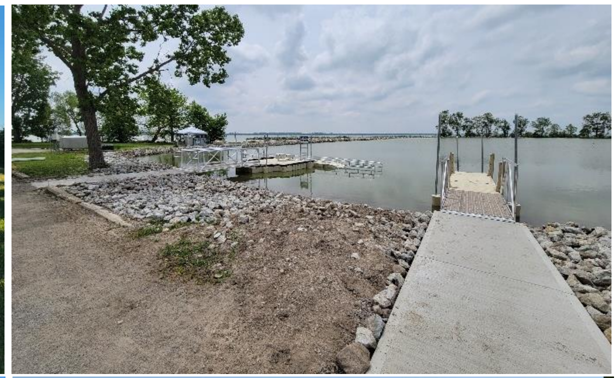
# Grand Lake St. Marys

## Adapative Management Plan Update

April 2023

## *Building on Success*



Grand Lake St. Marys Restoration Commission

GRAND LAKE ST. MARYS RESTORATION COMMISSION

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## The goal of the GLSM Restoration Commission is to:

Provide a holistic blueprint for the sustainable environmental and economic renewal of Grand Lake St. Marys and its contributing watersheds through an approach that will motivate and coordinate stakeholders to increase the ecological and economic effectiveness of restoration activities. These efforts will also help lake communities realize their potential to improve and protect the natural and economic resources of the region.

## Commission Members

- Board of Auglaize County Commissioners
- Board of Mercer County Commissioners
- City of Celina
- City of St. Marys
- Ohio Department of Natural Resources
- Greater Grand Lake Visitors Center
- Lake Facilities Authority
- Lake Improvement Association
- Mercer County Civic Foundation
- St. Marys Community Foundation
- Ag Solutions
- Wright State University Lake Campus
- Mercer Soil & Water Conservation District
- Ohio State University Extension

# PREFACE

This document is an Adaptive Management Plan (AMP) intended to supplement and update the Strategic Plan (SP) developed for Grand Lake St. Marys (GLSM) based on observed changes to the system since its inception in 2011. This document should be utilized in tandem with the original SP as an updated chapter which describes the latest objectives, strategies and actions needed to improve and protect GLSM's environmental and economic health based on the current system indicators.

- Section 1 lists the recommended actions necessary to continue building on recent success at Grand Lake St. Marys.

An Adaptive Management Plan is a living document and should be continually analyzed and modified as data is available to determine the effectiveness of the actions being undertaken. It is not intended to replace the SP, but to critically assess the path forward based on the observed responses to the system.

# EXECUTIVE SUMMARY

The Strategic Plan (SP) was formulated in 2011 to provide a framework and timeline for restoration of the Grand Lake St. Marys (GLSM) ecosystem utilizing nutrient management control and removal projects and economic management tools to implement solutions for current and future lake improvements and revitalization. The SP was integrated with ongoing efforts by the Ohio Environmental Protection Agency (OEPA), Ohio Department of Natural Resources (ODNR) and the GLSM Lake Restoration Commission (LRC) as part of a Consolidated Action Plan (CAP) which established an interrelated framework of objectives to synergistically pursue the ecologic and economic restoration of GLSM through the utilization of adaptive management protocols. In 2011, numerous management actions were identified for implementation through coordination with the primary stakeholders and adopted as Critical Response Actions (CRA). Completed and ongoing CRAs undertaken from 2011 through 2022 as a result of the SP included:

- Developed the GLSM Consolidated Action Plan (CAP)
- Establishment of the Lake Facilities Authority (LFA)
- Established Lake Manager Position
- Established Communications Plan
- Created Fund Raising Program
- Water quality monitoring stations were active and data was assessed
- Administered chemical alum treatments
- Dredged sediment depositions
- Treatment wetland establishment
- Rough fish removal
- Applied aeration and circulation technologies
- Water level management
- Implementation and new participation in multiple Best Management Practices (BMPs) and projects within the watershed.
- Establishment of Agricultural Solutions Group
- Development of Nine Element Watershed Plans for the entire watershed

The cumulative effect of these efforts has yielded benefits to both the ecologic and economic conditions of the lake. Monitoring of these trends moving forward has and will continue to provide valuable insight into the resiliency of the system to recover from extremes in annual weather cycles and act as an indicator of temporal lag time response in the system.

A review of the implemented CRAs successes and the recognized effects of their implementation provided guidance for the development of this updated Adaptive Management Plan (AMP). The AMP validated the goal of SP and extended its objectives to include: Water Quality Improvement, Study/Document, Coordinate, Public Outreach, Economic Revitalization, and Infrastructure Management. In support of these objectives, 22 CRAs were developed and/or continued as ongoing actions, 8 of which were identified as Critical Implementation Priorities (CIPs) as follows:

- Treatment wetland systems
- Re-establish public connection with the lake as a recreational destination for swimming and water contact sports
- Watershed Best Management Practices
- In-lake features development
- Management of channel water
- Natural/man-made infrastructure management
- Monitoring, documentation and modeling of scientific data
- Beneficial use of organic waste

Implementation of the CRAs with emphasis on the CIPs will occur over the next 5 years dependent upon funding. The implementation of this updated AMP necessitates the continued monitoring and modification of these efforts. This document serves as an update to the 2011 SP as well as the 2017 AMP.

# 1. Strategic Plan Updates

The Strategic Plan (SP) was developed as a coordinated response to environmental deterioration of GLSM and the economic stresses placed on the region as a result of those changes in the lake ecosystem. The objectives of the plan are still valid as adopted in the SP. The first update to the SP was made in the Adaptive Management Plan in 2017 (AMP 2017). This document serves as a second update to the SP and outlines successes implemented since 2017 and a plan for building on recent success. These updates will foster the continued implementation of SP.

## 1.1. OBJECTIVES

Six objectives were established in support of achieving the goals of the SP. Review of these objectives verified their continued validity for the AMP. However, as the plan has matured, additional objectives are warranted based on the knowledge derived from lessons learned over the last several years. The revised list of objectives is as follows:

- WATER QUALITY IMPROVEMENT – Carry forward the identification and implementation of coordinated actions that will lead to the improvement of water quality restoration of the lake ecosystem.
- STUDY/DOCUMENT– Promote the application of science and economic re-development analyses to understand the stressors impacting the environmental and economic systems in and around the lake. These effects will be documented to promote the most appropriate technologies and cost-effective solutions with the most far reaching benefits.
- COORDINATE – Provide a basis of interaction to coordinate and integrate the efforts experiences and resources of state, federal, private and business interests to achieve consensus on issues and solutions to realize a synergistic effect.
- PUBLIC OUTREACH – Establish open lines of communication to inform, educate and understand the needs and objectives of those who live within the ecological context of the system and holistically carry the message on to the overall populace.
- ECONOMIC REVITALIZATION - Seek funding to implement projects through grants, sustainable business opportunities, contributions, state/federal initiatives, and re-inoculate the economic drivers of the region. Funding mechanisms within the U.S. Environmental Protection Agency, the U.S. Army Corps of Engineers (USACE), Ohio Department of Environmental Protection, the Ohio Department of Natural Resources as well as through other nonprofit resources will be pursued as part of these coordinated efforts to effectively provide the greatest environmental and economic benefits for the lake.
- INFRASTRUCTURE MANAGEMENT – Manage the natural and man-made infrastructure to maximize its effectiveness on the lake ecosystem.

## 1.2. CRITICAL RESPONSE ACTIONS (CRAs)

Associated with each objective are specific action items to initiate and maintain progress toward achieving the strategic goal. These actions provide the fundamental substructure necessary for the implementation of specific project opportunities designed to improve the physical condition of the lake and the surrounding economy. These CRAs are presented below by objective.

### WATER QUALITY IMPROVEMENT

The planning and implementation of projects specifically designated to reduce in-lake and watershed nutrient loading as the primary drivers to restore the lake.

#### *Action Items*

1. Continued development of treatment wetlands, wildlife wetlands and littoral wetlands.
2. Development of in-lake features as protection for littoral wetlands and against shoreline erosion.
3. Foster increased placement of watershed best management practices including, but not limited to: drainage water management, edge of field practices, cover crops, and conservation crop rotation.
4. Develop a regional organic waste management program to collect, treat and dispose of animal waste and high phosphorus dredged material.
5. Promote management of stream water through stream restoration, two-stage ditches, etc.
6. Maintain and implement current nutrient management plans on all livestock farms in the watershed that meet the Distressed Watershed Rules requirements.

### STUDY/DOCUMENT

The availability of information and data to establish baseline conditions for measuring successes and providing supporting evidence for potential funding opportunities was a limiting factor prior to 2017. Starting in June of 2017, a wetland monitoring program has been implemented to evaluate the successes and monitor the efficacy of the treatment wetland systems in the watershed. This data has been successfully used to demonstrate and support the need for future wetland projects and has also been used as a metric and model for the improvement efforts in Lake Erie and other parts of the nation. The restoration efforts of GLSM has been shown through the strong tourism economics over the last few years. The goal in 2023 and beyond is to continue the monitoring program, and even expand the program through the State of Ohio’s H2Ohio program. This will aid in the continued strong tourism economics surrounding GLSM. Appendix B contains data summaries from each year of monitoring the treatment wetland systems along with published research projects from within GLSM.

#### *Action Items*

1. Continue and expand the existing wetland monitoring program utilizing Wright State University Lake Campus and the H2Ohio program.
2. Monitor new technologies installed within the GLSM watershed and publish associated research data.
3. Maintain relationships with USGS and the National Center for Water Quality to continue the assessment of water quality at the long-term gauging stations on Chickasaw and Coldwater Creeks.

## COORDINATION

Numerous groups/organizations including Ohio Department of Environmental Protection, Ohio Department of Natural Resources, Ohio Department of Agriculture, Natural Resources Conservation Service, Grand Lake/Wabash Watershed Alliance (dissolved in 2016), Mercer and Auglaize Soil and Water Conservation Districts, Ag Solutions, Lake Improvement Association, Lake Facilities Authority, etc. have been developing plans and implementing projects through a variety of funding sources in an effort to stem the degradation of Grand Lake St. Marys. The Lake Restoration Commission has done an excellent job of presenting a comprehensive front to synergize the overall work and allow for effective support at the federal, state and local government level.

### *Action Items*

1. Promote the development of sustainable business practices and provide economic incentives to promote growth in regions most directly impacted by the lake's condition.
2. Continue the efforts of the Lake Restoration Commission, as the unified voice for GLSM.
3. Continue to utilize the Lake Facilities Authority to receive and manage grant funds to develop new treatment projects across the watershed.

## PUBLIC OUTREACH

The regional scale of effect, which involves both the degradation of the lake as a resource and as a local and regional economic driver, influences and expands the realm of the stakeholders beyond that normally associated with a single degraded resource. As such, the integration of stakeholder comments and concerns is critical to the process of developing actions, strategies and solutions as a means to manage and distribute information about the activities and progress of the plan and the commission. Many of the commission's represented agencies take a leadership role in public outreach and will continue to do so as outlined below.

### *Action Items*

1. Mercer and Auglaize Soil and Water Conservation Districts have strong youth education programs to educate the younger generations on the importance of water quality and management of natural resources. ODNR has visited several schools, libraries and scout programs to inform children of the lake's influence on our region and the importance of natural resources.
2. The Lake Improvement Association has been integral in educating the public through their membership meetings, events, and social media accounts.
3. The Greater Grand Lake Region Visitor's Center provides information on GLSM to lake users and promotes GLSM and its many amenities both locally and regionally.
4. The commission will periodically provide elected official and State Agency Director tours of GLSM to keep them informed of the state of water quality and current and future projects.
5. Work with the Lake Facilities Authority and ODNR to continue projects while also managing existing projects.
6. Re-establish the public connection with the lake as a recreational destination for swimming and water contact sports through improvement of facilities and available opportunities. Also promoting

the existence and availability of the public natural spaces in GLSM watershed through tours, field days, social media and press releases.

## ECONOMIC REVITALIZATION

The creation of economic opportunities that establish sustainable actions which have the ability to fuel the local economy while resolving the historical causes and sources of the lake degradation are a key component to continuing the restoration and economic viability of the region. The creation of a "restorative economy" through the development and application of market-based solutions and innovative funding mechanisms, is critical and necessary. The diversity of multiple funding sources and partnerships, each targeting aspects of the problem from different angles and approaches, will over the long-haul fuel comprehensive and sustainable financial and ecologic solutions for the lake region. Within the last five years, there have been several developments of businesses and housing along and directly related to the lake.

To continue this development, policies that will help manage risk, and encourage/support the private sector will be established. This framework will create markets for building the critical mass necessary to attract sufficient financial and technical influxes which will influence landscape level improvements. Four different strategies will be utilized to initiate, establish and sustain the economic initiative focused on restorative processes.

### *Action Items*

1. Evaluate highest priority projects and prepare prospectuses as to the economic development value that will be realized from implementation. Convert data into a business plan based on the best financial avenues to provide funding for implementation.
2. Develop supporting economic studies and valuations to substantiate business prospectuses for development which will promote economic implementation strategies.
3. Establish a Local Park District to manage natural sites and foster the continued development of new natural greenspaces.
4. Initiate and foster the development of at least one sustainable business enterprise within the watershed that aids in treating critical stressors in the ecosystem.

## INFRASTRUCTURE MANAGEMENT

Manage the natural and man-made infrastructure to maximize its effectiveness on the lake ecosystem. During the 12 years since the SP has been implemented, significant work has been completed in developing infrastructure to address the primary stressors affecting the lake. Continued and coordinated effort is required to operate this infrastructure to its maximum benefit.

### *Action Items*

1. Continually update the existing Memorandum of Understanding (MOU) between the Ohio Department of Natural Resources and the Lake Facilities Authority and Mercer County Commissioners. This MOU outlines the management needed at each natural space in the watershed and calls for a yearly management plan for each site.
2. Maintain a robust dredging program on GLSM, which will require continual and consistent maintenance on mechanical dredges along with upgrades to equipment. The continued search for sites to dewater dredge material will be critical to the program's success.

