Promoting Clean and Safe Water in Lake Erie:

Ohio's Domestic Action Plan 2023 to Address Nutrients

In accordance with
the Great Lakes Water Quality Agreement

January 2024

Department of Agriculture
Department of Natural Resources
Department of Health
Environmental Protection Agency
Lake Erie Commission

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Introduction

A healthy Lake Erie is essential for a strong economy and high quality of life in Ohio. It is the source of drinking water for nearly 3 million Ohioans in shoreline communities, provides spectacular recreational opportunities, and supports billions of dollars of economic activity each year. Large parts of the Lake Erie watershed that drain directly to the lake are in Ohio. This includes most of the land area in the Maumee River watershed, the largest tributary to the lake. Protecting Lake Erie's water sources remains one of Ohio's biggest priorities.

Status of the Resource

Ohio has a long history of identifying problems and developing solutions regarding nutrient enrichment and harmful algal blooms (HABs) in Lake Erie. To summarize, after a lengthy but successful fight to reduce historically high nutrient levels in Lake Erie, algal blooms had nearly disappeared by the 1980s. In the mid-1990s, toxin-producing blue-green algal blooms began to appear in the western basin of Lake Erie. A particularly massive bloom occurred in 2003. Blooms of varying intensity have recurred most years since. Ohio EPA worked with experts to develop metrics that would accurately capture the impact of the bloom on Ohioans and ensure that the metric was rooted in the best science[1]. With the recommendations of that workgroup, Ohio EPA used satellite imagery of the algal blooms to assess recreational use of Lake Erie as "impaired" under the Clean Water Act in 2018, retroactive to 2016. This status has remained unchanged through the most recent Integrated Report in 2022[2]. The current forecast for Lake Erie HABs is available from the National Oceanic and Atmospheric Administration during the seasons when the algae are present[3].

Lake Erie has had a consistent area of low oxygen in the bottom waters of the central basin in the summer which impairs habitat for fish. Scientists call this low oxygen effect "hypoxia". While this is a naturally occurring annual event, it is believed that nutrient enrichment increases the size and brings it nearer to the shoreline drinking water intakes. The massive size of this phenomenon plus its occurrence at depth in the lake makes it difficult to measure the exact size and locations that are affected each year, although USEPA has a long standing monitoring program that provides information at selected sites[4]. Ohio has participated on a working group that is examining ways to improve analysis and reporting of hypoxia. A dynamic representation of hypoxia is available using NOAA's forecasting model[5].

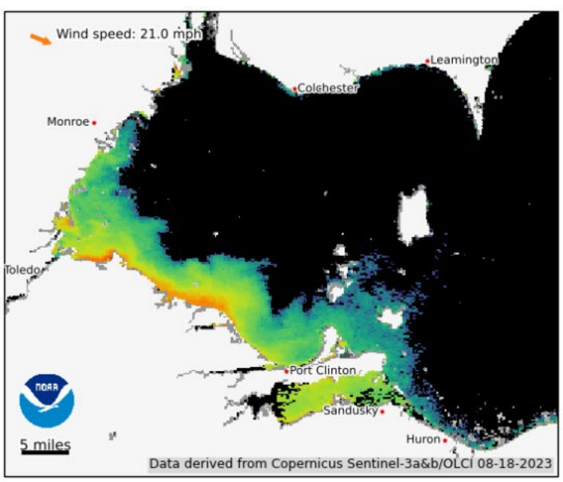


Figure 1: Remote sensing imagery of the Western Basin of Lake Erie showing the HAB intensity on 8-18-2023. Red indicates high intensity and blue indicates low intensity.

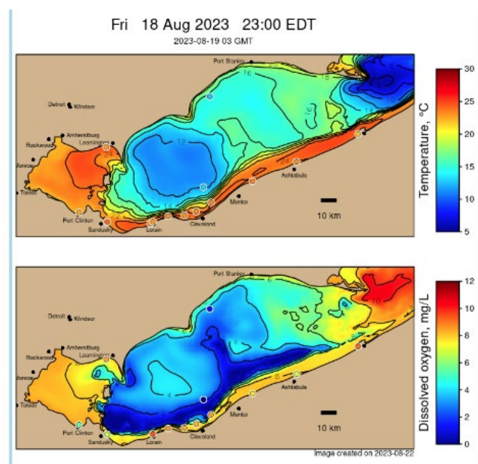


Figure 2: Hypoxia forecast model imagery showing temperature (top) and dissolved oxygen (bottom) in the lower part of Lake Erie for 8-18-2023.

[1] Davis, T.W., Stumpf, R., Bullerjahn, G.S., McKay, R.M.L., Chaffin, J.D., Bridgeman, T.B., Winslow, C. 2019. Science meets policy: A framework for determining impairment designation criteria for large waterbodies affected by cyanobacterial harmful algal blooms. Harmful Algae. 81: 59-64.

[2] ***https://epa.ohio.gov/static/Portals/35/tmdl/2022intreport/Full-2022-IR.pdf.***

[3] Figure 1 imagery obtained at ***https://coastalscience.noaa.gov/science-areas/habs/hab-forecasts/lake-erie/***. Daily imagery is available at this site during the HAB season, depending on cloud cover and other factors.

[4] ***https://www.epa.gov/great-lakes-monitoring/lake-erie-dissolved-oxygen-monitoring-program-technical-reports***

[5] ***https://www.glerl.noaa.gov/res/HABs_and_Hypoxia/hypoxiaWarningSystem.html***

The State of Ohio has been in the forefront of developing a response to algal blooms and low oxygen in Lake Erie. Building on the work of the Ohio Phosphorus Task Force, Ohio participated in efforts at the federal level through the Great Lakes Water Quality Agreement of 2012 (GLWQA) to link the harmful algal blooms and low oxygen levels to specific amounts of nutrients measured in the tributary rivers.

The governors of Ohio and Michigan and the premier of Ontario committed to a goal of reducing phosphorus loadings to Lake Erie by 40 percent through the signing of the western basin of Lake Erie Collaborative Agreement (Collaborative), first in 2015 and again in 2019. The Collaborative was intended to serve as the precursor to the Ohio Domestic Action Plan (DAP). Ohio's DAP will advance efforts toward the proposed nutrient reduction targets put forth in the GLWQA under Annex 4 (Nutrients). The Ohio DAP expands on the Collaborative implementation initiatives and includes the central basin as well as the western basin of Lake Erie.

Adaptive Management

The United States and Canada, as Parties to the GLWQA, have agreed to use an adaptive management (AM) approach to coordinate binational on-the-ground efforts and monitoring outcomes of management actions to achieve phosphorus reduction targets under Annex 4 of the Agreement. The AM approach recognizes uncertainties inherent in the management of complex social and environmental systems and seeks to reduce these uncertainties over time through active hypothesis testing and collaborative learning. The goal of the effort is to strike a balance between evolving understanding of ecosystem processes and modification of management actions accordingly to help advance ecosystem recovery. As a participating partner in the U, S. Federal Domestic Action Plan (US DAP), Ohio is also taking an AM approach within the Ohio DAP.

For the purpose of the binational AM Framework (currently under development by the Annex 4 Subcommittee), the AM cycle is defined by the following steps:

1. Set goals: Frame the problem and identify goals in terms of ecosystem outcomes that reflect broader societal values (i.e. LEOs, ERIs, P reduction targets).

2. Plan: Develop plans for monitoring, and other intentional processes that support AM (e.g., modeling, research synthesis, hypothesis development, prioritization of uncertainties, stakeholder engagement, and communication).

3. Implement: Implement AM activities and processes identified under Step 2.

4. Monitor: Monitor AM implementation progress and collect data to assess environmental conditions and ecosystem responses, help isolate impacts of management actions from natural variability in the system, and improve understanding of relevant social behaviors and natural processes.

5. Synthesize: Synthesize monitoring data, compare monitoring data to predicted/modeled outcomes, review conceptual models and emerging research to assess potential sources of divergence in predicted and observed outcomes, and refine key uncertainties.

6. Evaluate: Convene decision-makers, scientists, and stakeholders to review monitoring data and progress towards ecosystem goals, refine syntheses (data, modeling, and research), and develop and communicate recommendations for modified research priorities, model and hypothesis refinements, adjustments to monitoring programs, and revisions of ecosystem goals.

7. Make Decisions and Adapt: Review recommendations and make decisions regarding adaptation of ecosystem goals and plans to improve understanding and more effectively reach desired ecosystem states.

Ohio participates on the Annex 4 Subcommittee as a jurisdictional stakeholder during goal setting to provide feedback and local insight. For planning purposes, Ohio has prepared this Ohio DAP and has assisted in the preparation of the US Federal DAP, especially to summarize Ohio specific information in that planning document. The Ohio DAP sets forth Ohio's implementation actions under Annex 4 in concert with Ohio's state activities such as H2Ohio and the Maumee Watershed Nutrient Total Maximum Daily Load (TMDL). State agencies, particularly Ohio EPA, conduct monitoring in support of nutrient reduction efforts within Ohio and work with our state and federal partners to provide data for synthesis and evaluation at the federal level. Decision making and adaptation are performed both at the state level for actions under state jurisdiction, and as part of the broader Annex 4 team to provide input to decisions that are made by the Parties.

This Ohio DAP is the latest iteration of our AM process. Key updates to this version include additional target setting for the Portage River, lessons learned and adaptations to the H2Ohio program, and modifications to subwatershed targets and implementation actions for community sources based on the Maumee Watershed Nutrient TMDL. We remain confident in the overall strategy and intend to continue to broaden its implementation to work towards management change at a scale that will achieve results.

