Environmental Protection Agency

Maumee Watershed Nutrient TMDL 2024 Biennial Report

2024 Life on Lake Erie Photo Submission by Christine Crawford

Division of Surface Water
TMDL and Nonpoint Source Program
December 2024

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Executive Summary

The Maumee Watershed Nutrient Total Maximum Daily Load (TMDL) report highlights ongoing challenges and strategic initiatives to address water quality impairments in western Lake Erie, particularly those related to harmful algal blooms (HABs). Historically, these blooms arising from elevated phosphorus concentrations were worsened by municipal and industrial discharges, significantly impacting the region's drinking water and recreational uses. The Great Lakes Water Quality Agreement (GLWQA), implemented in 1972, supported funding, development, and implementation of projects and policy changes to reduce phosphorus loads. However, HABs resurfaced in the early 2000s, with annual occurrences noted since then.

The goal of the Maumee Watershed Nutrient TMDL, developed under the Clean Water Act, is to address and tackle these remaining challenges by eliminating impairments in drinking water, aquatic life, and recreational activities across Ohio's western Lake Erie assessment units. Approved by U.S. Environmental Protection Agency (U.S. EPA) on Sept. 28, 2023, the TMDL outlines specific phosphorus load reductions needed to meet water quality standards.

The report establishes accountability through biennial reports in collaboration with local, state, and federal partners. The inaugural 2024 report assesses progress toward TMDL goals. Key milestones categorized into planning, development, and implementation phases focus on enhancing collaboration, increasing nonpoint source strategies, and improving best management practices through initiatives like H2Ohio.

Monitoring is central to the TMDL's success. It relies on a tiered implementation pyramid approach that begins with programmatic indicators and moves toward more direct water quality assessments. Intermediate indicators will track changes in soil phosphorus levels and agricultural practices, while field-level measurements will be gathered through specific research initiatives, including the H2Ohio wetland monitoring program.

Overall, this comprehensive approach positions Ohio as a leader in addressing nutrient management and enhancing the health of its water resources while responding effectively to the challenges posed by HABs in western Lake Erie.

Overview of Maumee Watershed Nutrient TMDL

Impairments of Lake Erie

History of eutrophication in Lake Erie

HABs have historically impacted western Lake Erie due to high phosphorus concentrations from the Western Lake Erie Basin (WLEB) watershed. In Ohio, phosphorus entering the lake was primarily due to municipal and industrial sewage entering through direct discharges and via the Lake Erie tributaries. After the Great Lakes Water Quality Agreement (GLWQA) was enacted in 1972, phosphorus loads were cut by nearly half through reductions at wastewater treatment plants. Harmful algal blooms (HABs) reemerged in the early 2000s, with a particularly large bloom in 2003. Summertime HABs have been an annual occurrence ever since (Annex 4, 2015). Some assessment units in Lake Erie are listed as impaired for beneficial uses, specifically drinking water and recreation, associated with HABs (Ohio EPA, 2024 IR). Specifically, western Lake Erie's public drinking water supply beneficial use was listed as impaired in 2014, and recreation beneficial use was listed in 2018.

As HABs increase, collaborative efforts have emerged to address this issue. By understanding the causes and developing effective strategies, we are enhancing the health of Ohio's water resources. Our initiatives position Ohio as a leader in HAB management. Figure 1 highlights milestones that contributed to the Maumee Watershed Nutrient Total Maximum Daily Load (TMDL), which informs our implementation strategy. Together, we're improving the future of our waters!

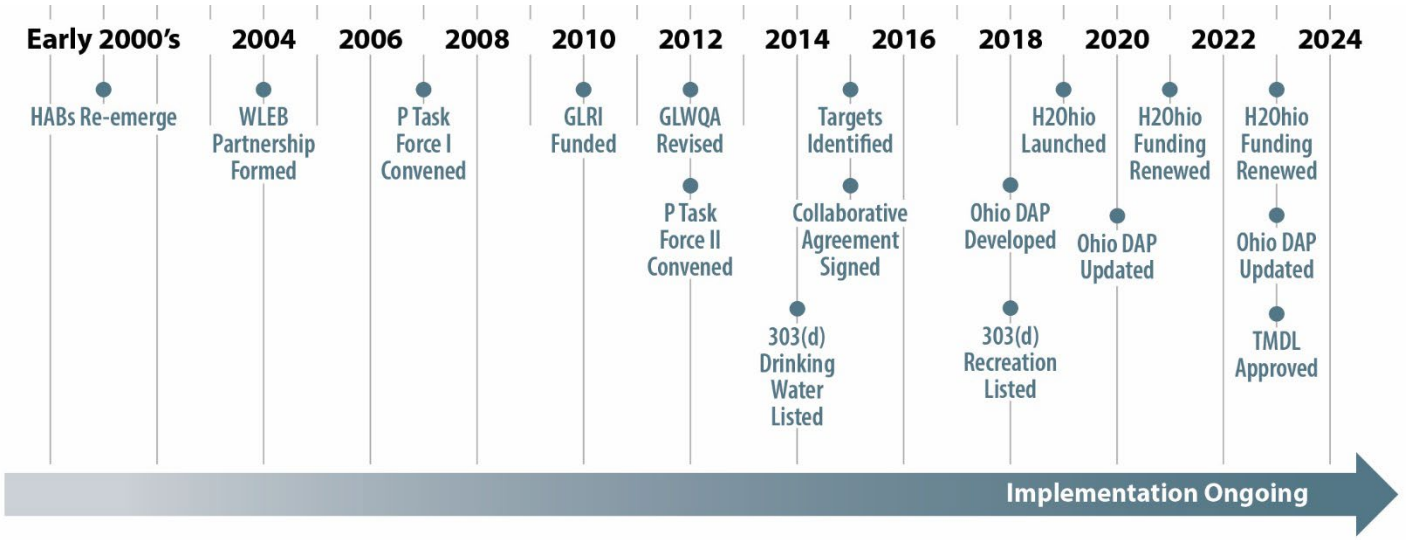

Figure 1. Historical actions that build a foundation for future implementation actions in the Maumee Watershed.

The Plan

Under the Clean Water Act and regulations from the U.S. Environmental Protection Agency (U.S. EPA), a TMDL must be developed for impaired waters. A TMDL is a process for planning water quality restoration that involves several key steps: watershed characterization, target identification, source assessment, load allocation, and implementation planning.

The Maumee Watershed Nutrient TMDL aims to eliminate impairments caused by algae in drinking water, aquatic life, and recreational activities in Ohio's western Lake Erie assessment units. To achieve this objective, the project focuses on reducing phosphorus loads from the Maumee watershed.

The TMDL specifies the phosphorus pollutant loads required to meet and maintain water quality standards in the western Lake Erie assessment units. These standards are particularly important for recreational uses, public drinking water, and aquatic life. U.S. EPA approved the TMDL on Sept. 28, 2023.

TMDL Commitments

The TMDL establishes accountability milestones linked to biennial reports in collaboration with local, state, and federal partners.

The 2024 Maumee Watershed Nutrient TMDL biennial report is the first since this commitment and will assess progress toward TMDL goals. It outlines milestones to be evaluated in the 2026 report (see Figure 2).

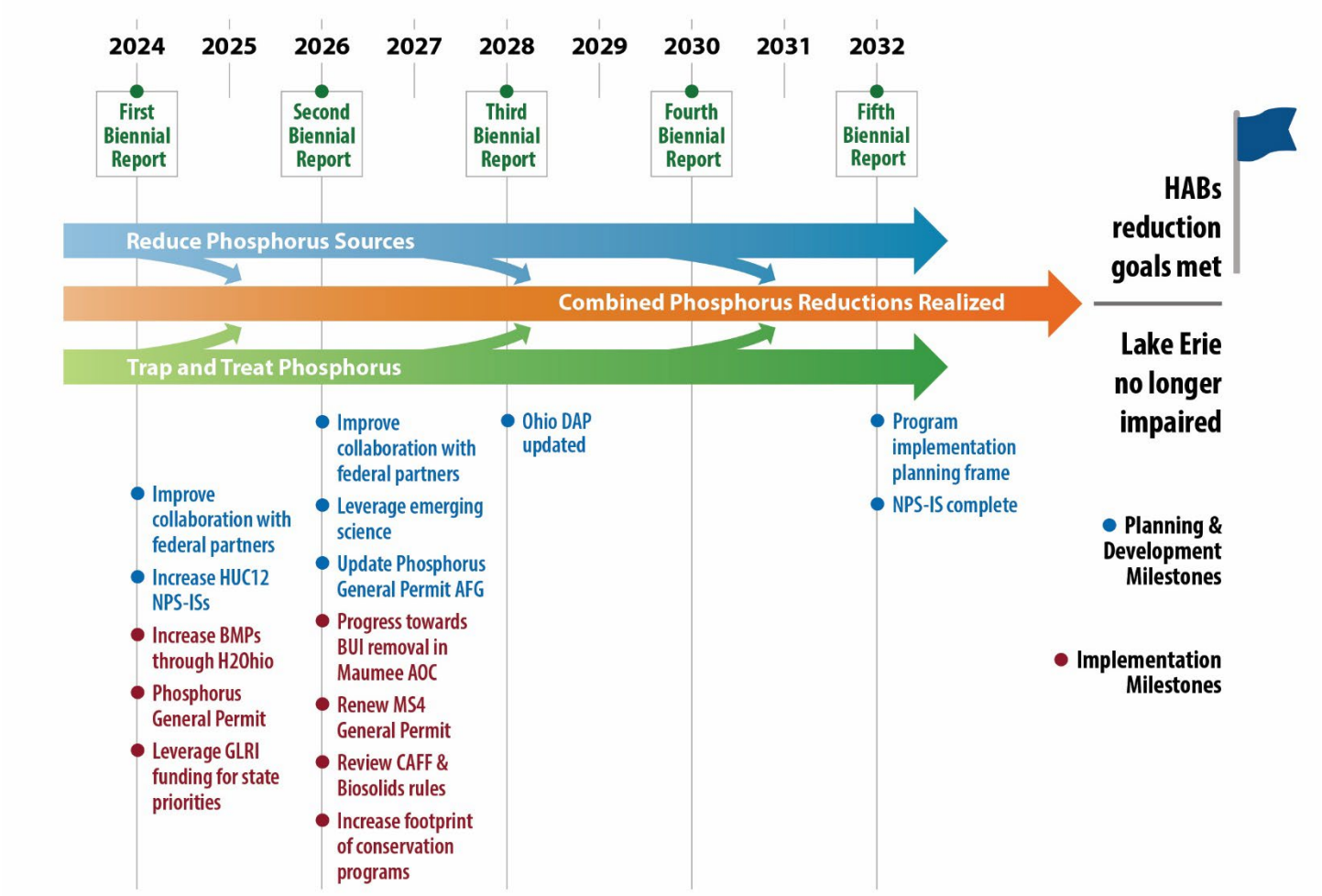

Figure 2. Established milestones for the current and future biennial reports. These milestones provide opportunities to review the effectiveness of each milestone and make adjustments where progress is not meeting expectations.

Milestones

The biennial report outlines milestones categorized as "planning and development" and "implementation." Planning milestones include updating Ohio's DAP, enhancing collaboration with federal partners, and increasing nonpoint source implementation strategies in the Maumee watershed. Implementation milestones focus on boosting best management practice implementation through H2Ohio, executing the phosphorus general permit, and leveraging Great Lakes Restoration Initiative (GLRI) funding for state priorities. More details are in the Tracking Implementation section.

Monitoring Environmental Outcomes

The TMDL project aims to restore western Lake Erie's beneficial uses by reducing phosphorus. Success will be measured through environmental outcomes, which require high implementation levels. Thus, tracking intermediate measures is essential to monitor progress, as illustrated in the implementation pyramid (Figure 3).

At the pyramid's base, we track implementation measures as programmatic indicators. This foundational level allows us to assess whether the programs are leading to meaningful changes. This section summarizes the initiatives carried out by various organizations, along with the projects and practices implemented. We will also explore industry-led efforts. A central theme of this section will be to highlight the collaborative initiatives undertaken. The identified milestones are included within this section of the pyramid.

As we move up the pyramid, data is collected to monitor intermediate indicators, which help determine whether management practices are truly making an impact. This section focuses on the trends in soil test phosphorus and the agriculture mass balance, accounting for phosphorus inputs from fertilizer sales and manure against the phosphorus removed through crop harvest. The Ohio Agricultural Conservation Initiative (OACI) conducts surveys to review farming practices.

The next level of assessment involves direct measurements of water quality at the field or project scale. Because collecting data at this level can be intensive and there are many projects to consider, research projects are most suitable for this type of measurement. This section highlights the findings from the H2Ohio wetland monitoring program for projects within the Maumee watershed, notable projects from the Harmful Algal Bloom Research Initiative (HABRI), and other HAB-related research.

The next level involves monitoring loads in streams throughout the watershed. A system of tiered gaging stations starts with sentinel watersheds that represent the diverse characteristics of the smaller drainage areas within the watershed. Following this, HUC-8 scale gages help us understand loadings from the watershed's subregions. At the top of this hierarchy is the monitoring station on the Maumee River at Waterville, which captures drainage from nearly the entire watershed. This section focuses on current trends at the Waterville Stream Gage station and presents findings from Ohio EPA's nutrient mass balance study.

Monitoring Lake Erie's water quality data is crucial for evaluating its ecological health, and Ohio EPA relies on multiple resources from the federal government. Consequently, assessing Lake Erie's ecological response is the highest priority in our environmental outcomes monitoring pyramid. This section provides an update on the status of western Lake Erie's beneficial uses and the measures implemented to protect public health.

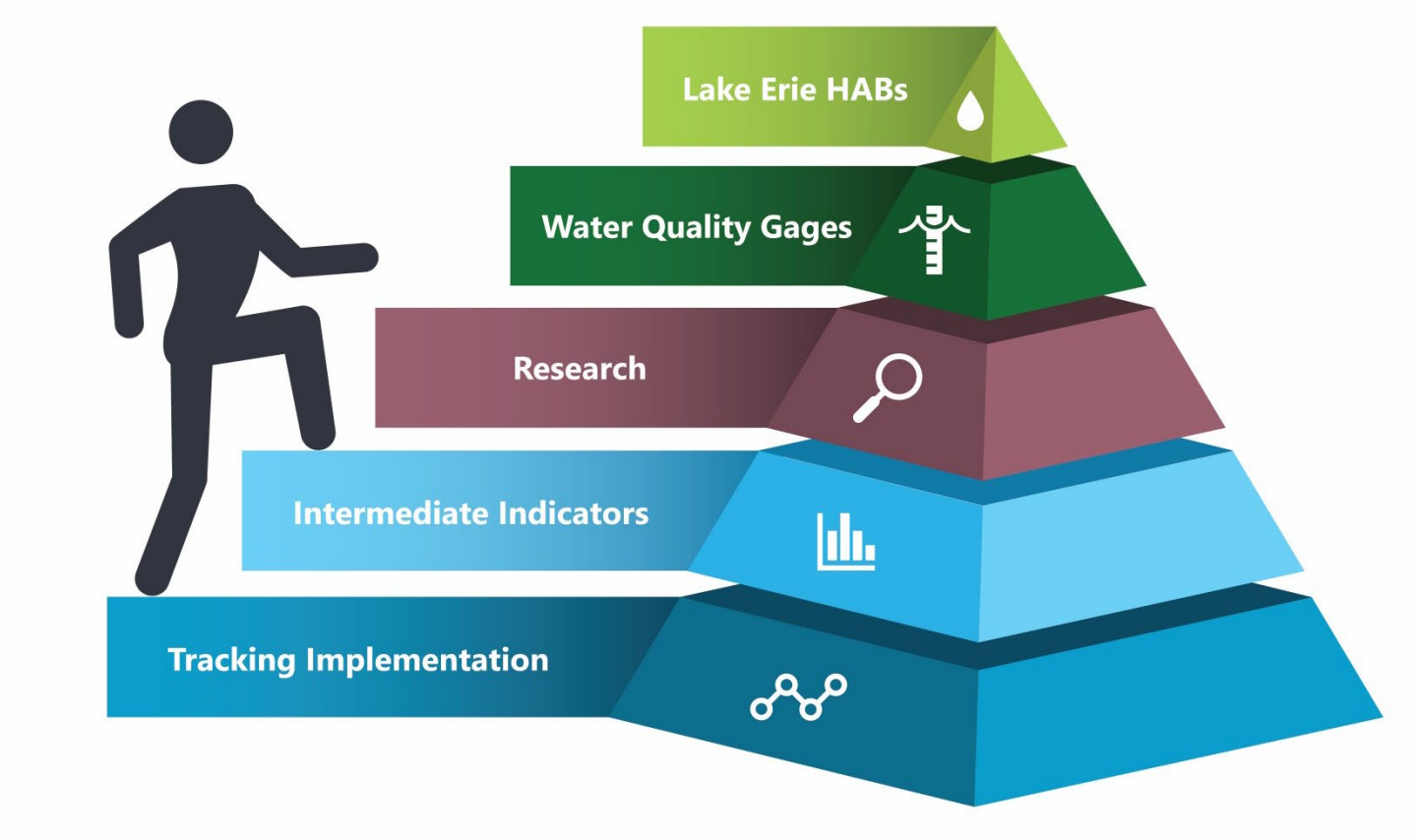

Figure 3. Pyramid demonstrating the different levels of TMDL implementation. Actions at the pyramid's base drive the higher levels' environmental responses.

Tracking Implementation

This section reviews practices and projects at the programmatic level that address changes in the landscape related to phosphorus sources. Changes must first be implemented at the base to achieve positive outcomes at the top of the pyramid, specifically in Lake Erie. This section will assess the progress made toward various milestones and explore other areas that may not have been designated as milestones.

Planning and Development Milestones

Nonpoint Source Implementation Strategies (NPS-IS)

These strategies are developed at the HUC-12 watershed scale, typically encompassing areas smaller than 30 square miles. In the Maumee watershed, 194 HUC-12s are either fully or partially located in Ohio. Planning based on HUC-12s enables more detailed inventories of critical areas and helps identify targeted projects that can effectively achieve water quality goals. Projects must be included in an NPS-IS to qualify for Section 319 nonpoint source or GLRI funding administered by Ohio EPA.

When far-field targets were published in the Ohio DAP, Ohio EPA worked with contractors and local partners to develop or update Maumee watershed NPS-IS to address loading into western Lake Erie. At the approval of the Maumee Watershed TMDL, 52 plans include far-field loading objectives. Alternate funding was secured for an additional 26 plans.