## 1.3. CRITICAL IMPLEMENTATION PRIORITIES

Within the identified CRA's, a specific subset is identified as critical to the current and future success of the AMP. Therefore, these items have been further vetted and refined for priority consideration and immediate action.

### 1. Treatment Wetlands, Wildlife Areas and Littoral Wetlands

**Purpose:** Treatment wetlands have been demonstrated to provide significant benefits in achieving nutrient reduction goals. Appendix A contains monitoring data from 2017-2022 for the Prairie and Coldwater Creek systems. 2022 also includes data from the Beaver Creek vegetated biofilter. The State of Ohio's H2Ohio program is monitoring the nutrient data from the Burntwood-Langenkamp Wetland Conservation Area, and data will be available later in 2023 and beyond.

**Action:** Establishment of treatment wetland systems on each drainage stream contributing to the lake. Big and Little Chickasaw Creek stream restoration and wetlands project is slated to be constructed in 2023. Continued implementation of the Mercer Wildlife Area project will be managed in 2023 and 2024. A treatment wetland system on Monroe Creek is projected to be installed and operational in 2024. Several land acquisitions for additional projects are also pending. Appendix B contains data summaries from each year (2017-2022).

### 2. Watershed Best Management Practices

**Purpose:** Watershed inputs to the lake influence the water quality of the system. Significant progress has been made to decrease nutrient loading from the contributing watersheds. Appendix B contains a monitoring summary of a saturated buffer and drainage water management practice installed in the watershed in 2020. Appendix D contains a list of referenced research including data from the long-term monitoring stations that have informed of the water quality improvement in-stream.

**Action:** Implement recommendations of Nine Element Plans. Continue to research new and upcoming edge of field Best Management Practices, and maintain current Nutrient Management Plans on all livestock farms within the watershed that meet the Distressed Watershed Rules criteria. Install additional natural stream restoration projects and two-stage ditches where possible.

### 3. Re-establish the public connection with the lake as a recreational destination for swimming and water contact sports

**Purpose:** Grand Lake as a destination for water contact recreation has been impacted by water quality concerns. The last several years have seen a great increase in lake usage. The re-establishment of community/cultural connections focused on utilization of the lake can be initiated through improvement of lake facilities designated for water contact and localized improvement of water quality.

Action: Continue the research into technologies that can provide localized water quality improvements at Lake beaches, in particular, Sunset Beach. Work with local groups to establish other infrastructure around the lake, such as kayak rentals, bicycle rentals and more.

### 4. In-Lake Features Development

Purpose: The shape, orientation and depth of GLSM creates long fetch lengths that can lead to increased erosion on its periphery. Specifically, shorelines and littoral wetland systems are susceptible to damage from wind driven waves. Development of in-lake features which limit fetch length and deflect wave energy can have a significant improvement on near shore erosion and water quality.

Action: Strategically develop in lake features i.e. islands and near shore bars to protect littoral wetlands and shoreline features. Improve the littoral wetland walls at both Prairie Creek and Coldwater Creeks to ensure their longevity and stability.

### 5. Management of Channel Water

Purpose: Numerous channels that serve residential communities are found on GLSM. Channel waters are not exposed to the same environmental conditions (wind, waves, mixing) as the main body of the lake. As such water quality can deteriorate more rapidly in these areas impacting public health and community opinion of overall status of lake health. Management of water quality in channels provides a recognized outlet for community interface with lake management and can resolve perceived threats to public health.

Action: Expand opportunities for channel water management by providing landowner education, assistance and pre-approved management options (e.g. wetland plant establishment and planting along banks, etc.) for implementation. Continue to promote the Lake Improvement Association's channel aeration program. A large number of linear aeration systems have been installed in the lake and ODNR has helped install pipes in areas where water transfer is an issue.

### 6. Natural/Man-Made Infrastructure Management

Purpose: Since the development of SP, significant amounts of infrastructure have been developed to address and/or support the reduction of nutrients in the system. This infrastructure requires coordinated operation and maintenance to provide maximum benefit to the system.

Action: Develop an operational plan and budget to assure the maximum benefit potential of the existing and proposed infrastructure projects can be realized.

### 7. Monitoring, documentation and modeling of scientific data

Purpose: Effective decision making for implementation of the AMP relies on developing and analyzing data for both the individual CRAs as well as the response of the system as a whole.

**Action:** Continue monitoring of the treatment wetlands and publishing data as it becomes available. Also continue to work with USGS, the National Center for Water Quality to evaluate stream water quality coming into the Lake. USDA-Agriculture Research Service also has three established edge-of-field systems that continue to collect data that can be share with stakeholders to make informed decisions.

8. Beneficial Use of Organic Waste

**Purpose:** Provide alternative use for organic waste and high phosphorus dredge material in the watershed which will limit inputs into the system as a non-point source discharge, in addition to establishment of a revenue producing business in the locality.

**Action:** Create economic incentive package to attract private development and investment. Continue to demonstrate different technologies through pilot projects focused on both agricultural wastes and dredge material.

## 1.4. PERFORMANCE MONITORING

### ENVIRONMENTAL QUALITY

- Microcystin Concentrations – the concentration of microcystin (µg/L) in the lake as an indicator of blue green algal production/impact
- Algae Biomass – the concentration of algal biomass through UV/VIS florescence as indicator of HAB activity
- Habitat Suitability Index – Metric of habitat quality around the watershed (QHEI)
- DO – Dissolved oxygen concentrations as an indicator of biological integrity
- Clarity – Depth of light penetration into the water as measured by a Secchi disk as an indicator of algal growth and density
- Flow – Quantity of water flowing into the lake from tributaries as well as out of the lake (Celina and St Marys) year-round to assess lake residence time, nutrient loading, and HAB proliferation
- Nitrogen – concentration of dissolved and total nitrogen measured in mg/L as an indicator of key nutrient in the system that drives algal growth
- Phosphorous – concentration of dissolved and total phosphorus measured in mg/L as an indicator of key nutrient in the system that drives algal growth

### ECONOMIC CLIMATE

- Number of Jobs – total number of jobs in the region as an indicator of growth
- Median Income – as an indicator of job value and growth
- Sales Tax – as an indicator of economic activity in the region
- Gross Revenues – as an indicator of total economic value

# Appendix A – 2017-2022 Accomplishments

**Accomplishments and Partnerships**

Since development of the GLSM Consolidated Action Plan and the Strategic Plan, the Commission has fostered and participated in partnerships with governmental, nonprofit, private and research entities to compile and calibrate information, continue ongoing work and compose the best and most sustainable solutions for the lake. These entities offer the most current research and/or experience in water quality and economics directly related to the issues of Grand Lake St. Marys:

**Environmental Consulting Businesses**

KCI Technologies, Inc.
Mad Scientist Associates, LLC
Access Engineering Solutions
Tetra Tech Inc.
Jones Fish Hatcheries & Distribution, LLC
Aquadoc Lake and Pond Management, Inc.

**Government Agencies (Local, State, and Federal)**

Auglaize Soil and Water Conservation District (Auglaize SWCD)
Clean Ohio Green Space Program
Grand Lake Wabash Watershed Alliance (dissolved in 2016)
Mercer Soil and Water Conservation District (Mercer SWCD)
Mercer County Ag Solutions
Natural Resources Conservation Service (NRCS)
Ohio Department of Agriculture (ODA)
Ohio Department of Health (ODH)
Ohio Department of Natural Resources (ODNR)
Ohio Environmental Protection Agency (OEPA)
U.S. Department of Agriculture (USDA)
U.S. Army Corps of Engineers (USACE)
U.S. Environmental Protection Agency (USEPA)

**Research/Educational Institutions**

Ball State University
Battelle Memorial Institute
Bowling Green State University
Findlay University
Heidelberg University
Ohio Northern University
Ohio State University
University of Dayton Research Institute
University of North Carolina – Institute of Marine and Environmental Sciences
Western Ohio Educational Foundation
Wright State University Lake Campus

These partnerships are intended to provide the best information and technological advancements to support physical, biological and environmental integrity of lake and surrounding watersheds. The intent of the Commission is to evaluate and build from these resources to deliver the most effective long-term economic solutions. The Commission supports this integrated approach as a unified platform for the future economic sustainability and health of Grand Lake St. Marys and her communities.

**Accomplishments and Progress 2017 - 2022**

- **Developed Non-Point Source Implementation Plans for all of GLSM Watershed:** Mercer SWCD has developed nine-element plans for all four 12-digit hydrologic unit code sub watersheds. Each one has been endorsed by the State of Ohio and funding has been garnered to implement several projects in the plans. Plans have been updated as projects are completed or added.

- **Dredge Sediment Depositions**: Through ODNR, 2,016,360 cubic yards of deposition material was removed from 2017 through 2022. Maintenance on the dredges has been an ongoing issue, exasperated by the supply chain shortages in the recent past. In 2022, one dredge was down for nearly the entire season waiting on parts for a failed transmission. Equipment will need to be upgraded in the future, along with addressing the challenge of finding sites for disposal of dredge material. Dredge material from the lake, after the dewatering process, has been transported out of the watershed through ODNR's dredge soil giveaway program.

- **Beneficial Use of Organic Waste**: A company called Bargertech, Ltd., proposed to install their Planet Saver initiative in Mercer County starting in 2020. Currently they expect construction of the facility to begin in 2023-2024. This project will accept liquid manure for complete processing into renewables, commercial fertilizers and clean water. Several other technologies have been piloted since 2017, notably, the Quick Wash® Phosphorus Recovery system, which was selected as one of the top ten technologies in the State of Ohio. Mercer County has been collaborating on several ongoing pilot projects, grant applications and proposals for manure nutrient recovery systems.

- **Treatment Wetland and Natural Area Establishment:** Since the middle of 2017, several projects have been established. The Windy Point Wetland project was installed in late 2019 utilizing Ohio EPA Section 319 funds. The Gilliland Nature Preserve Wetland was installed in 2021 also utilizing Ohio EPA Section 319 funds. In 2022, the Burntwood-Langenkamp Wetland Conservation Area was established using H2Ohio funds through ODNR. The Coldwater Creek Nature and Wildlife Corridor was also established in conjunction with the Burntwood-Langenkamp project. Phase 1 of the Mercer Wildlife Area project was installed in 2022. Phase 2 is slated for construction in 2023 and Phase 3 in 2024. A treatment wetland on Monroe Creek will be included with Phase 3 of the Mercer Wildlife Area. The Big and Little Chickasaw Creek wetlands project is scheduled for construction in 2023. Several Clean Ohio applications have been submitted by the LFA and Mercer County to acquire more land in the watershed for development of additional wetland and natural spaces.

- **Littoral Area Vegetation:** Several plantings have been completed in the Phase 2 littoral wetland at Prairie Creek. Utilizing wetland plant plugs, a planting occurred in September 2019, June 2020 and June 2022. An aerial seeding mix using a drone is planned for early 2023 as a frost seeding.

- **Stream Restoration:** In 2019, approximately 2,000 feet of the west branch of Beaver Creek was restored using natural channel design principles. This project is located within the Mercer County Elks Golf course and is highly visible to the public. Field days and tours were held in 2020 at the site to promote the practice.

- **Saturated Buffer:** Utilizing an Ohio EPA Section 319 grant, the newly developed edge of field practice, the saturated buffer was installed on the east branch of Beaver Creek in 2020. A willing and cooperative landowner (St. Charles Center) allowed this project to be installed and monitored. Thanks to funding from the Blanchard River Demonstration Farms (Ohio Farm Bureau and NRCS), this project was monitored for nutrient removal data from 2021 through the end of 2022. Data from that monitoring project is located in Appendix B.

- **Aeration and Circulation:** The Lake Improvement Association continues to offer their lake channel aeration and circulation program, where channel owners can receive financial assistance to install linear aeration in their lake channels. The results and benefits from these implements indicated potential localized DO level and redox potential discontinuity improvements within those channels.

- **Sunset (West) Beach Improvements:** In 2018, the effort to improve and enhance Sunset Beach, along the northern shore of Grant Lake St. Marys began. A State Capital Improvement grant was received to trial water quality improvement technologies and add amenities to the site. Utilizing those funds, along with effort provided by ODNR's Division of Parks and Watercraft, the beach was successfully transformed. The 8-acre area was semi-enclosed and dredged by ODNR. This was followed up with the additional of sand along the shore, the installation of a boat and kayak launch, a playground, restroom improvements, including a picnic area and beach volleyball. Several studies on water quality technologies were completed, including the use of algicides, alum and Phoslock®. In 2022, working in cooperation with The Ohio State University, a trial was completed with ozone generators and nanobubblers. Ohio State will likely continue this research into the next few years to determine its effectiveness. Sunset Beach was able to remain open to the public during the majority of the recreation season in 2021 and 2022.

- **Nutrient Management:** Mercer and Auglaize SWCD's continue to update nutrient management plans for farmers every three years. This includes an inspection of the farm along with updated soil tests, manure tests, crop rotations and crop yields. The SWCD and NRCS offices continue to work with farmers to improve their operations and best utilize their nutrients. Farmers in the watershed have made enormous strides with installing best management practices since the inception of the SP. Every livestock headquarters has improved manure storage and management, clean water management and installed in-field and edge of field practices to prevent nutrient runoff from their farms. These efforts have been critical for the in-stream nutrient reductions that have been noted.

- **Governor DeWine's H2Ohio Program:** In late 2019, the State of Ohio announced the new H2Ohio program, designed to improve water quality across the State of Ohio. The Ohio Department of Agriculture (ODA) has been tasked with farmer programs to improve water quality, the Ohio Environmental Protection Agency (EPA) has been tasked with improving water and wastewater infrastructure across Ohio, and the Ohio Department of Natural Resources (ODNR) has been tasked with expanding natural infrastructure across Ohio. Mercer and Auglaize County producers have been fortunate to be eligible for ODA's programming since H2Ohio's inception. Farmers have been able to participate in cover cropping, small grains, manure application, subsurface nutrient application and more. ODNR has also funded several wetland construction projects in the watershed including the Burntwood-Langenkamp Wetland Conservation Area, the Mercer Wildlife Area project and the Southwest Greenspace project.