H2Ohio

In March 2019, Governor DeWine introduced H2Ohio[6], a water quality initiative to invest in targeted, long-term solutions to ensure clean and safe water in Lake Erie and throughout Ohio. H2Ohio provides substantial resources to plan and implement targeted long-term water solutions. There are three strategies that are key to H2Ohio: land-based protection, water-based restoration, and science-based monitoring and research.

Through collaboration among the Ohio Department of Natural Resources (ODNR), Ohio Environmental Protection Agency (Ohio EPA), Ohio Department of Agriculture (ODA), and Ohio Lake Erie Commission (OLEC), H2Ohio addresses critical water quality needs and supports innovative solutions to some of the state's most pressing water challenges.

Though H2Ohio is a statewide initiative, it has been designed, in part, to address the specific needs of Lake Erie. The primary focus of H2Ohio for the purposes of the Ohio DAP will be on the implementation of agricultural best management practices (BMPs), wetland restoration, and improvements to wastewater infrastructure. Strategies adopted and funded as part of H2Ohio for nutrient reduction specific to Lake Erie are listed within this Plan. H2Ohio is moving the state in the right direction in nutrient reduction and overall water quality improvement, not only in the Western Lake Erie Basin, but across Ohio. Due to continued investment from Ohio's legislature, H2Ohio continues to adapt and expand to address Ohio's water quality issues in Lake Erie and beyond. A comprehensive look at H2Ohio's progress and achievements will continue to be available online at ***h2.ohio.gov***.

Goals of the Ohio Domestic Action Plan

The cornerstone of an adaptive management process is the goals that are established. The management objectives the State is trying to achieve in the Ohio DAP were defined through an interagency collaboration under Annex 4 (Nutrients) of the GLWQA[7] and are summarized here:

- Achieve a 40 percent total spring load reduction in the amount of total and dissolved reactive phosphorus (TP and DRP) entering Lake Erie's western basin from the Maumee River. A spring (March – July) Flow-Weighted Mean Concentration (FWMC) of 0.23 mg/l TP and 0.05 mg/l DRP and a target of 860 metric tons (1.9 million lb) total phosphorus and 186 MT (410,000 lb) dissolved reactive phosphorus in the Maumee River at the Waterville monitoring station is predicted to be a 40 percent reduction from the base year of 2008.
- Achieve a 40 percent total spring load reduction in the amount of total and dissolved reactive phosphorus (TP and DRP) entering Lake Erie's western basin from the Portage River.
- Achieve a 40 percent total spring load reduction in the amount of total and dissolved reactive phosphorus (TP and DRP) entering Sandusky Bay from the Sandusky River to protect water quality in Sandusky Bay.
- Achieve a 40 percent total annual load reduction in the amount of total phosphorus entering Lake Erie's central basin. This goal applies to priority tributary watersheds to the central basin of Lake Erie in Ohio, which include the Maumee, Portage, Sandusky, Huron, and Cuyahoga Rivers[8].

As additional information has become available the new information has been used evaluate the narrative targets from the GLWQA described above and identify numeric loading targets where possible. Table 1 presents springtime total phosphorus and DRP targets for priority tributaries that have HAB related targets. Note that while the Maumee

[6] ***http://h2.ohio.gov***.
[7] See Annex 4 Subcommittee Objectives and Targets Task Team recommended targets technical report (***https://binational.net//wp-content/uploads/2015/06/nutrients-TT-report-en-sm.pdf***).
[8] The spring load targets for the Maumee and Portage Rivers will also serve to reduce phosphorus to the central basin of Lake Erie.

TP target shows just the Ohio portion, the DRP target includes the whole watershed up to the Waterville monitoring station. The reason DRP cannot be divided by state is because of the technical difficulty in attributing DRP from a source to a downstream monitoring point. See the Maumee Watershed Nutrient TMDL Appendix 1 for further discussion of DRP. Table 2 presents annual total phosphorus targets that are aimed at addressing hypoxia.

Table 1: Phosphorus targets to address HABs. Maumee (DRP only), Portage, and Sandusky targets are developed at watershed monitoring points and are directly comparable to loads monitored by the National Center for Water Quality Research (NCWQR) at Heidelberg University. Maumee River Total Phosphorus (TP) is Ohio portion only, excluding Michigan and Indiana, based on Maumee Watershed Nutrient TMDL modeling which includes areas downstream of the NCWQR monitoring station.

	Spring Values (March 1-July 31)			
	2008 Baseline (or equivalent)		40% Reduction Targets	
Priority Tributary	Load metric tons	FWMC* mg/L	Load Metric tons	FWMC mg/L
Maumee River	1,128 TP (Ohio only) 302 DRP**	0.38 TP 0.08 DRP	686 TP (Ohio only) 186 DRP**	0.23 TP 0.05 DRP
Portage River***	81 TP DRP	TP DRP	69 TP 18 DRP	TP DRP
Sandusky River+	367 TP 69.1 DRP	0.38 TP 0.07 DRP	230 TP 43 DRP	0.23 TP 0.05 DRP
Huron River++	*Not available*	*Not available*	TBD	TBD

* FWMC – Flow-weighted mean concentration.
** DRP – DRP cannot be divided by state because of the technical difficulty in attributing DRP from a source to a downstream monitoring point. See the Maumee Watershed Nutrient TMDL Appendix 1[9] for further discussion.
*** Portage River baseline and targets are calculated based on the 2017 spring season. See Appendix F for further explanation.
+Sandusky River targets are calculated as 40% less than the monitored load from 2008.
++Huron River targets were not calculated. See Appendix F for further discussion on available data.

Ohio EPA conducted a study of the streamflow and water quality in the Toussaint Creek watershed in 2017-2019. Stream characteristics, in particular the low-lying, flat, and small size of the watershed, resulted in water chemistries that were dominated by lake backflow for most of the stream most of the time. As a result, it has been determined that it will not be feasible to establish loading targets for Toussaint Creek. The area is within the western basin watershed and will remain eligible for implementation activity as part of efforts through H2Ohio. See additional discussion in Appendix F.

Table 2: Phosphorus targets to address hypoxia.

Priority Tributary	2008 Annual Load (or equivalent) Metric Tons	40% Reduction Amount Metric tons	Target Load Metric tons
Maumee River*	2,863	1,145	1,718
Portage River**	237	95	142
Sandusky River*	1,100	440	660
Huron River**	205	82	123
Cuyahoga River*	452	181	271

*Annual load estimates and 40% reduction targets based on Maccoux, 2016 and represent the Ohio's portion of the watershed complex, including area downstream of the location monitored by the NCWQR.
**See Appendix F for further explanation, analysis was completed at the location monitored by the NCWQR.

[9] *https://epa.ohio.gov/static/Portals/35/tmdl/MaumeeNutrient/Appendix-1-Dissolved-Reactive-Phosphorus-Final.pdf*

Progress as of 2022

Progress on the response to the actions taken is currently difficult to determine. It will take time to see the response of these efforts, as detecting changes in water quality will take time. Generally, the smaller the magnitude of reduction, the longer it will take to detect the change in water quality.

The biggest driver in the system is stream discharge variability from year to year. For example, the extremely wet year in 2019 led to record unplanted crop acres in some areas. In some ways each year offers its own insight to progress or challenges but that makes trends hard to see. Figure 3 shows that the DRP load (also known as soluble reactive phosphorus, SRP) is widely variable from year to year, largely following the stream discharge.

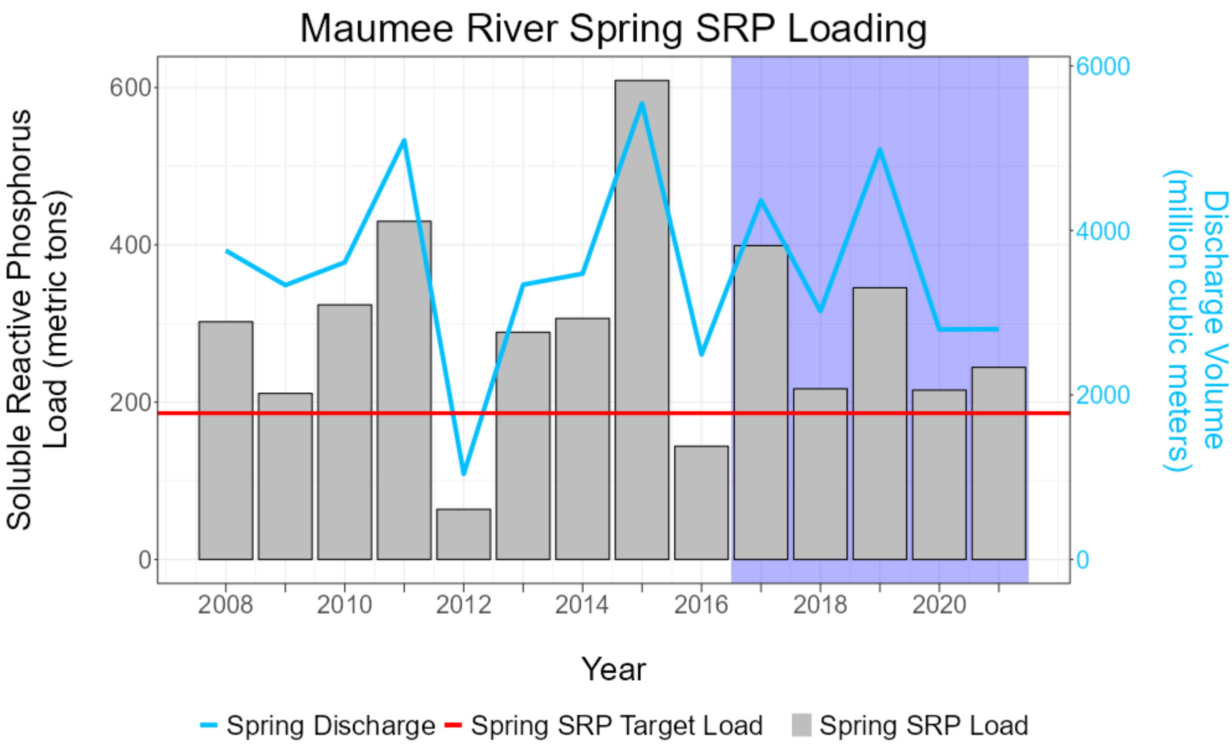


Figure 3. Spring soluble reactive phosphorus loading (SRP) for the Maumee River. From the Binational Adaptive Management Evaluation for Lake Erie (2017-2021) (in preparation). SRP is also referred to as Dissolved Reactive Phosphorus (DRP).

