure 17 below shows the different habitat quality on a measured level at locations in GLSM. The information is the most current that is available and is from the 2007 Ohio EPA TMDL.

RIVER MILE Fish/Invert.	IBI	MIwb	ICI	QHEI	Attainment Status
Grand Lake St. Marys (22-999)					
		Eastern Corn Belt Plains EWH (Existing)			
17.7	31	9.2	VP	44.0	No applicable criteria
16.7	32	8.6	VP	46.0	No applicable criteria
15.6	29	6.5	VP	51.5	No applicable criteria
15.1	30	8.5	VP	53.5	No applicable criteria

Figure 17: Habitat data for GLSM (Ohio EPA)

Date	Station No.	Chl. *a* (µg/L)	T-P (µg/L)	T-N (mg/L)	Secchi (m)	TSI (Chl. a)
U.S. EPA National Eutrophication Study (1973)						
08/01/73	01	86.2	186	2.36	0.46	74
	02	84.1	131	2.17	0.41	74
	03	88.4	115	2.30	0.46	75
	04	69.7	128	2.15	0.46	72
10/11/73	01	61.8	480	1.26	0.20	71
	02	63.2	123	1.75	0.41	71
	03	45.3	89	1.45	0.99	68
	04	47.4	83	1.25	0.99	68
Summer Average		68.3	167	1.84	0.55	72
Ohio EPA Clean Lakes Program (1992)						
08/19/92	L-1	119.6	120	1.40	0.3	78
	L-2	126.2	200	1.86	0.25	78
	L-3	115.4	120	1.70	0.25	77
09/11/92	L-1	124.1	110	1.65	0.25	78
	L-2	119.1	60	1.05	0.3	78
	L-3	127.8	150	1.65	0.3	78
Summer Average		122.0	127	1.55	0.28	78
Ohio EPA Clean Lakes Program (1999)						
08/11/99	L-1	238.3	250	4.15	0.2	84
	L-2	277.3	190	2.45	0.2	86
	L-3	246.5	190	2.96	0.2	85
09/09/99	L-1	-	200	2.62	0.2	-
	L-2	241.1	190	2.60	0.15	84
	L-3	266.6	220	2.44	0.15	85
Summer Average		254.0	207	2.87	0.18	85

Figure 18: Summary of GLSM Trophic Status Index Based on Chlorophyll a Concentration (TMDL GLSM 2007)

The most recent data available on the trophic status index (TSI) was found in a study by Steffan, M, etal (2013). Chlorophyll-a concentrations were collected from April through December of 2010. Using these chlorophyll-a concentrations from the months of June through October, an average value was determined to be 62.3 µg/L. Using the Carlson 1977 TSI formula, the TSI for 2010 was determined to be 70. The highest value listed in this study for 2010 was 110 µg/L, equating to a TSI of 77. A consistent TSI of 67 or less would remove the lake from a hypereutrophic status to a eutrophic status.

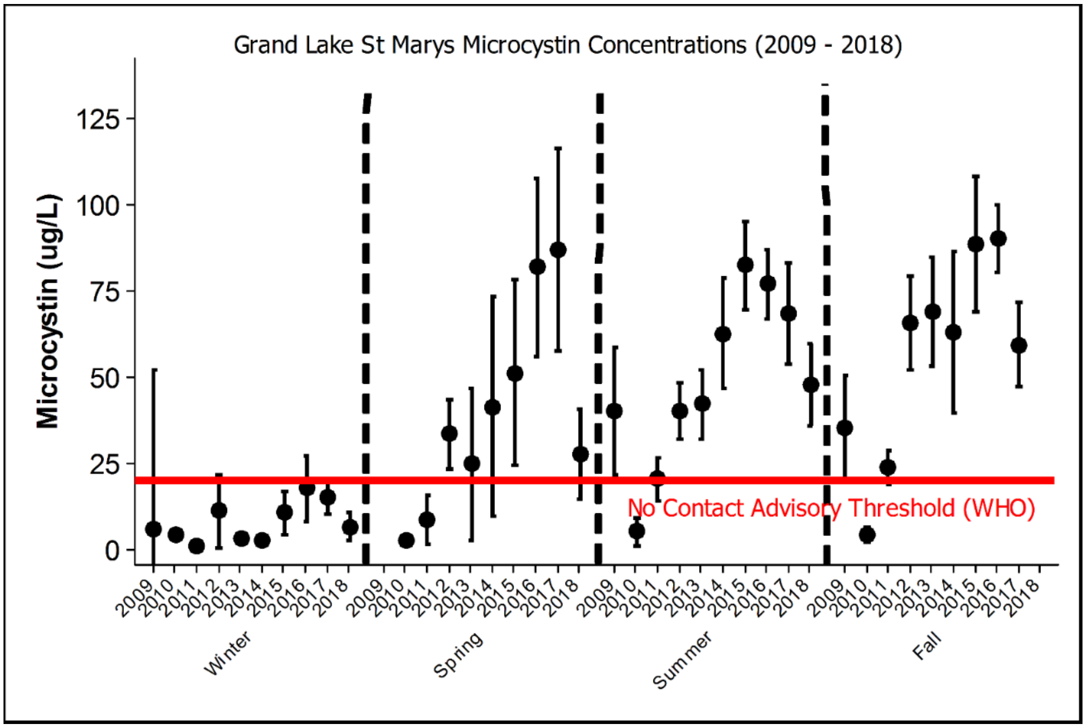

Figure 19: Average Seasonal Values of Microcystin Toxin Levels in GLSM from 2009 to 2018 (Jacquemin, 2018)

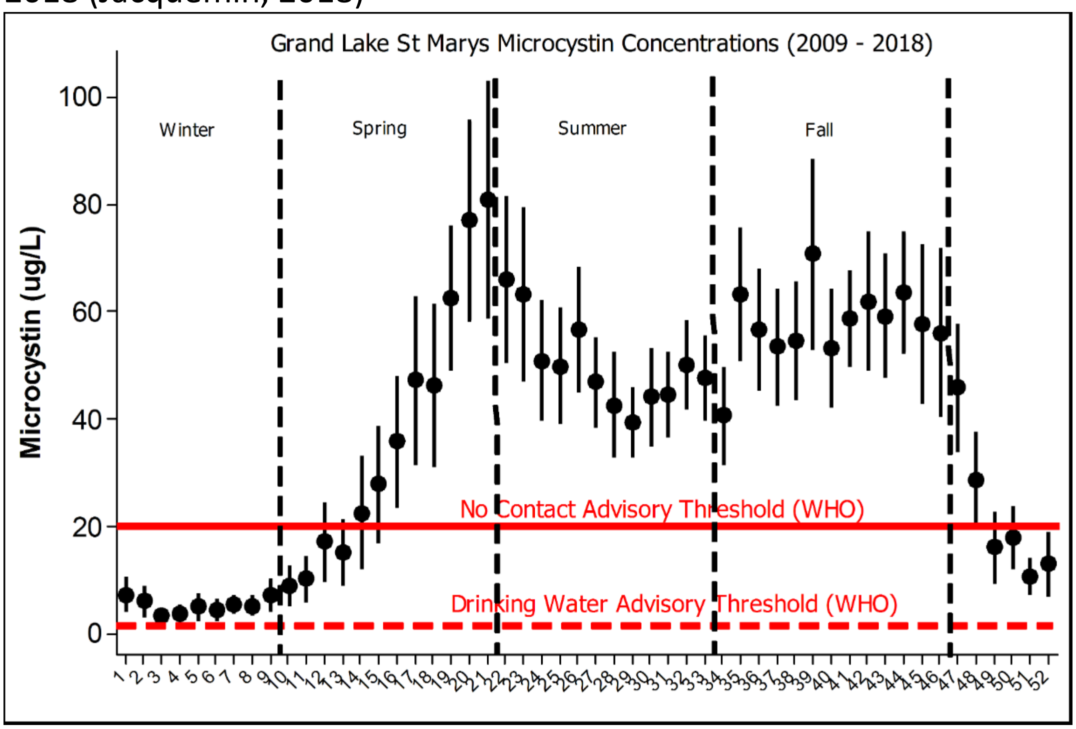

Figure 20: Average Weekly Microcystin Toxin Levels in GLSM from 2009 to 2018 (Jacquemin, 2018)

Figures 19 and 20 show the levels of microcystin toxin in GLSM over the last nine years. Levels are seasonally variable, but are well above the required level of 1.0 µg/L to meet the full attainment status for drinking water. Testing for the toxin did not begin until 2009, when data is readily available. Based on historical reports, cyanobacteria has been present in GLSM since the 1970's. GLSM has a significant internal phosphorus loading which will need to be addressed to meet the goals of this plan. The external phosphorus loading is also addressed in this plan and the approved plans for Beaver Creek and Chickasaw Creek HUC-12's.

3.2.3 Detailed Causes and Associated Sources

The causes and sources of impairment of Critical Area 1 are numerous, considering this critical area encompasses the body of water unequivocally affected, Grand Lake St. Marys. Causes of impairment within the watershed tributaries include: habitat alteration; nutrients such as nitrogen and phosphorus; and sedimentation. Sources of this impairment include: crop production; confined animal feeding operations; channelization; streambank destabilization; and removal of riparian vegetation. Causes of lake impairment is primarily the concentration of cyanobacteria and its associated toxins (see Figures 19 and 20). Sources of this impairment are due to: the watershed tributary sources listed above; removal of riparian vegetation and wetlands surrounding the lake due to residential development; and the internal loading of nutrients. See Figure 21 for a listing of causes and sources affecting Critical Area 1.

Causes	Sources
Direct Habitat Alteration	Residential development
Algae: Cyanobacteria and associate toxins	External and internal nutrient loading; dead end channels
Sedimentation	Shoreline destabilization

Figure 21: Causes and Sources of GLSM HUC-12 with Critical Area 1

3.2.4 Outline Goals and Objectives for the Critical Area 1

As explained in detail above, Critical Area 1 is impaired based upon the presence of cyanobacteria blooms and its associated toxins. This is due to both internal and external nutrient loading and extensive habitat alterations. Critical Area 1 contains very little cropland, and will focus on the sources of residential development, habitat loss and the creation of many dead-end back channels.