- **Communication:** The commission held a large tour for the State Agency Directors in 2017, 2019 and again in 2022. These events allow the commission to keep the state agencies and local officials informed of the state of GLSM and ongoing and future projects. The Lake Improvement Association holds monthly meetings to inform their members of ongoing and future efforts. The local media does an excellent job covering meetings to inform the general public. Several wetland project/natural spaces tours were held throughout the years. The Agriculture Education Series committee holds several tours and informational events each year as well, including events to update the public on the condition of GLSM and activity happening within the watershed.

# Appendix B – Annual Wetland Restoration Updates & Best Management Practice Studies

# Improving GLSM Water Quality Using Reconstructed Wetlands

Stephen J. Jacquemin[1], Theresa A. Dirksen[2], Phillip Poore[1], Nichole Mazzone[1], Tiffany Ricketts[1], Nicholas Gnau[1]

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[2] Agricultural Solutions, Mercer County Community and Economic Development Office, Celina OH

- Wetlands are essential components of healthy watersheds because they encourage habitat variability and increase biodiversity. They also provide essential ecosystem services such as nutrient processing and improving water quality
- Historically, wetlands dotted the landscape within the Grand Lake St. Marys (GLSM) watershed; however, due to land practice changes, the majority of these wetlands were altered or destroyed
- Treatment trains are an effort to reconstruct some of these wetlands to enhance habitat and improve water quality

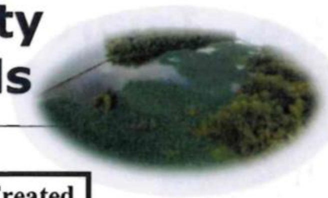
- Following the GLSM distressed watershed ruling in 2011, Prairie Creek and Coldwater Creek Treatment Trains were constructed in 2012 and 2015, respectively
- To assess the efficiency of these wetlands, monitoring of Coldwater Creek and Prairie Creek Treatment Trains began on June 1, 2017 with water samples collected weekly
- Inflow and outflow samples were tested for nitrate-N ($NO_3^-$), total phosphorus (TP) and dissolved reactive phosphorus (DRP) during the summer (June—August) and fall (September—November) 2017
- Flow in both the stream and the treatment train was monitored continuously to effectively determine the amount of stream flow being treated by the wetlands
- Pumps will be shut down during winter months (December—February) and resume in the spring (March—May)
- This summary sheet provides a synopsis of the 2017 summer and fall monitoring data and will contribute to the larger vision of a continued monitoring program to assess water quality in the region

| Coldwater Creek Treatment Train - Summer | | | Coldwater Creek Treatment Train - Fall | | |
|---|---|---|---|---|---|
| Parameter | Stream Concentration (mg/L) | TT % Removal | Parameter | Stream Concentration (mg/L) | TT % Removal |
| $NO_3^-$ | 3.28 | 40% | $NO_3^-$ | 0.36 | 21% |
| TP | 1.69 | 78% | TP | 1.08 | 25% |
| DRP | 0.39 | 46% | DRP | 0.20 | 0% |
| **Prairie Creek Treatment Train - Summer** | | | **Prairie Creek Treatment Train - Fall** | | |
| Parameter | Stream Concentration (mg/L) | TT % Removal | Parameter | Stream Concentration (mg/L) | TT % Removal |
| $NO_3^-$ | 5.35 | 41% | $NO_3^-$ | 0.44 | 32% |
| TP | 1.64 | 75% | TP | 1.04 | 71% |
| DRP | 0.72 | 88% | DRP | 0.27 | 85% |

Notes:
1. Weekly data collections were averaged by months and then averaged into seasons
2. Prairie Creek East outflow and West outflow were averaged

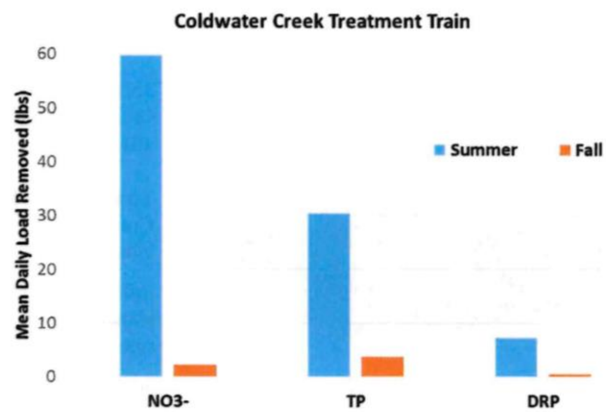
**Lake Restoration Commission**

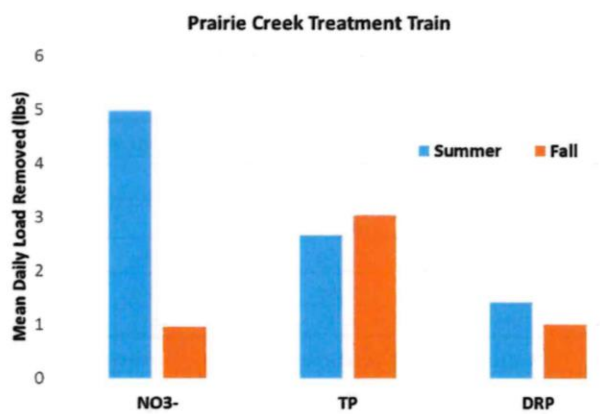
# Improving GLSM Water Quality Using Reconstructed Wetlands



| Coldwater Creek Treatment Train - % of Flow Actually Treated | |
|---|---|
| Summer | 29% |
| Fall | 35% |
| **Prairie Creek Treatment Train - % of Flow Actually Treated** | |
| Summer | 10% |
| Fall | 40% |

Note: Data collected from depth loggers installed in treatment train outfalls was compared to the historical 10-year average USGS in-stream flow region data




**Acknowledgements**

Thank you to Sean Finke (Ohio Department of Natural Resources, Division of Wildlife) for managing the treatment trains and to Abbey Hayward (former Grand Lake/Wabash Watershed Alliance) for historical records of Prairie Creek

**Lake Restoration Commission**

# Improving GLSM Water Quality Using Reconstructed Wetlands

Stephen J. Jacquemin[1], Theresa A. Dirksen[2], Phillip Poore[1], Gestawn McDonald[1], Chase Cobb[1], Jocelyn Birt[1]

[1] Agricultural and Water Quality Educational Center, Wright State University – Lake Campus, Celina, OH
[2] Agricultural Solutions, Mercer County Community and Economic Development Office, Celina OH

- Wetlands are essential components of healthy watersheds because they encourage habitat variability and increase biodiversity. They also provide essential ecosystem services such as nutrient processing and improve water quality
- Historically, wetlands dotted the landscape within the Grand Lake St. Marys (GLSM) watershed; however, due to land practice changes, the majority of these wetlands were altered or destroyed
- Treatment trains are an effort to reconstruct some of these wetlands to enhance habitat and improve water quality

- Following the GLSM distressed watershed ruling in 2011, Prairie Creek and Coldwater Creek Treatment Trains were constructed in 2012 and 2015, respectively
- To assess the efficiency of these wetlands, monitoring of Coldwater Creek and Prairie Creek Treatment Trains began on June 1, 2017 with water samples collected weekly
- Inflow and outflow samples were tested for nitrate-N ($NO_3^-$), total phosphorus (TP) and dissolved reactive phosphorus (DRP) during the spring (March—May), summer (June—August) and fall (September—November)
- Flow in both the stream and the treatment train was monitored continuously to effectively determine the amount of stream flow being treated by the wetlands
- Pumps are shut down during winter months (December—February)
- This summary sheet provides a synopsis of the June 2017—November 2018 monitoring data and will contribute to the larger vision of a continued monitoring program to assess water quality in the region

**Coldwater Creek Treatment Train**

| | Spring | | Summer | | Fall | | Winter | |
|---|---|---|---|---|---|---|---|---|
| Parameter | Stream Concentration (mg/L) | Percent Removal | Stream Concentration (mg/L) | Percent Removal | Stream Concentration (mg/L) | Percent Removal | Stream Concentration (mg/L) | Percent Removal |
| $NO_3^-$-N | 9.56 | 53% | 3.86 | 81% | 4.06 | 66% | 4.68 | 0% |
| TP-P | 0.28 | 55% | 0.44 | 65% | 0.34 | 37% | 0.16 | 0% |
| DRP-P | 0.11 | 74% | 0.15 | 46% | 0.10 | 5% | 0.06 | 0% |

**Prairie Creek Treatment Train**

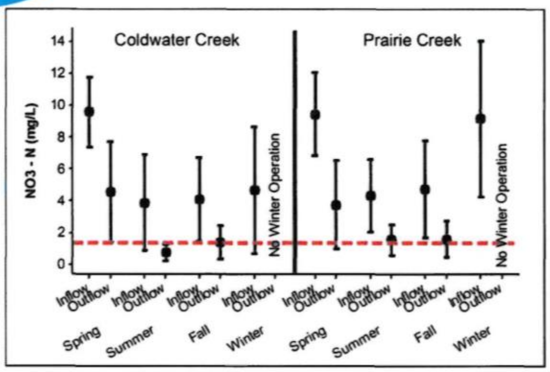
| | Spring | | Summer | | Fall | | Winter | |
|---|---|---|---|---|---|---|---|---|
| Parameter | Stream Concentration (mg/L) | Percent Removal | Stream Concentration (mg/L) | Percent Removal | Stream Concentration (mg/L) | Percent Removal | Stream Concentration (mg/L) | Percent Removal |
| $NO_3^-$-N | 9.43 | 60% | 4.29 | 64% | 4.71 | 67% | 9.15 | 0% |
| TP-P | 0.26 | 38% | 0.35 | 70% | 0.33 | 65% | 0.11 | 0% |
| DRP-P | 0.08 | 87% | 0.15 | 94% | 0.12 | 88% | 0.05 | 0% |

Notes: 1. Data shown here represent weekly data collections values averaged by season
2. Prairie Creek East and West outflows have been averaged into a single outflow value

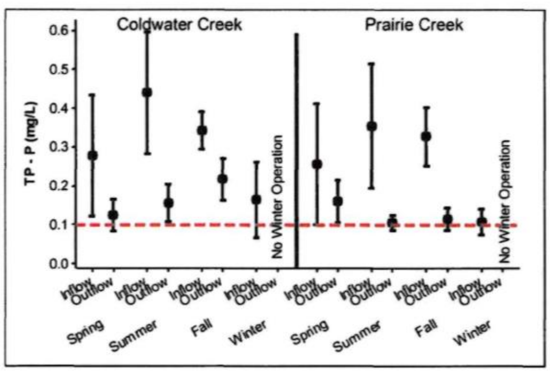
**Lake Restoration Commission**

# Improving GLSM Water Quality Using Reconstructed Wetlands

| Mean Daily Stream Flow (million gallons per day) | | | |
|---|---|---|---|
| Coldwater Creek | | Prairie Creek | |
| Season | MGPD | Season | MGPD |
| Spring | 23 | Spring | 6 |
| Summer | 9 | Summer | 2 |
| Fall | 5 | Fall | 1 |
| Winter | 20 | Winter | 5 |




| Target Wetland Flow Rate (million gallons per day) | | | |
|---|---|---|---|
| Coldwater Creek | | Prairie Creek | |
| Season | MGPD | Season | MGPD |
| Spring | 2 | Spring | 1.5 |
| Summer | 3.5 | Summer | 1.5 |
| Fall | 2 | Fall | 1.5 |
| Winter | 0 | Winter | 0 |




| Target Percentage of Creek Flow Treated | | | |
|---|---|---|---|
| Coldwater Creek | | Prairie Creek | |
| Season | Percent of Flow | Season | Percent of Flow |
| Spring | 8% | Spring | 25% |
| Summer | 40% | Summer | 66% |
| Fall | 42% | Fall | 100% |
| Winter | 0% | Winter | 0% |

Note: Red lines denote recommended concentration targets for nutrient loading

**Acknowledgements**

The Lake Restoration Commission would like to acknowledge and thank Sean Finke (Ohio Department of Natural Resources) for managing the GLSM wetlands, Abbey Hayward (former Grand Lake/Wabash Watershed Alliance Coordinator) for providing historical records of Prairie Creek, and to past Wright State University—Lake Campus students (Nichole Mazzone, Nicholas Gnau) for all of their efforts in monitoring and promoting conservation in the region.

**Lake Restoration Commission**

# Grand Lake St. Marys Watershed 2019 Update— Reconstructed Wetlands

Stephen J. Jacquemin[1], Theresa A. Dirksen[2], Jocelyn Birt[1], Benjamin Strang[1], Conner Ewing[1], Bradley Axe[1]

[1] Agricultural and Water Quality Educational Center, Wright State University – Lake Campus, [2] Mercer County Community and Economic Development Office

- Wetlands are essential components of healthy watersheds because they improve water quality by sequestering nutrients and reducing runoff rates, provide habitat for wildlife by increasing habitat variability, improve groundwater conditions by providing recharge points, and enhance public resource use potential by providing increased opportunities for recreation and education.

- Historical GLSM watershed surveys dating from the late 1800s to early 1900s indicate that nearly 100% of the south shore as well as a large percentage of the eastern and northern shores were lined with expansive wetland areas. However, due to land practice changes, almost all of these wetlands have been altered or destroyed.

- Following the GLSM Distressed Watershed ruling in 2011, Prairie Creek and Coldwater Creek wetlands were constructed in an effort to restore a portion of these once expansive wetlands. Prairie Creek wetlands (restored 2012) encompass 30 acres of restored habitat (0.9% of total area) plus an additional 70 acres of forested wetlands, draining an upstream watershed of 3,500 acres. Coldwater Creek (restored 2015) wetlands encompass 32 acres of restored habitat (0.3% of total area), draining an upstream watershed of 12,400 acres.