Scientists try to address these challenges by coming up with new tools. One such tool attempts to remove the effect of discharge variability on loading estimates using weighted regressions on time, discharge, and season (WRTDS). The smoothing provided by flow normalization aids interpretation of changes and detection of trends that would otherwise be obscured by year-to-year variability in discharge. While there is little evidence of recent trends in actual loads, we do see an apparent decline in flow-normalized SRP load (Figure 4). This trend suggests that some relative progress is being made in the Maumee watershed. Declines in flow-normalized SRP are encouraging. This form of phosphorus is highly available to algae. Increases in SRP loading have been tied to the resurgence of HABs in the late 1990s and 2000s (Baker et al., 2014, Stow et al., 2015)[10].

[10] For science citations, see Appendix A.

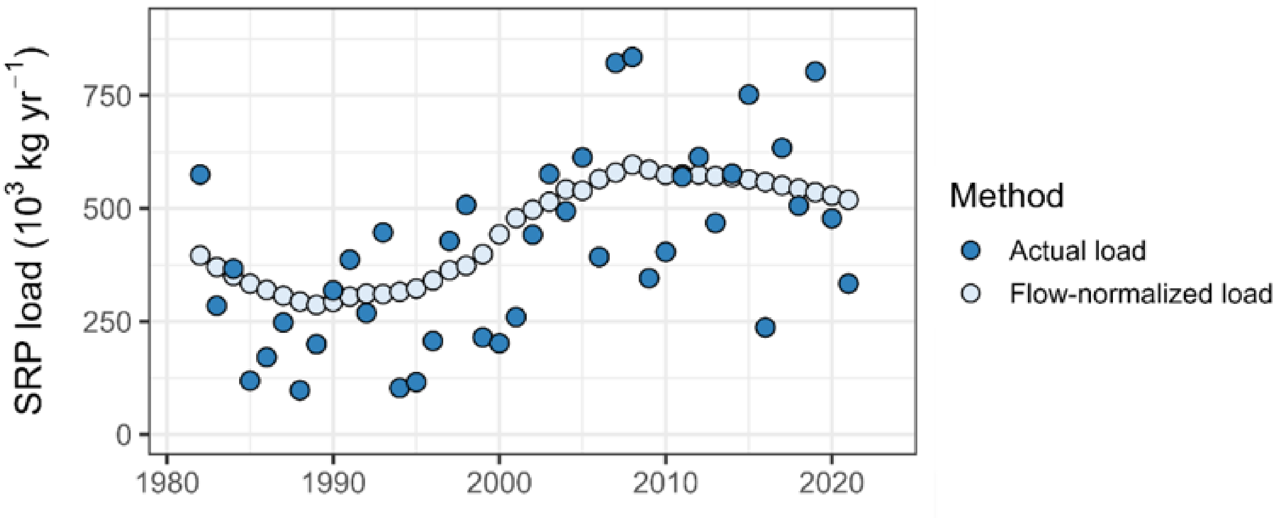


Figure 4. Actual, as measured (dark blue) and flow-normalized (light blue) loads for soluble reactive phosphorus for the Maumee River from 1982 – 2021. Source: F. Rowland, updated from Rowland et al. (2021).

Ohio's phosphorus efforts have generally focused on TP, which includes both particulate and dissolved fractions. The majority of dissolved phosphorus is DRP. This is the most biologically active fraction of TP. Because of DRP's changeability, tracking phosphorus using mass balance methods is done using TP. Also, many phosphorus reduction implementation actions or BMPs have been studied looking only at TP. Similar reasoning was used in the Maumee River Nutrient TMDL which was submitted by Ohio EPA to USEPA in 2023. A more detailed discussion of the challenges of managing DRP from nonpoint sources is available in Appendix 1 of that document.[11]

While efforts have historically focused on TP, Ohio has supported projects to improve the understanding of DRP sources and transport. These studies will help quantify the "sinks" and "sources" of all phosphorus forms. Sinks include accumulation of sediment and organic material in slow moving waterbodies (i.e., lakes and reservoirs), floodplains, and drainage ditches. The Ohio Department of Higher Education's Harmful Algal Bloom Research Initiative (HABRI) has funded a project at the Ohio State University, working alongside USGS, to explore the dynamics of phosphorus as it moves between dissolved and particulate forms in streams during rain events. The ODNR is funding a research program through its portion of H2Ohio called LEARN that is intensively studying the dynamics of phosphorus in created and stored wetlands to better understand how to reduce the loss of phosphorus as water is held back in these important components of Ohio's waterways. We expect to use the results of these studies to further inform the allocation of resources through the H2Ohio program.

Major Sources of Phosphorus in Ohio

Understanding Nutrient Sources

Nonpoint sources include agricultural, urban, or rural community runoff and natural sources. Agricultural sources of phosphorus are due to runoff of fertilizers (commercial and manure) and soil into waterways. The linkages between fertilizer applications, erosion, and transport to Lake Erie are complex. Ohio EPA reviewed the extensive literature about the contributions of nonpoint sources for the Maumee River Watershed Nutrient TMDL (Ohio EPA, 2023)[12]. This analysis is applicable to other agriculturally dominated Lake Erie tributary watersheds such as the Sandusky, Portage, and Huron Rivers. Recent research summarized for the TMDL suggests that manure and commercial fertilizer have similar edge of field losses when BMPs are utilized for application. This runoff is carried overland and via subsurface drainage networks (i.e. field tiles). Farm management practices can affect this drainage, which is also related to non-manageable factors including field slope, soil properties, and local climate.

Community-based sources of phosphorus result from non-agricultural land uses; they are generally from human and industrial waste. Most community-based sources are managed through the National Pollutant Discharge Elimination

[11] *https://epa.ohio.gov/static/Portals/35/tmdl/MaumeeNutrient/Appendix-1-Dissolved-Reactive-Phosphorus-Final.pdf*
[12] Document available at *https://epa.ohio.gov/divisions-and-offices/surface-water/reports-data/Maumee-river-watershed.*

System (NPDES) permitting program at Ohio EPA. These include municipal wastewater treatment plants, industrial facilities, municipal separate storm sewer (MS4) communities, and combined sewer overflows (CSOs). Home sewage treatment systems (HSTS; often referred to as septic systems) are a community source that is partially regulated by the NPDES program, if the HSTS is designed as a discharging system. Non-discharging HSTS are not regulated through the NPDES program, but when functioning properly, these HSTS provide excellent management of phosphorus. Both non-discharging and discharging HSTS systems can fail to treat waste as designed, which can result in phosphorus loss to the environment. Phosphorus runoff from developed land that is outside of an MS4 community is another community source not regulated by the NPDES program. Ohio EPA's 2022 Nutrient Mass Balance Study[13] calculated TP loadings for these sources, excluding MS4 communities. Figure 5 shows the wastewater treatment (including CSOs) and HSTS contributions in Ohio's largest Lake Erie Annex 4 priority tributaries. Appendix C contains detailed information about community sources.

The National Center for Water Quality Research (NCWQR) at Heidelberg University has been monitoring phosphorus in Ohio's key Lake Erie watersheds for over 40 years. These data are collected at a high frequency and provide a robust basis for understanding where and when phosphorus moves through these key tributaries.

In 2022, Ohio EPA used these data to update the biennial nutrient mass balance study to evaluate major sources of total phosphorus (Figure 5). The study covered select watersheds across the state, including four of the Annex 4 priority watersheds in Ohio (Maumee, Portage, Sandusky and Cuyahoga). This study calculated mass balance amounts for several nutrients including total phosphorus (TP; which includes particulate and dissolved fractions) and dissolved reactive phosphorus (DRP; a more biologically reactive fraction), as well as nitrogen. For a complete discussion of all the findings for all nutrients studied, please see the report.