Goals

The overall nonpoint source restoration goals of any NPS-IS plan is to improve IBI, Mlwb, ICI, and QHEI scores so that the partial or non-attainment status can achieve full attainment of the designated aquatic life use for that water body, in this case, an exceptional warmwater habitat. Removing the non-attainment status for drinking water is important for this critical area. Based on the 2018 Integrated Water Quality Monitoring and Assessment Report, a body of water used for public drinking water supply can only have one instance of exceedance of the standard within a five-year period. In the case of Grand Lake St. Marys, the microcystin toxin level must be less than 1.0 µg/L to be in full attainment status. As reviewed in Chapter 1, the City of Celina has expended significant resources to treat GLSM source water. Water quality standards set, which is a goal of this plan, are designed to protect source water quality to the extent that public water systems can meet the finished water standards by utilizing only conventional water treatment.

> Goal 1: To reduce microcystin toxin levels in Grand Lake St. Marys so that non-attainment drinking water use designation can be removed, specifically to reduce microcystin toxin levels in the lake (prior to treatment) to 1.0 µg/L. Figures 19 and 20 show historical microcystin toxin levels in GLSM.
>
> Goal 2: Remove hypereutrophic status of the lake by reducing the trophic status index to less than 67 based on chlorophyll *a* concentrations. The most current TSI score calculated is derived from data collected in the summer of 2010, which averaged 70, with a high that summer of 77. Figure 18 shows historical TSI scores.

Objectives

In order to achieve the overall nonpoint source restoration goals of removing the drinking water non-attainment status and reducing the trophic status index, the following objectives that address nutrient loading and cyanobacteria blooms need to be achieved in Critical Area 1. These objectives are the prioritized management measures and practices in Critical Area 1 and will be the primary objectives as projects are developed to improve the NPS impacts in this Critical Area.

> Objective 1: Install, enhance, and/or restore 400 acres of wetland habitat.
>
> Objective 2: Create and/or enhance 400 acres of in-lake littoral wetland habitat.
>
> Objective 3: Install aeration in 90 different dead-end channels.
>
> Objective 4: Continue the Ohio Department of Natural Resource's dredging program to exceed 300,000 cubic yards of dredging each calendar year.

Objective 5: Continue watershed efforts to decrease nutrient runoff from the land, as outlined in Critical Areas 2 and 3 of this plan, and as outlined in the Beaver Creek and Chickasaw Creek HUC-12 NPS-IS plans.

Objective 6: Continue rough fish removal from the lake through annual events and commercial fishing.

Objective 1 will be achieved by converting cropland to wetlands and enhancing wetlands and habitat around Grand Lake St. Marys. This can be accomplished by pumping water from the streams into constructed wetlands, like the existing Prairie Creek treatment train. This can also be achieved through natural flow-through wetlands. Enhancement of existing areas to boost their filtering power is another method of achieving wetland treatment. Tiles and overland flow can be routed into wetlands to improve water quality. The establishment of warm and cool season grasses also assist in improving water quality. The creation and restoration of wetlands and habitat will filter out phosphorus and nitrogen entering the lake, and in turn, decrease the microcystin toxin levels and trophic status index.

Objective 2 will include the creation of in-lake wetlands. Prairie Creek treatment train includes a 76-acre in-lake littoral wetland for providing additional filtering power. It is intended to route stream water into the littoral wetland once vegetation is well established. This model will also be used on Big and Little Chickasaw Creeks. In-lake wetlands could also be formed as islands in the middle of the lake, if this were permissible by the Army Corps of Engineers. These wetlands will filter out phosphorus and nitrogen entering the lake, and in turn, decrease the microcystin toxin levels and trophic status index.

Objective 3 will involve adding aeration to back channels throughout the lake. Adding oxygen to the dead-end channels aids in keeping algae surface scum out of those channels, reduces bottom sediment build-up and simply aids in circulation of the water. It helps to keep dissolved oxygen levels higher to improve habitat for wildlife in the channels. Aeration prevents phosphorus from leaching out of sediments, increases aerobic bacteria activity, reduces biochemical oxygen demand and results in reduced nitrogen levels. This will aid in decreasing the microcystin toxin levels and the trophic status index of Grand Lake St. Marys. Based on data from Diversified Pond Supplies, microcystin toxin levels in channels where aeration was present was 40-89% less than the microcystin toxin level at the Celina Water Treatment Plant. There are approximately 170 existing channels on GLSM. 40 channels have already installed aeration, and it is estimated that another 90 channels should have aeration installed. The remaining channels will be too difficult to access needed infrastructure to install the needed equipment.

Objective 4 is part of the continuing efforts of the Ohio Department of Natural Resources dredging program for GLSM. Starting in 2011, over 300,000 cubic yards of sediment slurry have been removed each year. Based on a study by Jacquemin, etal, the dredging program in 2018 removed 34,000 dry tons of sediment. Total suspended solids data collected at the Chickasaw Creek monitoring station shows that approximately 12,000 tons of dry sediment enters the lake each year (not including sand and gravel). This shows that the current dredging program is removing more sediment than what is coming into the lake from external sources each year.

Objective 5 includes all watershed best management practices within the GLSM watershed. This includes the goals, objective and projects outlined in this plan and the Beaver Creek and Chickasaw Creek NPS-IS plans. These projects are aimed to reduce nitrogen and phosphorus loading in the tributaries to the lake and include: edge-of-field practices; phosphorus reduction strategies; small grains programs; stream restoration projects; wetland development up-stream of the lake; manure nutrient separation and more. All of these objectives and projects are designed to meet the goals of this critical area.

Objective 6 is the removal of rough fish from the lake. It is estimated that GLSM has ha carp population between 250 and 500 pounds per acre which contributes 1,000 to 2,000 pounds of phosphorus to the lake's internal loading annually. Facilitating the removal of these fish has been an ongoing effort of the Grand Lake St. Marys Restoration Commission since its inception in 2011.

As these objectives are implemented, water quality monitoring (both project related and regularly scheduled monitoring) will be conducted to determine progress toward meeting the identified goals (i.e., water quality standards). These objectives will be reevaluated and modified if determined to be necessary.

When reevaluating, the committee that created this document will reference the Ohio EPA Nonpoint Source Management Plan Update (Ohio EPA, 2013), which has a complete listing of all eligible NPS management strategies to consider including:

-Urban Sediment and Nutrient Reduction Strategies;
-Altered Stream and Habitat Restoration Strategies;
-Nonpoint Source Reduction Strategies; and
-High Quality Waters Protection Strategies

3.3 Critical Area 2: Conditions, Goals and Objectives for Prairie and Little Chickasaw/Barnes Creek Area of GLSM HUC-12

3.3.1 Detailed Characterization

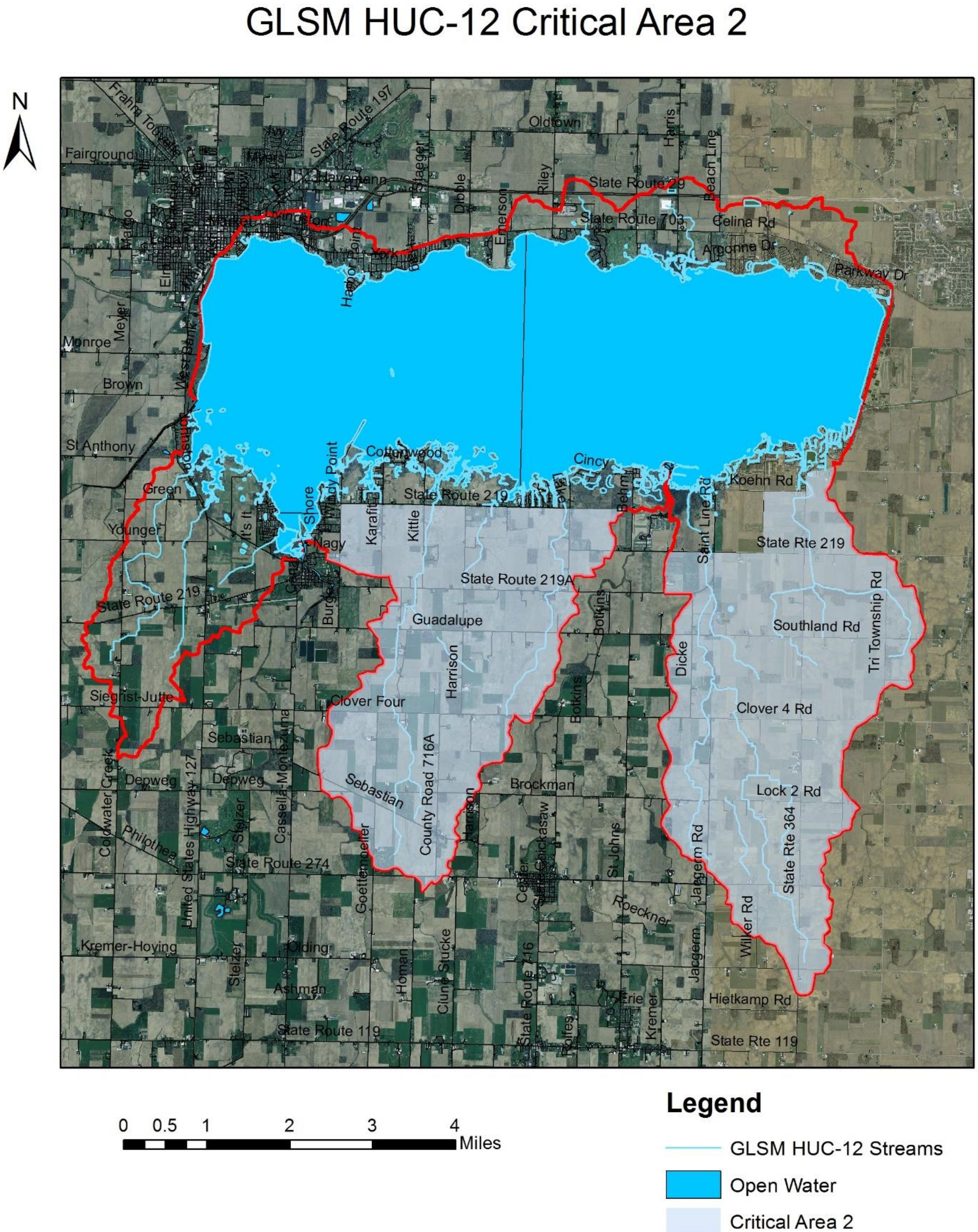

Figure 22: Critical Area 2 within GLSM HUC-12

The area defined as Critical Area 2 in the GLSM HUC-12 is targeted towards the Prairie Creek, Little Chickasaw Creek and Barnes Creek watershed area, which is just over 13,000 acres. This area contains a significant amount of livestock facilities and cropland. Opening up a larger window for manure application, ensuring that all nutrients applied are incorporated, having field cover over winter, and establishing more edge-of-field practices are objectives within this critical area. There are many ways to accomplish these objectives. A performance-based incentive offered to farmers will offset the cost of adding small grains to the rotation, adding cover crops as needed, side-dressing corn with manure or installing an edge-of-field practice. Wheat is not widely planted due to the profitability of planting the crop, which is nearly non-existent. It is estimated that farmers lose approximately $100 to $150 dollars per acre when planting and harvesting wheat instead of corn or soybeans.