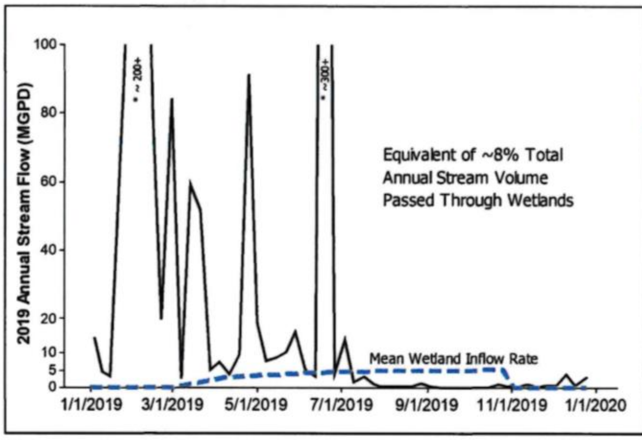
- To assess the efficiency of these wetlands for improving water quality in the region, weekly monitoring began in 2017. Monitoring consists of measuring stream and wetland flow volumes and testing for nitrate-N ($NO_3^-$), total phosphorus (TP), dissolved reactive phosphorus (DRP), and total suspended solids (TSS) during spring (March-May), summer (June-August), and fall (September-November) when water is actively pumped through the systems.

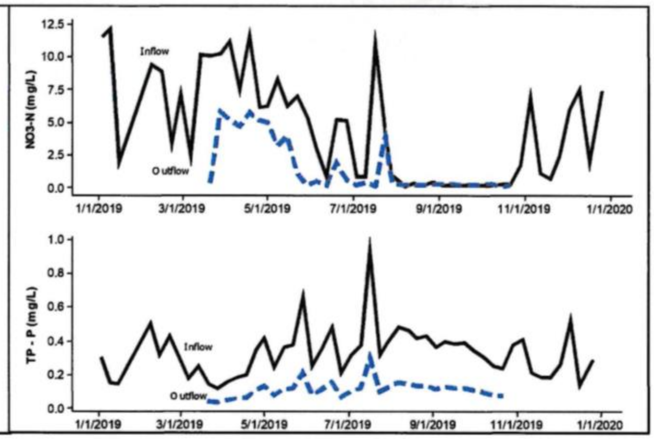
| Coldwater Creek - 2019 | | | | |
|---|---|---|---|---|
| Variable | Season | Avg. Stream Conc. (mg/L) | Avg. Conc. Reduction | Load Reduction (lb) |
| $NO_3^-$ | Winter | 7.04 | 0% | 0 |
| | Spring | 7.92 | 47% | 4,000 |
| | Summer | 2.56 | 46% | 4,500 |
| | Fall | 1.13 | 0% | 0 |
| TP | Winter | 0.31 | 0% | 0 |
| | Spring | 0.28 | 49% | 175 |
| | Summer | 0.42 | 51% | 550 |
| | Fall | 0.31 | 5% | 60 |
| DRP | Winter | 0.18 | 0% | 0 |
| | Spring | 0.13 | 90% | 130 |
| | Summer | 0.16 | 64% | 300 |
| | Fall | 0.11 | 63% | 90 |
| TSS | Winter | 29 | 0% | 0 |
| | Spring | 68 | 2% | 40,000 |
| | Summer | 55 | 54% | 90,000 |
| | Fall | 34 | 0% | 0 |

| Prairie Creek - 2019 | | | | |
|---|---|---|---|---|
| Variable | Season | Avg. Stream Conc. (mg/L) | Avg. Conc. Reduction | Load Reduction (lb) |
| $NO_3^-$ | Winter | 7.3 | 0% | 0 |
| | Spring | 8.8 | 67% | 1,200 |
| | Summer | 2.3 | 43% | 1,200 |
| | Fall | 1.8 | 31% | 0 |
| TP | Winter | 0.25 | 0% | 0 |
| | Spring | 0.29 | 86% | 62 |
| | Summer | 0.35 | 84% | 220 |
| | Fall | 0.27 | 70% | 95 |
| DRP | Winter | 0.12 | 0% | 0 |
| | Spring | 0.13 | 86% | 38 |
| | Summer | 0.13 | 84% | 105 |
| | Fall | 0.06 | 70% | 22 |
| TSS | Winter | 18 | 0% | 0 |
| | Spring | 45 | 1% | 0 |
| | Summer | 33 | 37% | 12,225 |
| | Fall | 30 | 65% | 6,700 |

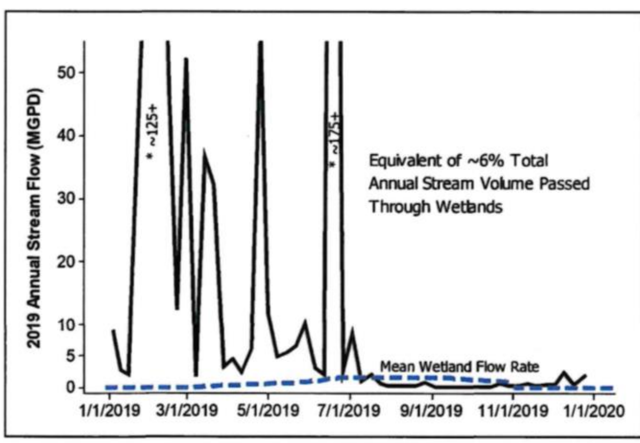
Lake Restoration Commission

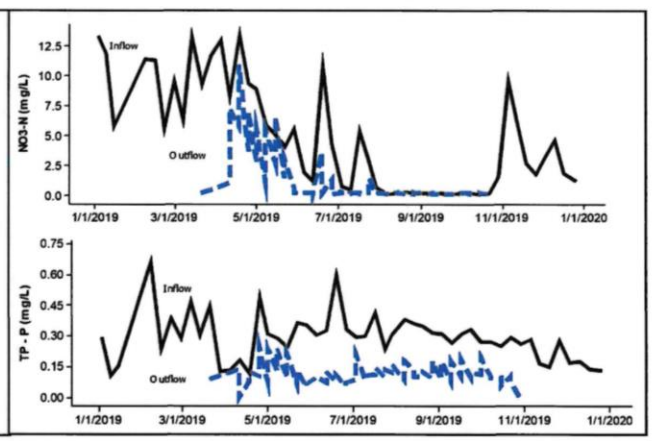
## Coldwater Creek Wetlands




## Prairie Creek Wetlands




**Acknowledgements**

The Lake Restoration Commission would like to acknowledge and thank the many individuals and organizations whose dedication and hard work in the region have served as the basis for the restoration, maintenance, operation, and monitoring of these wetland projects. In particular, the LRC thanks the Ohio Department of Natural Resources (notably, Sean Finke) for managing and maintaining the GLSM wetlands, the many local donors and partners (especially, G.A. Wintzer & Son) whose generous contributions have facilitated implementation of many water quality initiatives, local watershed groups (such as the Lake Improvement Association) who have worked to inform the public of lake status updates, news, and events, as well as past Wright State University—Lake Campus Students (N. Mazzone, N. Gnau, P. Poore, G. MacDonald) and GLSM Watershed Coordinators (A. Hayward) for their efforts in monitoring water quality as well as promoting conservation in the region. Lastly, we wish to thank the late Dr. Thomas Knapke, whose tireless work in the watershed brought people together towards a common goal of a cleaner and healthier environment for future generations.

# Grand Lake St. Marys Watershed 2020 Update – Reconstructed Wetlands

Stephen J. Jacquemin[1], Theresa A. Dirksen[2], Benjamin Strang[1], Conner Ewing[1]

[1] Agricultural and Water Quality Educational Center, Wright State University – Lake Campus, [2] Mercer County Community and Economic Development Office

- Wetlands are essential pieces of healthy environments because they filter nutrients, reduce runoff, recharge groundwater, provide wildlife habitat, and enhance public resource use by providing opportunities for recreation and education.

- Despite the innumerable benefits of wetlands, these natural spaces have experienced tremendous declines as estimates across the United States suggest that well over 50% have been destroyed. Wetland declines are even more apparent in some watersheds, such as Grand Lake St Marys, where almost all original wetland areas have been lost.

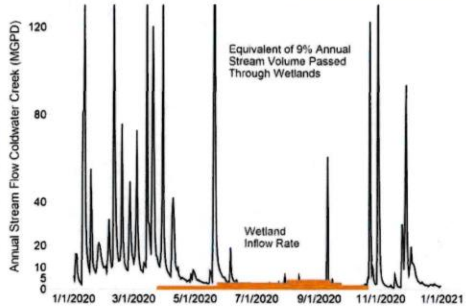
- Recent years have seen wetland acreage in GLSM increase, as stream side wetlands adjacent to Prairie Creek, Coldwater Creek, and Beaver Creek as well as many acres of in lake littoral wetlands have been restored. The continued restoration and monitoring of wetland spaces is critical towards realizing improved water quality and environmental health both in GLSM and beyond.

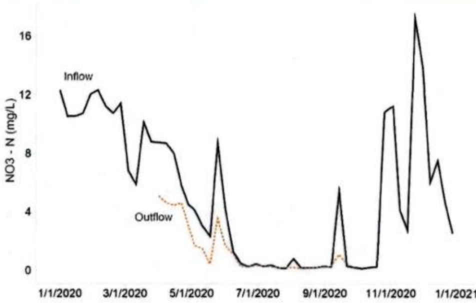
- GLSM wetlands have been monitored for nutrients and sediment weekly since 2017 in an effort to improve our understanding of their importance for both the local community and beyond. In GLSM, wetland acreage is expected to rise in the future as additional wetland treatment systems are already in the planning and implementation stages.

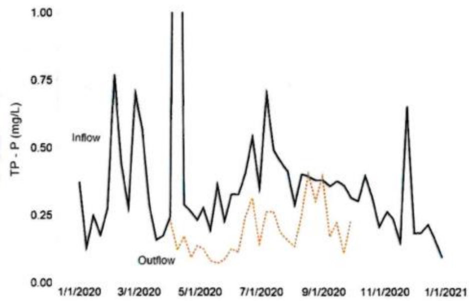
| Coldwater Creek Wetlands - 2020 | | | | | Prairie Creek Wetlands - 2020 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Variable | Season | Avg. Stream Conc. (mg/L) | Avg. Conc. Reduction | Load Reduction (lb) | Variable | Season | Avg. Stream Conc.(mg/L) | Avg. Conc. Reduction | Load Reduction (lb) |
| NO3 - N | Winter | 9.7 | 0% | 0 | NO3 - N | Winter | 11.75 | 0% | 0 |
| | Spring | 6.5 | 48% | 2,025 | | Spring | 9.63 | 45% | 900 |
| | Summer | 0.63 | 19% | 425 | | Summer | 1.21 | 7% | 300 |
| | Fall | 5.11 | 1% | 530 | | Fall | 5.77 | 0% | 60 |
| TP - P | Winter | 0.31 | 0% | 0 | TP - P | Winter | 0.22 | 0% | 0 |
| | Spring | 0.48 | 56% | 310 | | Spring | 0.4 | 41% | 80 |
| | Summer | 0.42 | 43% | 335 | | Summer | 0.42 | 43% | 155 |
| | Fall | 0.32 | 47% | 70 | | Fall | 0.31 | 35% | 50 |
| DRP - P | Winter | 0.16 | 0% | 0 | DRP - P | Winter | 0.08 | 0% | 0 |
| | Spring | 0.13 | 91% | 80 | | Spring | 0.08 | 66% | 15 |
| | Summer | 0.15 | 29% | 120 | | Summer | 0.11 | 74% | 80 |
| | Fall | 0.08 | 0% | 0 | | Fall | 0.08 | 43% | 5 |
| TSS | Winter | 48 | 0% | 0 | TSS | Winter | 23 | 0% | 0 |
| | Spring | 78 | 74% | 55,000 | | Spring | 53 | 14% | 5,000 |
| | Summer | 47 | 60% | 55,000 | | Summer | 39 | 0% | 1,850 |
| | Fall | 40 | 88% | 20,000 | | Fall | 38 | 4% | 4,250 |