To date, 72 plans have been approved in the Maumee watershed, with 63 incorporating far-field loading objectives (Figure 4).

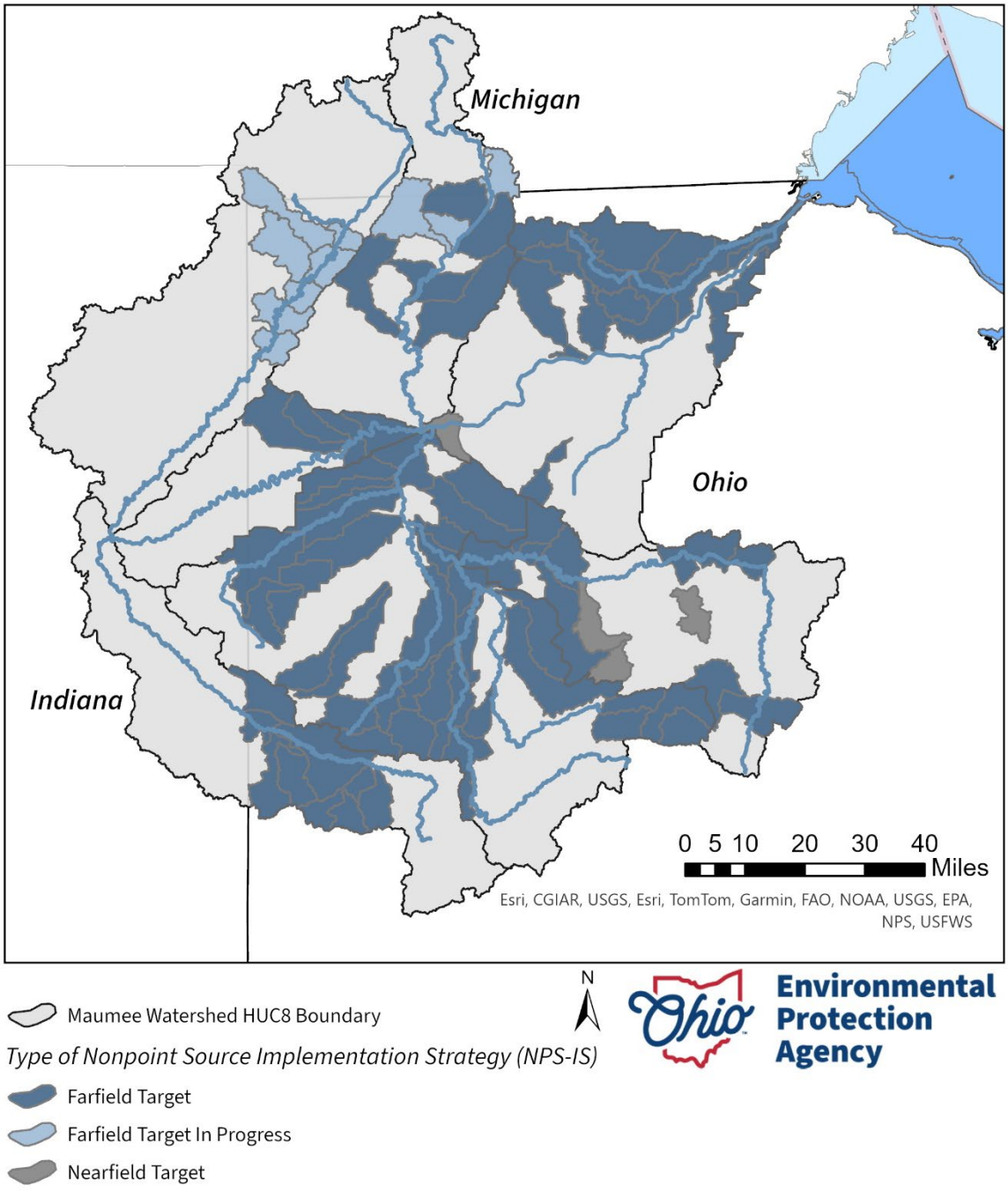

Figure 4. Ohio's Nonpoint Source Implementation Strategies (NPS-IS) status in the Maumee watershed.

Updates to Ohio's Domestic Action Plan

Ohio's DAP was updated in January 2024 to align the Maumee watershed HUC-12 far-field targets with the TMDL. The revised methodology identifies contributions from nonpoint sources in the nutrient mass balance study and distributes those loads to smaller HUC-12 watershed units. Components were renamed for clarity and to match their legal definitions consistent with the Maumee Watershed TMDL.

The nonpoint source category now excludes loads from permitted stormwater sources, such as municipal separate storm sewer systems (MS4), which are defined as point sources. This update reclassifies the remaining load as a "nonpoint source landscape load." While the changes are not large, they ensure better alignment between Ohio's DAP and the TMDL.

Other action items focus on establishing science-based priorities for agricultural BMPs and state programs to support H2Ohio combined with efforts to encourage implementation, outlining the Ohio Department of Natural Resources (ODNR)'s efforts to restore and enhance wetlands for nutrient reduction as part of H2Ohio; updated actions for communities, including H2Ohio support for home sewage treatment system remediation; and integrating the role of watershed planning at the local level to reduce nutrients efficiently, including distribution of the load reduction throughout the Maumee watershed.

More information can be found in Ohio's Domestic Action Plan 2023 to Address Nutrients.

Collaboration with Federal and State Partners

In partnership with the Ohio Lake Erie Commission (OLEC), Ohio Department of Agriculture (ODA) and ODNR, Ohio EPA works with federal agencies to reduce nonpoint source pollution in the Maumee watershed. Ongoing collaborations include initiatives like H2Ohio and projects under the Great Lakes Restoration Initiative. Notably, U.S. EPA joined the Western Lake Erie Basin Partnership and established a Western Basin Partnership Task Team for Communication.

H2Ohio: H2Ohio is Governor Mike DeWine's comprehensive, data-driven water quality plan to reduce HABs, improve wastewater infrastructure, and prevent lead contamination. The General Assembly first funded this initiative for the 2020-21 biennium with an investment of $172 million, and it has continued to increase with $270 million invested in fiscal year 2024. Initiatives include promoting agricultural management practices and natural infrastructure and addressing failing home septic systems. Ohio EPA works with the OLEC, ODA, and ODNR to implement the H2Ohio program. Funding programs directed toward nonpoint source management are implemented through ODA and ODNR. Projects to realize phosphorus reductions for the WLEB watershed, and more specifically, the Maumee watershed, have been prioritized through these efforts. Projects through this program will be discussed more in the *Implementation Milestones* section.

GLWQA – Annex 4 (Nutrients) Sub-committee: This annex is implemented by a subcommittee co-led by the Canada Water Agency and the U.S. EPA. Ohio is represented by OLEC, Ohio EPA, and ODNR. Through the nutrients annex the partied have committed to contribute to the achievement of the General and Specific Objectives of this Agreement by coordinating binational actions to manage phosphorus concentrations and loadings, and other nutrients if warranted, in the Waters of the Great Lakes.

Great Lakes Restoration Initiative (GLRI): Coordinated by U.S. EPA's Great Lakes National Program Office, this initiative aims to restore and maintain the chemical, physical, and biological integrity of the Great Lakes Basin ecosystem, aligning with the GLWQA.

The Great Lakes National Program Office works with various partners under the GLRI, launched in 2010. This nonregulatory program aims to protect and restore Great Lakes waters while providing resources to achieve key long-term ecosystem goals. Since its start, GLRI has significantly funded projects within the Great Lakes region.

OLEC works with state agencies to identify projects that align with the GLRI action plan focus areas. Four focus areas fund projects that align with the Maumee Watershed Nutrient TMDL goals. These focus areas are: Focus Area 1 – Delisting Areas of Concern (by addressing Habitat loss and wildlife impairment), Focus Area 3 – Nonpoint Source Pollution, Focus Area 4 – Habitat and Species, and Focus Area 5 – Foundations for Future Restoration Actions. While phosphorus management isn't the primary goal, under Focus Area 1 and 4, initiatives aimed at habitat restoration in wetland and riparian areas are vital for effective phosphorus control and improved water flow. Similarly Focus Area 5 has a broader scope but projects are funded for outreach and research related to management of nutrients.

Focus Area 3 has a specific objective to reduce nutrient loads from agricultural watersheds and improve the effectiveness of nonpoint source control efforts. Many state and federal agencies receive grants under this focus area to supplement funding for implementation of phosphorus reduction projects and monitoring efforts. These funds are delivered through numerous programs and are discussed throughout the document associated with the lead agency delivering the funds.

The Western Lake Erie Basin Partnership: This partnership was formed in 2005 to promote a healthy productive watershed and improve water quality. The collaboration includes the USDA-NRCS, federal and state agencies, and various partners dedicated to reducing phosphorus loading to rehabilitate Lake Erie. At their Sept. 26, 2023, meeting, they appointed the U.S. EPA's Great Lakes National Program Office director as a third co-chair to enhance their efforts. Check out the news release and visit the Western Lake Erie Basin Partnership website for more information.

The following sections highlight only a few of the many programs that are dedicating time, effort, and funding towards removing the beneficial use impairments of Lake Erie. The Public Works Commission uses the Clean Ohio Fund to place and protect land in conservation easements in the Maumee watershed. Ohio EPA's Water Resource Restoration Sponsor Program funds projects that protect high quality streams and wetlands. The H2Ohio Rivers Program supports river health and restoration through dam removal and land conservation.

Implementation Milestones

Ohio EPA, ODA, and ODNR, among others, are collaborating to reduce nonpoint and point source loads in the Maumee watershed through various programs. Funded by H2Ohio and GLRI, these agencies implement

projects and provide technical assistance. The following sections detail each agency's programs, industry-led nutrient reduction efforts, collaborative project implementation, and progress toward milestones.

Ohio EPA Programs

Great Lakes Restoration Initiative (GLRI) Projects

Ohio EPA has administered 16 GLRI grants totaling more than $16 million since 2014. Of these, 11 focused on projects in the Maumee watershed, investing more than $11 million for 36 projects (Figure 5). The list below details the GLRI grants, including lead organizations, project descriptions, and funding amounts (Table 1). Italicized projects are outside the Maumee watershed. These initiatives address nearshore health related to nonpoint source pollution.

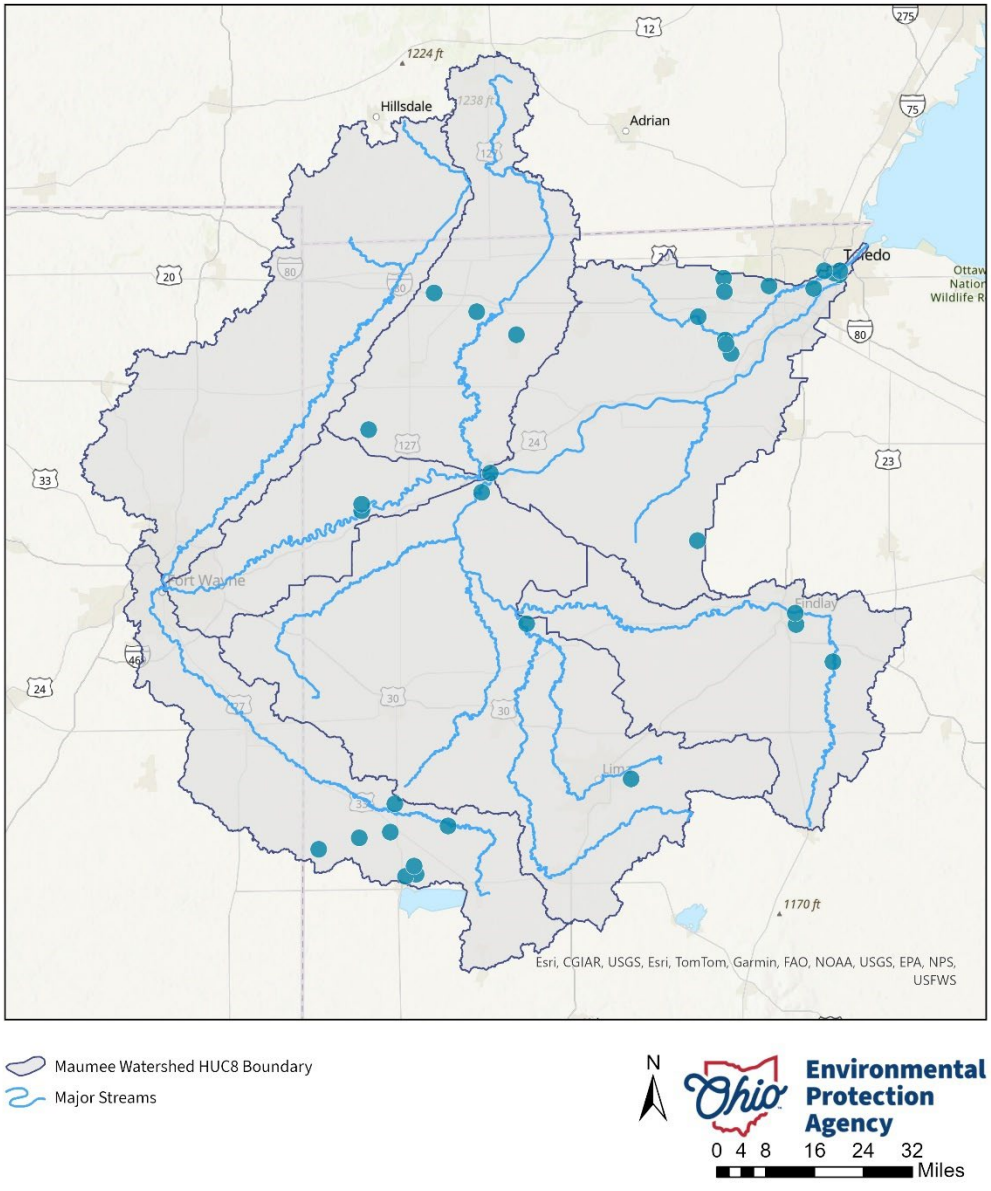

Figure 5. Projects in the Maumee watershed funded by GLRI through Ohio EPA.

OSU Lima Regional Campus Agricultural Runoff Treatment System Project: Conversion of three to four acres of low-producing cropland into floodplain retention and implementation of a water recycling system. Effectiveness will be monitored for two years after installation (Figure 6).

Figure 6. Ohio State University Lima Regional Campus Agricultural Runoff Treatment System. Photo by Rick Wilson.

Lapp Ditch Nutrient and Sedimentation Reduction: Creation of two acres of wetland to treat 34 acres of row crop, installation of water control structures, and development of 13 acres of seasonal wetlands. This project was part of a broader grant for nutrient reduction in the Maumee watershed, including constructing two-stage channels, installing grassed waterways, and developing 14 NPS-ISs (Figure 7).

Figure 7. Constructed wetland at the Lapp Ditch Nutrient and Sedimentation Reduction Project.

Table 1. GLRI Grants administered by Ohio EPA since 2014. Italicized lines indicate projects outside the Maumee River watershed.

Grant	Sub Grantees	Monetary Amount	Description of Activities
SEDM14	TMACOG	$250,000	Green Stormwater BMP retrofits
	Metroparks of Toledo Area	$458,000	Stream and wetland restoration
	Pheasants Forever	$325,000	Drainwater Control and Reuse
	Black Swamp Conservancy	$607,500	Stream Restoration and Agriculture/Nutrient Reduction BMPs
	Black Swamp Conservancy	*$301,471*	*Carter Historic Farm Wetland Restoration*
	Nature Conservancy	$245,000	Wetland Restoration; agricultural education and outreach
	Putnam County SWCD	$285,400	Agricultural/Nutrient Reduction BMPs
	OSU	$637,282	Monitoring and BMP research
	Wright State University	$79,584	Assessment of Nutrient and Sediment Retention Potential by Controlled Pond and Riparian Tile Buffer Systems
	City of Defiance	$400,000	Restoration of Pontiac Park: Wetlands and Streambank
	Mercer SWCD	$74,606	Deerfield Wetland Restoration
MAUM16	Lucas County SWCD	$39,614	Develop Habitat Restoration Plans for three HUC-12 watersheds in Swan Creek (Ai, Fewless, Lower Blue)
	City of Toledo	*$26,898*	*Develop Habitat Restoration Plans for two HUC-12 watersheds in WLEB watershed*
	Ottawa SWCD	*$39,947*	*Develop Habitat Restoration Plans for three HUC-12 watersheds in WLEB watershed*
	Lucas County	*$27,155*	*Develop Habitat Restoration Plans for two HUC-12 watersheds in WLEB watershed*
	Partners for Clean Streams	$36,917	Develop Habitat Restoration Plans for three HUC-12 watersheds in WLEB watershed
TRIB17	Lucas SWCD	$116,000	Agricultural/Nutrient Reduction BMPs
	Lucas County Engineer	$200,000	Stream and Riparian Corridor Restoration
	Black Swamp Conservancy	$368,000	Forest Riverland
	Tinkers Creek Watershed Partners	*$191,500*	*Stream Restoration*
	Geauga County Park District	*$260,765*	*Stream Restoration*
	West Creek Conservancy - Bigelow	*$356,000*	*Stream Restoration*
	West Creek Conservancy - Coventry	*$149,000*	*Stream Stabilization*
	City of Euclid	*$30,000*	*Stream Restoration*

	Chagrin River Watershed Partners	*$15,000*	*Stream Restoration*
AQUA21	University of Toledo	$310,903	Identify Chloride Reduction Areas, develop GIS database and map, develop QAPP to collect preliminary chloride data from critical areas selected for BMP implementation
	TMACOG[a]		Public communication and outreach
	Partners for Clean Streams[a]		Update approved NPS-ISs with chloride critical areas and meet with potential project implementers
MAUM21	Mercer SWCD	$82,700	2-Stage Ditch Restoration (Blierdofer Ditch)
	Mercer County Commissioners	$149,995	Grassed Waterways in Blierdofer HUC-12 WAU
	Fulton SWCD	$234,733	Agricultural Runoff and Drainage Water BMPs
	Putnam SWCD	$47,414	Cropland to Wetland Conversion (Lapp Ditch)
	Van Wert SWCD	$90,000	5 Grassed waterways
	OSU-Extension	$117,003	Develop 12-14 NPS-ISs
FARM22	Village of Archbold	$130,000	Agricultural runoff retention and treatment system
	OSU Lima Branch	$327,450	OSU-Lima Regional Campus Agricultural Runoff Treatment System Project
	Allen SWCD	$322,550	Ohio Agricultural Retention Treatment Systems
AUTO23	OSU	$500,000	Install and Manage Automated Drainage Water Management Systems at 10 locations in the Lost Creek Watershed for three years with water quality monitoring to demonstrate the effectiveness of this technology.
DTCH23	Mercer SWCD	$855,330	Green Ditch and Moorman Ditch (two 2-stage ditches)
	Williams SWCD	$171,500	Coulon Ditch (2-stage ditch/channel and stream crossing)
	Defiance SWCD	$196,717	Brenner Ditch (self-formed channel)
	Wyandot SWCD	*$217,325*	*Fruth Ditch*
LEAG23	Williams SWCD	$425,910	Implement agricultural grassed waterways and retention features. Develop seven new NPS-IS.
	Fulton SWCD	$336,734	Implement agricultural grassed waterways, retention features, and erosion controls. Develop two new NPS-IS.
	Ottawa SWCD	*$467,500*	*Agricultural wetland development and reconnection*
	TBD	$36,000	NPS-IS Development
	TBD	$150,234	Implementation of NPS-IS water management practices.