Due to the livestock density in the GLSM HUC-12, manure application to fields is necessary. Under the distressed watershed rules for GLSM, producers are required to collect soil tests a minimum of every three years, and at a minimum rate of one per 25 acres. Any producer generating over 350 tons or 100,000 gallons of manure per year are required to have a nutrient management plan. Because of the livestock component, every plan in the GLSM-HUC is a Comprehensive Nutrient Management Plan and is less than three years old. As a result of the CNMP development and an aggressive conservation planning approach by USDA-NRCS, nearly every on-farm resource concern has been addressed. These efforts were described in more detail in Section 2 of this report.

Seeing as how all nearly every on-farm resource concerns have been addressed, to make additional improvements in water quality, we need to look to the field level. This means ensuring that nutrients applied are incorporated or injected, allowing for a larger window for manure application to accommodate changing and variable weather patterns, and adding more edge of field practices. Wetlands that treat cropland runoff will also aid in water quality improvements. It is important to assist livestock facilities in managing their manure nutrients by ensuring that manure is applied during appropriate conditions and in an acceptable manner. Keeping a constant field cover through residue or cover crops will also contribute towards load reductions. Constant cover and double cropping can aid in increased water retention on fields, ultimately reducing runoff to streams.

3.3.2 Detailed Biological Conditions

Figures 23 and 24 below show the different habitat quality on a measured level at the 1.6 river mile on Prairie Creek and the 0.2/0.5 river mile on Little Chickasaw Creek, which is included in Critical Area 2. The information is the most current that is available and is from the 2007 Ohio EPA TMDL.

RIVER MILE Fish/Invert.	IBI	MIwb	ICI	QHEI	Attainment Status
Prairie Creek [Lake] (22-112)					
	Eastern Corn Belt Plains WWH (Existing)/MWH proposed				
1.6[A]	32*	8.9	VP*	46.0	NON/NON

[A] Boat sampling method

* Indicates significant departure from applicable WWH biocriteria (>4 IBI or ICI units, or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range.

ns Nonsignificant departure from biocriteria (≤4 IBI or ICI units or ≤0.5 MIwb units)

flow Performance limited by lack of water

Notes:
- The Modified Index of Well-Being (MIwb) is not applicable (NA) to headwater site types
- A qualitative narrative evaluation used when quantitative data were not available or unreliable due to current velocities less than 0.3 fps flowing over the artificial substrates (P = Poor, F = Fair, MG = Marginally Good, G = Good, VG = Very Good, E = Exceptional)
- Use attainment status based on one organism group is parenthetically expressed

Figure 23: Habitat Data for Prairie Creek, Part of the GLSM HUC-12 (Ohio EPA)

RIVER MILE Fish/Invert.	IBI	MIwb	ICI	QHEI	Attainment Status
Little Chickasaw Creek (04-521)					
	Eastern Corn Belt Plains WWH (Existing)/LRW proposed				
2.2	--flow	--	VP*	--	NON/NON
		Eastern Corn Belt Plains MWH (Existing)			
0.2/0.5[A]	27*	8.1ns	VP*	46.5	NON
Barnes Creek (04-535)					
	Eastern Corn Belt Plains WWH (Existing)/MWH proposed				
0.5	--flow	--	P*	--	(NON/NON)

[A] Boat sampling method

* Indicates significant departure from applicable WWH biocriteria (>4 IBI or ICI units, or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range.

ns Nonsignificant departure from biocriteria (≤4 IBI or ICI units or ≤0.5 MIwb units)

flow Performance limited by lack of water

Notes:
- The Modified Index of Well-Being (MIwb) is not applicable (NA) to headwater site types
- A qualitative narrative evaluation used when quantitative data were not available or unreliable due to current velocities less than 0.3 fps flowing over the artificial substrates (P = Poor, F = Fair, MG = Marginally Good, G = Good, VG = Very Good, E = Exceptional)
- Use attainment status based on one organism group is parenthetically expressed

Figure 24: Habitat Data for Little Chickasaw/Barnes Creek, Part of the GLSM HUC-12 (Ohio EPA)

3.3.3 Detailed Causes and Associated Sources

Sources of impairment are outlined from the 2007 Ohio EPA TMDL. Crop production and confined animal feeding operations create nutrient loading into waterways. The animal feeding operations range in size and design. The causes of degradation in Critical Area 2 mainly comes from crop production (including improper manure application), channelization, and the removal of riparian vegetation. Wheat (or other small grains) production is very low in the Critical Area, because of the profit loss of growing wheat over corn and soybeans. However, small grain production allows for a wider window of opportunity for nutrient application during periods of time when weather plays a less-critical role. See Figure 25 below for contributing causes and sources of impairment in Critical Area 2:

Causes	Sources
Direct Habitat Alteration	Non-irrigated crop production
Nitrate/Nitrite	Confined animal feeding operations
Phosphorus	Channelization – agriculture
Sedimentation	Removal of riparian vegetation and streambank destabilization

Figure 25: Causes and Sources of Impairment in Critical Area 2 within GLSM HUC-12

Projects that address the above attributes will have a positive effect on the attributes of NPS pollution in Critical Area 2.

Subwatershed (0512010102__)	Stream	Location (Monitoring Station)	Total Phosphorus (kg/day)	Flow Regime				
				High Flows 0-10	Moist Conditions 10-40	Mid-Range Flows 40-60	Dry Conditions 60-90	Low Flows 90-100
020	Prairie Creek	At Bridge on Kittle Road (300043)	Current Load	84.91	5.49	2.76	5.57	3.51
			% Reduction	-95%	-88%	-91%	-99%	-99%
			TMDL= LA+WLA+MOS	**4.63**	**0.72**	**0.26**	**0.08**	**0.02**
			LA	4.4	0.68	0.24	0.08	0.02
			WLA: Facilities	n/a	n/a	n/a	n/a	n/a
			WLA: MS4	n/a	n/a	n/a	n/a	n/a
			MOS (5%)	0.23	0.04	0.01	0	0

Figure 26: Phosphorus Loads at Prairie Creek Monitoring Location, 2007 TMDL (Ohio EPA)

Subwatershed (0512010102__)	Stream	Location (Monitoring Station)	Nitrate Nitrogen (kg/day)	Flow Regime				
				High Flows 0-10	Moist Conditions 10-40	Mid-Range Flows 40-60	Dry Conditions 60-90	Low Flows 90-100
020	Prairie Creek	At Bridge on Kittle Road (300043)	Current Load	5,484	170	57	No Data	No Data
			% Reduction	-99%	-95%	-95%	No Data	No Data
			TMDL= LA+WLA+MOS	**58**	**9**	**3**	**1**	**0.3**
			LA	55	8.55	2.84	0.95	0.28
			WLA: Facilities	n/a	n/a	n/a	n/a	n/a
			WLA: MS4	n/a	n/a	n/a	n/a	n/a
			MOS (5%)	3	0.45	0.16	0.05	0.02

Figure 27: Nitrate Nitrogen Loads and Prairie Creek Monitoring Location, 2007 TMDL (Ohio EPA)

Subwatershed (0512010102__)	Stream	Location (Monitoring Station)	Total Phosphorus (kg/day)	Flow Regime: High Flows 0-10	Moist Conditions 10-40	Mid-Range Flows 40-60	Dry Conditions 60-90	Low Flows 90-100
010	Barnes Creek	At Bridge on State Route 364 (300040)	Current Load	29.34	1.89	0.8	1.28	0.17
			% Reduction	-91%	-78%	-82%	-96%	-92%
			TMDL= LA+WLA+MOS	**2.80**	**0.44**	**0.15**	**0.05**	**0.01**
			LA	2.66	0.41	0.15	0.05	0.01
			WLA: Facilities	n/a	n/a	n/a	n/a	n/a
			WLA: MS4	n/a	n/a	n/a	n/a	n/a
			MOS (5%)	0.14	0.02	0.01	0	0
010	Little Chickasaw Creek	At Mercer County Road 219-A (Z01B13/CAFO15)	Current Load	74.8	2.22	0.52	0.73	No Data
			% Reduction	-94%	-70%	-54%	-89%	No Data
			TMDL= LA+WLA+MOS	**4.56**	**0.71**	**0.25**	**0.08**	**0.02**
			LA	4.33	0.67	0.24	0.08	0.02
			WLA: Facilities	n/a	n/a	n/a	n/a	n/a
			WLA: MS4	n/a	n/a	n/a	n/a	n/a
			MOS (5%)	0.23	0.04	0.01	0	0

Figure 28: Phosphorus Loads at Little Chickasaw/Barnes Creek Monitoring Location, 2007 TMDL (Ohio EPA)

Subwatershed (0512010102__)	Stream	Location (Monitoring Station)	Nitrate Nitrogen (kg/day)	Flow Regime: High Flows 0-10	Moist Conditions 10-40	Mid-Range Flows 40-60	Dry Conditions 60-90	Low Flows 90-100
010	Barnes Creek	At Bridge on State Route 364 near St. Marys Twp. bldg (300040)	Current Load	1,780	50	16	No Data	No Data
			% Reduction	-98%	-90%	-89%	No Data	No Data
			TMDL= LA+WLA+MOS	**35**	**5**	**2**	**1**	**0.18**
			LA	33	5	2	1	0.17
			WLA: Facilities	n/a	n/a	n/a	n/a	n/a
			WLA: MS4	n/a	n/a	n/a	n/a	n/a
			MOS (5%)	2	0.27	0.1	0.03	0.01
010	Little Chickasaw Creek	At Mercer County Road 219-A (Z01B13/CAFO15)	Current Load	2,857	116	34	No Data	No Data
			% Reduction	-98%	-93%	-91%	No Data	No Data
			TMDL= LA+WLA+MOS	**57**	**9**	**3**	**1**	**0.30**
			LA	54	8.56	2.84	0.95	0.29
			WLA: Facilities	n/a	n/a	n/a	n/a	n/a
			WLA: MS4	n/a	n/a	n/a	n/a	n/a
			MOS (5%)	3	0.44	0.16	0.05	0.01

Figure 29: Nitrate Nitrogen Loads at Little Chickasaw/Barnes Creek Monitoring Location, 2007 TMDL (Ohio EPA)

The 2007 TMDL loading data was used as the basis for load reduction calculations in this plan. A weighted average of all flow regimes (including data from other areas within the GLSM HUC-12) was used to determine the loading per year to GLSM from the GLSM HUC-12 in 2007. The entire GLSM watershed was declared “distressed” in 2011, and therefore, a number of practices were installed as a result, as shown in Chapter 2.2 of this report. Based on a data analysis by Jacquemin, etal (2018), it is assumed that these practices resulted in a 25% reduction in total phosphorus and a 24% reduction in nitrate-nitrogen loading. The Prairie Creek treatment train wetlands have also contributed to a reduction in nutrient loading since its installation in 2012. Based on data provided by Wright State University Lake Campus, the treatment train has resulted in a loading reduction of approximately 10% of nitrate-nitrogen and 6% of total phosphorus. Figure 30 shows the total phosphorus loading and goals, and Figure 31 shows the nitrate-nitrogen loading and goals.