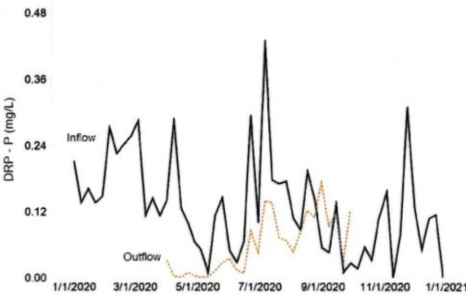
Lake Restoration Commission

## Coldwater Creek Wetlands

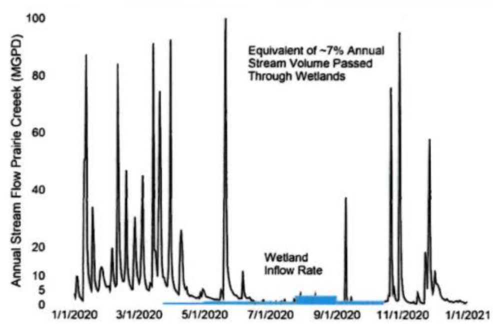



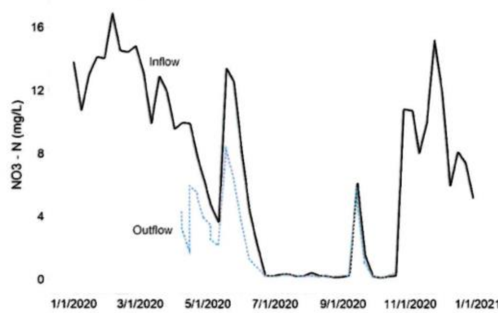



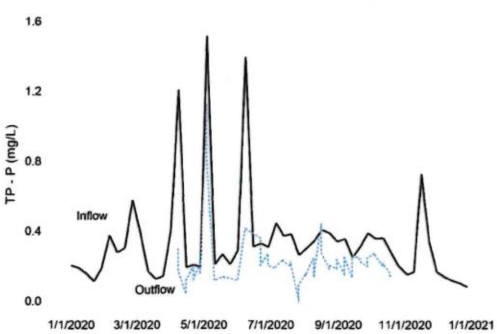



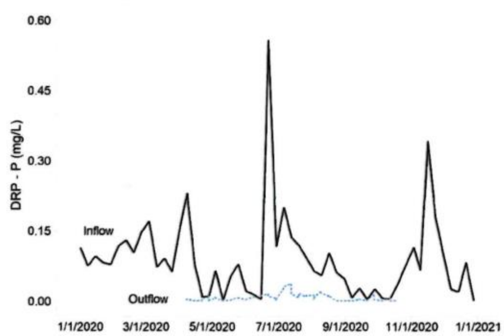

## Prairie Creek Wetlands





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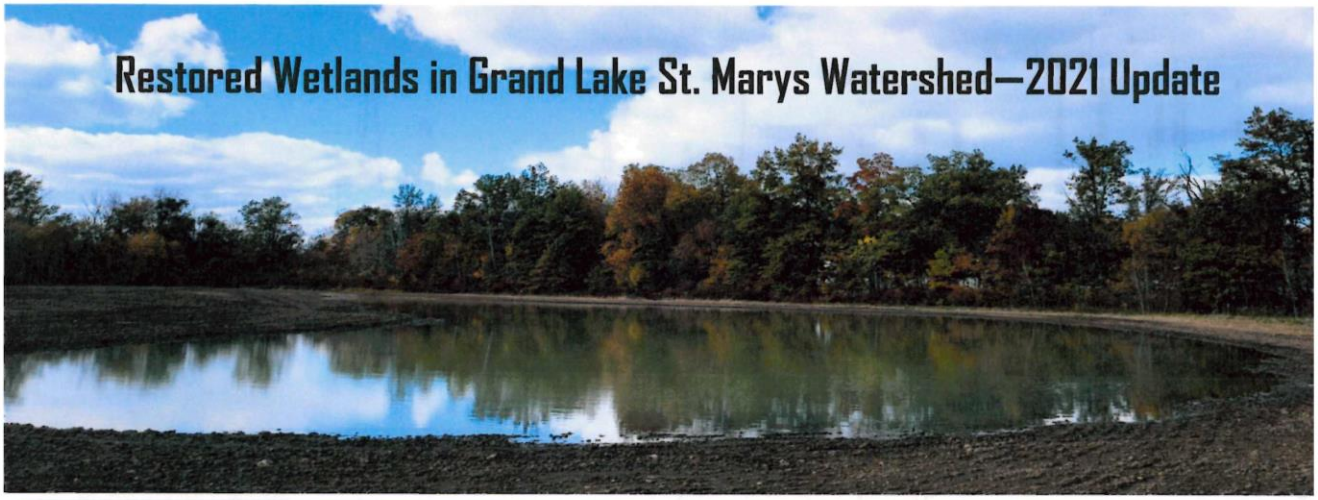
# Restored Wetlands in Grand Lake St. Marys Watershed—2021 Update



Stephen J. Jacquemin[1], Theresa A. Dirksen[2], Marie Zehringer[1], Kenneth Kline[1]

[1] Agricultural and Water Quality Educational Center, Wright State University – Lake Campus, [2] Mercer County Community and Economic Development Office

- Wetlands are essential parts of healthy environments because they filter nutrients, reduce runoff, recharge groundwater, provide wildlife habitat, and enhance public resource use by providing opportunities for recreation and education. Despite the innumerable benefits of wetlands, however, these natural spaces have experienced tremendous declines on a global level.

- In the United States, evaluations suggest that over 50% of wetland areas have been destroyed. Specific to Grand Lake St. Marys (GLSM), historical land surveys indicate that almost all original wetlands (estimated to have once constituted 30+% of watershed) have been lost.

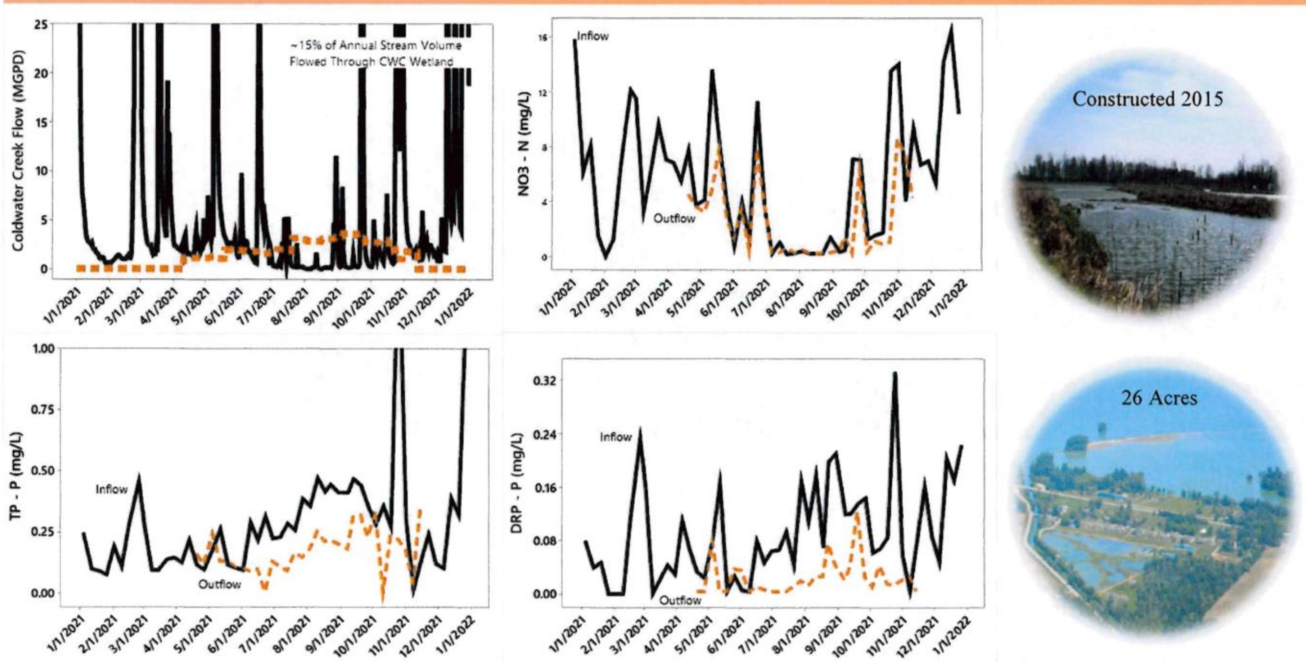
- However, in the past decade, GLSM has realized increases in wetland acreages as recent inventories indicate around 1,000 wetland acres (~1.5% watershed area) now exist. GLSM restored wetlands now include a variety of restored floodplains, flow through complexes, channel backwaters, edge of field pockets, and in-lake littoral systems. Several additional wetland areas are planned for 2022.

- The continued restoration and monitoring of wetlands is critical towards realizing improved water quality both in GLSM and beyond. Numerous GLSM wetlands have been monitored for nutrients, sediment, and hydrology on a weekly basis since 2017 to improve our understanding of their potential to improve water quality. Below are data from two of our long-standing focal sites from 2021.

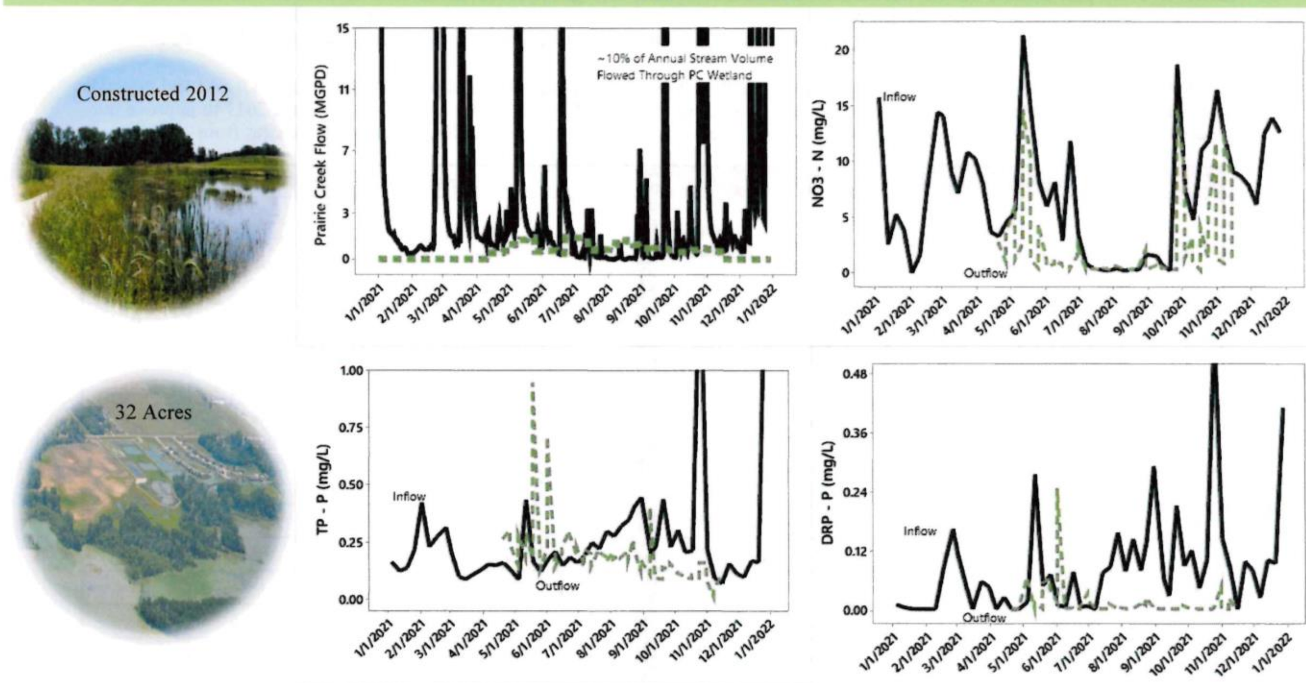
| Coldwater Creek Wetlands - 2021 | | | | | Prairie Creek Wetlands - 2021 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Variable | Season | Avg. Stream Conc. (mg/L) | Avg. Conc. Reduction | Load Reduction (lb) | Variable | Season | Avg. Stream Conc.(mg/L) | Avg. Conc. Reduction | Load Reduction (lb) |
| NO3 - N | Winter | 7.8 | 0% | 0 | NO3 - N | Winter | 8.39 | 0% | 0 |
| | Spring | 6.2 | 37% | 965 | | Spring | 8.54 | 59% | 2,502 |
| | Summer | 1.5 | 20% | 325 | | Summer | 1.79 | 66% | 1,202 |
| | Fall | 7.1 | 53% | 2,665 | | Fall | 9.72 | 56% | 1,215 |
| TP - P | Winter | 0.88 | 0% | 0 | TP - P | Winter | 1.02 | 0% | 0 |
| | Spring | 0.46 | 12% | 55 | | Spring | 0.49 | -80% | -216 |
| | Summer | 1.07 | 54% | 1,250 | | Summer | 0.8 | 25% | 132 |
| | Fall | 1.06 | 39% | 570 | | Fall | 0.9 | 65% | 281 |
| DRP - P | Winter | 0.27 | 0% | 0 | DRP - P | Winter | 0.24 | 0% | 0 |
| | Spring | 0.14 | 56% | 28 | | Spring | 0.14 | 11% | 38 |
| | Summer | 0.34 | 81% | 631 | | Summer | 0.27 | 91% | 154 |
| | Fall | 0.35 | 73% | 198 | | Fall | 0.4 | 94% | 147 |
| TSS | Winter | 52 | 0% | 0 | TSS | Winter | 48 | Due to settling pond excavation efforts, TSS values not reported. | |
| | Spring | 24 | -30% | -5,080 | | Spring | 24 | | |
| | Summer | 32 | 10% | 6,251 | | Summer | 22 | | |
| | Fall | 44 | 88% | 16,571 | | Fall | 36 | | |

Lake Restoration Commission

## Coldwater Creek Wetlands




## Prairie Creek Wetlands

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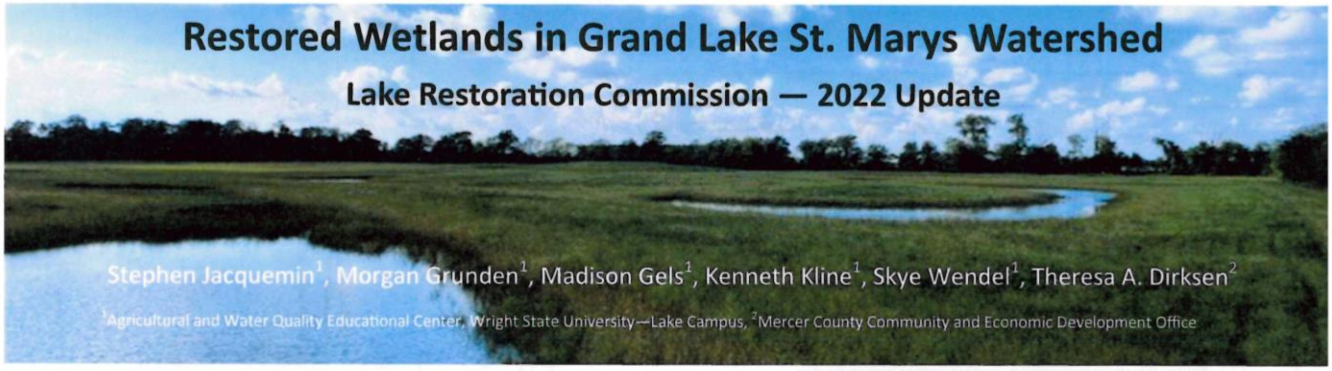


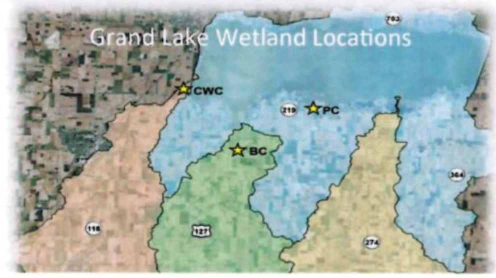
# Restored Wetlands in Grand Lake St. Marys Watershed