TAP23	Maumee Watershed Alliance	$900,000	Tests recovery of nutrients from swine manure applications through use of QuickWash technologies
	Ohio State University	$850,000	Study to compare soluble commercial phosphorus fertilizer with slow-release Struvite Dispersible Ganule technology.
MAUM24	Lucas County Engineer	$252,750	Nachtrab and Taylor Two-Stage Ditches
	Lucas County Engineer	$220,500	Wicks Two-Stage Ditch
	Toledo Metroparks	*$515,167*	*Prairie Creek Ditch Restoration and Baseglia Ditch*
	Ottawa SWCD	*$178,125*	*Agricultural Runoff Treatment System (wetland retention)*
	TBD	*$378,699*	*RFP for Nutrient/Sediment Reduction with Stream and Wetland Practices*

[a]subrecipients of grant to University of Toledo

Section 319(h) Program

The Section 319(h) program, established by the 1987 Clean Water Act amendments, aims to control nonpoint source pollution. Since 1990, Ohio EPA has secured and distributed Section 319 grant funds to tackle water quality issues related to nonpoint source pollution in the state. These grants focus on Ohio waters significantly impacted by such pollution and involve collaboration with watershed groups, ODA, ODNR, local SWCDs, and county engineers to implement watershed management plans and restore affected waters.

Since 2006, 18 projects in the Maumee watershed, including those below, have received funding, with 14 in the past decade, totaling over $2 million invested.

Marie DeLarme Wetland Restoration: Restored eight acres of previously farmed land (high-intensity crop production followed by 10 years of hay production) along Marie DeLarme Creek in the Forrest Woods Nature Preserve. Two acres were restored to seasonal wetlands (vernal pools) and six were restored to riparian woodland. The project aims to filter out excess nutrients and sediments and provide essential shelter and food for wildlife using the stream corridor, including the rare four-toed salamanders. This habitat will also serve as a buffer for the old-growth wooded wetlands at the core of the Forrest Woods Nature Preserve (Figure 8).

Figure 8. Marie DeLarme Wetland Restoration in the Forrest Woods Nature Preserve.

Nutrient Reduction Agriculture Practices Flat Run-Tiffin River: Implement best management practices for drainage water management, including grassed waterways and filter strips in high-risk areas of the Flat Run-Tiffin River watershed. Funded in fiscal year 2024, activities will take place over three years, with success measured by installing 10 acres of grassed waterways, 10 acres of filter strips, five water control structures, and 23 erosion control structures.

Phosphorus General Permit

Ohio EPA is using a watershed general permit to implement the wasteload allocation for the largest permitted phosphorus discharges in the Maumee watershed. The permit was issued on November 1, 2023. The general permit covered 39 facilities with a Cumulative Load Limit of 64,170 kg-TP for the March – July 2024 Spring season. The Cumulative Load Limit is the sum of the wasteload allocations assigned to each of the 39

facilities, plus 1,400 kg- TP from the allowance for future growth (AFG). As the AFG is allocated to new or expanded sources, the Cumulative Load Limit will remain the same but the buffer for existing facilities will be reduced. The Cumulative Load reported by facilities covered under the general permit for the 2024 spring season was 43,304 kg-TP (Figure 9), which is 20,866 kg-TP below the Cumulative Load Limit. For more information on the general permit, please visit Ohio EPA's Total Phosphorus – General Permit webpage.

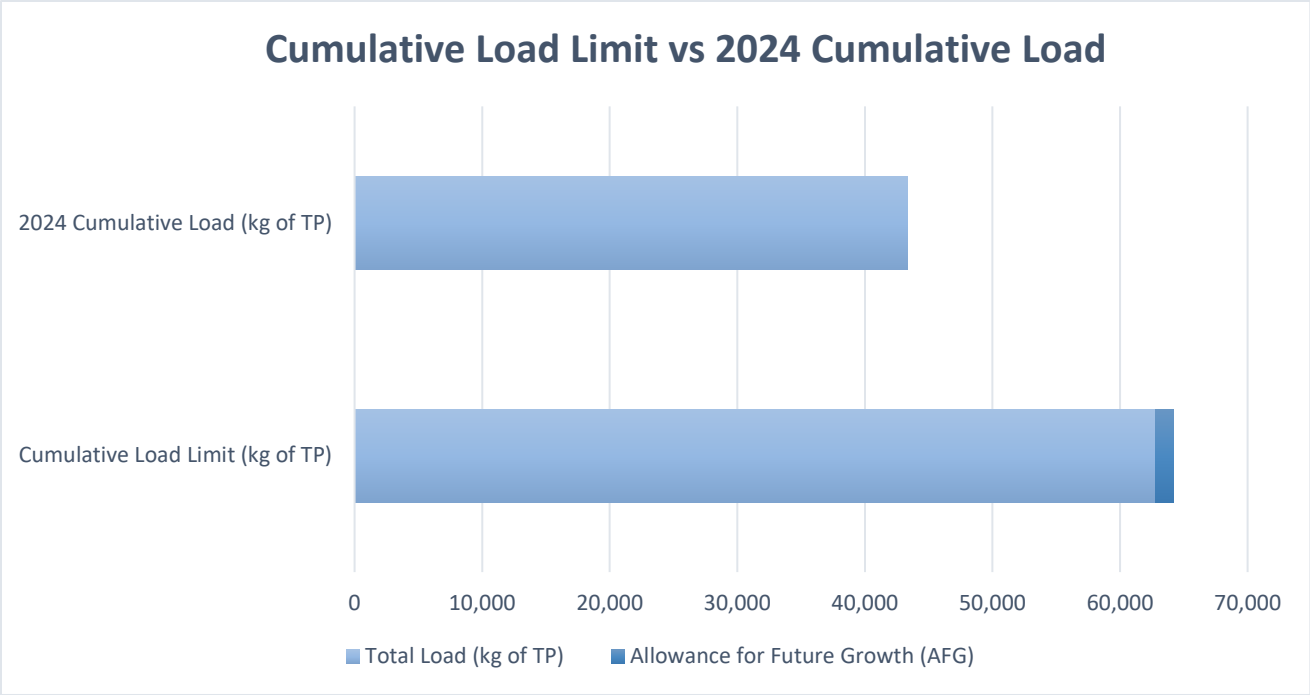

Figure 9. The Cumulative Load Limit for the Phosphorus General Permit, in kilograms (kg) of total phosphorus (TP), plotted alongside the 2024 Cumulative Load.

Ohio Department of Natural Resources

H2Ohio – Wetland and Natural Infrastructure Projects

ODNR funds natural infrastructure projects to restore wetlands and reconnect floodplains. As of 2024, 36 projects have been funded in the Maumee watershed, with 23 completed (Figure 10). Applications for wetland projects in the WLEB watershed are accepted year-round.

To monitor the impact of wetlands on water quality, ODNR partnered with the Lake Erie Aquatic Research Network (LEARN), which monitored 11 projects in the Maumee watershed, with four receiving intensive monitoring. H2Ohio funds through ODNR aim to reduce nutrients and sediments, and many projects incorporate existing features like canals or include an education component to increase benefits.

The focus of the **Fox-Shank Living Laboratory Project** expands beyond water quality. This unique project restored 16 acres of previously farmed land, including eight acres of wetland and 2.5 acres of riparian habitat. It serves as a living laboratory for the Otsego School District, with 1.5 acres set aside for the Future Farmers of America program to demonstrate the benefits of natural habitats for filtering agricultural runoff. Completed in 2023, it offers students immersive, hands-on learning opportunities.

Two projects incorporate the Miami-Erie Canal for floodplain reconnection or as part of the wetlands design. The **Independence Dam Canal Reconnection and Wetland Creation** project, completed in 2023, reconnects the Maumee River to the abandoned Miami-Erie Canal to act as a riparian corridor. The ongoing **City of St. Mary's Treatment Train** project is building a series of wetland pools for the canal waters to flow through to reduce sediment and nutrient loadings.

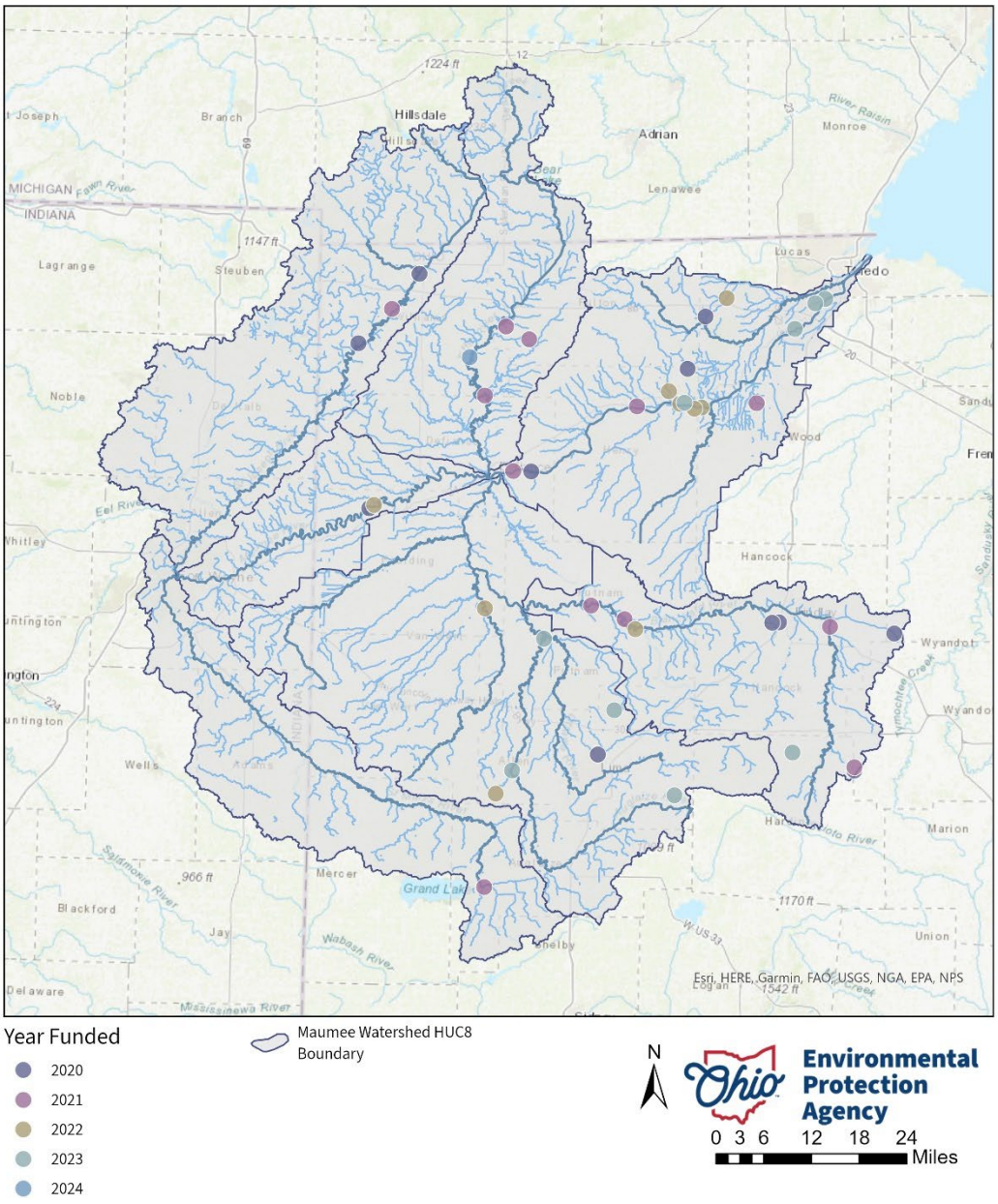

Figure 10. Wetland and natural infrastructure projects funded through H2Ohio within the Maumee watershed.

Ohio Department of Agriculture

H2Ohio – Agricultural Best Management Practices

H2Ohio is implementing conservation practices across 24 counties in the WLEB watershed, including the 14 counties of the Maumee watershed (Figure 11). Participating producers receive cost-share assistance for

nutrient management planning, subsurface phosphorus placement, manure incorporation, and overwintering cover.

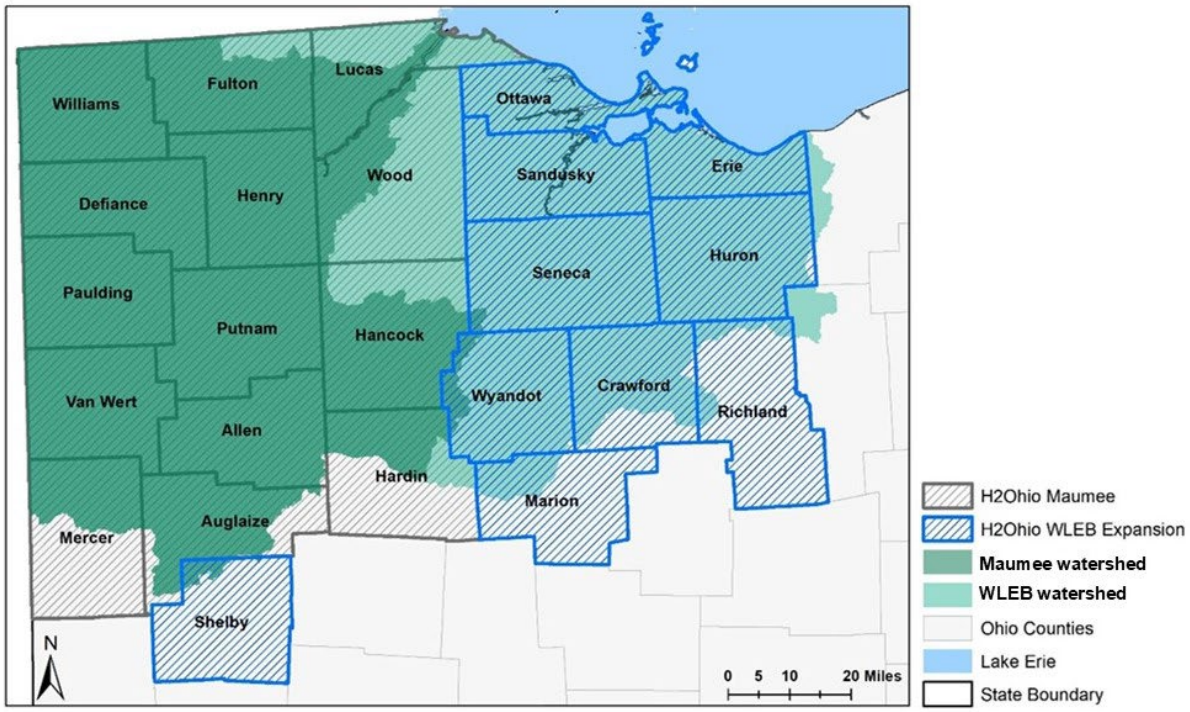

Figure 11. Map of the Ohio Department of Agriculture H2Ohio Western Lake Erie Basin (WLEB) watershed project area.

In 2022, a conservation ditch program was launched, allowing producers to convert channelized agricultural ditches into two-stage or overwide ditches. These ditches slow water movement, helping to retain sediment and nutrients. In 2023, ODA awarded $4.2 million for 11 projects to be completed by fall 2024. The Nature Conservancy created an interactive map of conservation ditches in Ohio and nearby states. Since 2003, 18 conservation ditches have been completed in the Maumee watershed, with nine projects currently under construction (Figure 12).