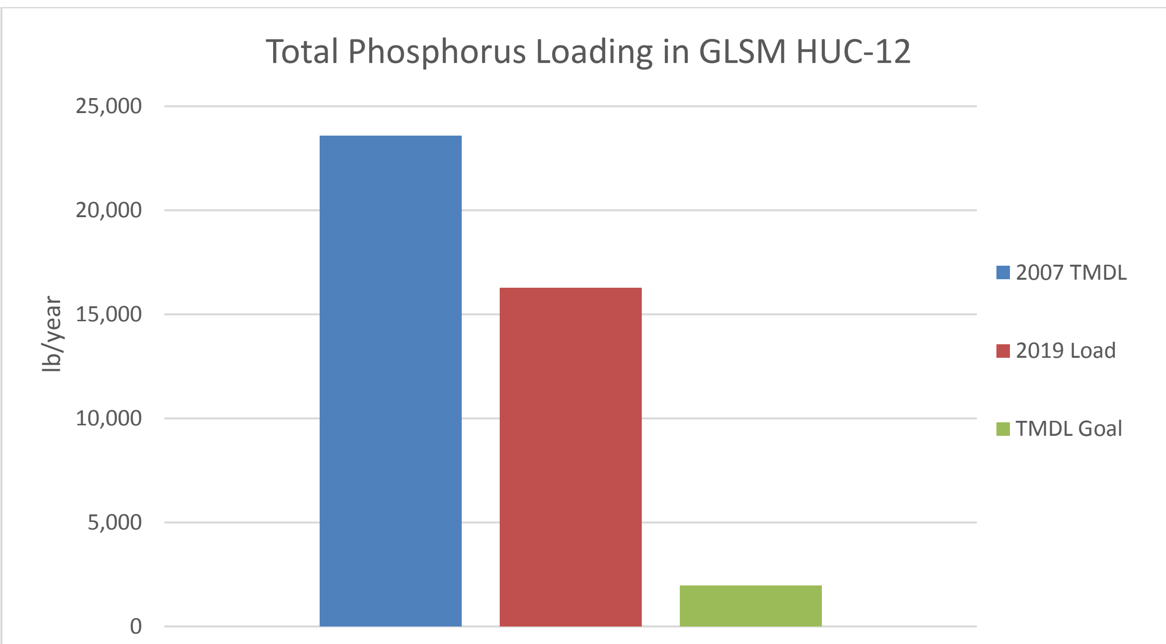

Figure 30: Total Phosphorus Loading in the GLSM HUC-12

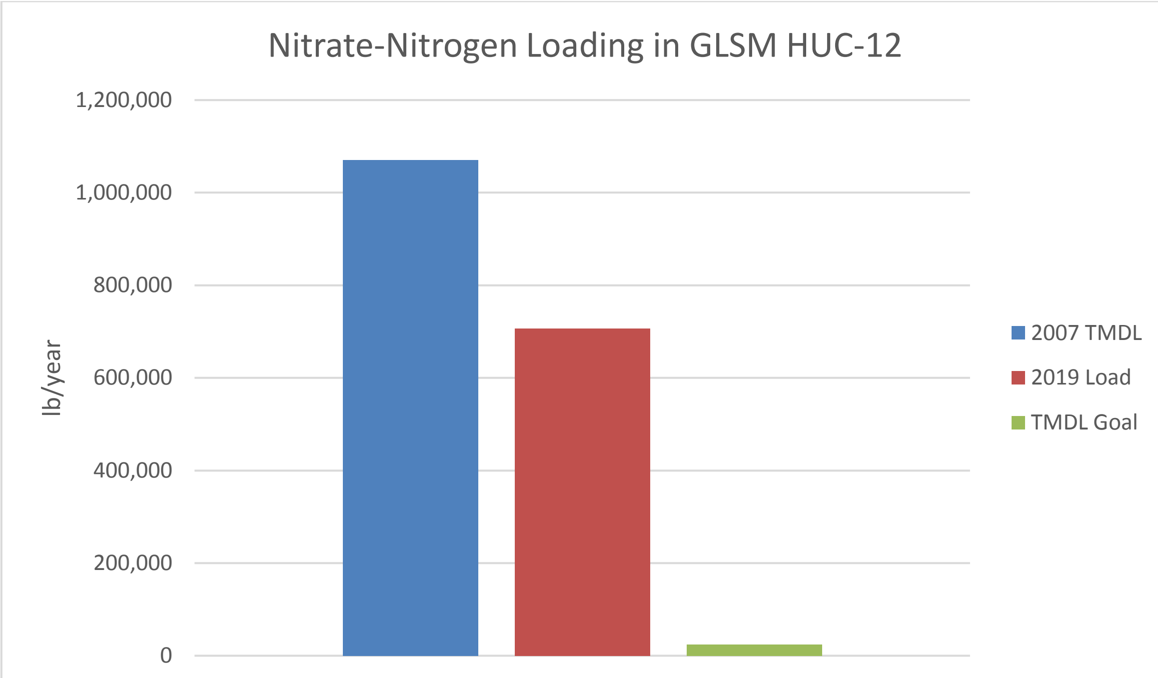

Figure 31: Nitrate-Nitrogen Loading in the GLSM HUC-12

3.3.4 Outline Goals and Objectives for the Critical Area

As explained in detail above, Critical Area 2 is primarily impaired based upon nutrient and sediment loading due to areas of high concentration of animal feeding operations and the land application of manure. A significant majority of the cropland in Critical Area 2 has artificial drainage. Most buffers along the streams are narrow, and the absence of edge-of-field conservation practices contributes high sediment loading during runoff events. The removal of small grains from the crop rotation has limited manure applications to the spring and fall, often when weather patterns are most unsuitable for manure application. Phosphorus and nitrates are carried into the water flow raising NPS pollution.

With sampling sites in nearby watershed that have similar landscape and history of livestock production, phosphorus and nitrate-nitrogen loading is a relevant factor in GLSM. This has an impact on the lake creating algal blooms and keeping the lake in non-attainment status for drinking water due to cyanobacteria toxins. A critical component of removing the non-attainment status for drinking water in GLSM is to reduce external nutrient loading. This Critical Area focuses on cropland within the Prairie Creek, Little Chickasaw/Barnes Creek areas of the GLSM HUC-12.

Goals

Goals in place are to achieve the overall nonpoint source restoration of reducing phosphorus and nitrogen levels with less sedimentation and channelization in streams. The big picture follows downstream to Grand Lake St. Marys to protect over 13,000 acres of lake from harmful algal blooms and sedimentation build up. To help gain full attainment status for drinking water in GLSM (and meet the goals of Critical Area 1), the following goals in the upstream watershed need to be achieved in Critical Area 2.

> Goal 1. Achieve average IBI score of 40 at the monitoring site. Currently at 27-32. Achieve average MIwb score of 8.3 at monitoring sites, which currently ranges from 8.1 to 8.9. Achieve average QHEI score of 60 at monitoring sites. Currently at 46-46.5.
>
> Goal 2: Reduce nitrate-nitrogen levels by 116,900 lbs/year in streams and creeks within Critical Area 2.
>
> Goal 3: Reduce phosphorus levels by 3,320 lbs/year in streams and creeks within Critical Area 2.

Objectives

In order to achieve the overall nonpoint source restoration goal of reducing sediment, phosphorus, and nitrogen levels to gain full attainment status for drinking water in the GLSM HUC-12, the following objectives that address sedimentation and nutrient loading need to be achieved in Critical Area 2. These objectives are the prioritized management measures and practices in Critical Area 2 and will be the primary objectives as projects are sought out and/or developed to improve the NPS impacts in this Critical Area. It should also be noted that achievement of the objectives described for this Critical Area 2 (upstream) will also show improvement in Critical Area 1.

> Objective 1: Add small grains back into the crop rotation on 5,000 acres to open the manure application window and ensure that nutrients are incorporated, injected or placed sub-surfacely. Producers will also need to ensure 90% field cover going into each winter.
>
> Objective 2: Install edge-of-field practices, such as buffers, saturated buffers, tile bioreactors, blind inlets, wetlands, drainage retention basins that would treat a minimum of 1,200 acres of cropland drainage.

Objective 3: Install one centralized sewer system within the watershed.

Objective 4: Eliminate 50 individual home sewage treatment systems.

Objective 1 will be achieved by adding a small grain that over-winters back into the crop rotation on a total of 5,000 acres in Critical Area 2. This objective will allow for more timely manure applications during the summer and reduce the amount of manure applications occurring in the spring and fall. Small grains in the rotation will also improve soil health and reduce weed pressure in the fields, which will improve water retention in the soil. By adding small grains to the rotation, placing manure/nutrients appropriately and adding a second crop or cover crop, it is estimated that this practice will reduce phosphorus loading from the 5,000 acres by 50% and nitrate loading by 40%. This equates to a reduction of 2,380 pounds of phosphorus per year and 85,100 pounds of nitrogen per year based on loadings shown in Figures 28 and 29.

Objective 2 will involve treating water from surface and tile flow over 1,200 acres within Critical Area 2. This can be accomplished with a variety of practices including saturated buffers, tile bioreactors, blind inlets, wetlands, drainage retention basins and more. It is assumed that these practices will result in a 50% reduction in phosphorus and a 60% reduction in nitrogen, correlating to a load reduction of 590 pounds of phosphorus per year and 30,700 pounds of nitrogen per year.

Objectives 3 and 4 will be achieved by installing a centralized sewer system for the area of St. Sebastian that will be treated by a local wastewater treatment plant. Load reductions are estimated at 350 pounds of phosphorus and 1,100 pounds of nitrogen per year. These load reductions are based on an assumption from Swann (2001) of 22 lb/year of nitrogen and 6.9 lb/year of phosphorus discharged per average failing septic system.