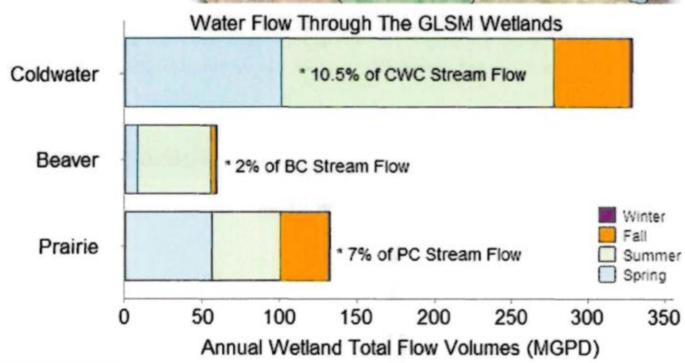
## Lake Restoration Commission — 2022 Update

Stephen Jacquemin[1], Morgan Grunden[1], Madison Gels[1], Kenneth Kline[1], Skye Wendel[1], Theresa A. Dirksen[2]

[1]Agricultural and Water Quality Educational Center, Wright State University—Lake Campus, [2]Mercer County Community and Economic Development Office

- Wetlands filter nutrients, reduce runoff, recharge groundwater, provide wildlife habitat, and enhance public outdoor recreation.
- Despite their ecological importance, however, these spaces have seen tremendous declines on the state and regional level — historical land surveys indicate that the majority of original wetlands (90+%) in the state of Ohio and Grand Lake St Marys (GLSM) watershed have been lost.
- However, in the past decade, over 1,000 wetland acres have been added to the GLSM watershed (~1.5+% watershed area). GLSM restored wetlands include a variety of restored floodplains, flow-through complexes, channel backwaters, edge of field pockets, and in-lake littoral systems.
- The continued restoration and monitoring of wetlands is critical to improving water quality in GLSM and beyond. Several additional GLSM wetlands are planned for 2023.
- Year round weekly monitoring of nutrients (dissolved phosphorus SRP, dissolved nitrogen NOx, total phosphorus (TP), sediment (TSS), and hydrology began in 2017 and continues to improve our understanding of the potential for wetlands to improve water quality. Below are data from three of our long-standing sites from 2022.

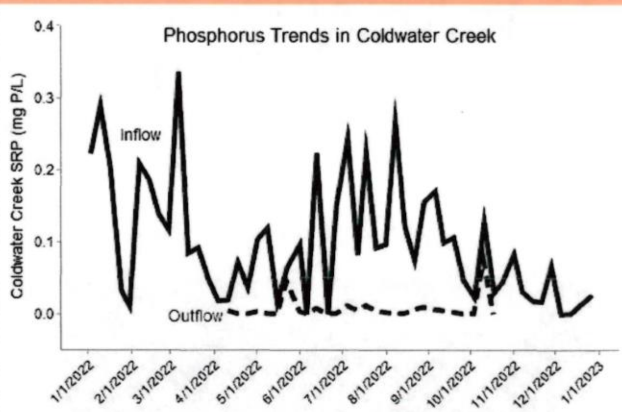



## Coldwater Creek Wetlands

| Coldwater Creek Wetlands - 2022 | | | | |
|---|---|---|---|---|
| Variable | Season | Avg. Stream Conc. (mg/L) | Avg. Conc. Reduction (%) | Load Reduction (lbs) |
| NO3-N | Winter | 7.26 | * | 0 |
| | Spring | 8.56 | 51% | 3025 |
| | Summer | 1.41 | 48% | 955 |
| | Fall | 0.82 | 60% | -25 |
| TP-P | Winter | 1.22 | * | 0 |
| | Spring | 0.71 | 19% | 30 |
| | Summer | 1.27 | 55% | 340 |
| | Fall | 0.85 | -4% | 40 |
| SRP-P | Winter | 0.17 | * | 0 |
| | Spring | 0.07 | 91% | 50 |
| | Summer | 0.14 | 96% | 200 |
| | Fall | 0.05 | 68% | 25 |
| TSS | Winter | 95.5 | * | 0 |
| | Spring | 47.2 | 0% | -3450 |
| | Summer | 40.4 | 2% | 1305 |
| | Fall | 38.0 | -50% | -1260 |

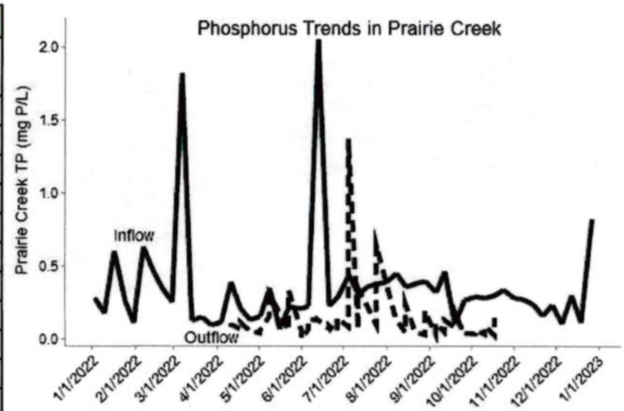
** CWC was a sediment source at times due to bioturbation from rough fish populations*




## Prairie Creek Wetlands

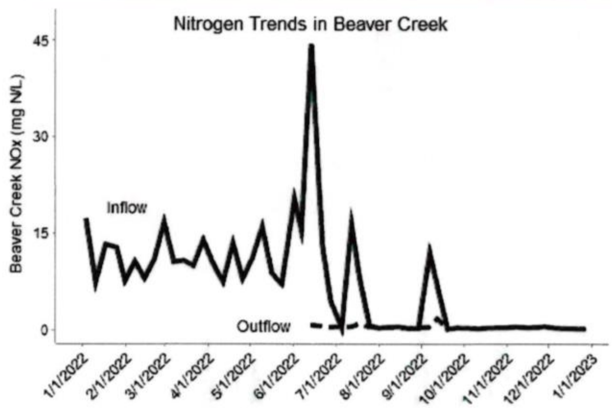
| Prairie Creek Wetlands - 2022 | | | | |
|---|---|---|---|---|
| Variable | Season | Avg. Stream Conc. (mg/L) | Avg. Conc. Reduction (%) | Load Reduction (lbs) |
| NO3-N | Winter | 7.61 | * | 0 |
| | Spring | 8.59 | 42% | 1400 |
| | Summer | 1.30 | 44% | 255 |
| | Fall | 0.34 | 39% | 48 |
| TP-P | Winter | 0.46 | * | 0 |
| | Spring | 0.34 | 66% | 95 |
| | Summer | 0.37 | 46% | 103 |
| | Fall | 0.24 | 70% | 48 |
| SRP-P | Winter | 0.19 | * | 0 |
| | Spring | 0.07 | 77% | 35 |
| | Summer | 0.09 | 86% | 30 |
| | Fall | 0.03 | 79% | 6 |
| TSS | Winter | 71.10 | * | 0 |
| | Spring | 36.77 | 55% | 9435 |
| | Summer | 45.25 | -74% | 12510 |
| | Fall | 35.75 | 55% | 8800 |

** PC was a sediment source at times in 2021 due to bioturbation from rough fish but winter 21-22 management actions facilitated overall improvement for 2022*





## Beaver Creek Wetlands





| Beaver Creek Wetlands - 2022 | | | | |
|---|---|---|---|---|
| Variable | Season | Avg. Stream Conc. (mg/L) | Avg. Conc. Reduction (%) | Load Reduction (lbs) |
| NO3-N | Winter | 11.49 | * | 0 |
| | Spring | 14.36 | * | 2110 |
| | Summer | 4.91 | 89% | 1844 |
| | Fall | 0.41 | * | -4 |
| TP-P | Winter | 0.48 | * | 0 |
| | Spring | 0.19 | * | 16 |
| | Summer | 0.57 | 28% | 73 |
| | Fall | 0.29 | * | -2 |
| SRP-P | Winter | 0.23 | * | 0 |
| | Spring | 0.08 | * | 6 |
| | Summer | 0.38 | 25% | 46 |
| | Fall | 0.15 | * | -6 |
| TSS | Winter | 125.90 | * | 0 |
| | Spring | 48.00 | * | 7030 |
| | Summer | 33.46 | 74% | 9720 |
| | Fall | 23.92 | * | 185 |

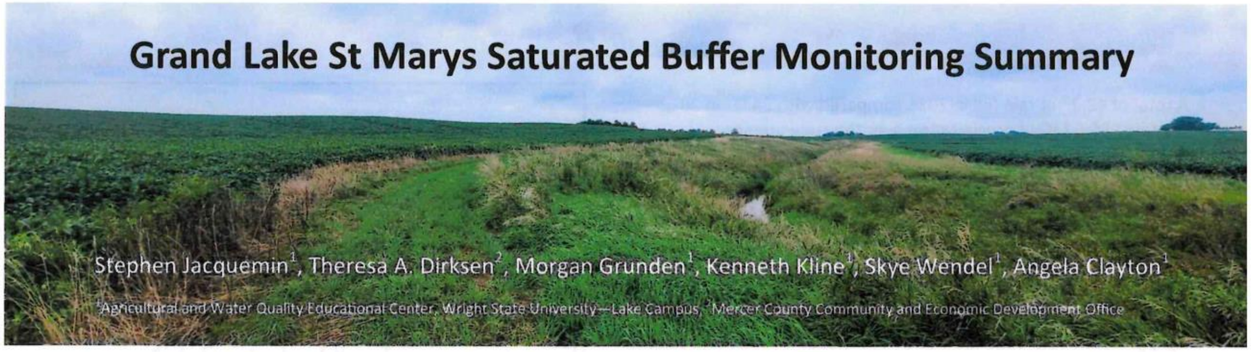
** BC operated for the first time this year and established baseline characteristics for future reference. Note that inflow volume at the site led to outflows primarily during the summer with water pumped in other times of year for settling sediment.*

## Grand Lake St Marys Lake Restoration Commission

**Acknowledgements**

The LRC would like to acknowledge those whose dedication to conservation has supported the restoration of these wetlands: the ODNR (Sean Finke), local donors (G.A. Wintzer & Son), watershed groups (Lake Improvement Association), past WSU—Lake Campus technicians, and the late Dr. Thomas Knapke.

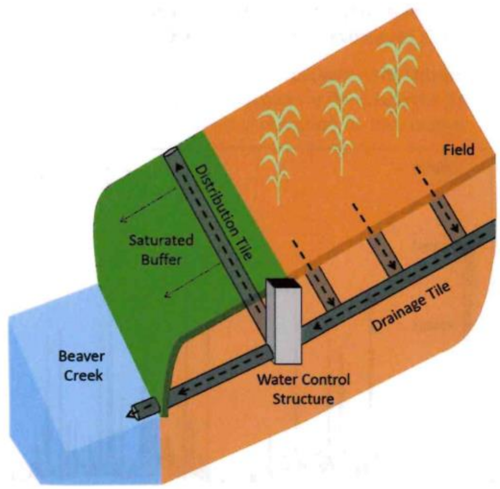
# Grand Lake St Marys Saturated Buffer Monitoring Summary



Stephen Jacquemin[1], Theresa A. Dirksen[2], Morgan Grunden[1], Kenneth Kline[1], Skye Wendel[1], Angela Clayton[1]

[1]Agricultural and Water Quality Educational Center, Wright State University—Lake Campus, [2]Mercer County Community and Economic Development Office

- Saturated buffers are a conservation practice which diverts subsurface tile drainage water through restored riparian areas.
- Rerouted water is distributed laterally from a perforated distribution tile via a control structure where gravity can then gradually move water through the riparian soils as it makes its way to an adjacent stream.
- Changing the flow of water from a typical tile flowing directly into the stream to one that moves through the riparian subsurface reduces flashiness of field discharge, allows the ground to saturate and hold more water, and provides an opportunity for nutrient reduction through adsorption with sediment, uptake from riparian vegetation, as well as denitrification.
- Ideal sites should have a riparian buffer planted with grasses/trees/shrubs, be at least 30' wide, be lower in elevation than the field, have soils that contain at least 1.2% organic matter, contain loam like soils to facilitate gradual water movement, and have a stable stream bank (NRCS CPS Code 604).
- As saturated buffers are a relatively new practice, they are currently underutilized with much potential to expand across the state of Ohio.
- Grand Lake St Marys Watershed has struggled with excess nutrient loading for decades— however, with recent conservation efforts showing promise, this tool could be a positive addition to further improve water quality.




** Conceptual schematic of a saturated buffer*

## St Charles Center Saturated Buffer Design

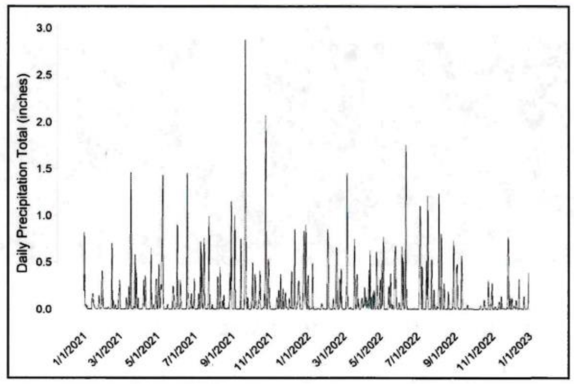
- Study area was a 27 acre subwatershed field adjacent to Beaver Creek that has historically been no-till corn/soybean with rye cover crop.
- Riparian area was approximately 30' wide planted with mixture of tolerant grasses (e.g. orchard, timothy, alfalfa, clover, milkweed, susan).
- Predominant soils were Blount silt loams (60%) and Glynwood silt/clay loams (33%) in field with Eel silt loams along the riparian (5%).
- Survey elevations of field ranged from 918'-938', riparian from 914'-917', and stream from 903'-905' (overall field slope of 2.6%).
- Saturated buffer was installed using 1200' of 8'' distribution tile set at 910' (elevation) connected to a 12'' wide 3-chambered water control structure.
- A network of buffer groundwater wells were installed at 5', 10', and 20' intervals to assess water quality changes as water moved away from the distribution tile.
- Adjacent to the study watershed, a paired watershed draining 37 acres was used to record free flowing drainage (no control box) as a reference.
- Hydrology of the site was consistently monitored while water sampling for nutrient analyses took place immediately following ½''+ rain events.
- Before and after soil sampling from established strata horizons (O, A, E, B, C) was also conducted to assess nutrient changes in the riparian and field areas.