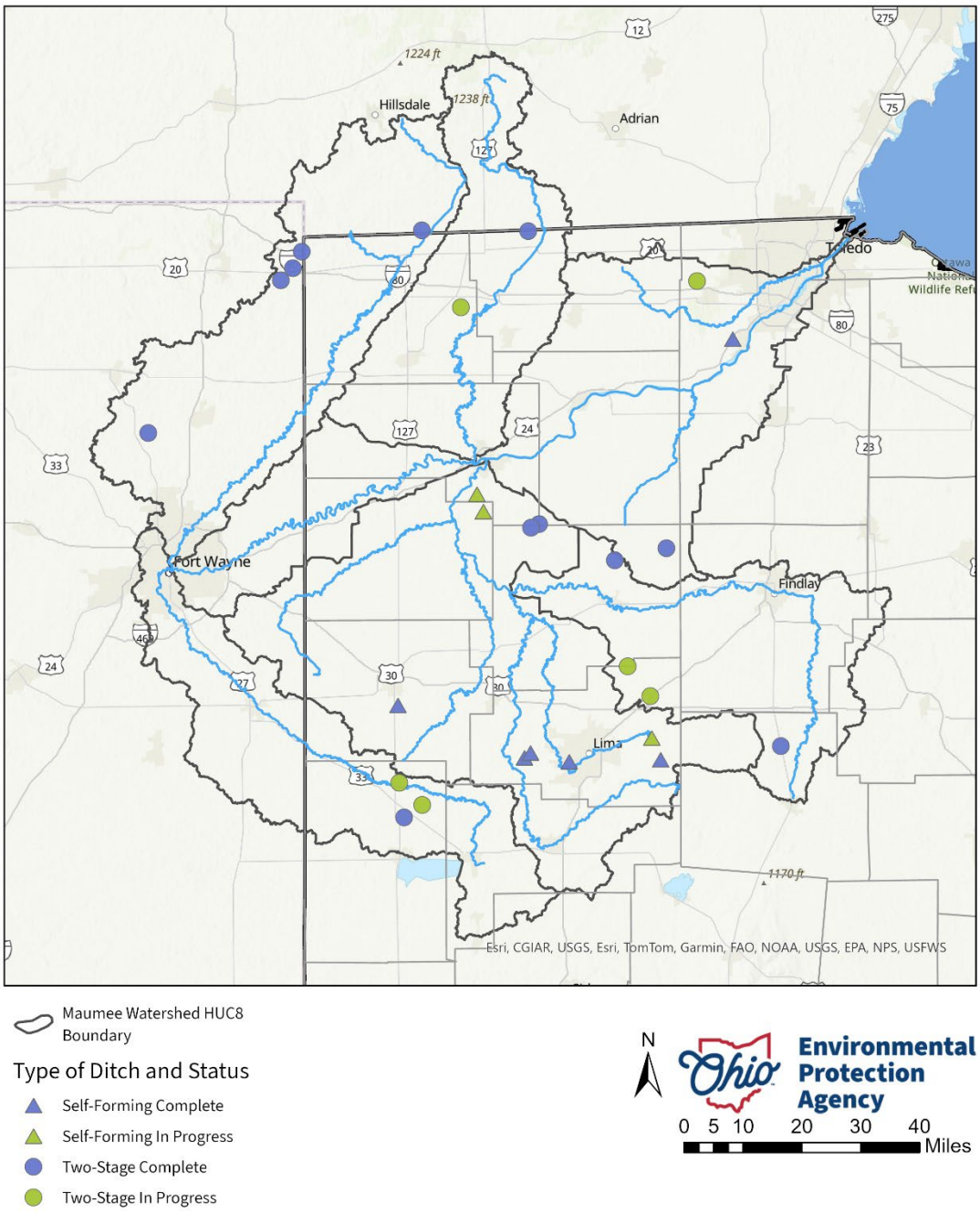

Figure 12. Conservation Ditches in the Maumee Watershed.

A newly formed phosphorus advisory group will provide input on developing a program to explore phosphorus removal structures for mitigating phosphorus loss from high-risk fields. The group will also promote information sharing about removal technologies and impacts.

The H2Ohio program focuses on proactive nutrient, erosion, and water management through participants' required nutrient management plan. This plan evaluates soil nutrient levels, operational needs, and manure sources, providing annual Tri-State recommendations. Producers receive cost-share for plan development by

agricultural retailers, SWCDs, or private consultants. Once approved, the plan governs nutrient application, encouraging producers to apply nutrients only when soil tests indicate a need. It follows the 4R principles – right source, right rate, right time, and right place – to minimize nutrient loss into waterways.

In 2023, over 1.2 million acres had completed H2Ohio practices in the 14 county Maumee watershed project area (Table 2).

Table 2. 2023 H2Ohio completed practices across the 14 county Maumee watershed project area.

Practice	Acres
Voluntary Nutrient Management Plan (VNMP) Implementation	796,100
Variable Rate Technology (VRT) Phosphorus Application	167,200
Subsurface Phosphorus Application	120,600
Manure Incorporation	37,200
Conservation Crop Rotation: Small Grains	74,300
Conservation Crop Rotation: Forages	4,700
Overwintering Cover Crop*	2,200
Conservation Ditches	8.5 miles 14,432 Acres

**Many Overwintering Cover Crops and Conservation Crop Rotation practices were rolled into an updated Practice Standard in the 14 Maumee counties. This led to lower numbers in some of those counties for 2023.*

The H2Ohio initiative initially promoted small grains, like winter wheat, to enhance crop rotation. These grains protect soil and allow for effective manure nutrient use while reducing nutrient loss risk. Recent updates broaden the definition of "overwintering cover," giving producers more options while retaining the benefits of small grains and other cover crops. In the mid-20th century, wheat was commonly grown in Ohio, but its popularity declined as soybeans became favored. The decline of wheat acreage in the Maumee watershed from 1950 to 2023 is evident in the data (Figure 13).

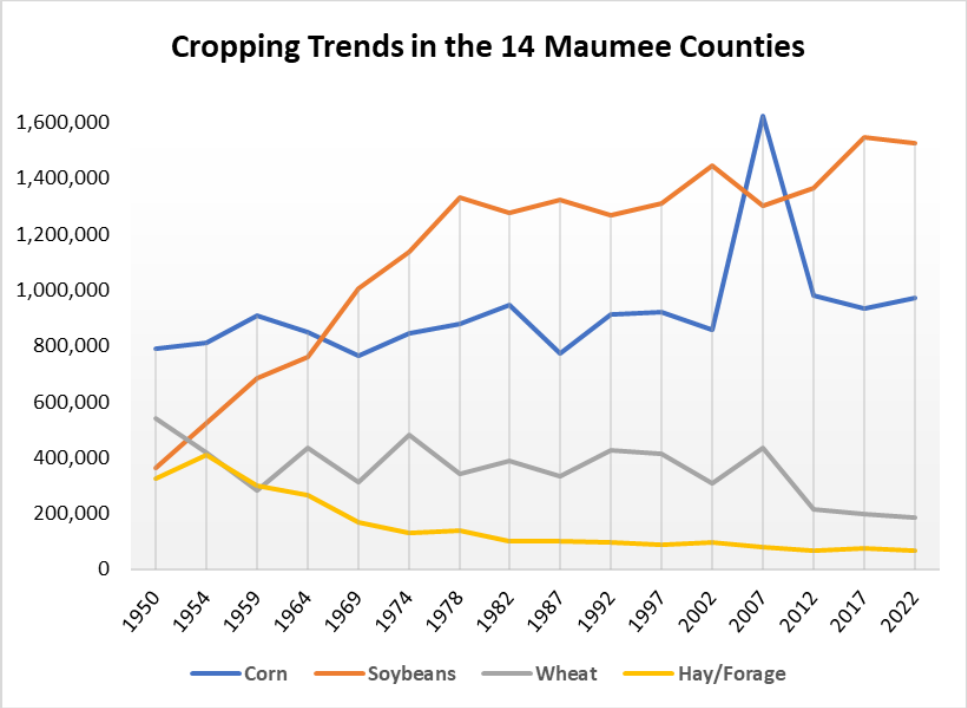

Figure 13. From 1950 to 2022, corn, soybeans, wheat, and hay/forage were produced in the 17 counties touching the Maumee watershed—National Agricultural Statistics Service.

Natural Resource Conservation Service (NRCS)

The USDA's Natural Resource Conservation Service (NRCS) runs programs to reduce soil erosion, enhance water supplies, and improve water quality. Some key programs have supported practices and assistance in the Maumee watershed.

Environmental Quality Incentives Program (EQIP)

The Environmental Quality Incentives Program (EQIP) is a conservation initiative that helps farmers, ranchers, and forest landowners integrate conservation practices. EQIP provides technical and financial support to address natural resource issues, including improving air and water quality, conserving water, enhancing soil health, reducing erosion, and creating wildlife habitats.

Great Lakes Restoration Initiative

GLRI funding enhances NRCS Farm Bill projects in priority Great Lakes watersheds, such as the Maumee watershed. It focuses on farm research via demonstration farms and edge-of-field studies, fostering partnerships with various organizations, and implementing practices to reduce phosphorus runoff from agricultural fields.

Regional Conservation Partnership Program (RCPP)

The RCPP is a collaborative approach to conservation that addresses natural resource challenges on agricultural land. More than 40 organizations from Ohio, Michigan, and Indiana work together through the Tri-State Western Lake Erie Basin Phosphorus Reduction Initiative to reduce phosphorus runoff into WLEB.

RCPP encourages collaboration between NRCS and its partners to provide conservation assistance to producers and landowners.

NRCS has funded the State of Ohio and local partners to support farmers in implementing conservation practices in the WLEB watershed, including the Maumee watershed, with $17.5 million in 2016 and $22.6 million in 2021. A notable project from 2001 is the Shallow Run Pilot Watershed in the Blanchard watershed, which involves collaboration among NRCS, ODA, local SWCDs, OSU, and other agricultural and research organizations. This project aims to saturate the watershed with conservation practices and monitor its impacts compared to a control watershed.

Western Lake Erie Basin Initiative EQIP

The United States and Canada are collaborating to restore Lake Erie and the Great Lakes. The U.S. Department of Agriculture's NRCS and other federal, state, and non-government partners aim to reduce phosphorus loading in Lake Erie through various projects. By offering technical and financial aid to farmers for conservation practices, NRCS supports improved water quality and soil health in the region. Since its launch in 2016, the NRCS Western Lake Erie Basin Initiative has committed $59.2 million in EQIP funding to tackle HABs. From 2013 to 2023, about 70% of EQIP funding in the Maumee watershed came from Great Lakes-specific programs (Figure 14), resulting in an additional $118.3 million for farmers to achieve HAB reduction goals.

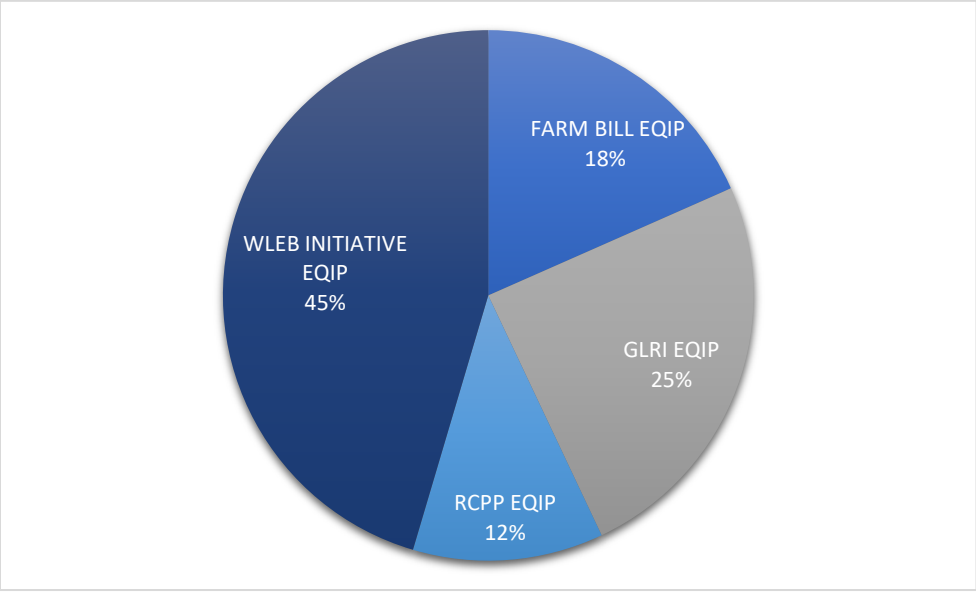

Figure 14. Percentage of funding allocated by each EQIP program in the Maumee Watershed from 2013 to 2023.

From 2013 to 2023, NRCS consistently funded BMP practices in the Maumee watershed called “treated acres.” Funding increased significantly from $3.3 million in 2013 to $6.7 million in 2014, with over $3 million invested annually throughout the decade. The number of treated acres varies yearly, as not all practices are measured in acres. In 2023, more than 2,800 acres had NRCS practices implemented (Figure 15).

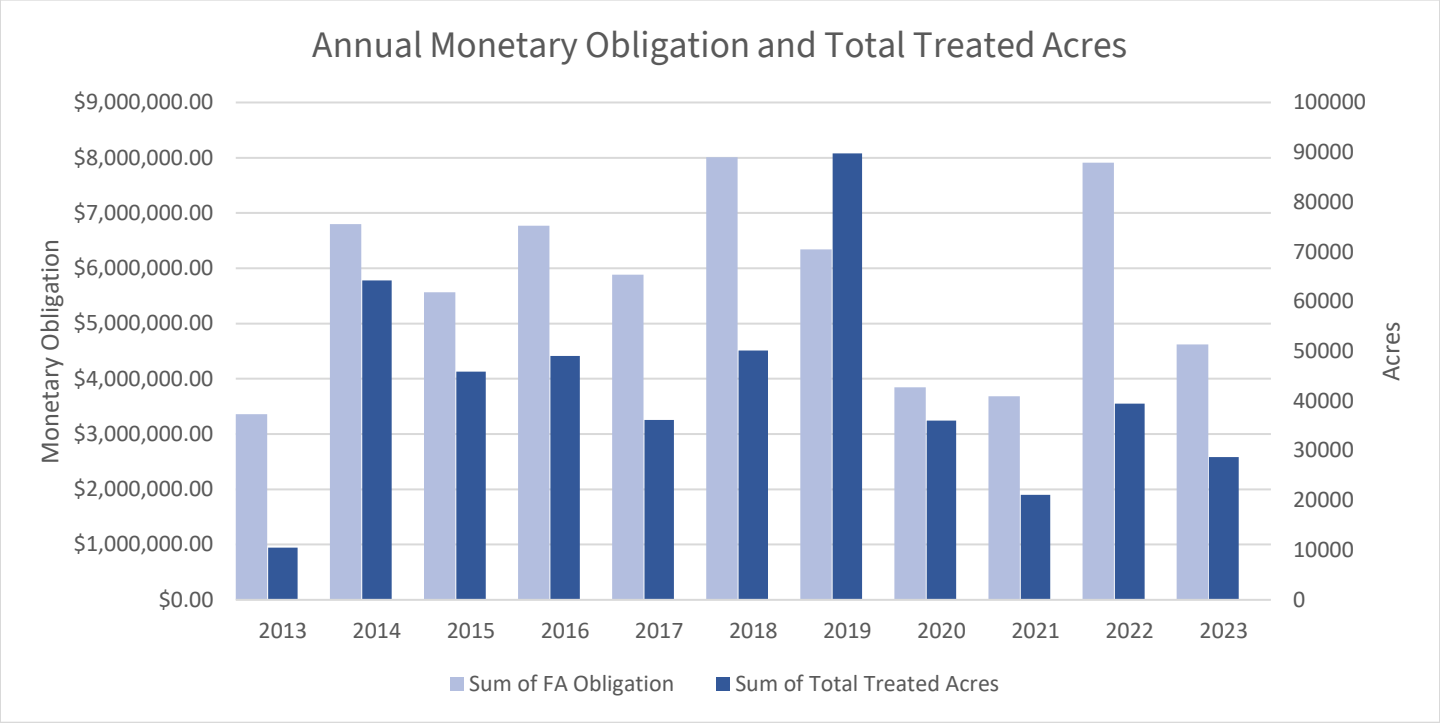

Figure 15. Sum of monetary obligation and treated acres for all NRCS programs from 2013 to 2023.

One way to assess BMP implementation through NRCS programs is by examining funding per cropland acre in a county, which can indicate adoption rates. However, this may be skewed if funding goes to expensive, one-time practices.

The monetary obligation per cropland acre in the Maumee watershed from 2013-2023 shows Hardin County with the highest at $93, while Fulton County has $51 per acre (Figure 16). This reflects more than 1,400 contracts and more than $9 million invested in BMPs. Other programs offer monetary and technical support for BMPs, which may explain the varying contract numbers.

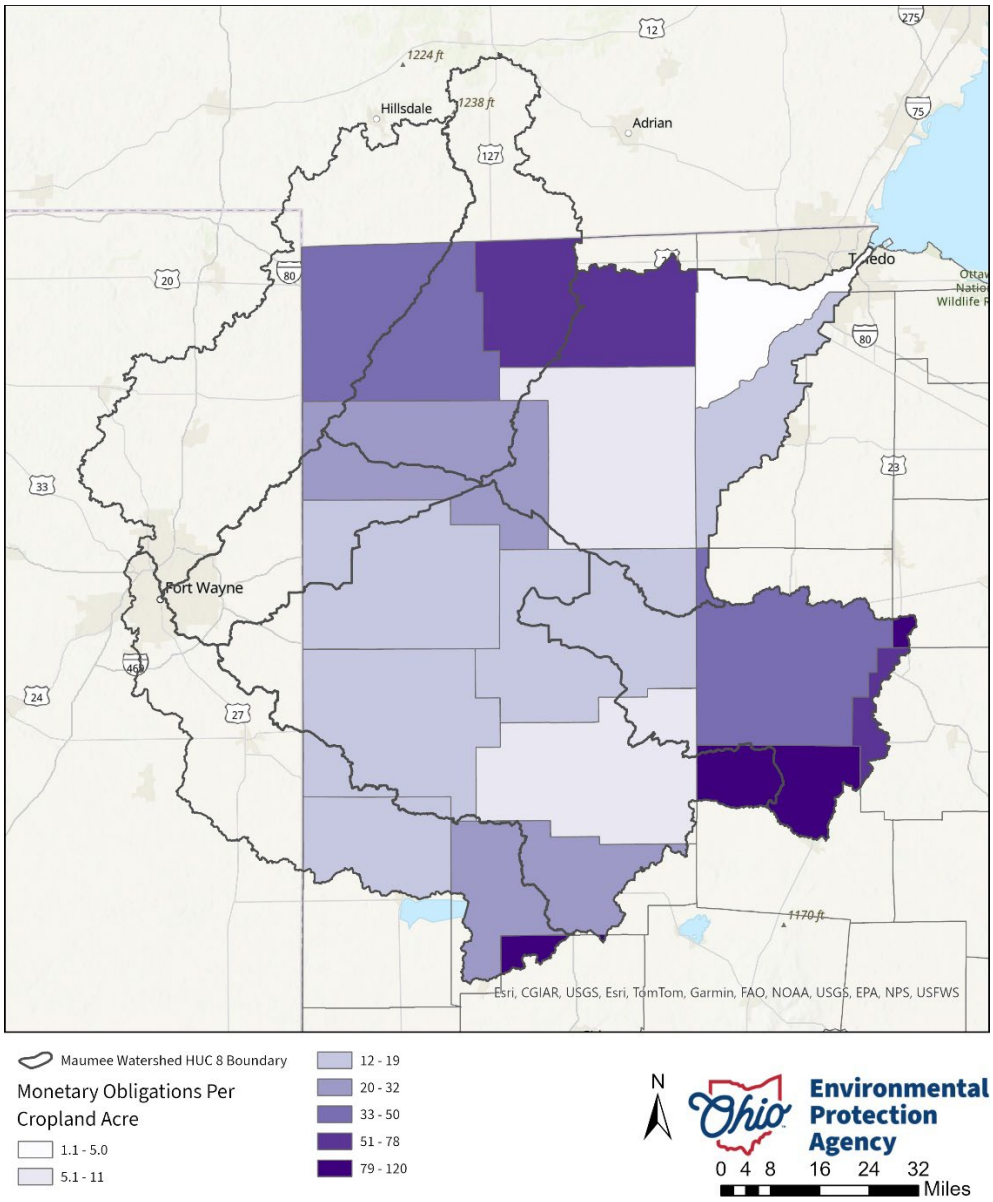

Figure 16. Monetary Obligations Per Cropland Acre within the Maumee Watershed from 2013-2023.