As these objectives are implemented, water quality monitoring (both project related and regularly scheduled monitoring) will be conducted to determine progress toward meeting the identified goals (i.e., water quality standards). These objectives will be reevaluated and modified if determined to be necessary. For instance; many agricultural BMPs can be “stacked” (a systems approach) that will also incrementally improve the quality and quantity of runoff and drainage waters and in-stream water quality.

When reevaluating, the committee that created this plan will reference the Ohio EPA Nonpoint Source Management Plan Update (Ohio EPA, 2013), which has a complete listing of all eligible NPS management strategies to consider including:

-Urban Sediment and Nutrient Reduction Strategies;
-Altered Stream and Habitat Restoration Strategies;
-Nonpoint Source Reduction Strategies; and
-High Quality Waters Protection Strategies

3.4 Critical Area 3: Conditions, Goals and Objectives for Livestock Operations of GLSM HUC-12

3.4.1 Detailed Characterization

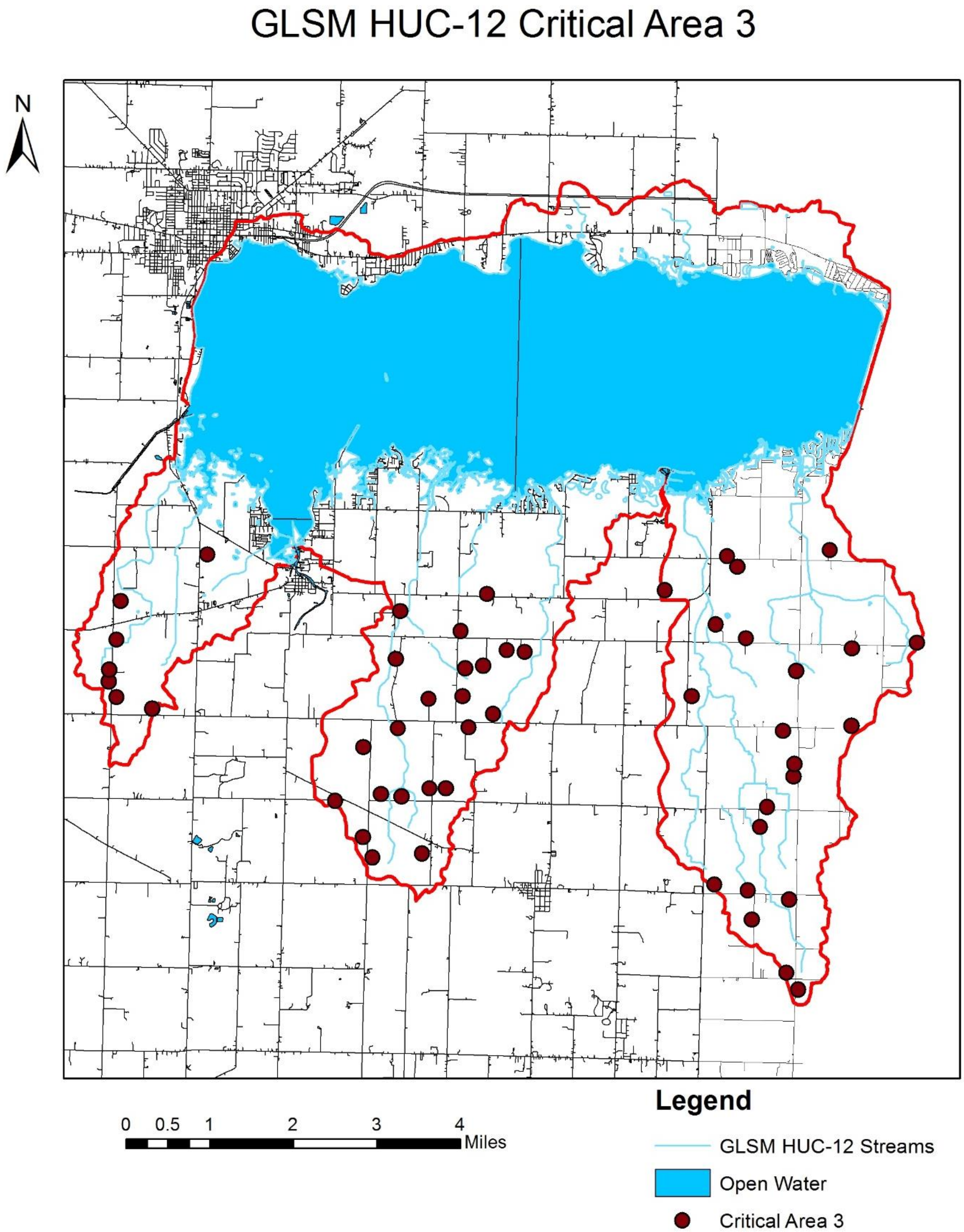

Figure 32: Critical Area 3 within GLSM HUC-12

The area defined as Critical Area 3 in the GLSM HUC-12 is targeted towards all livestock production facilities. Liquid manure can be a source of runoff quickly when not applied at the right rate, right time or under the correct soil moisture conditions. Due to the high water content of liquid manure, moving the manure to areas where it is most needed is quite costly. Swine operations are of particular concern, as many facilities were built in the 1990's on land without an appropriate cropland base. Technologies are available today to aid the in the separation of liquids and solids, while isolating a high percentage of phosphorus (up to 90%) and a lower percentage of nitrogen (up to 30%) in the solid fraction. By utilizing separation technology, livestock farmers would then be able to more affordably move phosphorus and nitrogen to cropland where the nutrients are needed.

Manure transfer to land outside the watershed can also aid in positively affecting nutrient runoff. Livestock producers that have a need to transfer manure to acres with a soil test phosphorus value showing the need for additional nutrient application can be advantageous to water quality. Soil tests that are less than 50 ppm (100 lb/acre) phosphorus are ideal for manure application. A performance reimbursement for moving manure to acreage with a soil test of less than 50 ppm will allow producers to move manure to where it is needed. The 2007 Ohio EPA TMDL report for the GLSM watershed points to the brokering the export of manure from the watershed as a method to reduce overland sources of nutrients.

Figure 30 shows that there are a significant number of livestock operations within the GLSM HUC-12. Because of the distressed watershed rules, farmers are required to collect soil tests a minimum of every three years. The farmers have the data to show which acres are in need of additional nutrient and which acres have a high legacy soil test phosphorus value. To achieve the goals outlined for Critical Area 3, it is important to encourage the application of manure to acres that maintain a soil test within the agronomic range outlined in the Tri-State Fertility Guide.

3.4.2 Detailed Biological Conditions

There is no biological data specified for Critical Area 3.

3.4.3 Detailed Causes and Associated Sources

The main causes and sources identified in Critical Area 3 are **Nitrate/Nitrite and Phosphorus due to confined animal feeding operations**. Critical Area 3 is focused solely on the confined animal feeding operations, which range in size and design. Focusing on nutrients produced by these facilities will have a positive effect on NPS pollution within the GLSM HUC-12.

3.4.4 Outline Goals and Objectives for the Critical Area

As explained in detail above, Critical Area 3 is focused on the nutrients generated by confined animal feeding operations. Removing nutrients from the GLSM HUC-12, will aid greatly in improving phosphorus and nitrogen loadings to the streams within the watershed.

With sampling sites in the watershed that have similar landscape and history of livestock production, phosphorus and nitrate-nitrogen loading is a relevant factor in GLSM. This has an impact on the lake creating algal blooms and keeping the lake in non-attainment status for drinking water due to cyanobacteria blooms and associated toxins.

Goals

Goals in place are to achieve the overall nonpoint source restoration of reducing phosphorus and nitrogen levels in streams. The big picture follows downstream to Grand Lake St. Marys to protect over 13,000 acres of lake from harmful algal blooms and sedimentation build up. To help gain full attainment status for drinking water in GLSM (and meet the goals for Critical Area 1), the following goals that address nutrient enrichment need to be achieved in Critical Area 3.

> Goal 1: Reduce nitrate-nitrogen levels by 40,600 lbs/year in streams and creeks within the GLSM HUC-12.
>
> Goal 2: Reduce phosphorus levels by 1,130 lbs/year in streams and creeks within the GLSM HUC-12.

Objectives

In order to achieve the overall nonpoint source restoration goal of reducing phosphorus and nitrogen levels to gain full attainment status in the GLSM HUC-12, the following objectives that address nutrient loading need to be achieved in Critical Area 3. These objectives are the prioritized management measures and practices in Critical Area 3 and will be the primary objectives as projects are sought out and/or developed to improve the NPS impacts in this Critical Area. It should also be noted that achievement of the objectives described for this Critical Area 3 (upstream) will also show improvement in Critical Areas 1 and 2.

> Objective 1: Process two to three million gallons of liquid swine or dairy waste using manure separation/nutrient concentration technologies.

Objective 2: Apply six million gallons or 25,000 tons per year of swine, dairy or beef manure to acreage where a soil test shows the need for phosphorus, while following best management practices for manure application.

Objective 1 will focus on liquid manure processing. Using nutrient concentration technologies, liquid manure will be separated into different forms in order to put up to 90% of the phosphorus into a concentrated form with a smaller volume that can be transported out of the watershed economically to cropland requiring phosphorus inputs. The remaining nutrients left behind can continue to be land applied and utilized as crop uptake. This objective is estimated to remove approximately 280 pounds of phosphorus and 3,600 pounds of nitrogen per year from streams in the GLSM HUC-12.

Objective 2 will focus on applying manure to acres with soil test phosphorus levels of less than 50 ppm (100 lb/acre). Six million gallons or 25,000 tons of manure appropriately land applied will equate to a load reduction of approximately 850 pounds of phosphorus and 37,000 pounds of nitrogen per year from streams in the GLSM HUC-12.

As these objectives are implemented, water quality monitoring (both project-related and regularly scheduled monitoring) will be conducted to determine progress toward meeting the identified goals (i.e., water quality standards). These objectives will be reevaluated and modified if determined to be necessary. For instance; many agricultural BMPs can be “stacked” (a systems approach) that will also incrementally improve the quality and quantity of runoff and drainage waters and in-stream water quality.