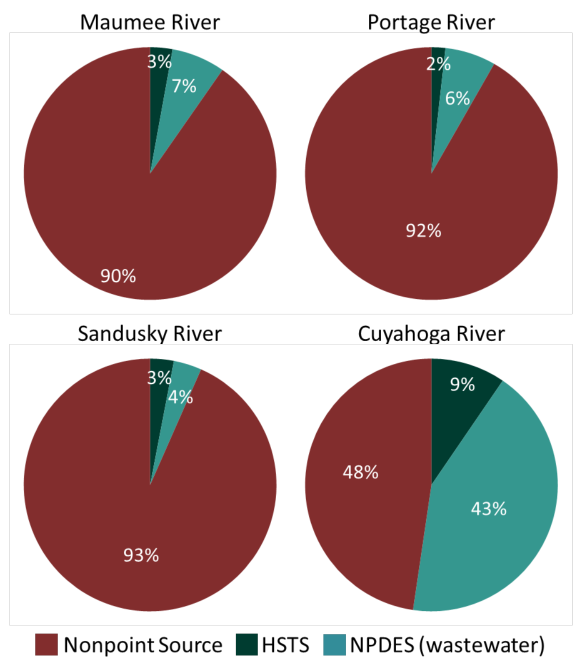


Figure 5: Proportions of total phosphorus averaged over water years 2017-2021. Maumee River includes entire watershed in Ohio, Michigan and Indiana. Nonpoint source includes both agricultural and urban nonpoint sources. HSTS: home sewage treatment systems. NPDES: National Pollutant Discharge Elimination System. Data from Ohio EPA Nutrient Mass Balance Study 2022.

Sources of Phosphorus in the Maumee River Watershed

The Maumee River watershed is the top priority area in Ohio to address excessive nutrient impacts to Lake Erie due to its large size, extensive agricultural land use, and importance to HAB growth. Springtime (March 1 to July 31) phosphorus loads from the Maumee River watershed have been identified as the most critical to reduce the occurrence of HABs in the western basin of Lake Erie.

Figure 3 shows that 90 percent of the Maumee's phosphorus load is from nonpoint sources (average result from 2017-2021 water years). These are diffuse sources that cannot be attributed to a discharge pipe. Runoff from agricultural fields and developed areas are examples of nonpoint sources. The ODA, with its partner Ohio State University Extension, has evaluated fertilizer use in the Maumee River watershed in Ohio and shown on average that more phosphorus is removed by crop harvest than applied via commercial fertilizer and manure.

To address impairments due to HABs and to aquatic life due to excess nutrients, Ohio EPA finalized and submitted the Maumee Watershed Nutrient TMDL to U.S. EPA in June 2023. The TMDL provided allocations for community sources

[13] The following source discussion is extracted, in part, from the Nutrient Mass Balance Study. For more details and a complete set of figures, see document at ***epa.ohio.gov/static/Portals/35/documents/2022-NMB-Final.pdf***.

discussed above (generally, wasteload allocation in TMDL), nonpoint sources (load allocation in TMDL), future growth, and a margin of safety. The Maumee Watershed Nutrient TMDL provided these allocations as a bulk sum at the watershed outlet. To facilitate nonpoint source planning efforts at the HUC12 scale the Maumee Watershed the load allocation was extrapolated to the HUC12 watershed scale. These targets can be utilized for developing nine-element nonpoint source implementation strategies. See Appendix A for additional details about how these targets were extrapolated and the results of the analysis.

Sources of Phosphorus in Other Annex 4 Priority Tributaries in Ohio

In addition to the Maumee, Figure 3 shows the total phosphorus loading sources to the Portage, Sandusky, and Cuyahoga Rivers. These are all Annex 4 priority Lake Erie tributaries. The source contributions to the Portage and Sandusky River watersheds are similar to the Maumee. The Cuyahoga River watershed is much more urbanized and has a more even split between wastewater treatment and nonpoint sources of total phosphorus. The Ohio Nutrient Mass Balance report contains further details on these watersheds' nutrient sources and current loads.

The remaining Annex 4 priority watersheds are the Huron River, Vermilion River, and Grand River. These rivers drain to the Central Basin, and are not tributary to areas with extensive HABs. While the Huron River was identified for load reductions to reduce nearshore HABs there are not extensive data demonstrating this phenomenon. Contributing loads from these tributaries are smaller – an order of magnitude less than the Maumee River load – approximately 100-300 metric tons annually (MTA) each). Because these are a low proportion of Ohio's total load and are not associated with HABs, the primary focus remains on the larger tributaries, especially the Maumee River.

Strategies and Implementation Actions

Overarching Strategies

There are four overarching strategies that Ohio will use to reduce nutrient loss. First, we will focus on agricultural nutrient, land, and water management since agriculture has been identified as a significant source of phosphorus to Lake Erie. Second, we will be restoring wetlands to recover their function in removing nutrients from the waterways. Third, we will be addressing community sources including HSTS and wastewater treatment infrastructure. Fourth, we will be continuing to encourage the use of watershed planning at the county and local level to assist with placing nutrient reduction practices on farm fields and in-stream to maximize nutrient reduction potential.

Addressing nutrient loss from agriculture will occur through policies and programs primarily run through the ODA, but also in partnership with county soil and water conservation districts (SWCDs), watershed coordinating groups, the Ohio Agriculture Conservation Initiative (OACI), and private agribusiness firms. Wetland restoration and enhancement will be run through ODNR. Ohio EPA will oversee reductions from community sources, including funding from H2Ohio for HSTS remediation as well as innovative water and wastewater treatment technologies. Watershed planning, which will assist in finding suitable locations for structural projects, will continue to be a joint effort between Ohio EPA, ODA, and SWCDs and/or watershed coordinating groups. The OLEC will continue planning and implementation oversight including coordination between the agencies and the governor's office as needed.

Ohio continues to move in the right direction to reduce nutrient runoff, combat harmful algal blooms on Lake Erie, and make key investments in water infrastructure. Through the H2Ohio program, more than 2,400 farmers have enrolled 1.5 million acres of farmland into voluntary conservation practices that are proven to reduce phosphorus runoff across the 24 counties that make up the Western Lake Erie Basin watershed. Additionally, H2Ohio has provided funding to construct and enhance 170 wetland projects across the state that filter nutrients out of the water. As of the end of calendar year 2023, 108 of these projects were in the Lake Erie watershed. More than 59,000 Ohioans will be served by one of H2Ohio's 65 water infrastructure projects. Working together, the Governor's Office and the Ohio General Assembly have completed three two-year budget cycles that have supported the long-term objectives of H2Ohio in improving water quality in the Lake Erie basin and in other areas of the state.

Actions to Address Nutrient Loss from Agriculture

Based on the source analysis above, most of the actions required to achieve the load reduction goals in Ohio will need to come in the form of agricultural nonpoint source controls also known as BMPs. Funding to implement these BMPs will continue to come from State programs such as H2Ohio; federal programs such as U.S. Farm Bill programs, section

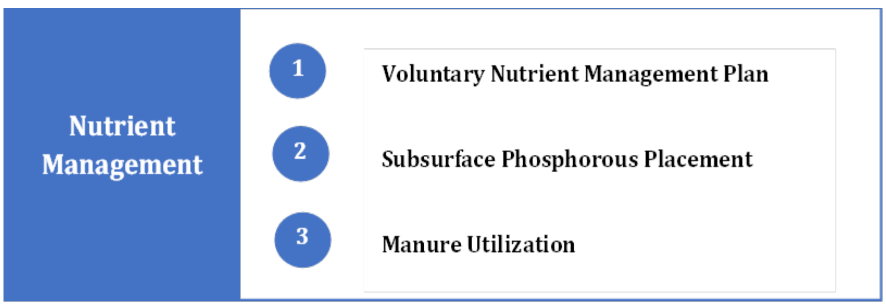
319 Clean Water Act funds, and the Great Lakes Restoration Initiative; and private-public partnerships with interested corporations and nongovernmental organizations. Federal programs will be discussed in more detail in the federal U.S. Domestic Action Plan. We will focus here on the Lake Erie related components of Ohio's state funded H2Ohio program. Based on Ohio's experience as the program has developed, there have been some adjustments to the H2Ohio program organization and requirements.

Agricultural Land Management with H2Ohio

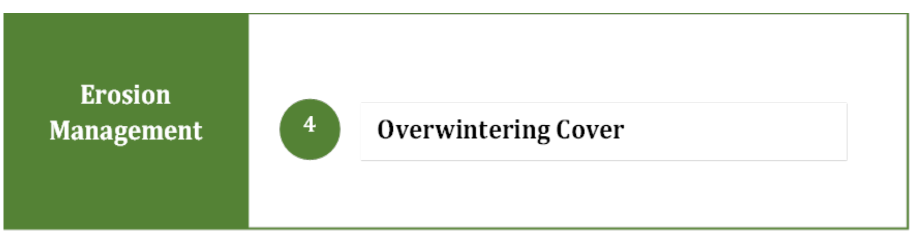
On average, per-acre phosphorous losses across Ohio's agricultural lands are small relative to crop needs. Therefore, in order to achieve large nutrient reductions at a basin scale, there is a need for widespread adoption of conservation practices. To streamline this effort, ODA has prioritized BMPs that are effective and widely applicable to the region's agricultural industry. A comprehensive package of programs that deliver resources for agricultural land management under H2Ohio has been developed. A broad overview is provided here and in Appendix B. More details and information about current program enrollment opportunities can be viewed at the following website: ***http://h2.ohio.gov/agriculture/***.

The agricultural BMPs incentivized by H2Ohio through ODA can be grouped into three broad categories: nutrient management, erosion management, and water management.