** Study site outline and setup*

** This site is the second saturated buffer in Mercer County and the first of its kind in the Grand Lake St Marys Watershed*

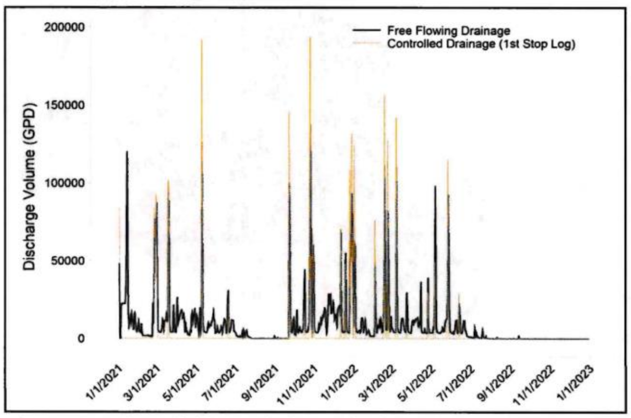
## Precipitation and Field Drainage Discharge

- A total of 42.2'' of rain fell in 2021 compared with 34.9'' in 2022 — totaling ~56.6 MG of precipitation over the subwatershed.
- The adjacent subwatershed tile discharge was watershed weighted to match drainage sizes to provide an estimate of what tile flows *would have been* at the buffer study site had no control box been present.
- Adjusted total subsurface tile volumes from the free flowing comparison site indicated ~6.75 MG drained into the stream.
- The super majority of discharge from the study site occurred over 10 days or less in both 2021 (60% of all volume) and 2022 (85% volume).
- Field tiles under controlled drainage ran 45 and 25 days in 2021 and 2022, respectively, compared to 300 and 189 days under free drainage.
- Precipitation that did not make its way to the tiles likely either ran off as surface runoff or seepage, was taken up by growing crops, evaporated, or remained in the soil.



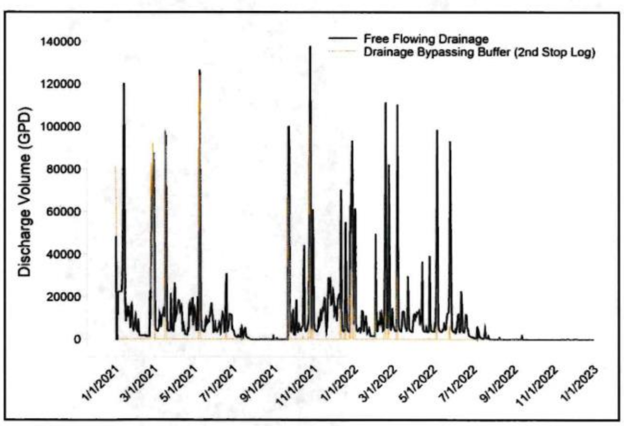

** Daily rainfall totals over the two year study period*

** View of the free flowing drainage comparison site*




** Comparison of controlled drainage discharge vs free flowing drainage discharge volumes*

- A total of 3.3 MG drained from the study field (first stop log) —representing ~48% of the total flow that *would have drained* with no control box.
- A total of 1.4 MG drained over the second stop log, bypassing the buffer section of the control box — representing ~21% of the total flow.



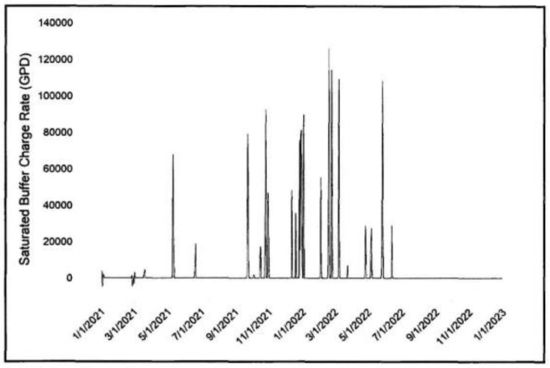

** Comparison of discharge bypassing the saturated buffer vs free flowing volumes*

**Flow Data (Volumes in Total Gallons)**

| Year | Variable | Winter | Spring | Summer | Fall |
|---|---|---|---|---|---|
| 2021 | Free Flowing Site Discharge | 1,733,999 | 1,144,372 | 200,813 | 1,483,628 |
| | Field Discharge | 998,306 | 362,555 | 30,069 | 770,716 |
| | Discharge Bypassing Buffer | 668,239 | 250,092 | 3,537 | 313,017 |
| 2022 | Free Flowing Site Discharge | 1,026,961 | 1,052,088 | 101,155 | 409 |
| | Field Discharge | 798,311 | 305,074 | 0 | 0 |
| | Discharge Bypassing Buffer | 147,118 | 30,872 | 0 | 0 |

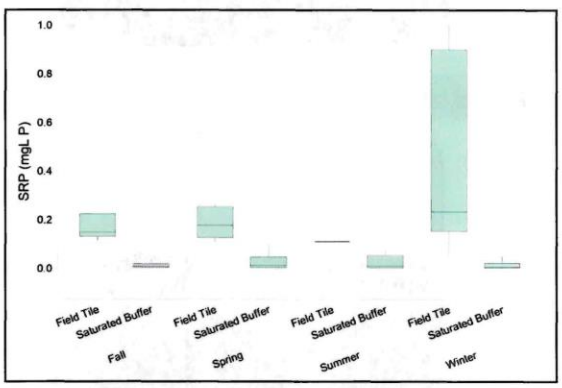
** Saturated buffers provide valuable wildlife habitat—during this studies, dozens of species of birds were noted*

## Nutrient Reductions




** Calculated from flow volume leaving the field minus volume leaving the buffer*

| Saturated Buffer Charge Total Volume (Gallons) | | |
|---|---|---|
| **Season** | **2021** | **2022** |
| Winter | 330,067 | 651,193 |
| Spring | 112,463 | 274,202 |
| Summer | 26,532 | 0 |
| Fall | 457,699 | 0 |



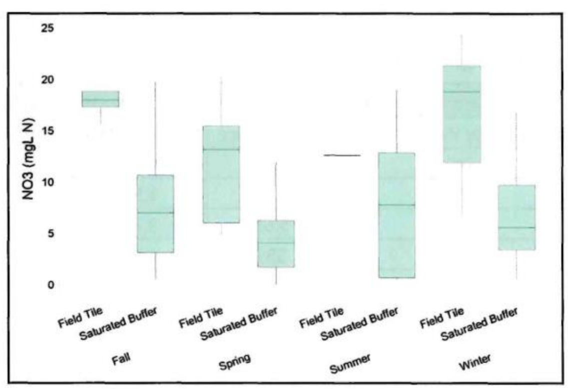

** Soluble reactive phosphorus mean concentrations by season*

** Undergraduate lab student analyzing samples for nutrients*

- Over the two years a total of 1.85 MG passed through the buffer—with the majority of water saturating the riparian during the Fall (2021) and Winter (2022) months.
- Lack of rain during the second half of 2022 resulted in no water detected to have entered the buffer.
- No appreciable backflow events were detected.
- The buffer charged on 27 occasions (water leaving field) - including 17 events in 2021 and 10 in 2022.
- Of the water leaving the field, the buffer captured ~57% over the two years (43% in 2021 and 84% in 2022).

** Overhead view of 3-chamber box actively charging—note water flowing over first stop log (right) from the field and no water flowing over the second stop log (left) indicating an active charge event*

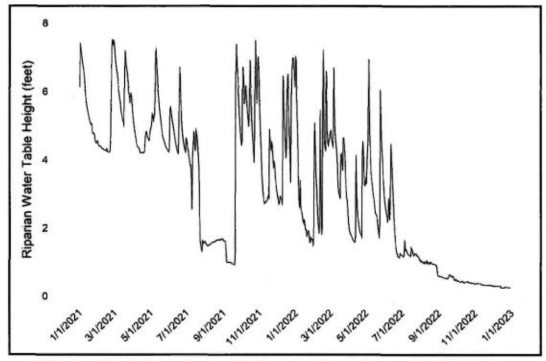
- Water sampling captured data from 24 of 27 runoff events.
- Overall nutrient reductions, comparing Field Tile to average Buffer Monitoring wells indicated an ~59% decrease in NOx and 84% decrease in SRP concentrations.
- Critical spring decreases were 58% N and 40%P.
- In addition to SRP and NOx, TP and TSS values from the tile were also reduced as particulates are not transported through the distribution tile.



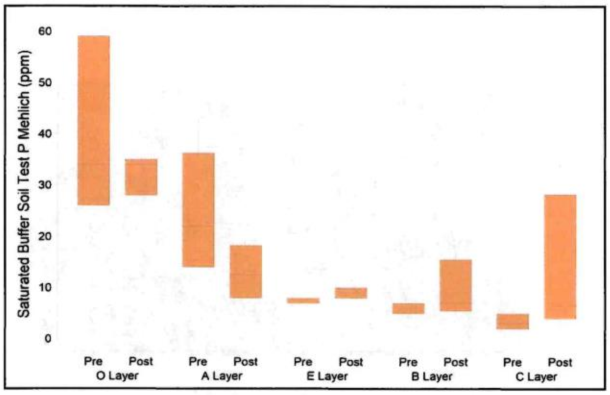

** Nitrate—Nitrogen mean concentrations by season*

## Sediment Characteristics and Groundwater Saturation

- Soil test P levels exhibited a decline over the monitoring period near the surface and an increase in deeper layers—likely indicating uptake of P from surface plants and deposition (adsorption) of P into the subsurface.
- Factoring in Aluminum and Iron, soil P storage capacity statistics (SPSC) were all positive indicating likelihood of additional P capacity in the buffer.
- Unfortunately, STP levels in the field adjacent to the riparian went up markedly (about 45%) in the surface horizons (O & A)—and while SPSC values are still positive, indicating this field sediment is technically still a P sink—it does signal potential problems in the future.




** Water table in the saturated buffer over time adjacent distribution line*




** Soil test phosphorus levels arranged by increasing depth of soil strata before and after study*

** Soil sampling for phosphorus levels*

## Surface Runoff Potential

- Given that saturated buffers are an extension of drainage water management strategies, it is reasonable to question their impact on surface runoff.
- This study did not directly assess surface water runoff volumes or concentrations.
- Past studies on DWM have suggested that surface runoff could increase by as much as 50% compared with free flowing sites given the raised water table.
- However, recent meta analyses have pointed out that while surface runoff may increase post DWM, that these upticks likely pale by an order of magnitude or more, in comparison to the amount of water reduced from managed tile flow.
- While not part of this study, surface water concentrations and observations were made on a single large surface flow event following a nearly 2" spring rain on a dormant crop—essentially emblematic of a 'worst' case runoff scenario.

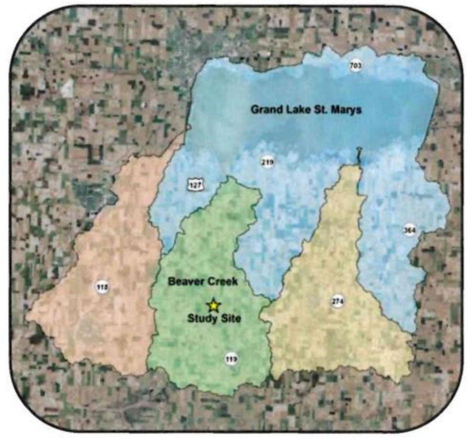
| Surface Runoff Event Case Study (*Post* 1.9" 24 HR Precipitation) | | | |
|---|---|---|---|
| Water Quality Variable (mgL) | Field Surface | Buffer Surface | Percent Change |
| SRP | 1.24 | 0.94 | - 24% |
| TP | 2.12 | 1.55 | -27% |
| NOx | 5.65 | 8.29 | + 47% |
| TSS | 591 | 340 | - 42% |

- Given the elevation of the control box coupled with the depth loggers and field observations, it was possible to estimate how many surface runoff events occurred over the study. In 2021, surface runoff occurred 7 times with 3 being 'large' events lasting 12 hours or more. In 2022, surface runoff occurred 5 times with 1 being a 'large' event lasting more than 12 hours.
- Despite these surface events, we are encouraged by the overall reduction in surface P loading as a result of the restored buffer.

** Surface runoff event—note concentrated flow area leaving study field and flowing through restored buffer area prior to discharging into the adjacent Beaver Creek*

## Moving Forward and Learning More

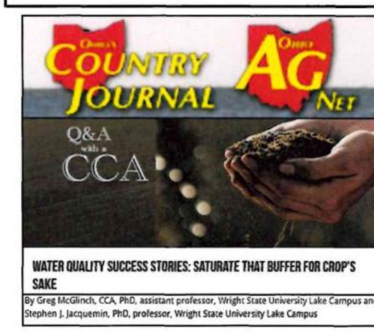
- Additional sites for saturated buffers are needed across the state of Ohio—particularly in northwest Ohio.
- Future monitoring needs to include surface runoff directly as other controlled drainage study results have been mixed.
- Saturated buffers represent a high impact edge of field practice that do not take many acres out of production, are affordable to install (between $5,000 and $10,000), are supported by certain cost share programs, and can be easily managed and maintained.
- Contact your local Soil and Water Conservation District or Natural Resources Conservation Service office today about this practice (NRCS CPS Code 604).




** Site location situated within GLSM watershed in NW Ohio—many opportunities for future sites here and elsewhere around the state*

** Saturated buffer establishment*

- For more overview information, read through 'Questions and Answers about Saturated Buffers for the Midwest' by Jaynes et al. (2018) and published through Purdue Extension (ABE-160).
- For more technical information, read through 'On the potential for saturated buffers in northwest Ohio to remediate nutrients from agricultural runoff' by Jacquemin et al. (2020) and published through PeerJ.
- For more commentary, read through 'Saturate that buffer for crop's sake' by McGlinch and Jacquemin (2023) and published through Ohio's Country Journal.