When reevaluating, the committee who created this plan will reference the Ohio EPA Nonpoint Source Management Plan Update (Ohio EPA, 2013), which has a complete listing of all eligible NPS management strategies to consider including:

-Urban Sediment and Nutrient Reduction Strategies;
-Altered Stream and Habitat Restoration Strategies;
-Nonpoint Source Reduction Strategies; and
-High Quality Waters Protection Strategies

Chapter 4: Projects and Implementation Strategy

4.1 Overview Tables and Project Sheets for Critical Areas

Below are the projects and evaluation needs believed to be necessary to remove the impairments to the GLSM HUC-12 as a result of the identified cause and associated sources of nonpoint source pollution. Because the attainment status is based on biological conditions, it will be necessary to periodically reevaluate the status of the critical area to determine if the implemented projects are sufficient to achieve restoration. Time is an important factor to consider when measuring project success and overall status. Biological systems in some cases can show response fairly quickly (i.e. one season); other systems may take longer (i.e., several seasons, years) to show recovery. There may also be reasons other than nonpoint source pollution for the impairment. Those issues will need to be addressed under different initiatives, authorities or programs which may or may not be accomplished by the same implementers addressing the nonpoint source pollution issues.

For the GLSM HUC-12, there are three Project and Implementation Strategy Overview Tables (subsections 4.2.1, 4.3.1 and 4.4.1). Each critical area overlying primary causes and associated sources of nonpoint source impairments. If another nonpoint source impairment is identified for one of the existing critical areas, it will be explained and added to that critical area's table. If a new impairment is determined that has a different critical area, a new table will be created for that new critical area. The projects described in the Overview Tables have been prioritized using the following three-step prioritized method.

Priority 1 Projects that specifically address one or more of the listed Objectives for the Critical Area.

Priority 2 Projects where there is land-owner willingness to engage in projects that are designed to address the causes and sources of impairment or where there is an expectation that such potential projects will improve water quality in the GLSM HUC-12.

Priority 3 In an effort to generate interest in projects, an information and education campaign will be developed and delivered. Such outreach will engage citizens to spark interest by stakeholders to participate and implement projects like those mentioned in Priority 1 and 2.

Project Summary Sheets (PSS) are in subsections 4.2.2, 4.3.2, and 4.4.2. These PSS provide the essential nine elements for short-term and/or next step projects that are in development and/or in need of funding. As projects are implemented and new projects are developed, these sheets will be updated. Any new PSS created will be submitted to the state of Ohio for funding eligibility verification (i.e., all nine elements are included).

4.2 Critical Area 1: Overview Table and Project Sheets for GLSM HUC-12

The information included in the Critical Area 1 Overview Table is a condensed overview of all identified projects needed for nonpoint source restoration of the GLSM HUC-12 Critical Area 1. Project Summary Sheets are included for short term projects or any project that is considering seeking funding in the near future. Only those projects with complete Project Summary Sheets will be considered for state and federal NPS program funding.

4.2.1 Critical Area 1: Project and Implementation Strategy Overview Table

The GLSM HUC-12 Critical Area 1 is based on non-attainment status of aquatic life use designation, the non-attainment status for drinking water and the non-attainment status for recreation. The Critical area 1 Overview Table provides a quick summary of what needs to be done, where, and what problem (cause/source) will be addressed and includes projects at all levels of development (i.e. concept, need funding, in progress). This overview table is intended to show a prioritized path toward the restoration of the GLSM HUC-12.

Critical Area 1: Project Overview Table for GLSM HUC-12 (05120101-0204)							
Goal	**Objective**	**Project #**	**Project Title** *(EPA Criteria g)*	**Lead Organization** *(criteria d)*	**Time Frame** *(EPA Criteria f)*	**Estimated Cost** *(EPA Criteria d)*	**Potential/Actual Funding Source** *(EPA Criteria d)*
Urban Sediment and Nutrient Reduction Strategies							
Altered Stream and Habitat Restoration Strategies							
1,2	1,2	1	Windy Point Wetland Restoration & Creation	Mercer County	Short	$165,000	EPA 319, Pheasants Forever, ODNR-DOW
1,2	1,2	2	Little Chickasaw Creek Treatment Train and Littoral Wetland	Lake Facilities Authority	Short	$2,700,000	Clean Ohio, State Funding
1,2	1,2	4	Wetland Enhancement & Restoration	Lake Facilities Authority; ODNR	Long	$6,000,000	EPA 319, Clean Ohio, ODNR, State Funding
Agricultural Nonpoint Source Reduction Strategies							
1,2	5	8	Watershed Nutrient Reduction Practices	Mercer SWCD; Ag Solutions	Varies	Varies	EPA 319, USDA-NRCS, State Funding, Local Sources
High Quality Waters Protection Strategies							
1,2	3	3	Channel Aeration Project at Windy Point	ODNR	Short	$40,000	EPA 319, ODNR, Local Sources
1,2	3	5	Channel Aeration	Local	Medium	$480,000	EPA 319, ODNR, Local Sources
1,2	4	6	In-lake and Channel Dredging	ODNR	Ongoing	$1,500,000 annually	ODNR
1,2	6	7	Rough Fish Removal	ODNR; Local	Varies	Varies	ODNR; Local
Other NPS Causes and Associated Sources of Impairment							

Section 4.2.2 Critical Area 1 Project Summary Sheets

The Project Summary Sheets provided below were developed based on action or activities needed to restore GLSM to an exceptional warmwater habitat, attain full attainment status for drinking water and reduce the trophic status index of the lake. These projects are considered next step or priority/short term projects, or those that have been more thoroughly planned. Medium and longer term projects will most likely not have a summary sheet, as these projects are not ready for implementation.

Critical Area 1: Project 1

Nine Element Criteria	Information needed	Explanation
n/a	Title	Windy Point Wetland Restoration and Creation Project
criteria d	Project Lead Organization & Partners	Mercer County Commissioners and Ag Solutions; Mercer SWCD
criteria c	HUC-12 and Critical Area	GLSM HUC-12 (05120101-0204)
criteria c	Location of Project	GLSM HUC-12, State Route 219 and Lake Vista Road (40^{o}30'21" N, 84^{o}32'20"W)
n/a	Which strategy is being addressed by this project?	Altered Stream and Habitat Restoration Strategy
criteria f	Time Frame	Short (1-3 Years)
criteria g	Short Description	This project will create 14.3 acres of wetlands, both created and restored. 5.6 acres will be under water and 8.7 acres will be planted to grasses and forbs. A small drainage ditch, which drains water from a nearby residential area will be routed into the wetlands. The wetland outlet structure will feed back into the channel near Windy Point to aid in circulation of the water. This project will reduce nutrient and sediment loading into Grand Lake St. Marys.
criteria g	Project Narrative	This project will improve habitat conditions directly surrounding Grand Lake St. Marys. This project will establish 14.3 acres of functioning wetland and highly efficient warm-season grasses and forbs and will improve water quality by routing a small drainage ditch from a nearby residential area. The land is owned by the Mercer County Commissioners and the 14.3 acres will be placed into an environmental covenant (and filed with the property deed) to ensure that the wetlands and habitat are maintained as designed. There will be public access to the wetlands via parking space and a walking path. The site was intended for future development and this project will perpetually prevent any future development.
criteria d	Estimated Total cost	$165,000 (approximately $92,000 grant with $73,000 matching)
criteria d	Possible Funding Source	Ohio EPA 319(h); local funding; ODNR-DOW
criteria a	Identified Causes and Sources	Cause: Direct Habitat Alteration Sources: Residential development and shoreline destabilization.

criteria b & h	Part 1: How much improvement is needed to remove the NPS impairment for the whole Critical Area?	The goals of this critical area are to reduce cyanobacteria toxin levels in Grand Lake St. Marys so that the non-attainment drinking water use designation can be removed. A microcystin toxin level of less than 1.0 µg/L will need to be achieved for a period of five years. Another goal is to reduce the trophic status index, based on chlorophyll a concentrations, to less than 67. It is estimated that approximately 400 acres of additional on-land wetlands and 400 acres of in-lake wetlands within the critical area will be needed to achieve these goals.
	Part 2: How much of the needed improvement for the whole Critical Area is estimated to be accomplished by this project?	It is recognized that there is a lag time associated with nonpoint source-related projects and measured lake response. The main goals in this critical area are to reduce the cyanobacteria toxin levels in Grand Lake St. Marys to achieve a full attainment status for drinking water and to reduce the trophic status index. This project will meet nearly 4% of objective 1 for Critical Area 1. Any load reduction in the watershed is going to correspond to a decrease in nutrients in the lake, thereby reducing the fuel for cyanobacteria growth.
	Part 3: Load Reduced?	Estimated: 9.2 lbs P/year, 40.2 lbs N/year and 9.2 tons sediment/year
criteria i	How will the effectiveness of this project in addressing the NPS impairment be measured?	Staff from Ohio EPA-DSW Ecological Assessment Unit will perform a future watershed-wide monitoring event to determine progress (through IBI, ICI and QHEI) from non to full attainment. Wright State University Lake Campus will be performing project-specific IBI and QHEI evaluations before and after project installations. WSU-LC is also continually collecting data on the treatment train wetlands throughout the watershed.
criteria e	Information and Education	This project includes a walking path that will be maintained by Mercer County that will be connected to the existing Franklin Township nature trails. Signage will be posted on-site and Mercer County and Mercer SWCD will develop outreach materials, press releases and a tour of the site to promote the project.