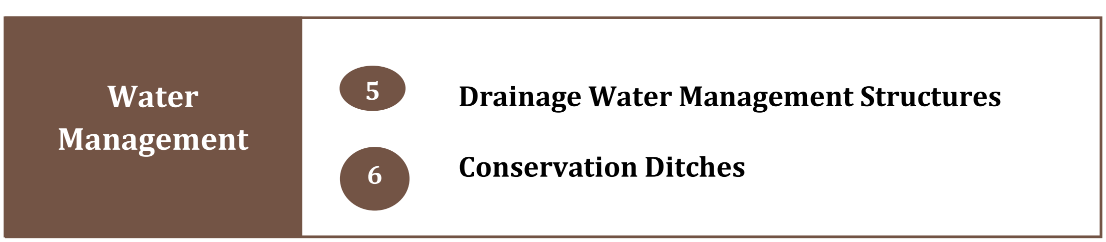
Nutrient Management is a generalized term that can be summarized with the "4R" concept — using the **right** nutrient source at the **right** rate and **right** time in the **right** place. ODA views nutrient management as the most efficient strategy for reducing nutrient loss because it takes a proactive approach to addressing acute losses to the environment, and also prevents the development of legacy sources. The three H2Ohio practices associated with this category are listed below:



Erosion Management practices are intended to slow or stop the loss of soil-attached nutrients by reducing soil disturbance, maintaining soil cover and increasing soil water-holding capacity. The H2Ohio practice associated with this category is listed below. Importantly, this practice encompasses several cropping strategies including establishing cover crops, winter annual crops, and hay/forage crops.



Water Management includes practices that detain or slow water flow, settle suspended sediments, and remove dissolved nutrients from water. The two ODA H2Ohio practices associated with this category are listed below:



As part of the H2Ohio initiative, agricultural producers are receiving H2Ohio incentives after successfully implementing BMPs #1-5. BMP #6 is available for SWCDs and county engineers to implement in conjunction with the county Petition Ditch Program (ORC 6131) or the Conservation Works of Improvement (ORC 940). Currently, all six of these practices are being offered in the 24 counties of the WLEB (Figure 6).

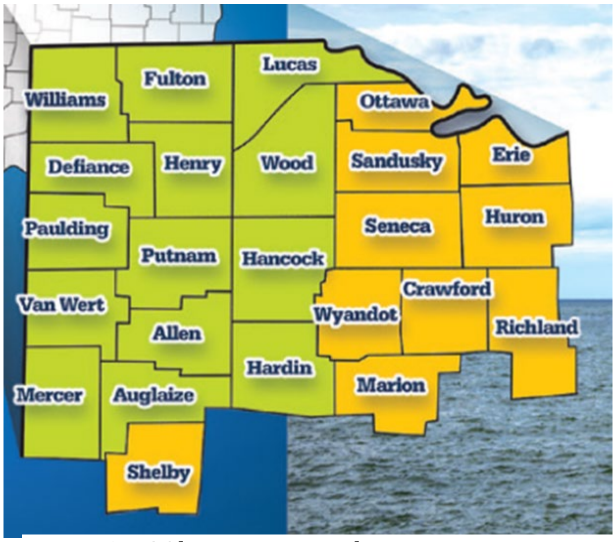


Figure 6: H2Ohio counties in the WLEB.

The keystone practice of H2Ohio is the Voluntary Nutrient Management Plan (VNMP). An SWCD-approved VNMP is required for all producers participating in H2Ohio cropland BMPs. Implementing nutrient management related BMPs requires coordination between individual producers, agricultural retailers, custom applicators, SWCDs and others. VNMPs covering nearly 1.5 million acres of cropland have been developed through H2Ohio, as noted in the H2Ohio Annual Report; this showcases the regional commitment toward agricultural nutrient stewardship.

All BMPs require field level or site -specific planning, and in the case of practices #5 and #6, engineering design and approval. To accomplish planning and implementation at this scale, support and participation from SWCDs, Nutrient Service Providers (NSPs), USDA-NRCS and other partners is crucial. To effectively reach growers, SWCDs operate at the county level as primary contacts. SWCD staff conduct outreach, manage enrollment, contract management, coordinate with Nutrient Service Providers (NSPs) and agencies, verify BMP implementation, and manage participant data.

To reach H2Ohio's implementation goals, attention has been given to removing the barriers associated with BMPs that require significant changes to agricultural operations. One such barrier is the equipment required to achieve subsurface phosphorous placement (practice #2). ODA is addressing this need by providing financial assistance for producers purchasing qualifying nutrient-placement equipment. This initiative, under the H2Ohio program is called the Equipment Purchase Assistance Program and began late in calendar year 2023.

The Soil and Water Phosphorus Program, also known known as Senate Bill 299 programming, initiated in 2018, provided funding for SWCD staff with specific nutrient management responsibilities, as well as BMP implementation in the WLEB. This program and related funding have been consolidated under the H2Ohio program through Ohio's 2024-2025 Biennium Budget.

In addition to tracking implementation at the watershed scale, it is important for producers to see their positive management changes over time. The Ohio Agriculture Conservation Initiative (OACI)[14] is a partnership of the agriculture, conservation, environmental, and research communities to recognize farmers for their dedication to utilize established methods to improve water quality in Ohio and to increase the number of best management practices being implemented on farms. Producers register confidentially with OACI to assess their current conservation adoption level, to promote continuous improvement, and highlight positive changes associated with H2Ohio participation. OACI is also undertaking statistical survey efforts to better understand current on-farm conservation and nutrient management efforts. Agricultural Land Management with the Lake Erie Conservation Reserve Enhancement Program

ODA, in partnership with ODNR, is also making additional funding available to farmers through the Lake Erie Conservation Reserve Enhancement Program (Lake Erie CREP). CREP is the country's largest private-land conservation program. Administered by the USDA Farm Service Agency in partnership with ODA and local SWCDs, CREP targets high-priority conservation areas in exchange for removing environmentally sensitive land from production. In return for establishing permanent resource-conserving plant species, farmers are paid an annual rental

[14] For more about OACI please visit ***https://h2.ohio.gov/oaci-faqs/*** or the OACI site at ***https://oaci.azurewebsites.net/main/home***.

rate along with other federal and state incentives as applicable per each CREP agreement. Participation in the Lake Erie CREP is open to landowners in 27 Ohio counties (also see map in Appendix D). Practices available in the Lake Erie CREP are the following:

Table 3: Lake Erie CREP list of practices and payments.

Lake Erie CREP State Water Quality Incentive Payments			
Practice Code	Description	New Enrollment Bonus per Acre (paying agency)	ReEnrollment Bonus per Acre (paying agency)
CP1	Escarpment Areas and Filter & Recharge Areas - Introduced Grasses	$500 (ODA)	$250 (ODA)
CP2	Escarpment Areas and Filter & Recharge Areas - Native Grasses	$500 (ODA)	$250 (ODA)
CP5A	Windbreaks	$0	$0
CP21/CP 21S	Grassed Buffers/Saturated Buffers	$500 (ODA)	$250 (ODA)
CP22	Forested Riparian Buffers	$2,000 (ODNR)	$0
CP23 & CP23A	Wetlands	$2,000 (ODNR)	$250 (ODA)

Additional discussion about Lake Erie CREP specific to wetlands is provided in the next section.

Agricultural Regulatory Programs

ODA administers laws and rules in partnership with SWCDs, Ohio EPA, ODNR and others to ensure agricultural operations in Ohio are supported with clear standards and expectations for environmental stewardship. The following regulatory framework (Table 2) includes a permit program for the largest producers of livestock and authority to resolve pollution complaints involving non-permitted operations through technical consultation, fines, and ultimately, referral to the permit program. The Division of Livestock Environmental Permitting (DLEP) manages Ohio's livestock permits and inspections. There are no lawful discharges of untreated livestock manure in Ohio. Specific rules also apply to farms operating in the western basin of Lake Erie. Changes to these regulatory programs would require legislative action. Livestock Permitting rules are scheduled for a 5 year rule review which will be underway during the coming DAP planning cycle.

Table 4: Agricultural Regulatory Programs

Program	Description	Ohio Revised Code (ORC)	Ohio Administrative Code (OAC)
Concentrated Animal Feeding Facility Permit to Operate	Assures the proposed facility has developed appropriate best management plans in the areas of manure management, insect and rodent control, animal mortality and emergency response.	***903***	***901:10***
Concentrated Animal Feeding Facility Permit to Install	Assures the proposed building, its facilities and location will adequately support such an operation.	***903***	***901:10***
Agricultural Pollution Abatement	Establishes rules and complaint-based enforcement to prevent sediment and manure runoff from non-permitted agricultural operations.	***939***	***901:13-1-18***
WLEB Manure Management	Establishes additional manure application rules related to weather conditions for operations within the Western Basin of Lake Erie.	***939.08*** ***939.09***	***905.326***
Livestock Management Certification	Assures livestock managers and manure applicators receive training and are informed about utilizing livestock waste according to regulations and best practices.	***903.07***	***901:10-1-06***
WLEB Fertilizer Application Restrictions	Establishes fertilizer application restrictions related to weather conditions for operations in the WLEB.	***905.326***	

Future Work and Adaptive Management

ODA is committed to the Adaptive Management framework set forth in the GLWQA and is leveraging partnerships and funding to support implementing and evaluating innovative practices and strategies that have potential for future expansion and adaptation. Some of these initiatives include funding for Edge-of-Field research evaluating the efficiency of stacked BMPs, a sub-watershed scale pilot project looking at the effects of consolidated high BMP implementation, and farm-scale case studies demonstrating the economic effects of BMPs on farm operations. Additionally, ODA is funding demonstrations and research through the Conservation Action Project (CAP) intended to show producers the potential for maintaining lower soil test levels of phosphorous and reduced application. Legacy sources from soils with elevated phosphorus levels also continue to be a topic of research, and ODA is working with partners to evaluate efficient programmatic options to strategically address these sites.