The NRCS practices can be categorized by their general uses, including “nutrient management”, “manure management”, “nutrient, erosion, and drainage water management”, “grazing”, “forestry”, and “other”. For the Maumee Watershed Nutrient TMDL, relevant practices include “nutrient management”, “manure management”, and “nutrient, erosion, and drainage water management”. From 2013 to 2023, 97% of EQIP monetary obligations went to these categories, with 43% for “nutrient, erosion, and drainage water management” and 32% for “manure management” (Figure 17).

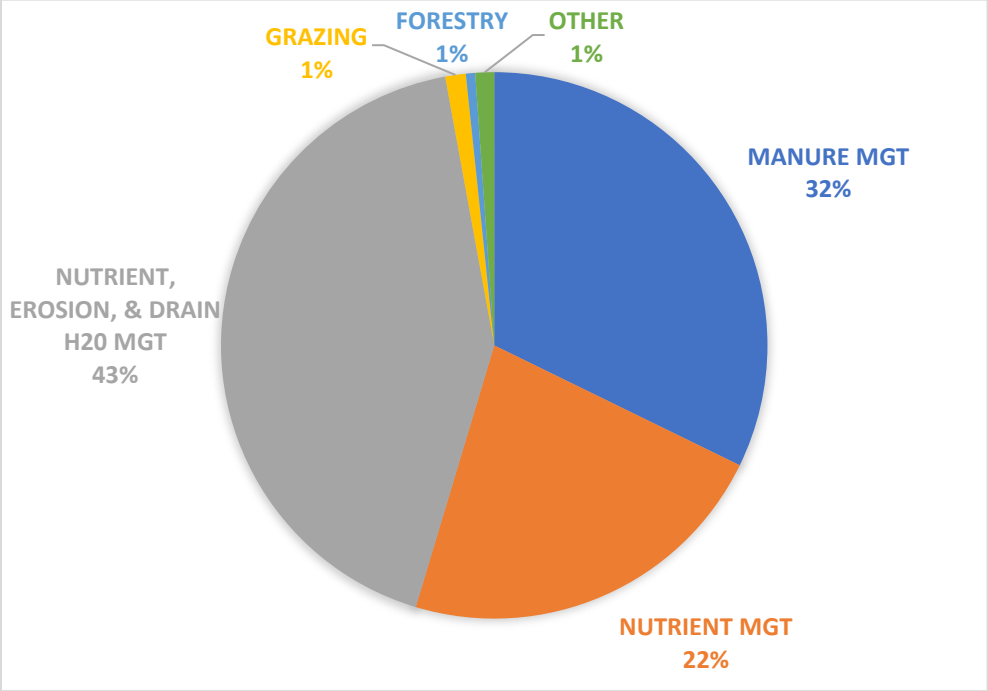

Figure 17. Percent of total monetary obligation for EQIP practices by general category from 2013 to 2023.

Industry-led efforts

4R Nutrient Stewardship

The 4R Nutrient Stewardship Framework is a collaboration between the Fertilizer Institute, the International Plant Nutrition Institute, the International Fertilizer Industry Association, and the Canadian Fertilizer Institute. It promotes the use of fertilizers sustainably through the right source, rate, time, and place, considering economic, social, and environmental factors. Launched in 2014, 2024 marks 10 years for Ohio's 4R Nutrient Stewardship Certification program, encouraging agricultural retailers and crop consultants to adopt best practices via a yearly audit process. A notable success of these programs is the reduction in phosphorus application to Ohio fields by 16% compared to 2004 (4R Nutrient Stewardship Certification 2024).

Studies such as King et al. (2018) have shown that following these guidelines reduces phosphorus loss. It is estimated that more than 35% of WLEB watershed farmland had implemented 4R practices two years after the program started (Vollmer-Sanders et al. 2016). The 4R Website reports these following accomplishments:

- 54 Certified Branch facilities
- 43 facilities in the WLEB watershed (this includes Michigan)
- 23 facilities in counties that are part of the Maumee watershed
- 5,000 clients serviced
- 2.5 million total acres serviced
- 1.41 million acres serviced in WLEB watershed
- 820,000 acres serviced in counties that are part of the Maumee watershed

Manure Management

Research in the early 2000s showed that 70% of the nitrogen and phosphorus given to animals was excreted (National Research Council, 2001). Farmers have adopted strategies such as those described here to mitigate nutrient waste and its economic impact.

Phytase and other enzymes in livestock feeds: Supplementing livestock diets with enzymes can reduce nitrogen and phosphorus excretion by improving digestion. For instance, adding phytase to the diets of monogastric animals, such as swine and poultry, helps release phosphorus from phytic acid in corn, which they poorly digest.

Studies have shown that using enzyme supplements can significantly lower nutrient content in manure. For example, Shirley and Edwards (2003) found that nitrogen and phosphorus retention increased from 50% in the control group to 70% with the highest phytase levels. Applegate et al. (2008) reported a 15-30% reduction in phosphorus in manure. Although initially not economically feasible, phytase has become more available and affordable, leading to increased adoption of this practice.

Low phytate corn: Corn contains high levels of phytic acid, which monogastric animals digest poorly. An alternative to enzyme supplementation is using corn hybrids with lower indigestible phytate phosphorus. A study by Ertyle et al. (1998) found that pigs and chickens fed “low-phytic-acid” corn excreted less phosphorus in their manure than those given conventional corn varieties (Ertl et al., 1998).

Phased feeding: Phased feeding aligns nutrient inputs with animal growth requirements through a tailored diet that meets specific nitrogen and phosphorus needs at each growth stage. This method can decrease nutrient excretion, as demonstrated by Wu et al. (2000), who found a linear relationship between phosphorus intake and fecal phosphorus excretion.

Conservation Reserve Program/Conservation Reserve Enhancement Program

The Conservation Reserve Program (CRP) is a Farm Service Agency program in which farmers are paid to remove environmentally sensitive land from agriculture and plant species to enhance environmental health. Contracts last 10-15 years and aim to improve water quality, prevent soil erosion, and protect wildlife habitat.

The Conservation Reserve Enhancement Program (CREP), a component of CRP, addresses specific conservation issues. For example, the Lake Erie CREP initiated in 2000 aims to establish 67,000 acres of conservation practices.

As of February 2024, more than 58,000 acres are enrolled in CRP, with Defiance County having the most acreage (Figure 18).

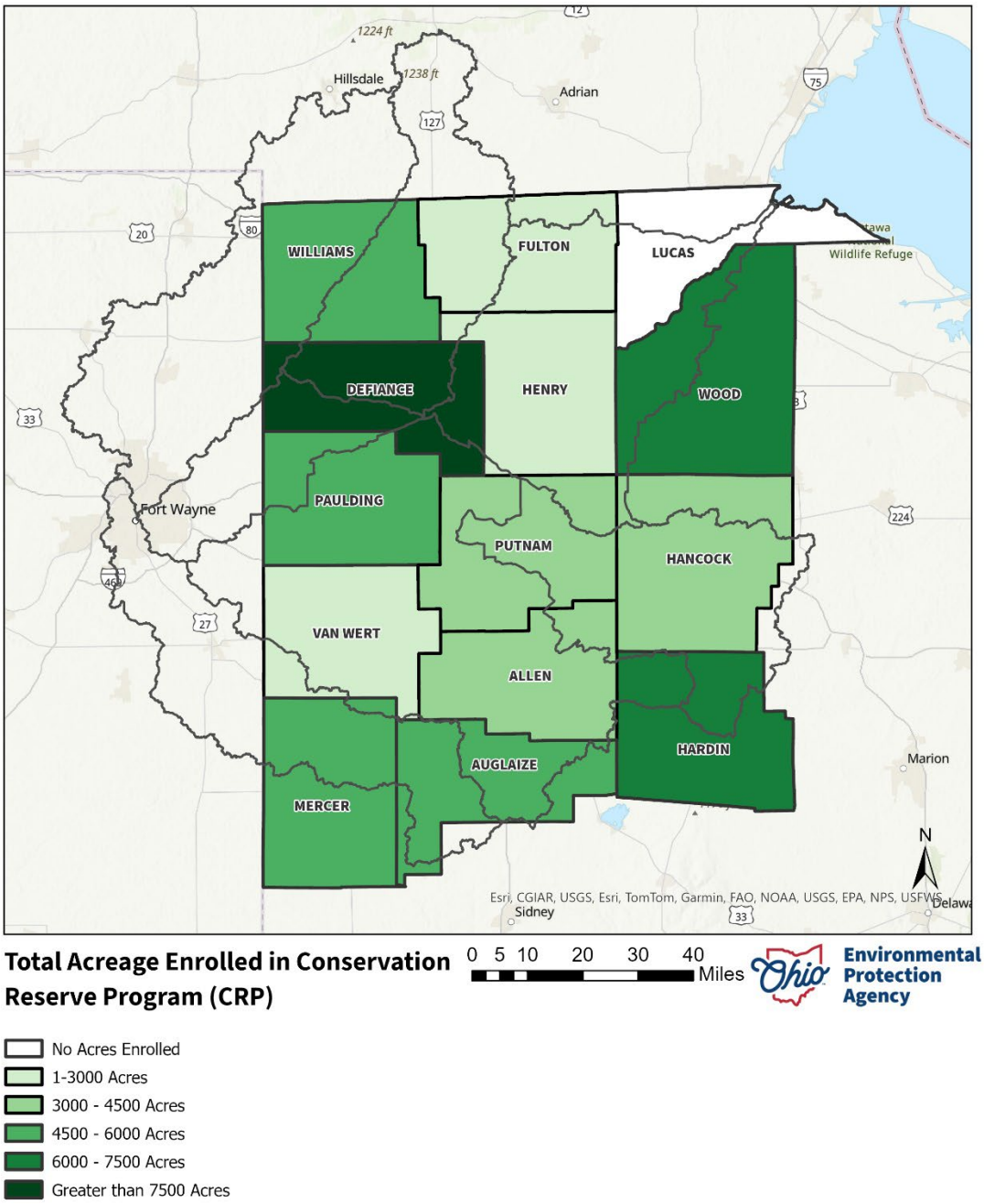

Figure 18. Total acreage enrolled in Conservation Reserve Program (CRP) in counties within the Maumee watershed (Ohio portion).

Collaboration and Partnerships through Overarching Programs

A key milestone in the Maumee Watershed Nutrient TMDL initiative is collaboration with federal partners to reduce nonpoint source loads. Progress is evident through the implementation of projects funded by the GLRI, H2Ohio, and farm conservation programs. Projects implemented through these programs bring together federal, state, and local partners. More than 50 organizations, including federal agencies, state agencies, municipalities, local groups and county conservation districts, have been partners of projects implemented in the Maumee watershed.

The Maumee Area of Concern (AOC) exemplifies this teamwork, bringing together partners such as the Great Lakes Commission, the University of Toledo, Toledo Metroparks, Toledo-Lucas County Port Authority, ODNR, and many others (Figure 19). On Sept. 9, 2024, U.S. EPA showcased the Maumee AOC and its ongoing projects such as those described below. More details are available on the GLRI webpage, the Maumee AOC website, or its interactive map.

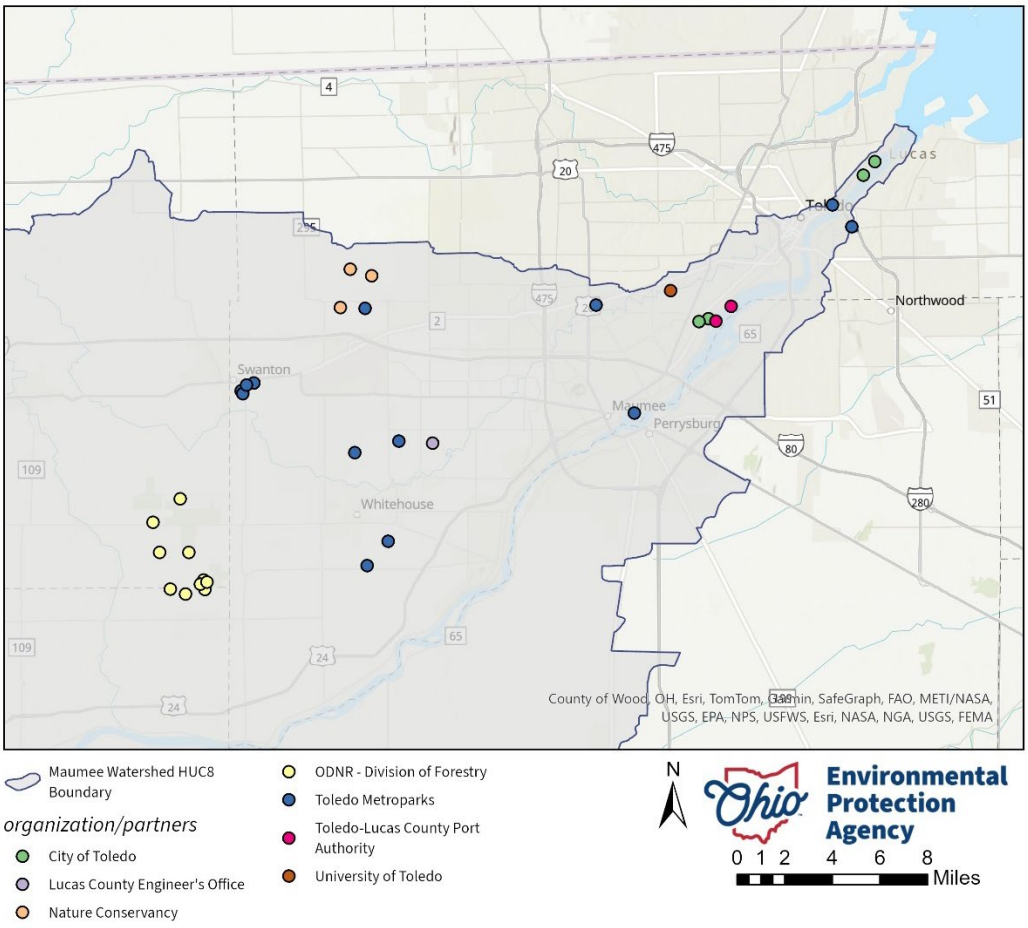

Figure 19. Projects within the Maumee Watershed-portion of the Maumee Area of Concern.

The following three projects received AOC-GLRI funding that are underway and shows the collaboration between organizations.

University of Toledo Medical Center (UTMC) Swan Creek Stream Restoration: The Great Lakes Commission has received funding from the GLRI for a project aimed at stabilizing banks, reducing erosion and sedimentation, creating fish and macroinvertebrate habitats, and improving stream development. This will take place along Swan Creek, next to Metroparks Toledo's Swan Creek Preserve and the University of Toledo's Medical Center, with construction expected to start in 2026 (Figure 20).

Figure 20. University of Toledo Medical Center (UTMC) Swan Creek Stream Restoration Project. Photos by Cherie Blair, Ohio EPA.

Audubon State Nature Preserve Islands Restoration: The Toledo Metroparks received GLRI funding for this project to protect the Ewing and Grape Islands, restore eroded areas, control invasive species, and enhance habitats. Features will include rock barrier reefs, riparian plantings, stone shelves, engineered log jams, planted hummocks, and submerged logs (Figure 21).

Figure 21. Audubon State Nature Preserve Island Restoration Project. (Left) Island with edge heavily impacted by erosion with kayaker for scale. Photo by Partners for Clean Streams. (Right) Overview of the island. Photo by Lucas County SWCD.

Clark Island and Delaware/Horseshoe Island Restoration Project: This project, funded by GLRI and H2Ohio, aims to improve and restore more than 63 acres with a budget of $13.5 million. Construction began on Jan. 8, 2024 with completion anticipated in fall 2025. The GLRI portion will enhance 12 acres of wetlands and manage 29 acres for Phragmites, featuring a rock barrier reef, cove improvements, and invasive species management. The H2Ohio portion will enhance 6.9 acres of wetlands, including an open backwater area and breakwater islands. The project will improve water quality, reduce sedimentation and nutrient loading, and protect against island erosion (Figure 22 - Figure 25).

Figure 22. Overview of Clark Island. Photo by Verdantas.

Figure 23. Clark Island project in progress. Photo by Cherie Blair, Ohio EPA.

Figure 24. Delaware Island has created microtopography for fish and macroinvertebrates, as shown in a photo by Cherie Blair, Ohio EPA.

Figure 25. Lead project partners from ODNR, Ohio EPA, City of Toledo, Toledo- Lucas County Port Authority, and others touring the Clark Island project. Photo by Cherie Blair, Ohio EPA.

ODNR's Division of Forestry received funding from the GLRI to expand the Maumee State Forest by eliminating tile drains from formerly farmed land and enhancing wetlands and forested areas.

In 2022, they received additional GLRI funding for a stream restoration project on Blue Creek at the Maumee State Forest Hight Property. In collaboration with The Nature Conservancy, this project aimed to restore habitats, stabilize stream banks, restore the riparian buffer, and install living wattle fences to protect a Category 3 wetland and enhance water retention.

Since 2014, GLRI has allocated nearly $5 million to ODA to support initiatives like the Ohio Clean Lakes Initiative and H2Ohio to reduce phosphorus in Lake Erie through nutrient management and agricultural BMPs. This funding has facilitated technical assistance and incentives for local landowners. EQIP funding also helps connect landowners with government resources for BMP implementation.

OLEC received funding through GLRI to support Ohio's Domestic Action Plan. The grant supported the acquisition of subsurface fertilizer placement equipment, promotion of 4R Nutrient Stewardship, construction of structural BMPs in urban and agricultural watersheds, and development of NPS-IS watershed plans.

Progress Toward Milestones

Ohio EPA has identified six milestones to track progress removing beneficial use impairments from western Lake Erie. Some milestones, like updating Ohio's DAP, are easy to measure, while others, such as improving collaboration with federal partners, are more complex. Many previous projects highlight the diverse partnerships and collaborative efforts among federal, state, and local organizations. Measurable progress toward the milestone goals is shown below.