Critical Area 1: Project 2

Nine Element Criteria	Information needed	Explanation
n/a	Title	Little Chickasaw Creek Treatment Train and Littoral Wetland
criteria d	Project Lead Organization & Partners	Lake Facilities Authority
criteria c	HUC-12 and Critical Area	GLSM HUC-12 (05120101-0204)
criteria c	Location of Project	GLSM HUC-12, State Route 219, just west of Mercer-Auglaize County Line (40°30’3” N, 84°27’44”W)
n/a	Which strategy is being addressed by this project?	Altered Stream and Habitat Restoration Strategy
criteria f	Time Frame	Short (1-3 years)

criteria g	Short Description	Figure 3 shows the proposed concept for the Little Chickasaw and Big Chickasaw Creek Treatment Train. Approximately 70 acres of on-land wetlands will be created and restored and 76 acres of in-lake littoral wetlands will be developed.
criteria g	Project Narrative	This project will restore and create approximately 70 acres of on-land wetlands and 76 acres of in-lake littoral wetlands. The littoral wetlands will be filled with dredge material until sediment is within six inches of the surface. Wetland vegetation will be seeded as necessary once the area is filled. This area will provide filtering of nutrients and sediment. Water from Little Chickasaw Creek and Chickasaw Creek will be pumped into the on-land wetlands to facilitate nutrient and sediment removal.
criteria d	Estimated Total cost	$2,700,000
criteria d	Possible Funding Source	Clean Ohio Funds; State Funding
criteria a	Identified Causes and Sources	Cause: Nutrient Loading, Sedimentation and Direct Habitat Alteration Sources: Channelization and non-irrigated crop production.
criteria b & h	Part 1: How much improvement is needed to remove the NPS impairment for the whole Critical Area?	The goals of this critical area are to reduce cyanobacteria toxin levels in Grand Lake St. Marys so that the non-attainment drinking water use designation can be removed. A microcystin toxin level of less than 1.0 µg/L will need to be achieved for a period of five years. Another goal is to reduce the trophic status index, based on chlorophyll a concentrations, to less than 67. It is estimated that approximately 400 acres of additional on-land wetlands and 400 acres of in-lake wetlands within the critical area will be needed to achieve these goals.
	Part 2: How much of the needed improvement for the whole Critical Area is estimated to be accomplished by this project?	It is recognized that there is a lag time associated with nonpoint source-related projects and measured lake response. The main goals in this critical area are to reduce the cyanobacteria toxin levels in Grand Lake St. Marys to achieve a full attainment status for drinking water and to reduce the trophic status index. This project will meet 17% of objective 1 for Critical Area 1 and 19% of objective 2 for Critical Area 1.
	Part 3: Load Reduced?	Estimated: 1,505 lbs P/year, 70,060 lbs N/year; 70 tons/year sediment
criteria i	How will the effectiveness of this project in addressing the NPS impairment be measured?	Wright State University-Lake Campus has been monitoring all three existing wetland areas already developed in the Grand Lake St. Marys watershed. This project will be added to Wright State's monitoring program after it is constructed and established. Results from the existing wetlands have shown an average nitrogen reduction of 65% and an average phosphorus reduction of 50%.
criteria e	Information and Education	This project will be promoted with public meetings, tours, press releases, news articles, and social media. Monitoring results will be shared periodically with the public as well.

Critical Area 1: Project 3

Nine Element Criteria	Information needed	Explanation
n/a	Title	Channel Aeration Project at Windy Point
criteria d	Project Lead Organization & Partners	ODNR
criteria c	HUC-12 and Critical Area	GLSM HUC-12 (05120101-0204)
criteria c	Location of Project	GLSM HUC-12, south of Grand Lake St Marys on Windy Point Road (40º30'33"N; 84º32'23"W)
n/a	Which strategy is being addressed by this project?	High Quality Waters Protection Strategies
criteria f	Time Frame	Short (1-3 years)
criteria g	Short Description	This project will add aeration to the channel at Windy Point, using a new nanobubble technology.
criteria g	Project Narrative	This project will add a 150 gallon per minute nanobubble generator and pump to the channel by Windy Point. This channel is used by Grand Lake St. Marys emergency personnel and the US Freshwater Boaters Alliance. This channel experiences many harmful algal blooms and has a great need for added aeration. This site will be an excellent location to trial a new type of aeration process as a pilot project.
criteria d	Estimated Total cost	$40,000 ($24,000 grant; $16,000 matching)
criteria d	Possible Funding Source	ODNR; Local Sources
criteria a	Identified Causes and Sources	Causes: Nutrient Loading; Direct Habitat Alteration Sources: Channelization; residential development; non-irrigated cropland production
criteria b & h	Part 1: How much improvement is needed to remove the NPS impairment for the whole Critical Area?	The goals of this critical area are to reduce cyanobacteria toxin levels in Grand Lake St. Marys so that the non-attainment drinking water use designation can be removed. A microcystin toxin level of less than 1.0 µg/L will need to be achieved for a period of five years. Another goal is to reduce the trophic status index, based on chlorophyll a concentrations, to less than 67. It is estimated that approximately 40 access channels (23%) currently have an aeration system in place. Another 90 channels (57%) still need aeration to achieve the objective.
	Part 2: How much of the needed improvement for the whole Critical Area is estimated to be accomplished by this project?	It is recognized that there is a lag time associated with nonpoint source-related projects and measured lake response. The main goals in this critical area are to reduce the cyanobacteria toxin levels in Grand Lake St. Marys to achieve a full attainment status for drinking water and to reduce the trophic status index. This project will meet 2% of objective 3 for Critical Area 1.
	Part 3: Load Reduced?	This item is not related to load reduction per se. However, it is estimated there will be a 40-89% reduction in microcystin toxin levels within treated channels.

		*§319 program will not be listed as a potential funding source until a determination is made related to project eligibility.
criteria i	How will the effectiveness of this project in addressing the NPS impairment be measured?	Visual observations will be made as to the quality of water in the channel. Comparisons to channels with other types of aeration and no aeration can be made. Aeration typically decreases the amount of surface scum, which is a great visual improvement. The equipment supplier and Mercer SWCD will also be engaging in dissolved oxygen monitoring before and after the installation of their nanobubble technology. Dissolved oxygen readings will be taken at specified intervals in relationship to the equipment location. These readings will aid in determining the reach of the equipment and whether this equipment is superior to other aeration equipment already installed on many channels in the lake. The higher the dissolved oxygen level, the better water quality in the channel.
criteria e	Information and Education	ODNR will be using this project as a pilot for the nanobubble technology, so this project will be promoted with press releases, news articles, and social media. Monitoring results will be shared periodically with the public as well.

Section 4.3 Critical Area 2: Overview Table and Project Sheets for Prairie Creek and Little Chickasaw/Barnes Creek Areas of GLSM HUC-12

The information included in the Critical Area 2 Overview Table is a condensed overview of all identified projects needed for nonpoint source restoration of the GLSM HUC-12 Critical Area 2. Project Summary Sheets are included for short term projects or any project that is considering seeking funding in the near future. Only those projects with complete Project Summary Sheets will be considered for state and federal NPS program funding.

4.3.1 Critical Area 2: Project and Implementation Strategy Overview Table

The GLSM HUC-12 Critical Area 2 is based on non-attainment status of aquatic life use designation and nutrient and sedimentation loading. The Critical Area 2 Overview Table provides a quick summary of what needs to be done, where, and what problem (cause/ source) will be addressed and includes projects at all levels of development (i.e. concept, need funding, in progress). This over view table is intended to show a prioritized path toward the restoration of the GLSM HUC-12.

Critical Area 2: Project Overview Table for GLSM HUC-12 (05120101-0204)							
Goal	**Objective**	**Project #**	**Project Title** *(EPA Criteria g)*	**Lead Organization** *(criteria d)*	**Time Frame** *(EPA Criteria f)*	**Estimated Cost** *(EPA Criteria d)*	**Potential/Actual Funding Source** *(EPA Criteria d)*
Urban Sediment and Nutrient Reduction Strategies							
1,2,3	3,4	3	St. Sebastian Centralized Sewer	Mercer County	Long	$1,500,000	WPCLF, RPIG
Altered Stream and Habitat Restoration Strategies							
Agricultural Nonpoint Source Reduction Strategies							
1,2,3	1	1	Small Grains Program	Mercer SWCD	Short	$400,000	EPA 319, USDA-NRCS
1,2,3	2	2	Edge of Field Practice Program	Mercer SWCD	Medium	$250,000	EPA 319, USDA-NRCS
High Quality Waters Protection Strategies							
Other NPS Causes and Associated Sources of Impairment							

Section 4.3.2 Critical Area 2 Project Summary Sheets

The Project Summary Sheets provided below were developed based on action or activities needed to restore the Critical Area to meet the goals outlined in this plan. These projects are considered next step or priority/short term projects that have been more thoroughly planned. Medium and longer term projects will most likely not have a summary sheet, as these projects are not ready for implementation.

Critical Area 2: Project 1

Nine Element Criteria	Information needed	Explanation
n/a	Title	Small Grains Program
criteria d	Project Lead Organization & Partners	Mercer County SWCD
criteria c	HUC-12 and Critical Area	GLSM HUC-12 (05120101-0204)
criteria c	Location of Project	GLSM HUC-12, south of Grand Lake St. Marys cropland in Prairie Creek and Little Chickasaw/Barnes Creek areas
n/a	Which strategy is being addressed by this project?	Agricultural Nonpoint Source Reduction
criteria f	Time Frame	Short (1-3 years)
criteria g	Short Description	Enroll approximately 2,000 acres of cropland into a three-year commitment to grow small grains, then land apply and incorporate nutrients from June to early September while also maintaining field cover throughout the winter.
criteria g	Project Narrative	This Critical Area is highly populated with dairy, beef and swine. Small grains have been typically removed from the crop rotation because the profitability of growing small grains is so low. However, the value of small grain production in this Critical Area is very high because it would allow for timelier manure/nutrient applications. Providing a performance-based incentive to add small grains to the rotation and apply manure from June through September would reduce the runoff risk associated with land nutrient applications. This project will also require 90% field cover going into the winter months through the use of residue or cover crops. If enrolled, the producer will be required to incorporate or inject nutrients, or ensure that a cover crop will be planted following manure application. Applying nutrients during the summer months with incorporation or injection will yield an approximate 50% reduction in phosphorus runoff and a 40% reduction in nitrogen runoff, according to Heidelberg University research. This program would require a two-year minimum requirement to enroll acreage into the program. For example, a producer could sign up 50 acres, using one field the first year and a different field for the second year. The performance-based incentive would be approximately $100 per acre each year.
criteria d	Estimated Total cost	$400,000

criteria d	Possible Funding Source	Ohio EPA 319(h); USDA-NRCS (EQIP or CIG)
criteria a	Identified Causes and Sources	Cause: Nutrient Loading Source: Channelization and non-irrigated crop production
criteria b & h	Part 1: How much improvement is needed to remove the NPS impairment for the whole Critical Area?	The goal is to raise the IBI score above 40, to raise or maintain or increase the MIwb score above 8.3, and raise the QHEI score to 60. The ultimate goal is to reduce cyanobacteria toxin levels in Grand Lake St. Marys so that the non-attainment drinking water use designation can be removed. A microcystin toxin level of less than 1.0 µg/L will need to be achieved for a period of five years. With numerous livestock facilities in the Critical Area, it is necessary to apply manure to cropland. This project will enroll 2,000 acres (approximately 15% of the Critical Area) where small grains will be grown and to allow for manure application during the summer months when runoff potential is at its lowest.
	Part 2: How much of the needed improvement for the whole Critical Area is estimated to be accomplished by this project?	There is recognition that there is lag time associated with nonpoint source-related projects and measured stream response. However, measured stream nitrate and phosphorus levels can directly impacted after rain events if nutrients are incorporated. By shifting nutrient applications to the summer, the runoff risk is even lower. The goal of this project is to reach 2,000 acres of cropland, which equates to 15% of the cropland in the critical area. The overall objective is to reach 5,000 acres, which is 40% of the critical area. It is estimated that this project will lead to a reduction of 34,000 lb N/year and 980 lb P/year. This is based on starting levels as shown in Figures 28 and 29.
	Part 3: Load Reduced?	34,000 lbs N/year and 980 lbs P/year
criteria i	How will the effectiveness of this project in addressing the NPS impairment be measured?	Staff from Ohio EPA-DSW Ecological Assessment Unit will perform a future watershed-wide monitoring event to determine progress (through IBI, ICI and QHEI) from non to full attainment. Wright State University-Lake Campus collects weekly water samples from Prairie Creek at State Route 219. These samples are tested for total phosphorus, dissolved phosphorus, total suspended solids and nitrate. These samples can be used to monitor nutrient levels in the stream. Wright State University Lake Campus will also be performing project-specific IBI and QHEI evaluations before and after project installations.
criteria e	Information and Education	This project will be promoted with public meetings to inform producers, press releases, news articles, social media and personal contacts from Mercer SWCD to eligible producers. Overall reduction results will be shared with the public.