Actions to Restore Wetlands

A wetland is an area of land that has unique characteristics because it is either seasonally or permanently covered by shallow water. Wetland ecosystems are home to specialized plant species adapted for life in saturated soil conditions, and wetlands provide critical habitat to a wide variety of animal species, from amphibians to waterfowl. Swamps, marshes, bogs, and similar areas— situated inland, along streams, or along the coast are all considered different types of wetlands.

Beyond wildlife habitat, the additional ecosystem services that wetlands perform are critical to the wider Great Lakes environment because wetlands slow the movement of water across the landscape. Intercepting and slowing runoff reduces the risk of flooding and erosion on stream corridors and downstream infrastructure and improves water quality by capturing or removing sediment and nutrients. This water-filtering capability is why wetlands are sometimes referred to as 'nature's kidneys.'

Historically, wetlands were not highly valued by society for these functions. Over the last few centuries, wetlands in Ohio have decreased in number and acreage, primarily due to agricultural and urban development, water level fluctuations, shoreline stabilization, and other modifications to drainage patterns. The 2006-2007 National Wetland Inventory identified 47,323 individual wetlands in Ohio's Lake Erie watershed, totaling 289,447 acres. By comparison, the total acreage of the Lake Erie watershed is approximately 7.5 million acres. The large-scale water quality issues addressed by the Ohio Domestic Action Plan can be attributed, in part, to the widespread loss of the ecosystem services provided by wetlands that once existed in northwest Ohio.

ODNR is the lead state agency working to restore, enhance, and create coastal, riparian, and inland wetlands, and promote the use of forested buffers to improve water quality and fish and wildlife habitat. ODNR has developed a strategic approach focused on investing in natural infrastructure to provide nutrient reduction and water quality benefits to Lake Erie. These projects will be implemented using sound science, landscape conservation design principles, and robust monitoring to measure progress in achieving water quality improvement goals.

ODNR's wetland creation and restoration efforts under H2Ohio funding occur across the state, but wetlands created primarily for nutrient reduction purposes are focused in northwest Ohio. These areas include: 1) the Lake Erie coastal region between the Maumee River and the Toussaint River; 2) the Sandusky Bay region; and 3) the Maumee and Sandusky River watersheds. These areas have been identified as either primary sources of phosphorus and/or are primary phosphorus pathways into Lake Erie. Each wetland project is designed to maximize surface water nutrient reduction capability. Projects that are currently underway or in development by ODNR are listed in Appendix D.

The Lake Erie CREP, mentioned in the previous section, has a broad mix of incentivized project types that includes wetlands. To further incentivize the establishment of wooded riparian buffers and wetlands under the Lake Erie CREP, ODNR is offering H2Ohio funds to provide a one-time incentive payment of $2,000 per acre. More information about this program is provided in Appendix D.

Wetland ecosystems provide a relatively low-cost, natural mechanism for nutrient reduction with many environmental benefits. ODNR is committed to creating and restoring thousands of wetland acres over the next decade in the Lake Erie watershed.

Actions to Reduce Community Sources

Every community in Ohio's Lake Erie watershed has already played a significant role in reducing nutrient loads. Opportunities remain for communities to participate in additional nutrient reduction that will continue to improve conditions in local receiving streams as well as downstream in Lake Erie. The following provides an overview of the implementation actions addressing HSTS and wastewater treatment plants -- community-based sources of nutrients. See Appendix C for an extended discussion on these sources. The appendix also includes details about CSOs and storm water sources.

Community-Based Nutrient Reduction - HSTS

Ohio Department of Health (ODH) rules for sewage treatment systems require that all new and existing systems are issued an operation permit with an identified maintenance schedule, and for discharging systems, a sampling schedule to ensure the system is meeting discharge standards. As of Jan. 1, 2015, all new and modified systems are required to be covered by Ohio's general NPDES permit (OHK000004) and are issued an operation permit by the county health department. County health departments are the lead agencies for addressing system problems or nuisance conditions. County health departments are required to report to ODH all operation permits issued. Ohio EPA will continue to work with communities to look for opportunities to eliminate poorly operating sewage treatment facilities.

ODH will continue to work with local health departments to ensure implementation of their Operation and Maintenance Tracking Programs for sewage treatment systems as required in the Ohio Administrative Code and provide options and resources for implementing operations and maintenance tracking including identification of failing sewage treatment systems within targeted watersheds[15].

Upon identification of a failing system, local health departments will establish specific action plans and timeframes for correction of the nuisance conditions. These plans may include repair, alteration, or replacement of the sewage treatment system. Local health departments also work with state and local government agencies and local public sewage treatment providers to facilitate extending sewers to areas of concentrated failing HSTS where possible.

Starting with the passage of the American Recovery and Reinvestment Act in 2009 and continued with funding support from Congress, Ohio EPA, in coordination with ODH, has provided between $10 to $13 million annually to local counties and health departments to repair or replace failing HSTSs for low to moderate income homeowners. Since 2016, Ohio EPA has awarded almost $82 million to Ohio local health departments to direct to eligible homeowners. In the first four rounds of H2Ohio funding, ten counties in the Lake Erie watershed received supplemental funding of over $2 million to help residents address failing HSTS. Ohio EPA offers three options to direct this funding assistance to homeowners for improvements to failing HSTS. These include development of a local loan capitalization program, principal forgiveness loans (grant-like funding) to local health departments, and H2Ohio grants. Principal forgiveness and H2Ohio grants are the most popular of the three options.

Ohio EPA has provided additional funding through the H2Ohio initiative for infrastructure projects that improve water quality[16]. This funding has supplemented other sources allowing difficult to finance projects to move forward. A focus of these projects has been the extension of sewers to areas with high densities of homes with failing HSTS. Ohio EPA also works with communities to extend sewers to areas with poorly performing small treatment systems. Table 5 identifies sewerage projects that have been facilitated through the H2Ohio program.

Table 5. Sewerage projects facilitated by H2Ohio Funding in the Lake Erie watershed.

Project	County	H2Ohio Funding	Population	Connections
Kunkle Sanitary Sewer & WWTP Project	Williams	$500,000	260	91
Shoreland Avenue-Holliday Drive Sanitary Sewer Extension	Lucas	$300,000	45	19
Eagle Creek / Springlake Subdivisions	Hancock	$625,000	231	100

[15] Located on the "Information for LHDs" page (***https://odh.ohio.gov/wps/portal/gov/odh/know-our-programs/sewage-treatment-systems/INFORMATION-FOR-LHDS/***) under an expandable heading titled "Operation and Maintenance Tracking Program Resources for Local Health Districts".

[16] List of H2Ohio funded projects is available at ***https://data.ohio.gov/wps/portal/gov/data/view/h2ohio-epa-hsts***.

Community-Based Nutrient Reduction – Wastewater Treatment (Final Outfalls)

Efforts to enhance the removal of phosphorus from municipal sewage wastewater treatment facilities and applicable industrial facilities have been ongoing in the state. Ohio continues to encourage phosphorus optimization within the Lake Erie watershed. Optimization focuses on source reduction, operational improvements, and minor facility modifications to reduce current effluent concentrations cost effectively. In addition to voluntary optimization efforts, some facilities have been required to take actions to improve local water quality. These actions are often taken in response to the development of a total maximum daily load (TMDL) to address impairment. Appendix C provides details about the impact of these actions at point sources.

Table 6: Ohio EPA Water Pollution Control Load Fund wastewater upgrades.

LE Basin Ultimately Receiving Treated Wastewater	Loan Values for Projects	Principal Forgiveness Provided with Loans	Loans with Nutrient Rate Reduction
Western	$205,964,200	$12,762,242	$84,566,701
Sandusky	$72,561,624	$3,550,000	$40,400,397
Central	$874,413,236	$3,660,000	$90,167,051
Total	**$432,186,670**	**$19,912,242**	**$215,134,149**

The State of Ohio has invested in these nutrient reduction efforts by offering financial assistance to communities with NPDES permits for wastewater treatment plant upgrades and combined sewer separation projects. Through its Water Pollution Control Loan Fund, Ohio EPA provided Lake Erie communities with over $2.6 billion in wastewater resource infrastructure project loan funds between 2009 and 2018. From 2019-2022 an additional $432 million was invested in wastewater infrastructure. Half of those funds were awarded an interest rate reduction for projects that included equipment and facilities at publicly owned wastewater treatment plants to reduce the levels of phosphorus and other nutrients. Nearly $20 million were provided as principal forgiveness. These funds all contribute to projects that in some manner result in nutrient reductions. Table 6 breaks down the 2019-2022 funding by Lake Erie basin.

Using Watershed Planning to Aid Practice Placement

The State of Ohio has long recognized the importance of strategic planning on the geographic basis of watersheds. The most recent commitment to this strategy was enacting House Bill 7 (133rd General Assembly), which created a statewide watershed planning and management program. Each large (USGS HUC6) watershed in the state was assigned a Watershed Coordinator to assist in planning, coordination, identifying critical areas, and reporting on regional water quality. Watershed Coordinators assist with existing conservation programs such as H2Ohio, provide region-specific coordination for future work, and support SWCD and other local watershed planning.

Several agricultural BMPs, such as VNMPs and overwintering cover, are broadly applicable and local conservation staff can promote these on all acres feasible with growers. However, modeling research (Martin et al. 2019[17]) has shown that strategic placement of structural practices is important in meeting the load reduction target efficiently. One way to determine the best placement is through a local watershed planning effort. Therefore, along with other county efforts, Ohio will continue to encourage the development of local watershed plans for the most effective placement of structural practices.