- Ohio's DAP updated - finalized in January 2024
- Increased implementation of BMPs through H2Ohio
    - 19 new wetland projects funded since fiscal year 2022
    - In 2023, over 1.2 million acres completed practices through H2Ohio
- Leverage of GLRI funding through grants and projects
    - Ohio EPA received six grants for fiscal years 2022 and 2023 to place multiple projects and practices in the Maumee watershed
    - The Maumee portion of the Maumee AOC received GLRI funding for 12 ongoing projects
    - ODNR and ODA have received funds through GLRI
- Phosphorus General Permit
    - 2023 seasonal load was below the wasteload allocation assigned to the general permit
- Increase HUC-12 NPS-ISs from 58 to 72 as of December 2024

Intermediate Indicators

Intermediate indicators help evaluate the effectiveness of BMPs. Soil test phosphorus trends and agricultural phosphorus mass balance will be used as these indicators. ODA analyzed data from crop production, fertilizer sales, and livestock populations in the Maumee watershed and WLEB watershed to assess nutrient trends and mass balance in the region (methodology adopted from Bundy and Sturgul, 2001).

Livestock Trends and Nutrient Mass Balance

ODA compiled data from crop production, fertilizer sales, and livestock populations in the Maumee watershed to evaluate the watershed's trends and nutrient mass balance.

Livestock Population

The USDA Census tracks livestock populations and is available on the National Agricultural Statistics Service website. To enhance accuracy, USDA data was supplemented with ODA's Division of Livestock Environmental Permitting information to address privacy-related omissions. Populations of dairy cows, beef cattle, hogs, poultry, and turkeys were tabulated and converted to animal units, showing a 9.7% increase in total animal units in the Maumee watershed since the 2017 census (Figure 26). This trend reflects a rise from a historic low in the early 2000s, noted in the Maumee Watershed Nutrient TMDL report (Ohio EPA, 2023).

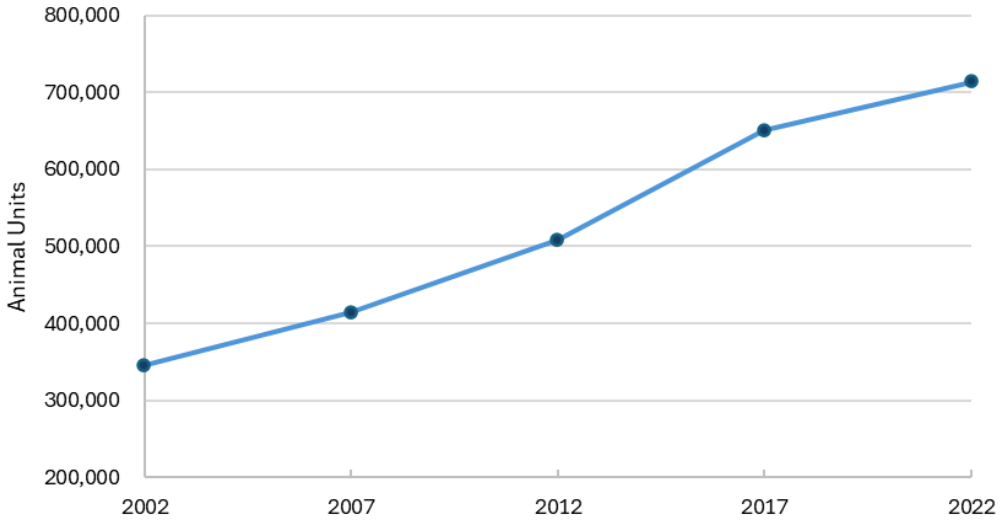

Figure 26. Animal units in the Maumee watershed in Ohio (2002 to 2022). Source: National Agricultural Statistics Service & Ohio Department of Agriculture Division of Livestock Environmental Permitting.

Manure Phosphorus

Livestock data was used to estimate the amount of manure phosphorus (on a P_2O_5 basis) produced in the basin, using established values of manure nutrient concentration for each species. The summary of manure P_2O_5 produced is shown in Figure 27. Manure P_2O_5 produced increased 7% from 2017 to 2022.

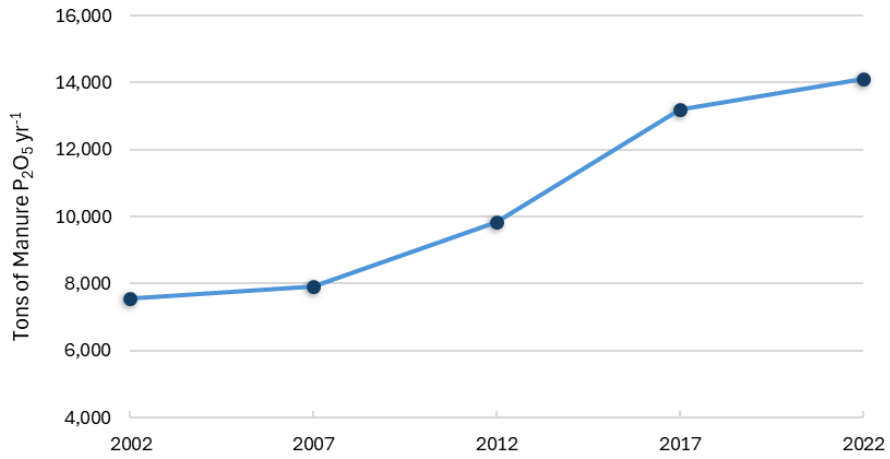

Figure 27. Estimated tons of manure P2O5 are produced annually in the Maumee watershed in Ohio—Source: National Agricultural Statistics Service & Ohio Department of Agriculture Division of Livestock Environmental Permitting.

Phosphorus Fertilizer Sales

Fertilizer sales data are useful indicators of applications across a multi-county area. ODA's Division of Plant Health tracks these sales. Data from 2006 to 2023 comes directly from the ODA, while data from 1987 to 2005 is sourced from NuGIS records. This information reflects phosphorus sales (as P2O5) in the Maumee watershed from 1987 to 2023 (Figure 28).

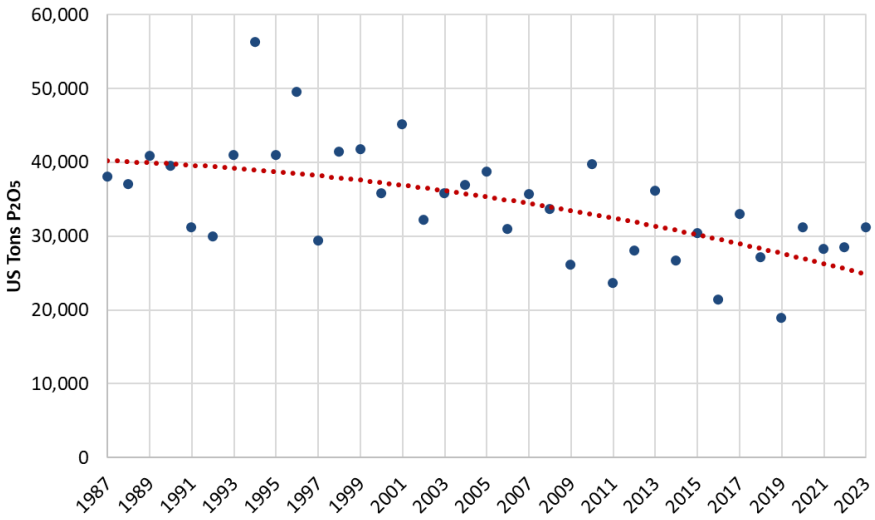

Figure 28. Phosphorus fertilizer sales (on a P2O5 basis) in the Maumee watershed in Ohio from 1987 to 2023. Source: Ohio Department of Agriculture, Division of Plant Health and NuGIS.

Since the mid-nineties, phosphorus fertilizer sales have dropped by 20% to 30%, even as crop yields continue to rise (Figure 29). This trend is evident in the Maumee watershed counties and WLEB watershed counties.

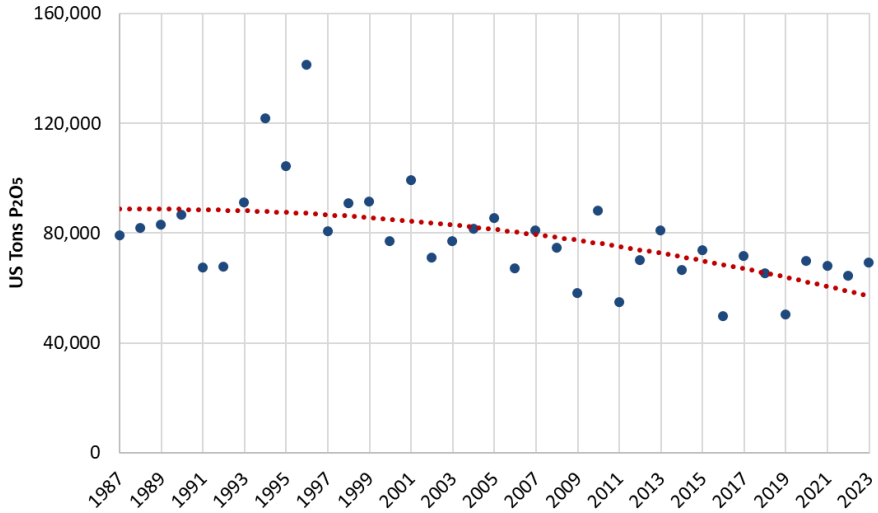

Figure 29. Phosphorus fertilizer sales (on a P2O5 basis) in the 24 WLEB watershed counties from 1987 to 2023. Source: Ohio Department of Agriculture, Division of Plant Health and NuGIS.

The decline in phosphorus fertilizer sales can be attributed to improved education and training in nutrient management practices. Using soil tests and crop yields, producers can accurately determine the nutrients needed, preventing over-application and reducing costs while minimizing nutrient runoff into waterways.

This decline began in the mid-1990s, aligned with the release of the Tri-State Fertilizer Recommendations by The Ohio State University Extension. This joint effort by Michigan State University, The Ohio State University, and Purdue University enhanced nutrient management education.

The 4R Nutrient Stewardship Certification Program, introduced in 2014, further boosted awareness, and the H2Ohio initiative launched in 2020 expanded engagement, bringing hundreds of thousands of acres under nutrient management plans in Northwest Ohio.

Agriculture Nutrient Mass Balance

Analyzing phosphorus fertilizer sales and manure phosphorus alongside crop nutrient removal provides a precise mass balance of inputs and outputs. Using NASS survey data and 2020 Tri-State Fertilizer Recommendations, ODA calculated the annual P2O5 removed from corn, soybeans, and wheat in Ohio's Maumee watershed, alongside data on fertilizer sales and manure P2O5 production (Figure 30).

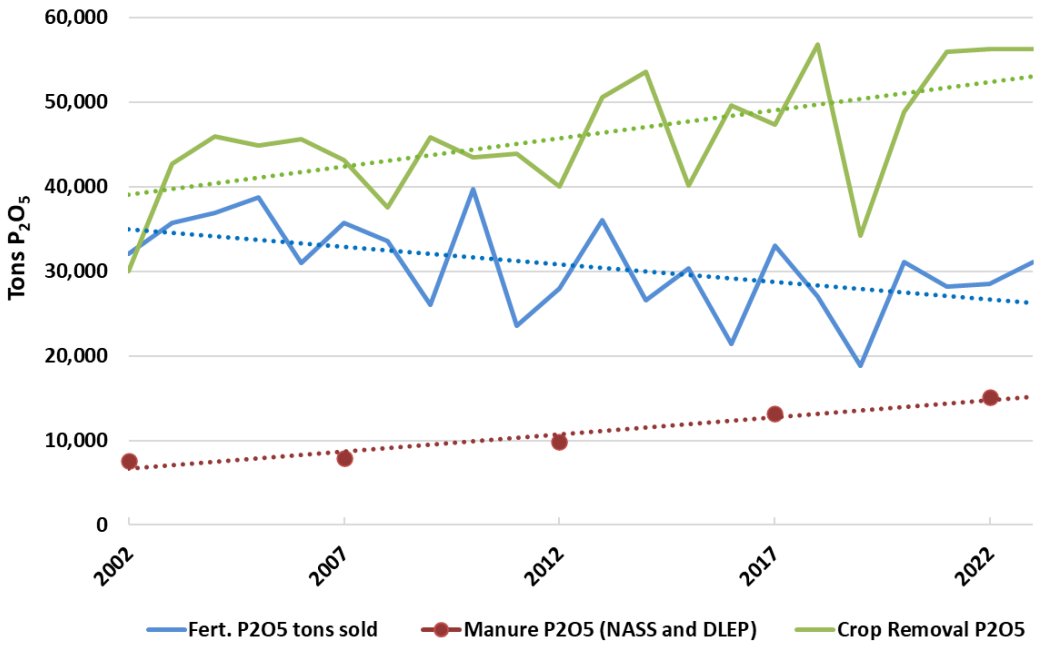

Figure 30. Fertilizer, manure, and crop removal P2O5 in the Maumee watershed in Ohio. Source: Ohio Department of Agriculture, Division of Plant Health, Division of Livestock Environmental Permitting, and National Agricultural Statistics Service.

Since 2002, phosphorus fertilizer sales have consistently been lower than crop removal. Combined, fertilizer and manure phosphorus are below crop removal since 2007. As of the 2022 census, phosphorus fertilizers met 51% of crop needs, manure 26%, while biosolids and other fertilizers contributed less than 10%. This results in a phosphorus deficit, leading to declining soil phosphorus levels.

Soil Test Phosphorus Trends

Ohio soil test data from 2005 to 2020, obtained from the Fertilizer Institute, categorizes phosphorus levels based on Tri-State agronomic levels. "Low" indicates a "Build-up" level for improved crop yield, while the "Agronomic Range" is sufficient for production without extra nutrients. "High" and "Very High" levels do not require nutrient applications. Although county-specific data is unavailable, statewide analysis shows an increase in soils within the agronomic range from 2005 to 2020, with a decrease in High or Very High ranges (Figure 31).

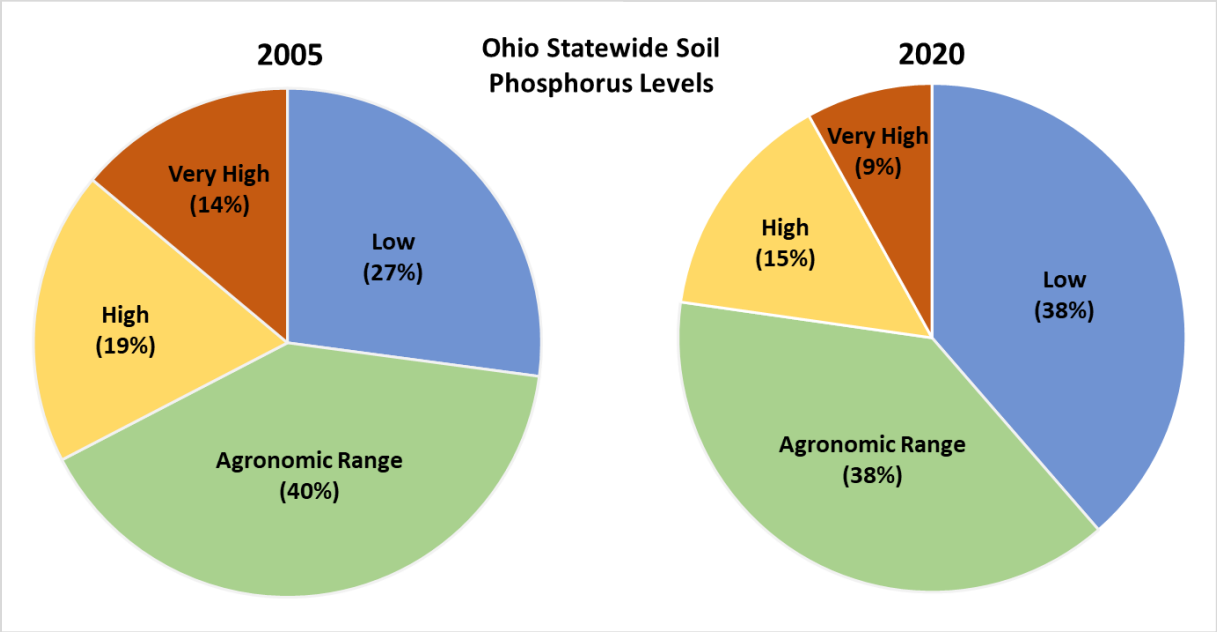

Figure 31. Ohio soil phosphorus levels (statewide) from 2005 and 2020 grouped by major agronomic levels. Source: The Fertilizer Institute.

The mean soil test value decreased by approximately 24% from 2005 to 2020, underlining the broad decrease in soil phosphorus across the state (Figure 32).

Statewide Soil Test Phosphorus Values

Year	Samples	Mean M3 Phosphorus (PPM)
2005	85,777	34
2010	248,760	32
2015	327,982	28
2020	273,753	26

Figure 32. Ohio (statewide) soil test phosphorus values. Source: The Fertilizer Institute.

While the most current data is at the statewide level, some county-level data is also available. A publication by Dayton et al. (2015) collected and analyzed county-level soil data throughout the state. The study's findings noted:

“In 2014, 84% of counties had a negative P balance, ranging from −2 to −49 Mg P yr−1, demonstrating P outputs exceeded P inputs. Of the 16% of counties with a positive P balance, only two drain into the WLEB.”

ODA's mass balance analysis reveals that phosphorus outputs in the Maumee watershed exceed inputs. Dayton's study of 24 WLEB watershed counties found that 16 had decreasing soil phosphorus trends, five showed no significant change, and three had increasing trends – one was in the Maumee watershed. While

some fields have high phosphorus levels, most are within or near the agronomic range, indicating an overall decline in soil phosphorus levels.

Ohio Agricultural Conservation Initiative (OACI)

In 2021, the Ohio Agricultural Conservation Initiative (OACI) surveyed the Lower Maumee River watershed and found that more than 66% of farmers were in cost-share programs and 54% of fields had voluntary nutrient management plans (OACI 2022, Figure 33).