Section 4.4 Critical Area 3: Overview Table and Project Sheets for Livestock Operations in GLSM HUC-12

The information included in the Critical Area 4 Overview Table is a condensed overview of all identified projects needed for nonpoint source restoration of the GLSM HUC-12 Critical Area 3. Project Summary Sheets are included for short term projects or any project that is considering seeking funding in the near future. Only those projects with complete Project Summary Sheets will be considered for state and federal NPS program funding.

4.4.1 Critical Area 3: Project and Implementation Strategy Overview Table

The GLSM HUC-12 Critical Area 3 is based on non-attainment status nutrient loading. The Critical Area 3 Overview Table provides a quick summary of what needs to be done, where, and what problem (cause/ source) will be addressed and includes projects at all levels of development (i.e. concept, need funding, in progress). This over view table is intended to show a prioritized path toward the restoration of the GLSM HUC-12.

Critical Area 3: Project Overview Table for GLSM HUC-12 (05120101-0204)							
Goal	**Objective**	**Project #**	**Project Title** *(EPA Criteria g)*	**Lead Organization** *(criteria d)*	**Time Frame** *(EPA Criteria f)*	**Estimated Cost** *(EPA Criteria d)*	**Potential/Actual Funding Source** *(EPA Criteria d)*
Urban Sediment and Nutrient Reduction Strategies							
Altered Stream and Habitat Restoration Strategies							
Agricultural Nonpoint Source Reduction Strategies							
1,2	2	1	Manure Transfer	Mercer SWCD	Short	$375,000	USDA-NRCS; State & Local Sources
1,2	1	2	Nutrient Separation Project	Mercer County Ag Solutions	Medium	$750,000	USDA-NRCS; USDA-CIG
High Quality Waters Protection Strategies							
Other NPS Causes and Associated Sources of Impairment							

Section 4.4.2 Critical Area 3 Project Summary Sheets

The Project Summary Sheets provided below were developed based on action or activities needed to restore the Critical Area to meet the goals outlined in this plan. These projects are considered next step or priority/short term projects that have been more thoroughly planned. Medium and longer term projects will most likely not have a summary sheet, as these projects are not ready for implementation.

Critical Area 3: Project 1

Nine Element Criteria	Information needed	Explanation
n/a	Title	Manure Transfer
criteria d	Project Lead Organization & Partners	Mercer County SWCD
criteria c	HUC-12 and Critical Area	GLSM HUC-12 (05120101-0204)
criteria c	Location of Project	GLSM HUC-12, south of Grand Lake St. Marys. Farmers that produce liquid manure and have a need to export their manure out of the watershed.
n/a	Which strategy is being addressed by this project?	Agricultural Nonpoint Source Reduction Strategy
criteria f	Time Frame	Short (1-3 years)
criteria g	Short Description	Manure will be transferred to acres showing a need for phosphorus (soil test phosphorus levels of 50 ppm or 100 lb/acre or below) that are outside the GLSM watershed.
criteria g	Project Narrative	The GLSM HUC-12 has 49 swine, dairy and beef operations. Many years of applying manure to acreage directly surrounding the operations has created some high soil test phosphorus levels, which create higher chances of leaching nutrients. Moving manure to acreage outside the watershed with a soil test showing the need for additional nutrients will allow for a reduction in nutrients within the HUC. It is assumed that by removing manure nutrients from the watershed, an overall 30% reduction in nitrate and phosphorus stream loading will occur. Farmers would be paid per ton or gallon moved based on the distance travelled with the manure. The program would include two or three years of payments based on the amount of manure hauled each year. The objective is to move 25,000 tons or six million gallons of manure each year.
criteria d	Estimated Total cost	$375,000
criteria d	Possible Funding Source	USDA-NRCS EQIP; State & Local Sources
criteria a	Identified Causes and Sources	Cause: Nutrient Loading Source: Confined Animal Feeding Operations (NPS)

criteria b & h	Part 1: How much improvement is needed to remove the NPS impairment for the whole Critical Area?	Reducing nutrient applications to cropland that is at or above maintenance level for crop removal is a necessary goal. Manure is still being applied to these acres at a phosphorus draw-down rate. This project will allow for less manure to be applied to acres already above the Tri-State Fertility Guide recommendations by moving the manure to acres at or below those recommendations. Transferring 25,000 tons (approximately 20% of manure produced) out of the watershed will achieve the reductions necessary to meet the goals of this plan. The ultimate goal is to reduce cyanobacteria toxin levels in Grand Lake St. Marys so that the non-attainment drinking water use designation can be removed. A microcystin toxin level of less than 1.0 µg/L will need to be achieved for a period of five years.
	Part 2: How much of the needed improvement for the whole Critical Area is estimated to be accomplished by this project?	It is recognized that there is a lag time associated with nonpoint source-related projects and stream response. This project will transfer approximately 44,600 pounds of phosphorus and 98,000 pounds of nitrogen out of the watershed per year. This equates to half of the overall objective of implementing this practice in the GLSM HUC-12.
	Part 3: Load Reduced?	18,600 lbs N/year and 425 lbs P/year
criteria i	How will the effectiveness of this project in addressing the NPS impairment be measured?	Staff from Ohio EPA-DSW Ecological Assessment Unit will perform a future watershed-wide monitoring event to determine progress (through IBI, ICI and QHEI) from non to full attainment. Wright State University-Lake Campus collects weekly water samples from Prairie Creek at State Route 219. These samples are tested for total phosphorus, dissolved phosphorus, total suspended solids and nitrate. These samples can be used to monitor nutrient levels in the stream. Wright State University Lake Campus will also be performing project-specific IBI and QHEI evaluations before and after project installations.
criteria e	Information and Education	This project will be promoted with public meetings to inform producers, press releases, news articles, social media and personal contacts from Mercer SWCD to eligible producers. Overall project results will be shared with the public as well.

Works Cited

D.B. Janyes and T.M. Isenhart. (2014). Reconnecting Tile Drainage to Riparian Buffer Hydrology for Enhanced Nitrate Removal. Journal of Environmental Quality Technical Report.

Francesconi, etal. (2015). Effect of Replacing Surface Inlets with Blind or Gravel Inlets on Sediment and Phosphorus Subsurface Drainage Losses. Journal of Environmental Quality.

Heidelberg University. (2015). Research on Water Quality: http://ocj.com/2016/10/research-yielding-some-clear-answers-to-murky-water-quality-questions/.

Jacquemin, Stephen, etal. (2018). Changes in Water Quality of Grand Lake St. Marys Watershed Following Implementation of a Distressed Watershed Rules Package. The Journal of Environmental Quality.

Jacquemin, Stephen, etal. (2018). Improving GLSM Water Quality Using Reconstructed Wetlands. Lake Restoration Commission.

KCI Associates of Ohio. (2017). Grand Lake St. Marys Adaptive Management Plan. Grand Lake St. Marys Restoration Commission.

Lochtefeld, Joe (2011). Diversified Pond Supplies. Shallow Water/Linear Aeration in Grand Lake St. Marys (GLSM).

Mercer County Auditor. Retrieved 10-17-2016, from Mercer County Ohio.

Mercer Co Comp Plan (2013). Mercer County Comprehensive Plan. Retrieved 10 17, 2016, from Mercer County Ohio: mercercountyohio.org/plancomm/PDF%20Files/2013Comprehensive%20Plan.pdf

Mercer SWCD. (2016). Mercer SWCD reference materials. Mercer Soil and Water Conservation District.

Steffan, Morgan, etal. (2013). Taxonomic Assessment of a Toxic Cyanobacteria Shift in Hypereutrophic Grand Lake St. Marys. Harmful Algae.

TMDL GLSM. (2007). Total Maximum Daily Loads for Beaver Creek and Grand Lake St. Marys Watershed: epa.state.oh.us/portals/35/tmdl/BeaverGLSM_TMDL_final_aug07.pdf

WAP. (2015). Grand Lake St. Marys and Wabash River Watershed Action Plan. Retrieved 11 10, 2016, from Mercer Soil and Water Conservation District

Lake Erie Task Force. (2013). Lake Erie Phosphorus Task Force II Final Report. Retrieved 12 13, 2016. http://lakeerie.ohio.gov/portals/0/reports/task_force_report_october_2013.pdf

Swann, Chris. (2001). The Influence of Septic Systems at the Watershed Level. http://owl.cwp.org/mdocs-posts/the-influence-of-septic-systems-at-the-watershed-level/

Appendices

Appendix A: Acronyms and Abbreviations

The acronyms and abbreviations below are commonly used by organizations working to restore Ohio's watersheds; many of which are included in the NPS-IS plan.

A

AOC Area of Concern

B

BMP Best Management Practice

D

DNR Department of Natural Resources

H

HUC Hydrologic Unit Code

I

ICI Invertebrate Community Index

M

MIwb Modified Index of Well Being

MWH Modified Warmwater Habitat

O

ODA Ohio Department of Agriculture

ODNR Ohio Department of Natural Resources

OEPA Ohio Environmental Protection Agency

Q

QHEI Qualitative Habitat Evaluation Index

S

SWCD Soil and Water Conservation District

T

TMDL	Total Maximum Daily Load
TSI	Trophic Status Index
<u>U</u>	
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
<u>W</u>	
WAP	Watershed Action Plan
WSU-LC	Wright State University-Lake Campus
WWH	Warm Water Habitat
WWTP	Waste Water Treatment Plant

Appendix B: Index of Figures