The primary purposes of local watershed plans are to identify critical areas for implementation, organize stakeholders, set local water quality goals and implementation objectives for conservation practice implementation, identify implementers and funding sources, and most importantly, develop funding-eligible "shovel-ready" projects with willing participants. Ohio's Nonpoint Source Pollution Implementation Strategy (NPS-IS)[18] is the framework to develop nine-element watershed strategies and establish project eligibility for federal funding. This framework may also used to determine placement for projects funded through H2Ohio.

[17] Martin, J.F., Kalcic, M.M., Aloysius, N., Apostel, A.M., Brooker, M.R., Evenson, G., Kast, J.B., Kujawa, H., Murumkar, A., Becker, R., Boles, C., Redder, T., Confesor, R., Guo, T., Dagnew, A., Long, C.M., Muenich, R., Scavia, D., Wang, Y., Robertson, D., 2019. Evaluating Management Options to Reduce Lake Erie Algal Blooms with Models of the Maumee River Watershed. Final Project Report – OSU Knowledge Exchange. Available at ***http://kx.osu.edu/project/environment/habri-multi-model***.

[18] Nine-Element NPS-IS in Ohio: ***https://epa.ohio.gov/divisions-and-offices/surface-water/guides-manuals/9-element-nps-is-tools***.

Each nine-element NPS-IS is written for a 12-digit Hydrologic Unit Code (HUC12) watershed ranging in size from about 10-40 square miles and average about 26 square miles in area. The NPS-IS is a key mechanism for analyzing load reduction opportunities, as well as addressing local water quality and associated issues. A key element of each nine-element plan is to explicitly identify load reduction targets needed to restore water quality. Appendix A presents far-field targets for HUC12s in the Maumee Watershed that are recommended to be included in each NPS-IS in the Maumee River watershed. These targets were updated in 2023 so they are consistent with both the Maumee Watershed Nutrient TMDL and the Lake Erie Annex 4 targets.

Far-field load reduction planning efforts at the HUC12 level are well underway in the WLEB (Figure 7). The intent is to focus on completing the southern portion of the Maumee River watershed, and then include the remainder of the Maumee, Portage, Sandusky, Huron, and Cuyahoga River watersheds as time and funding become available. Some of the earliest nine-element watershed plans in the Lake Erie watershed did not include a far-field nutrient reduction component, so a coordinated effort to work with regional stakeholders to update the existing plans is currently ongoing.

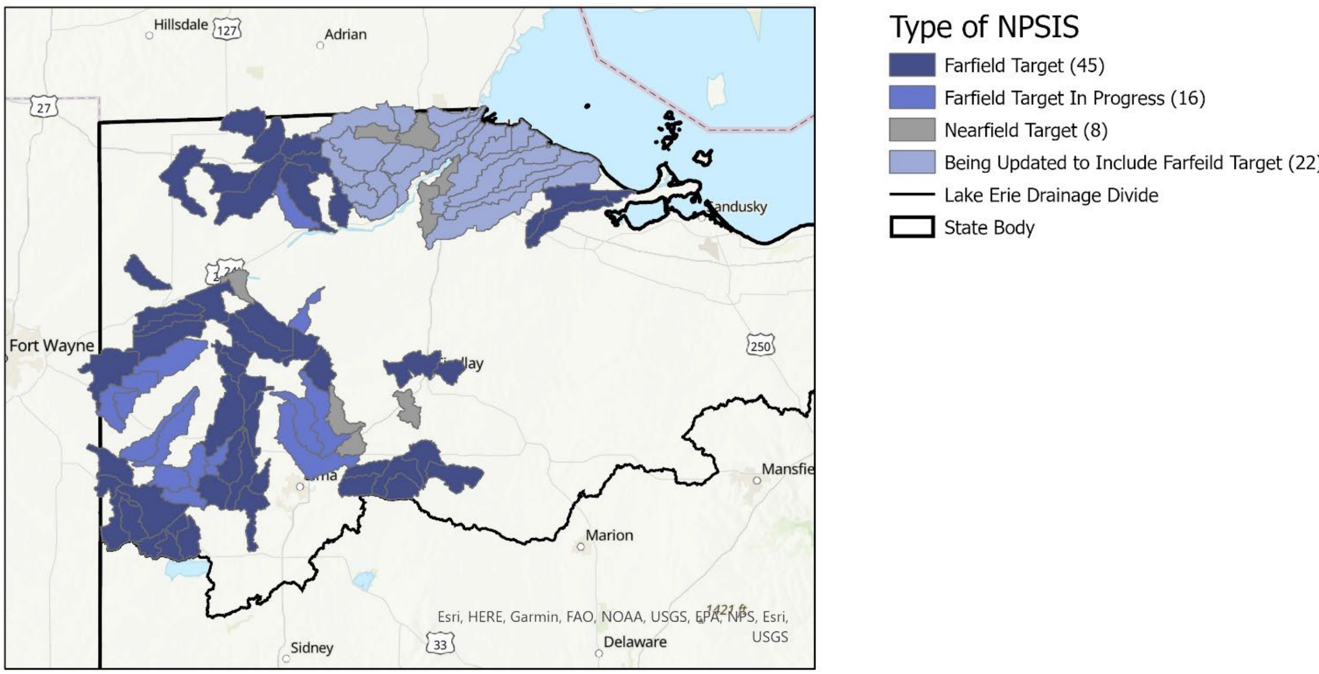


Figure 7: Watershed planning for HUC12s in the Maumee River watershed -- existing NPS-IS and plans under development (10-2022). Ohio EPA also maintains an online interactive map of NPS-IS plans[19]. In addition to those HUC-12 WAUs shown, there are nine (9) additional HUC-12 WAUs in the Tiffin and St. Joseph's watersheds, where there are new NPS-ISs under contract for development as of August 2023.

Agricultural Land Management Tools for 9-Element Watershed Plans

While agricultural conservation practices are implemented at the field scale, watershed planning can be used to identify critical areas at a broader but reasonable scale and help organize and prioritize projects and actions across many farms within a community.

In addition to providing the local planners with target loads at the HUC12 level, Ohio recommends that local planners review the list of H2Ohio funded best management practices. This list of BMPs includes recommended practices that local SWCDs, watershed groups, local governments, farmers, and others can implement on their own or with state and federal support. Local watershed stakeholders are encouraged to use the list of BMPs to facilitate discussions during the planning process.

[19] Link to map is at ***https://epa.ohio.gov/monitor-pollution/maps-and-advisories/nonpoint-source-implementation-strategies***.

House Bill 7 (133rd General Assembly) initiated the ODA Watershed Program with the directive to engage in collaborative, regional-scale watershed planning and management. Regional Watershed Plans have been developed for the purpose of supporting local conservation initiatives, developing new regional programs, and to help guide the expansion of the H2Ohio program. Region 1 and Region 2 cover Ohio's Lake Erie watershed.

The plans provide regional watershed characterization, water quality data and goals, funding opportunities, and analysis of applicable management measures. The ODA Watershed Program works with local, state, and federal partners to help support implementation. The ODA Regional Watershed Plans are located online[20].

Another tool that is available in Ohio for planning in agricultural landscapes is USDA's Agricultural Conservation Planning Framework (ACPF). The ACPF uses a watershed approach to identify sites that may be suitable for specific hydrology-based BMPs within a HUC12 using GIS tools designed to find conservation opportunities along drainage paths across different agricultural landscapes. While not a comprehensive tool for siting all possible practices, it will be useful in this context because of its focus on water retention in agricultural landscapes. The ACPF has been completed for several HUC-12 watersheds in the western Lake Erie basin (WLEB) and will supplement local watershed plan development. Please see the Actions by Partner Organizations tables (Appendix G) for more information on how The Nature Conservancy is working to broaden access to ACPF maps in Ohio.

Community Based Tools for 9-Element Watershed Plans

Although the focus for planning will be on agricultural practices, plans can have practices such as stream restoration that address urban nonpoint sources (e.g. non-permitted storm water) as well as HSTS sources of nutrients.

Ohio communities face many challenges with aging storm water management infrastructure, combined sewer overflows, impervious surfaces, and continued pressure to reduce the rate and amount of runoff that is entering Ohio streams from the urban and suburban landscape. Peak discharge volume reduction decreases overall volume of discharge which is directly related to loading reduction. Loading is also reduced because improved retention of urban runoff also incrementally reduces erosional stressors on streambanks; and reduces stream bed scour which can disconnect streams from floodplain access where sediment and nutrients are readily processed.

Ohio is encouraging, and communities are embracing, green infrastructure and Low Impact Development (LID) practices. Some examples that are consistent with Ohio's Nonpoint Source Management Plan (2019-2024)[21] and the Ohio Balanced Growth Program[22] include:

- Storm water retention practices (detention ponds, wet ponds and wetlands);
- Storm water infiltration and filtration practices (rain gardens, bio-retention, infiltration basins, grassed swales, permeable pavement/pavers);
- Increase permeable surfaces (green parking areas & roofs, eliminate curbs and gutters); and
- Restoration of channelized streams, riparian buffers and floodplains.

Ecosystem Services Tools for 9-Element Watershed Plans

Loss of wetlands, increased agricultural drainage, and floodplain disconnection along with the modification of in-stream channel and habitat conditions are the highest magnitude causes of aquatic life use impairment in Ohio streams. The nine-element watershed plans are designed to restore attainment of aquatic life use within each HUC12 by implementing practices such as stream restoration, streambank restoration, floodplain restoration, wetland restoration, riparian restoration, and others. These "ecosystem service" conservation efforts can be used to achieve far-field nutrient load reduction targets by increasing nutrient assimilation in streams and wetlands, encouraging floodplain deposition of silt and sediment, reducing stream bank erosion, and overall discharge (volume) reduction. Suitable wetland protection or restoration projects should be included in watershed plans when appropriate for the critical areas identified in the plans.