PeerJ

**On the potential for saturated buffers in northwest Ohio to remediate nutrients from agricultural runoff**

Stephen J. Jacquemin[1], Greg McGlinch[2], Theresa Dirksen[3] and Angela Clayton[1]

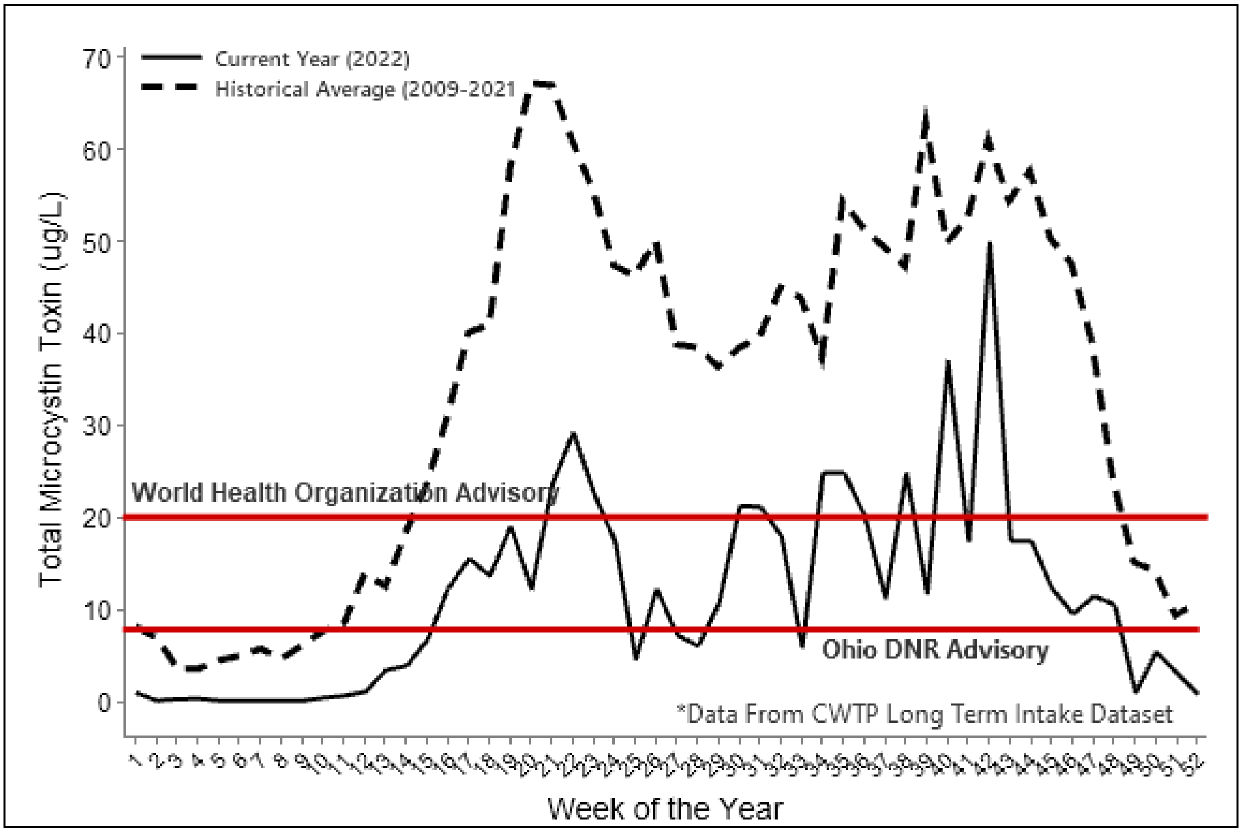
[1] Agriculture and Water Quality Education Center, Wright State University - Lake Campus, Celina, OH, USA
[2] Department of Horticulture and Crop Science, The Ohio State University, Columbus, OH, USA
[3] Mercer County Community and Economic Development Office, Celina, OH, USA

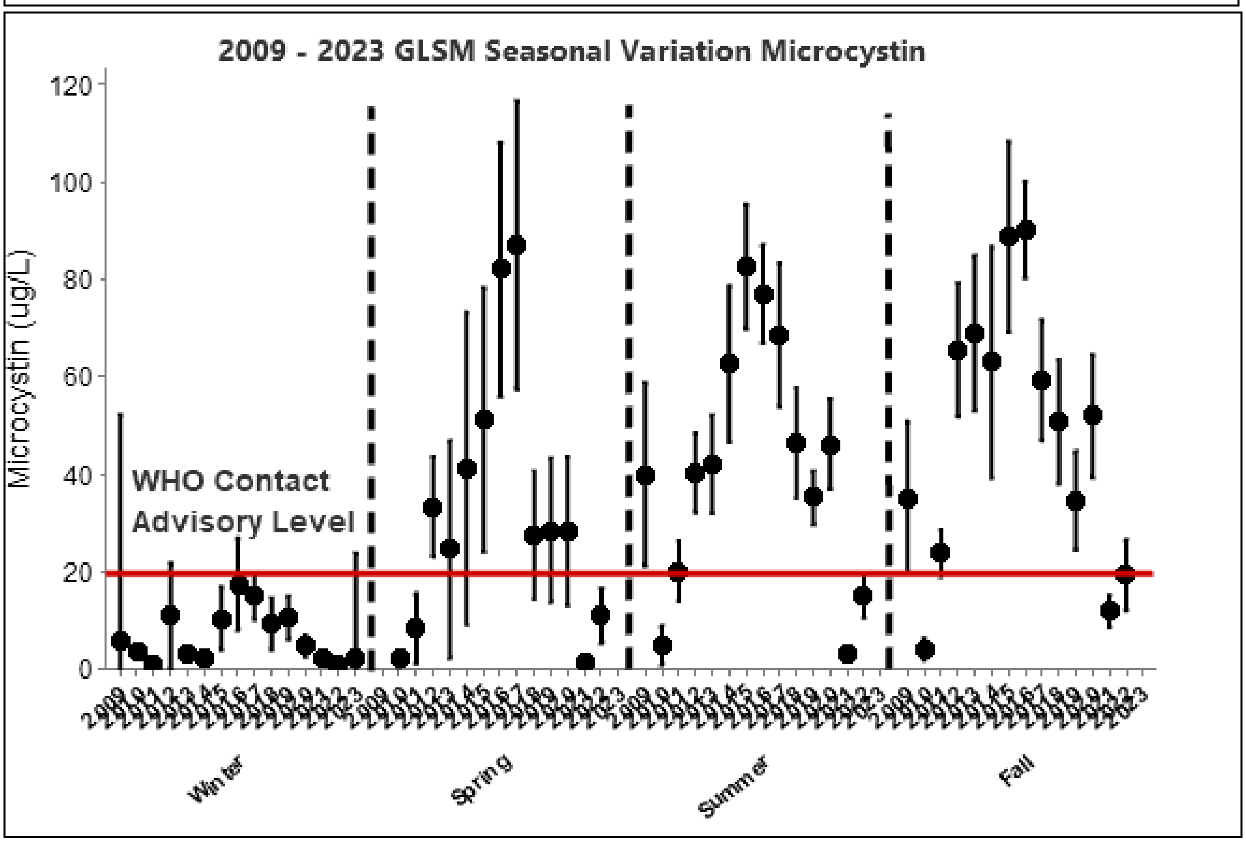
Blanchard River DEMONSTRATION FARMS NETWORK

*Acknowledgements*

We wish to thank the Blanchard River Farms Demonstration Network and their partners at Ohio Farm Bureau, USDA Natural Resources Conservation Service, as well as the Great Lakes Restoration Initiative for supporting this project. Ohio's 319 Program provided funding for installation of the buffer through the Mercer Soil and Water Conservation District. In addition, we thank the strong local support for the project, including the St Charles Center as well as VTF Excavation, and Cy Schwieterman Inc. Lastly, much appreciation to the many Lake Campus undergraduate students involved in the project over the years: K Kline, B Strang, C Ewing, B Axe, M Gels, S Wendel, and A Selby, whose many long hours in the field made the data collection and results possible.

# Appendix C – Microcystin Toxin and Algal Biomass Updates


Current Year (2022)
Historical Average (2009-2021
Total Microcystin Toxin (ug/L)
World Health Organization Advisory
Ohio DNR Advisory
*Data From CWTP Long Term Intake Dataset
Week of the Year


2009 - 2023 GLSM Seasonal Variation Microcystin
Microcystin (ug/L)
WHO Contact
Advisory Level
Winter
Spring
Summer
Fall

# Appendix D – Sharing Science – Peer Refereed GLSM Publications

Jacquemin SJ, Doll JC, Johnson L, Newell SE. 2023 – *Online Early*. Exploring long term trends in microcystin toxin values associated with persistent harmful algal blooms in Grand Lake St Marys. Harmful Algae.

Qian SS, Arend KK, Jacquemin SJ, Sullivan MP, Kowalski KP. 2023. Estimating phosphorus retention capacity of flow-through wetlands. Ecological Engineering.

Jacquemin SJ, Birt J*, Senger Z*, Axe B*, Strang B*, Ewing C*, Kinney B*, Newell SE. 2022 – *Online Early*. On the potential for reconstructed wetlands to remediate fecal coliform loading in an agricultural watershed. Hydrobiologia.

González-Rocha J, Bilyeu L, Ross SD, Foroutan H, Jacquemin SJ, Ault AP, Schmale III DG. 2022 – *Online Early*. Sensing atmospheric flows in aquatic environments using a multirotor small uncrewed aircraft system (sUAS). Environmental Science: Atmospheres.

Bilyeu L, Bloomfield B, Hanlon R, González -Rocha J, Jacquemin SJ, Ault AP, Birbeck J, Westrick J, Foroutan H, Ross SD, Powers CW, Schmale III DG. 2022 – *Online Early*. Drone-based particle monitoring above two harmful algal blooms (HABs) in the USA. Environmental Science: Atmospheres. DOI: 10.1039/d2ea00055e.

Hanlon R, Jacquemin SJ, Birbeck J, Westrick J, Harb C, Gruszewski H, Ault A, Scott D, Foroutan H, Ross SD, González -Rocha J, Powers C, Pratt L, Looney H, Baker G, Schmale III DG. 2022. Drone-based water sampling and characterization of three freshwater harmful algal blooms (HABs) in the United States. Frontiers in Remote Sensing. *Section Unoccupied Aerial Systems*: 1-16, 3:949052. DOI: 10.3389/frsen.2022.949052.

Jacquemin SJ, Cubberley MS. 2022. Documentation of a massive lake wide fish die off on Grand Lake St Marys, with notes on long-term changes in the fish assemblage and watershed habitat over the past century. American Midland Naturalist 187(1): 104-112.

Jaqueth AL, Jacquemin SJ. 2020. Potential of pasture grasses to reduce soil runoff in simulated spring seeding applications. *Forage and Grazing Lands Brief*. Crop, Forage, and Turfgrass Management 6(1): DOI: 10.1002/cft2.20071.

Jacquemin SJ, McGlinch G, Dirksen T, Clayton A. 2020. On the potential for saturated buffers in northwest Ohio to remediate nutrients from agricultural runoff. PeerJ. DOI: 10.7717/peerj.9007.

Jacquemin SJ, Johnson LT, Dirksen TA, McGlinch G. 2018. Changes in water quality of Grand Lake St. Marys watershed following implementation of a manure application ban. Journal of Environmental Quality 47(1): 113-120. *Study Selected for Journal Issue Cover Page Feature*.

# Appendix E – Five Year Goals and Proposed Timeline

| | | 2023 | | | | 2024 | | | | 2025 | | | | 2026 | | | | 2027 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Action** | **Objective** | **Q1** | **Q2** | **Q3** | **Q4** | **Q1** | **Q2** | **Q3** | **Q4** | **Q1** | **Q2** | **Q3** | **Q4** | **Q1** | **Q2** | **Q3** | **Q4** | **Q1** | **Q2** | **Q3** | **Q4** |
| | **Water Quality Improvement** | | | | | | | | | | | | | | | | | | | | |
| 1 | Develop Treatment Wetlands | | | | | | | | | | | | | | | | | | | | |
| 2 | Protect In-Lake Features | | | | | | | | | | | | | | | | | | | | |
| 3 | Watershed BMP's | | | | | | | | | | | | | | | | | | | | |
| 4 | Organic Waste Management | | | | | | | | | | | | | | | | | | | | |
| 5 | Stream Restoration | | | | | | | | | | | | | | | | | | | | |
| 6 | Nutrient Management | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
| | **Study/Document** | | | | | | | | | | | | | | | | | | | | |
| 1 | Continue Lake & Wetland Monitoring | | | | | | | | | | | | | | | | | | | | |
| 2 | Monitor new BMP's | | | | | | | | | | | | | | | | | | | | |
| 3 | USGS/National Center for Water Quality | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
| | **Coordination** | | | | | | | | | | | | | | | | | | | | |
| | All Actions | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
| | **Public Outreach** | | | | | | | | | | | | | | | | | | | | |
| 1 | Youth Education | | | | | | | | | | | | | | | | | | | | |
| 2 | LIA Events & Meetings | | | | | | | | | | | | | | | | | | | | |
| 3 | GGLRVC Promotion | | | | | | | | | | | | | | | | | | | | |
| 4 | State Agency Tours | | | | | | | | | | | | | | | | | | | | |
| 5 | LFA Project Management | | | | | | | | | | | | | | | | | | | | |
| 6 | Public Connection to Lake & Open Spaces | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
| | **Economic Revitalization** | | | | | | | | | | | | | | | | | | | | |
| | All Actions | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
| | **Infrastructure Management** | | | | | | | | | | | | | | | | | | | | |
| 1 | MOU & Management Plans | | | | | | | | | | | | | | | | | | | | |