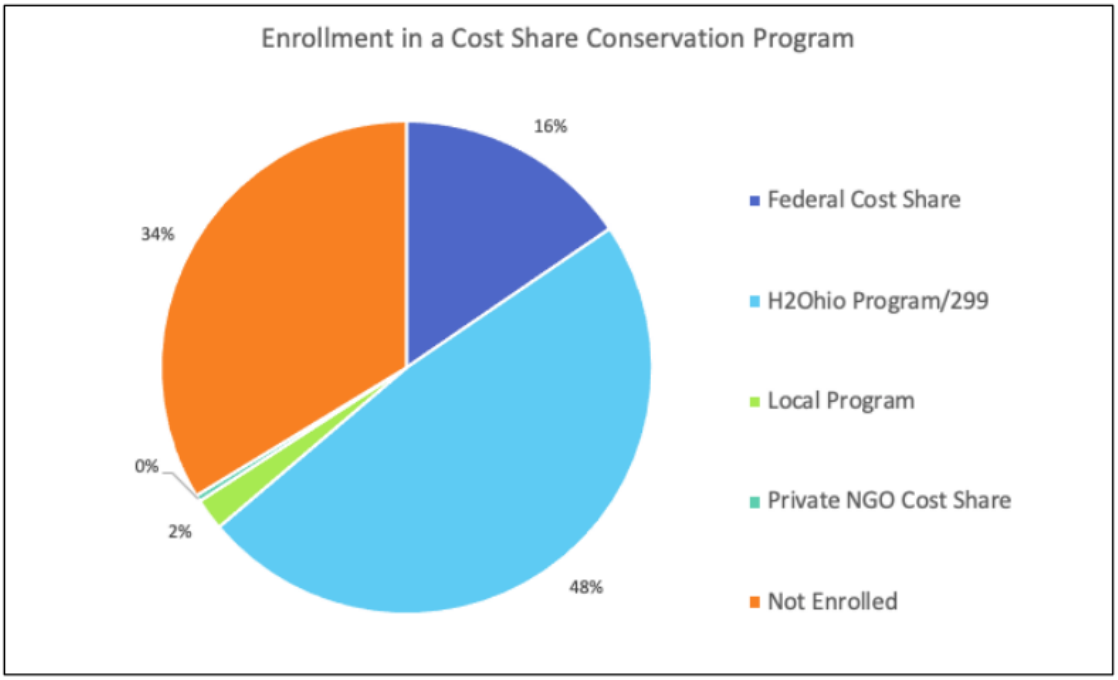

Figure 33. Summary of fields enrolled in cost-share programs. Source: OACI (2022)

The Lower Maumee River watershed will be resurveyed to note any changes in farm practices, along with a baseline survey of the Auglaize watershed (HUC 8: 04100007). OACI plans to conduct these surveys every three years. Visit OACI's webpage to learn more about the Lower Maumee River Watershed Survey.

Research

H2Ohio Wetland Monitoring

In 2023, the H2Ohio monitoring program assessed 25 projects, with eight designated as focal projects for more frequent sampling of water, vegetation, soil, and related processes. Four wetlands in the Maumee watershed were selected as focal projects: the Forder Bridge Treatment Train Wetland, St. Joseph's Restoration Project, Oakwoods Nature Preserve East, and Oakwoods Nature Preserve West. Preliminary results from the H2Ohio Wetland Monitoring Program 2023 report show early successes in nutrient retention and highlight areas for improvement in design and management.

Seven other H2Ohio wetland projects listed below are monitored routinely but not classified as focal projects (LEARN 2023b).

- Otsego Schools Wetlands Restoration (Fox Shank Living Laboratory)
- Oak Openings Preserve Wetland Restoration
- Van Order Wetland and Forest Restoration
- Springville Marsh Wetland Extension
- St. Joseph Confluence Wetland Reconnection
- Weisgerber-Pohlman Nature Preserve Restoration
- Sugarcamp 7 Blanchard Habitat Project

Forder Bridge Floodplain Reconnection

The Forder Bridge Floodplain Reconnection project restored wetlands on a 54-acre site next to the Maumee State Scenic River in Paulding County (Figure 34). Activities included installing passive treatment wetlands, recontouring streambanks to reconnect the Maumee River to its floodplain, and adding riffle-grade control structures to reduce streambank erosion. The project was completed in 2021, with monitoring beginning in 2022.

Figure 34. Forder Bridge Floodplain Reconnection Project. Photos by Ohio Department of Natural Resources.

Monitoring data from 2023 indicates that the Forder Bridge Floodplain Reconnection Project has retained an estimated 4-45 pounds of total phosphorus and 22-290 pounds of total nitrogen (Figure 35). Future monitoring efforts will involve the installation of water sensors and a weather station. These tools will measure the volume of water and concentration of nutrients flowing from the treatment train outlet.

	Nutrient Load Reduced (lbs)	
	Total Phosphorus	Total Nitrogen
FALL	0–2	0–1
WINTER	1–7	9–60
SPRING	1–9	8–57
SUMMER	2–13	4–56
TOTAL	4–31	21–175

Figure 35. Nutrient load reductions of the Forder Bridge Floodplain Reconnection. Source: LEARN (2023a, OHSU_The-H2Ohio-Wetland-Monitoring-Program-ForderBridge-Case-2024.pdf (lakeerieandaquaticresearch.org)

St. Joseph's River Restoration Project

The St. Joseph River Restoration project restored 56 acres of wetlands and forests and converted tiled and ditched waterways into natural streams (Figure 36). It aimed to show how sustainable farming enhances water quality and included funding to purchase nearly 94 acres of farmland along the river. Completed in 2021, monitoring began soon after.

Results show the project removed 20 to 50 pounds of total phosphorus and 600 to 800 pounds of total nitrogen. The 22 acres of wetland can store up to 2,263 pounds of total phosphorus and 7,447 pounds of total nitrogen. Future monitoring will involve deploying additional sensors and at least one automated water sampler to collect samples during high-flow events (LEARN 2023a).

Figure 36. St. Joseph's River Restoration project ribbon cutting. Photo by Ohio Department of Natural Resources.

Oakwoods Nature Preserve East and Oakwoods Nature Preserve West

The Oakwoods Nature Preserve East project restored 65 acres of former agricultural land, primarily converting it into wetlands and planting the remaining area as a native prairie (Figure 37). Its main goals are to restore natural water flow and capture excess nutrients and sediment from nearby farmland.

The Oakwoods Nature Preserve West project involved creating and restoring wetlands, woodlands, and prairie on 77 acres of floodplain. Goals include reconnecting Aurand Run to its floodplains, treating nutrient-rich water through three acres of forested wetlands, removing underground drain tiles, and enhancing habitats along Aurand Run.

Both projects are part of the larger restoration effort at Hancock Park District's Oakwoods Nature Preserve and were completed in 2021, with monitoring beginning later that year. Together, they have prevented 82 pounds of total phosphorus from entering the Aurand Run watershed. In the 2022 growing season, wetland plants stored 4,746 pounds of total nitrogen and 1,728 pounds of total phosphorus. Future monitoring will involve deploying water level sensors and installing an automated sampler to collect water samples during water exchange periods with Aurand Run.

For project highlights, watch the video on ODNR's Youtube Channel.

Figure 37. Oakwoods Nature Preserve. Photo by Marissa Ganzfried, Ohio EPA.

Harmful Algal Bloom Research Initiative (HABRI) Projects

The Harmful Algal Bloom Research Initiative (HABRI) was created in response to the 2014 Toledo water advisory, with the Ohio Department of Higher Education allocating two million dollars for research at Ohio's universities to tackle the harmful algal bloom issue in Lake Erie.

HABRI focuses on four areas: tracking blooms at their sources, ensuring safe drinking water, protecting public health, and engaging stakeholders. Several projects that may inform the implementation of the Maumee Watershed Nutrient TMDL fall under the first two areas.

Funding for fiscal years 2024 and 2025 has been announced for 17 new projects, including four that involve studies in the Maumee Watershed or Lake Erie. More details about these projects can be found on the Ohio Sea Grant's website.

The 2023 Harmful Algal Bloom Research Initiative Report, released in September 2023, summarizes completed and ongoing projects. Below, we highlight those relevant to the Maumee watershed, focusing on local impact and best practices in nutrient management.

Completed Projects

Evaluating the impact of rivers on phosphorus delivery to western Lake Erie—Data modeling and on-site surveying analyzed phosphorus movement in the Maumee watershed. The findings will help decision-makers

understand whether streams are a source or sink for phosphorus and how to reduce nutrient runoff. Jim Hood led the project from Ohio State University.

Preventing Blooms by Slowing Down Water Flow on Farm Fields – The study confirmed that tile drainage systems in Ohio farmland cause streams to transport nutrients more quickly. However, automated drainage water management can reduce this by slowing water flow. This project was led by Steve Lyon at The Ohio State University.

Ongoing Research

Quantifying the Role of Sediment in Phosphorus Exports from Drainage Networks: sources, Recency and DRP Interactions - This project explores how sediment composition, source, and age affect instream phosphorus cycling, led by Jim Hood at Ohio State University.

Optimizing Manure Application Timing and Soil Health Testing to Improve Water Quality Outcomes and Farmer Profitability—Researchers at Ohio State University are conducting trials to compare the effects of applying manure in spring on growing crops versus applying it in the fall on bare soil. Preliminary results suggest spring side-dressing enhances nitrogen use efficiency, increases yield, and reduces nitrate and phosphorus loss. Leonard Deiss leads the project.

Evaluating Field- and watershed-scale water quality benefits of H2Ohio conservation practices in the Maumee watershed – Researchers are studying the effectiveness of H2Ohio's conservation practices in the Maumee watershed through remote sensing and modeling. The project is led by Asmita Murumkar, Jay Martin from Ohio State University, and Kevin Czajkowski from the University of Toledo.

Evaluation of a Modified Two-Stage Ditch Design Approach for Sediment and Nutrient Removal: Researchers are quantifying sediment and nutrient retention in two-stage ditch channels and self-forming channels. The data has been used to inform programmatic decisions for the H2Ohio program. John Witter and Dan Mecklenberg are leading this project from Ohio State University.

Other Research Projects

Great Lakes Restoration Initiative (GLRI) Funded Projects

The GLRI funds projects aligned with specific action plan focus areas. Focus Area 5 aims to inform and assess Great Lakes restoration efforts, particularly evaluating the effectiveness of practices and predicting HAB toxicity.

A 2020 study by Jacquemin et al. found that saturated buffers in the Maumee watershed effectively diverted a quarter of tile-drained runoff and reduced nitrogen and phosphorus levels to below detectable limits.

The Ohio State University and the University of Toledo received a joint grant to study the timing of toxin production in cyanobacteria blooms and the presence of harder-to-treat microcystins. Their goal is to create a model to forecast cyanobacterial toxicity. This project, funded in 2023, will run through 2026.

Army Corps of Engineers Harmful Algal Bloom projects

The Water Resources Development Act of 2018 authorized the U.S. Army Corps of Engineers (USACE) to undertake a five-year research initiative focused on scalable technologies for detecting, preventing, and managing HABs. Coordinated by the U.S. Army Engineer Research and Development Center (ERDC), the initiative aims to reduce HAB frequency and impacts on the nation's water resources and includes three focus areas: prevention, detection, and management. More detailed information about current projects and technology can be found in the 2024 USACE freshwater Harmful Algal Bloom Research and Development report.

Projects relevant to the Maumee Watershed Nutrient TMDL will specifically address HAB prevention related to nutrient management. Below is a brief description of one such project in the Maumee watershed.

Developing scalable HAB prevention technologies in the Ohio region – The Ohio State University and the USDA Agricultural Research Service (USDA-ARS) have joined forces to evaluate USDA-approved BMPs for nutrient management on fields with legacy phosphorus. Innovative BMPs and designs will be identified, implemented, and monitored. The findings from this study will help assess regional management needs, as outlined in the USDA's 2024 report. As of February 2024, two research articles have been published or are under review based on the current findings *Techno-Economic Analysis of Phosphorus Removal Structures* (Scott et al. 2023) and *Quantifying Phosphorus Loads from Legacy Phosphorus Fields* (Brooke et al., in review).

On November 22, 2024, ERDC released a call for proposals for projects to significantly reduce the frequency and effects of HABs associated with water resources development projects, demonstrate innovative technologies or combinations oof technologies for HAB prevention or management at large field scales, or generate field-scale cost and technology performance data to guide informed technology use and support technology transfer. The deadline for submissions is January 27, 2025. More information on this call for proposals can be found on the ERDC website.

Conservation Effects Assessment Project (CEAP)

The Conservation Effects Assessment Project (CEAP) analyzes watersheds to evaluate the impact of conservation practices in the WLEB watershed, informed by a farmer survey. This assessment measures effects from NRCS-funded practices, other programs like H2Ohio, and privately implemented practices.

The 2012 CEAP Edge of Field Study found that conservation efforts in the WLEB watershed, including the Maumee watershed, significantly reduced pollutants at the edges of fields. The estimated pollution reductions are summarized here and detailed in the 2012 study (NRCS CEAP Report, 2016).

- ***Annual Sediment Losses reduced by 80%*** (13.4 million tons per year),
- ***Annual Nitrogen Losses reduced by 26%*** (60.9 million pounds per year)
- ***Annual Total Phosphorus Losses reduced by 61%*** (14.9 million pounds per year)
- The practices in place ***reduced the total P load reaching Lake Erie by 41% compared to no practices in place***.

The 2016 CEAP study evaluated the impact of agricultural practices and pollutants from the mouth of the Maumee watershed. It found that practices introduced in 2012 reduced total phosphorus by 41% compared to scenarios without these practices, demonstrating the effectiveness of conservation efforts. The NRCS will repeat the CEAP study to assess progress in the watershed.

Water Quality Gages

Water Quality Monitoring in Streams

Comprehensive water quality data for evaluating phosphorus loads are collected at over 20 locations throughout the watershed, from small HUC-12 watersheds to the Maumee River near Waterville, Ohio (Figure 39). The Waterville gaging station has been central to water quality assessment for more than 40 years, thanks to the NCWQR at Heidelberg University and Ohio's leadership. The NCWQR monitors additional stations in the watershed, while the USGS oversees water quality at major tributary outlets, small tributary stations, and key state line crossings. Trends have been evaluated using flow-weighted mean concentrations and other flow normalization methods with these data (Annex 4 Adaptive Management Task Team, 2023). These measures were utilized in the TMDL report to evaluate the baseline and target conditions and serve as important measures of progress at the watershed outlet and throughout the watershed.

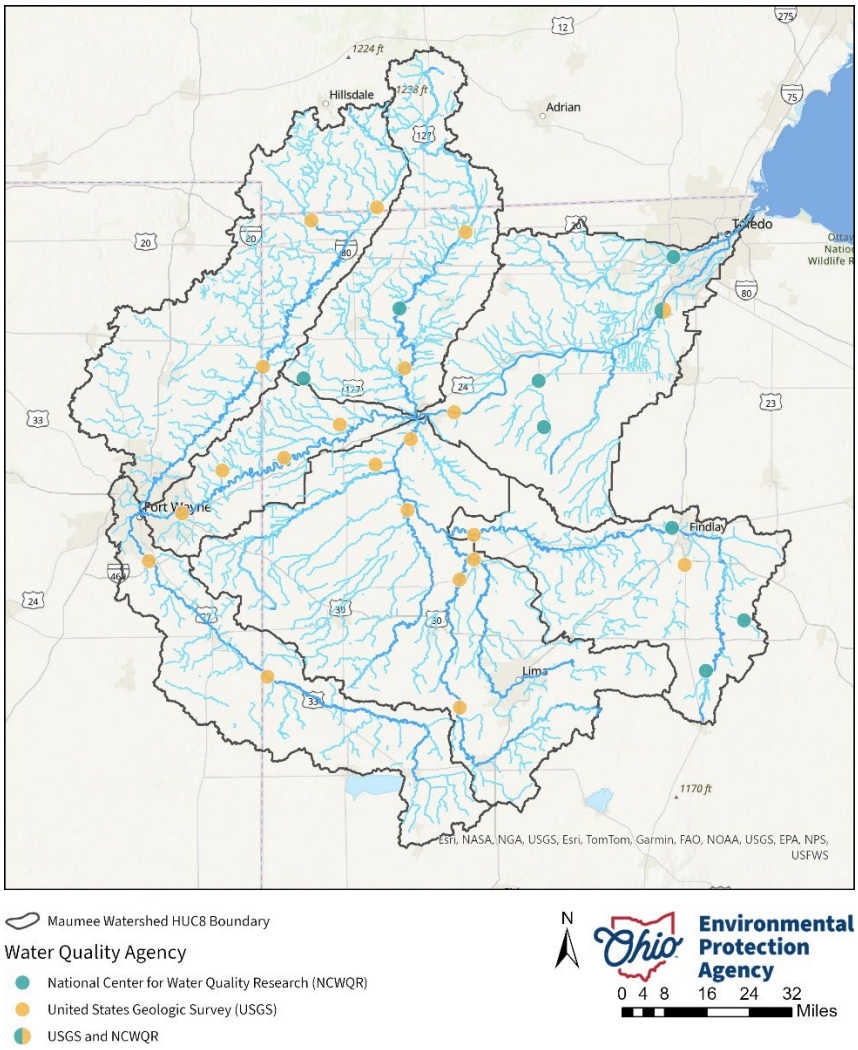

Figure 38. Stream Gage Stations monitored by USGS and National Center for Water Quality Research (NCWQR) in the Maumee Watershed.

The data shows spring total phosphorus (TP) and soluble reactive phosphorus (SRP) loads, targets, and flow measurements from 2008 to 2024 at the Maumee River at the Waterville station (Figure 40). From 2021 to 2024, SRP loads are near the target, but spring TP loads remain high. Recent decreases in water flow may be contributing to lower nutrient outputs. Ongoing monitoring aims to assess the effectiveness of fertilizer reductions on these changes.

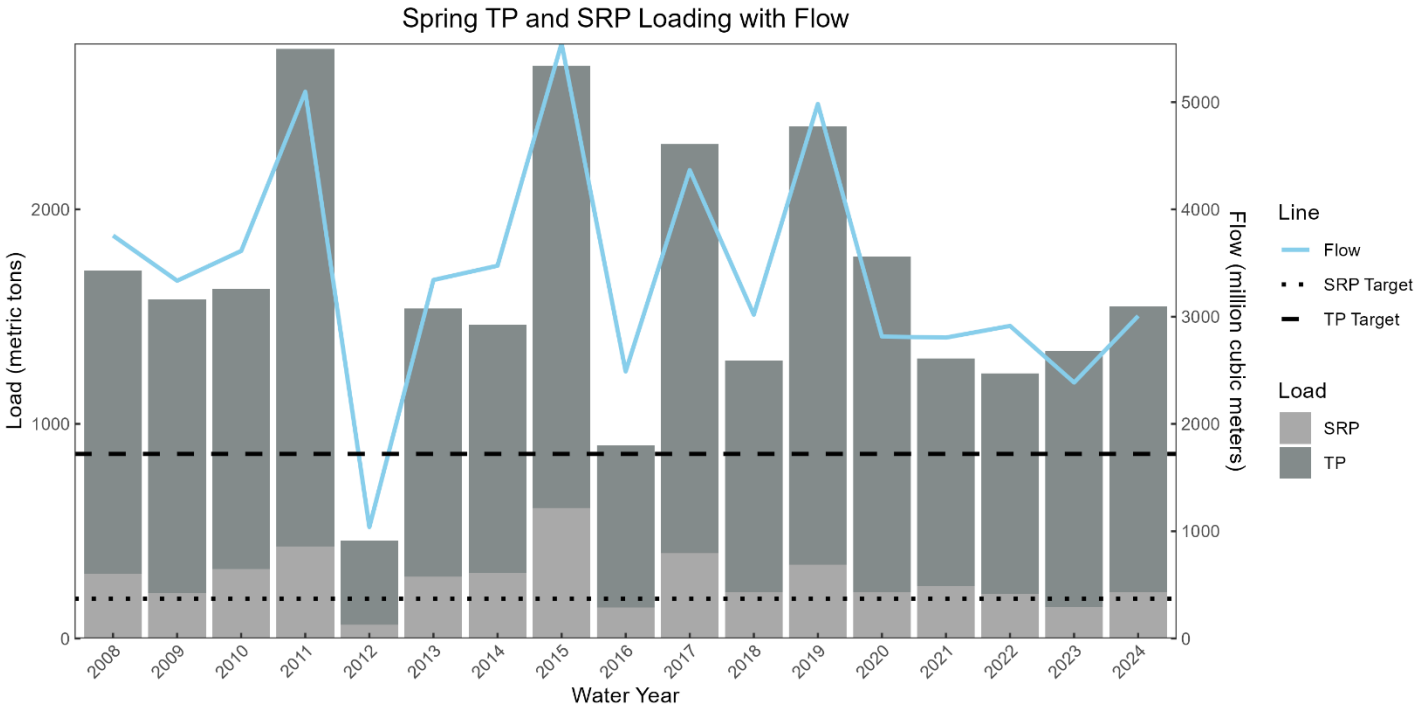

Figure 39. Spring Total Phosphorus (TP) and Soluble Reactive Phosphorus (SRP) loads at the Waterville Gage Station annually since 2008. Flow is represented as the solid blue line. The spring TP target is represented as the dashed line. The spring SRP target is represented as the dotted line—source: National Center for Water Quality Research.

Ohio EPA Nutrient Mass Balance Report

The nutrient mass balance study calculates annual total nitrogen and phosphorus loads across Ohio's watersheds. By analyzing these loads, the Ohio EPA can identify excess nutrient sources and prioritize resources for reduction efforts.

The 2022 edition of the *Nutrient Mass Balance Study of Ohio's Major Rivers* revealed that the Maumee watershed had the highest annual total phosphorus load, with 90% coming from nonpoint sources. The 2024 edition, set for release in late 2024, will include more recent data for the Maumee watershed and provide insights on annual phosphorus loads and concentration curves over the past 10 years.

This report will highlight differences among the state's watersheds in terms of total loads and source contributions and will be available on Ohio EPA's Nutrient Pollution – Finding Solutions webpage.

Lake Erie HAB Status

Lake Erie supports essential uses like recreation, public drinking water, and aquatic life. However, HABs in western Lake Erie are preventing these uses from meeting goals (Table 3), which led to the creation of the Maumee Watershed Nutrient TMDL. Ohio EPA assesses these uses every two years in the integrated water quality monitoring and assessment report (IR), with the latest report completed in March 2024. More details and historical reports are available on Ohio EPA's IR website. The following sections discuss how we measure HABs and efforts to protect the public from them.

Table 3. Summary of impairments addressed by Maumee Watershed Nutrient TMDL.

Lake Erie assessment unit	Cause of impairment (Beneficial Use)
041202000201 Lake Erie Western Basin Shoreline (≤3m)	Algae (Recreation use) Algae: Cyanotoxins (Public drinking water use) Nutrients (Aquatic life use)
041202000301 Lake Erie Western Basin Open Water (>3m)	Algae (Recreation use) Algae: Cyanotoxins (Public drinking water use)
041202000101 Lake Erie Islands Shoreline (≤3m)	Algae (Recreation use) Algae: Cyanotoxins (Public drinking water use) Nutrients (Aquatic life use)

Quantifying HABs and Attainment Metrics

In western Lake Erie, HABs are primarily caused by the microscopic cyanobacteria *Microcystis*. These blooms can grow large enough to be seen from space, presenting both challenges and opportunities for quantification. The small cyanobacteria move with water currents, resulting in patchy distributions that can change quickly due to weather conditions.

Researchers have developed reliable methods to measure the density of HABs using both in-water sensors and remote sensing from planes and satellites. They have published reports documenting bloom severity during the past 22 years. More information is available on the National Oceanic and Atmospheric Administration's website.

Recreation Use

Ohio EPA uses satellite-derived measures of cyanobacteria density to evaluate recreation use for algae in western Lake Erie. The assessment considers the spatial coverage and temporal variability of algal blooms, using daily satellite imagery organized into 10-day increments during the recreation season. For recreational use to be deemed acceptable, the bloom area must not exceed 30% for more than two of these periods.

From 2018 to 2023, western Lake Erie has consistently failed to meet the recreation use goal for algae (Table 4). To be considered in attainment, no more than two years can fail to meet this goal in a rolling six-year period. As a result, the area remains impaired for recreation due to HABs, with the earliest possible attainment year being 2028, contingent on meeting the goal from 2024 to 2028. Data will be reviewed and updated biennially, with details found in Section F of Ohio's 2024 Integrated Report. This metric also applies to nearby shoreline areas.

Table 4. Several 10-day periods that do not meet recreation use goal based on HABs covering ≥30% of the area with a density of ≥20,000 cells/mL. Adapted from table F-18 in 2024 IR, Section F: Recreation Use.

	Western Lake Erie Recreation Use (Algae)	
Year	10-day frames exceeding ≥30% coverage threshold	total frames
2018	6	12
2019	5	12
2020	3	10
2021	4	10
2022	8	14
2023	4	13

Public Drinking Water Supply Use

Satellite observations and sampling data help drinking water systems manage changes in source water due to HABs. In Ohio, public water systems using surface water must monitor microcystins, a cyanotoxin produced by HABs, and these data are used to assess public drinking water supply use as specified in Section H of the 2024 Integrated Report.

Nine western public water systems drawing water from western Lake Erie have detected microcystins in their source water. The state threshold for microcystins is 1.6 µg/L, and the use is impaired where there are two exceedances are at least 30 days apart. All three assessment units in western Lake Erie are impaired due to cyanotoxins (Table 5).

Public water systems are optimizing treatment to ensure safe drinking water, and data on cyanotoxins from these systems and Ohio EPA are available via an interactive map tool.

Table 5. Summary of public water system monitoring data with microcystin detections identifying impaired conditions in western Lake Erie (excerpt from Table H-2 in 2024 IR: Section H).

Assessment unit	Cause of impairment	Summary of key water quality data
041202000201 Lake Erie Western Basin Shoreline (≤3m)	*Algae* Two public water systems had at least two raw water samples with microcystin concentrations above the threshold.	Carroll Township and Ottawa County had raw water samples that exceeded the microcystins threshold in 2010, 2011, 2013-2015, and 2017-2022. Maximum detection of microcystins was 22.4 µg/L in August 2019.
041202000301 Lake Erie Western Basin Open Water (>3m)	*Algae* Four public water systems had at least two raw water samples above the threshold for microcystins.	Oregon's raw water samples exceeded the microcystins threshold in 2010, 2011, 2013-2019, and 2021-2023. Toledo's samples exceeded the threshold in 2010, 2011, 2013-2015, 2017-2019, and 2021-2023. Marblehead's samples exceeded the threshold in 2015, 2017, and 2021. Kelleys Island's results were above the threshold from 2015, 2017, 2018, and 2021.
041202000101 Lake Erie Islands Shoreline (≤3m)	*Algae* Three public water systems had at least two raw water samples	Put-In-Bay had sample results above the threshold in 2010, 2013-2015, 2017- 2019, and 2021. Camp Patmos had results above the threshold in 2010, 2013- 2015,

	above the threshold for microcystins.	and 2017-2019. Lake Erie Utilities had results above the threshold in 2014, 2015, and 2018-2020.

Aquatic Life Use

The nutrient reductions in the Maumee Watershed Nutrient TMDL address impairments to aquatic life in the shoreline areas of Lake Erie's western and island regions. Current assessments are based on fish community data, revealing that less than 25% of samples in western Lake Erie met the goals from 2011 to 2018 (see Section G of the 2024 Integrated Report).

Ohio EPA is developing new metrics for aquatic life use across all Lake Erie areas (details in Section I of the 2024 report). In 2020, Ohio EPA collaborated with experts from The Ohio State University's Ohio Sea Grant College Program to create metrics for three open water assessment units and evaluate those for four shoreline units.

The workgroup identified key metrics that reflect environmental changes within the Lake Erie ecosystem. A draft document outlining these metrics and their applications has been created, and Ohio EPA is working on rules to implement these recommendations in future reports. Ohio EPA monitors Lake Erie's water quality and biology every year, with data available on the Lake Erie program website. They will also participate in the National Coastal Waters Assessment in 2025.

Protecting Public Health

Efforts to reduce nutrients and curb HABs in western Lake Erie are ongoing, but actions are in place to protect the public from their impacts. Ohio has two response strategies to safeguard drinking water and recreational waters from cyanotoxins. Significant investments have improved drinking water treatment, developed new technologies, and assessed health impacts related to HABs.

The nine public water systems in western Lake Erie serve nearly 600,000 people. Since implementing Ohio's drinking water regulations for HABs in 2016, these systems have created short-term treatment optimization plans and long-term strategies to remove cyanotoxins. The City of Toledo has invested more than $500 million on improvements since a 2014 advisory (WTOL.com), while Ohio EPA ensures compliance with monitoring regulations.

State park managers display signs about HABs to protect beachgoers, and Ohio EPA's website provides resources for reporting potential blooms. The Ohio Department of Health (ODH) offers water quality data and notifications about recreation advisories through its BeachGuard website and provides resources for healthcare providers.

Research investments from federal and state sources aim to deepen understanding of HABs, improve technologies, and identify ways to mitigate the impacts of HABs. For example, a project from Dr. Justin Chaffin at The Ohio State University focused on quantifying microcystins and modeling cyanotoxin production, which could enhance reporting measures.

NOAA provides modeling products on its Lake Erie HAB website to project and assess HAB conditions, including data based on spring phosphorus loads and satellite observations. During the HAB season, NOAA

shares bi-weekly updates and seasonal summaries comparing annual bloom severity (Figure 41). The 2024 assessment was moderately severe, with blooms beginning on July 1, peaking in mid-August, and diminishing within a week. Archived data are accessible, and future projections start in May.

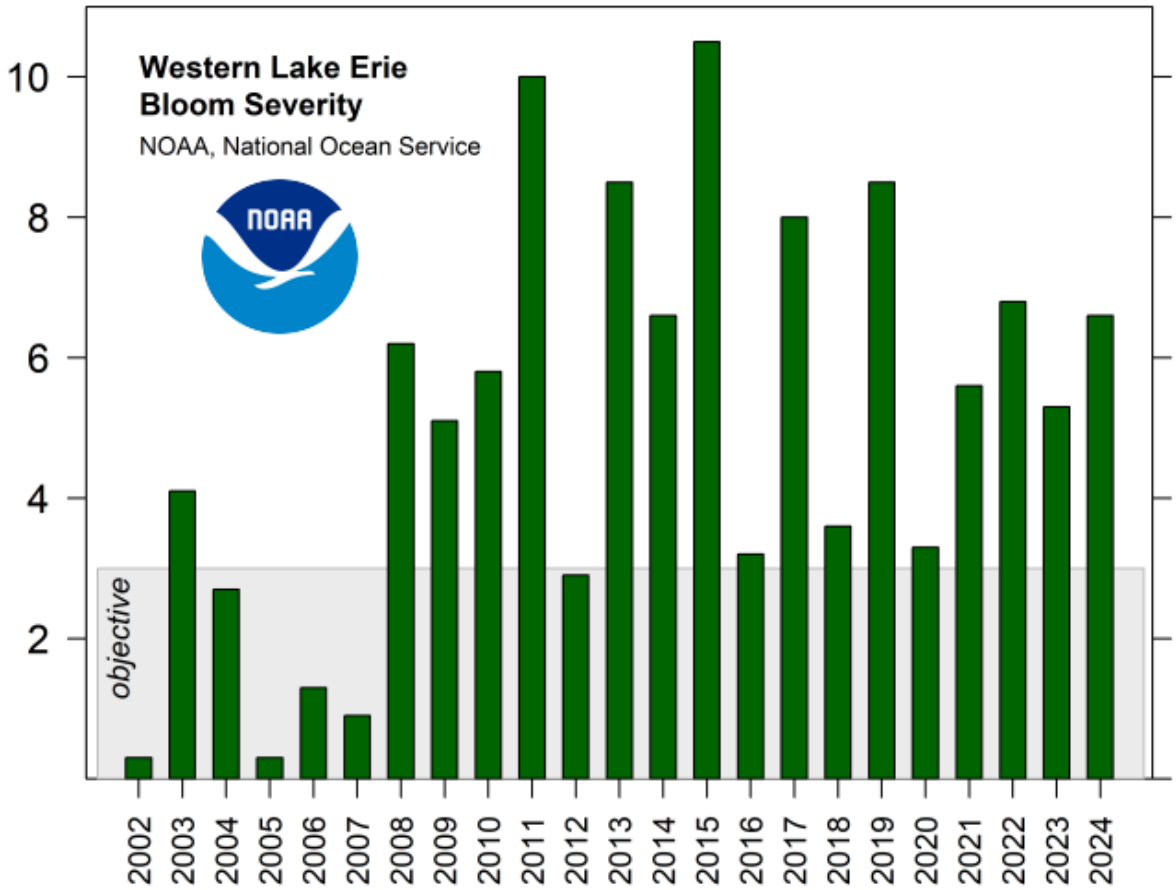

*Figure 40. Bloom severity index (SI) for 2002-2024. The SI is based on amount of biomass over the peak 30-days. From NOAA-NCCOS **2024 Western Lake Erie HAB Seasonal Assessment**.*

2026 Maumee Watershed Nutrient TMDL Biennial Report

Initially, only a few milestones were set for 2026 in the Maumee Watershed Nutrient TMDL, as they were tied to scheduled program actions. Given the progress on current milestones and other initiatives, the following milestones will be established and evaluated in the 2026 Biennial Report:

Renew MS4 General Permit (implementation milestone): The MS4 general permit, set for renewal in 2026, outlines stormwater pollution reduction actions for communities with phosphorus wasteload allocations in the TMDL. While many communities in the Maumee watershed are already taking additional measures to manage phosphorus, the renewal will include new regulated entities not currently implementing these practices.

Review CAFF and Biosolids Rules (implementation milestone): Ohio EPA and ODA collaborate on manure management and nutrient requirements under ODA's CAFF rules and Ohio EPA's biosolids regulations. State

law requires a review of these administrative rules every five years to ensure their relevance. This review process involves extensive outreach to stakeholders. The outcomes and impacts on the Maumee watershed will be reported in the 2026 Biennial Report.

Increase footprint of conservation programs (implementation milestone): ODA plans to maintain priorities for the Maumee watershed and the WLEB watershed over the next biennium. The aim is to expand the H2Ohio Program and similar federally funded initiatives from one-third to one-half of the row crop acres in the Maumee watershed. Funding for conservation ditches through ODA's H2Ohio Best Management Practices and the GLRI will help expand this network. Additionally, ODNR will continue to study and fund wetlands through H2Ohio.

Improve collaboration with federal partners (planning milestone): Ohio EPA, ODA, ODNR and OLEC will collaborate with federal partners to reduce nonpoint source loads in the Maumee watershed. This effort aims to enhance ongoing partnerships.

Leverage emerging science (planning milestone): Research projects are integrated into ongoing watershed implementation efforts. As new data becomes available, updates will be included in the programs. For example, the LEARN network's wetland monitoring data identifies areas needing wetlands and suitable types. Research from HABRI projects, such as evaluating conservation ditches, informs the H2Ohio initiative.

A pilot watershed project in Potato and Shallow Run aims for more than 70% adoption of agricultural BMPs and will continue through 2027. The 2026 Biennial Report may include updates on programmatic changes and the project's progress.

Continue implementation of the TMDL WLA with the Phosphorus General Permit (implementation milestone): The Phosphorus General Permit includes 1,400 kg – TP from the allowance for future growth (AFG). As the AFG is allocated to new or expanded facilities, the cumulative load limit will remain the same but the buffer for existing facilities will be reduced. New and expanding facilities will include additional technology and lower individual effluent limits. Future Biennial Reports will provide an update on the AFG and updated on new technology implemented at facilities will be an ongoing milestone for future reports.

Progress toward Beneficial Use Impairment (BUI) removal for the Maumee Area of Concern (AOC) (implementation milestone): The Maumee AOC includes the Lower Maumee River watershed and several tributaries draining into western Lake Erie. Restoration efforts focus on removing BUIs related to the degradation of fish and wildlife populations, benthic habitats, and loss of habitats. Although these efforts don't specifically target phosphorus management, restoring wetlands and riparian areas will help improve phosphorus retention and slow water movement. The AOC is implementing management action projects to meet BUI restoration targets. Once all BUIs are removed, the AOC can be delisted, making tracking progress essential in future reports until that goal is achieved. Progress toward removal of BUIs in the Maumee AOC as of 2024 are:

- Wildlife habitat and population projects are expected to be completed in 2025 (20 projects, $27.4 million from all funding sources).

- Aquatic habitat and population projects are expected to be fully funded in late 2025 or early 2026 ($55 million from all funding sources).

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