Process and Timeline

[20] ***https://lakeerie.ohio.gov/planning-and-priorities/02-domestic-action-plan/03-domestic-action-plan-2023***. The Lake Erie watershed encompasses Region 1 and Region 2 of the ODA Regional Watersheds.
[21] ***https://epa.ohio.gov/divisions-and-offices/surface-water/about/ohio-nonpoint-source-pollution-control-program***.
[22] See ***https://balancedgrowth.ohio.gov*** for more information about program recommendations and resources.

With a possible 194 HUC12s in the Maumee River watershed alone, we recognize that it will take additional time for a significant number of nine-element watershed plans to be completed or revised. The SWCDs will likely decide how many and which of their HUC12s need this degree of analysis and on what schedule, in order to allow their practice placement goals to be met. Additional funding for watershed plans continues to be sought. While this is a key action, it is not the only action that will be taken, nor is it necessary to limit actions to areas with approved nine-element watershed plans.

Other Actions

Total Maximum Daily Loads

The Total Maximum Daily Load (TMDL) program focuses on identifying and restoring beneficial uses in polluted rivers, streams, lakes, and other surface waterbodies that are identified as impaired on the Section 303(d) list in the Integrated Report that Ohio EPA maintains. A TMDL is a written, quantitative assessment of water quality problems in a waterbody and contributing sources of pollution. It specifies the amount of pollutant reduction needed to meet water quality standards, allocates pollutant load reductions, and provides the basis for taking actions needed to restore the beneficial uses of a waterbody. Each TMDL report includes an implementation plan that lists these actions.

There are a few Ohio TMDLs in the Lake Erie watershed that have recommended actions for nutrient reductions to address local, near-field, beneficial use impairments. An analysis of the load reductions detailed in the existing phosphorus near-field TMDLs indicates that while helpful, these reductions will not be enough to achieve load reductions needed for far-field (Lake Erie) purposes[23]. These TMDLs can be found here: ***https://epa.ohio.gov/divisions-and-offices/surface-water/reports-data/total-maximum-daily-load-tmdl-program***.

Ohio EPA developed and submitted the Maumee Watershed Nutrient TMDL to USEPA for approval as of June 30, 2023[24]. This effort is intended to address far-field impairments in western Lake Erie due to harmful algal blooms and nutrients. The Implementation Plan in the Maumee Watershed Nutrient TMDL calls for biennial reporting on activities to achieve nutrient reduction goals. This is a parallel activity to the Ohio DAP, and Ohio intends to keep the two efforts fully integrated.

Private Organizations Actions Summary

Meeting the targeted phosphorus reductions will include efforts from nongovernmental organizations and the private sectors. A supplement of actions in the Lake Erie basin by nongovernmental and private actors is included as a supplemental table on the web page with the final version of the Ohio DAP.

Dredge Material Open Lake Placement Ban

Each year, harbors on Ohio's north shore must be dredged to keep the shipping channels open so commodities can move in and out of the ports. Nearly 1.5 million tons of material are dredged annually. Historically, much of the dredged material was dumped in the open waters of Lake Erie. However, with passage of Senate Bill 1, this is no longer an option as of July 1, 2020 (except under certain specific circumstances). Diverting this material to other uses or locations will improve Lake Erie water quality by removing a source of phosphorus.

Monitoring and Tracking

Water Monitoring Programs

In an Adaptive Management framework, monitoring of system response and tracking towards goals is a necessary function to evaluate actions being taken so that necessary adjustments can be made.

It is the goal of the overall water quality monitoring strategy in Ohio to include monitoring data from edge of field, sub-watershed, Annex 4 priority watersheds, and Lake Erie in order to provide a total picture of nutrient sources and

[23] Methodology for Connecting Annex 4 Water Quality Targets with TMDLs in the Maumee River Basin. Task Order Number EP-B175-00001 (Aug. 9, 2018). ***https://www.epa.gov/sites/production/files/2018-10/documents/annex4_methodology_with_appendices_20180809-508.pdf***.

[24] ***https://epa.ohio.gov/divisions-and-offices/surface-water/reports-data/maumee-river-watershed***.

the nutrient delivery system. The primary indicator of progress will be water quality monitoring and associated load calculations at the key downstream station on each of the Annex 4 priority watersheds in Ohio.

Ohio water resource agencies, Heidelberg University and USGS are all involved in tributary nutrient monitoring throughout the Lake Erie watershed. This monitoring includes sampling of key tributary pour points, like the Maumee River at Waterville, which are used to track the Annex 4 nutrient reduction targets. In the Maumee and Sandusky River watersheds there are additional upstream monitoring locations. There are more than 20 monitoring stations in the Maumee River watershed alone. These include a monitoring station near the mouth of every major Maumee River subwatershed (HUC8). Due to the great size of the Maumee River watershed, monitoring on these major subwatersheds will be used to track nutrient trends over time at a more manageable scale than just at Waterville.

Additionally, several monitoring stations in the Maumee and Sandusky watersheds are located on much smaller tributaries that drain less than 50 square miles. These stations monitor "sentinel watersheds" and are key to understanding the success of nutrient reduction implementation practices. While it is not possible to monitor at every HUC12 outlet, the current network of sites has been established to cover key locations and provide data that are more useful in evaluating different practices and improving surveillance of areas with higher potential for nutrient loss. Appendix E outlines this monitoring program in greater detail.

ODNR is currently supporting extensive wetland monitoring work, especially in the WLEB and Sandusky Bay. In addition to identifying key water quality thresholds that will eliminate HABs, ODNR is developing pre-construction baseline datasets to compare the "flow-thru" and other wetland restoration projects once completed through post-construction monitoring.

In addition, ODNR is continuing to work cooperatively with partners (Cleveland Water Alliance, city of Sandusky, Bowling Green State University, and others) to develop a low-cost sensor network to monitor water quality within Sandusky Bay and at the Old Woman Creek National Estuarine Research Reserves. ODNR anticipates that once fully developed, this sensor technology would be applied to assist with monitoring upgraded coastal wetland systems along the western basin shoreline as well.

Through the NPDES permit program, facilities regulated by Ohio EPA through NPDES permits collect nutrient data for their wastewater. That information is reported to Ohio EPA monthly through the electronic discharge monitoring report system (often referred to by its acronym eDMR). This enters the information into a database that evaluates compliance with permit conditions and is also utilized for the Nutrient Mass Balance Study and other program purposes.

Ohio EPA regulates public drinking water systems in Ohio. The Agency requires cyanobacteria and cyanotoxin monitoring on a regular basis from all plants using surface water[25]. Monitoring requirements are adjusted based on various schedules assigned to plants. Plants with historic cyanotoxin detections in finished drinking water or with high source water susceptibility and limited treatment options are moved to a more frequent monitoring schedule. The Division of Drinking and Ground Waters tracks all HAB monitoring data from public water systems via a database and maintains an interactive map where the public can access these data[26]. Drinking water advisories are also available online[27]. Surface water data for beaches and other water bodies is available via BeachGuard[28].

Tracking Actions

Tracking BMP, Wetland, and Community Actions

As a part of the H2Ohio initiative, agricultural BMP projects routed through Soil and Water Conservation Districts are tracked via a digital platform already in use (Beehive). ODA is also developing additional software (MyFarms) to manage program enrollment and contract management tasks. These software upgrades will allow ODA to refine

[25] Detailed requirements are listed at ***https://epa.ohio.gov/divisions-and-offices/drinking-and-ground-waters/public-water-systems/harmful-algal-blooms.***

[26] ***https://geo.epa.ohio.gov/portal/apps/dashboards/e72499f345ec43579513da521d83347e***.

[27] Drinking water advisory portal is available at ***https://oepa.maps.arcgis.com/apps/webappviewer/index.html?id=5b1c1a32a7954cedb094c11dc7fd87b7***.

[28] ***https://ohio.gov/wps/portal/gov/site/residents/resources/beachguard***.

tracking of practice enrollment and implementation[30], as well as improve ODA's ability to assess program impact. This platform is currently under development.

Ohio is currently tracking extent of adoption of agricultural BMPs by county (number of acres enrolled, number of acres completed, funds committed, funds disbursed), number and type of completed wetlands projects, number and type of Ohio EPA infrastructure projects completed (HSTS and water treatment/wastewater treatment infrastructure), and programmatic progress towards the phosphorus load targets for the Maumee River in Ohio.

The USDA Farm Service Agency administers the Lake Erie Conservation Reserve Enhancement Program, which includes tracking and reporting number of contracts, payments, practices and acres enrolled in the program. ODNR is providing supplemental funding for wetlands specific projects from agency H2Ohio funds and is tracking and reporting that effort under H2Ohio.

Tracking Watershed Plans and Planning Implementation

Ohio EPA maintains lists and maps of approved and in-progress NPS-IS watershed plans that are available online[29].

The State of Ohio intends to develop and implement a tracking mechanism that will summarize project lists from multiple NPS-IS plans in one database to streamline project and conservation practice implementation. This system is intended to align with or build off of the already successful Areas of Concern Management Actions project tracking system — *Maumee AOC Data Management & Delisting System 3.0*.

Potential projects that are developed as part of the NPS-IS process are developed with explicit associated estimates of nutrient and sediment load reductions that are based on modeling and some limited performance research. Once the NPS-IS plans are approved and the tracking lists are created, we should be able to begin to develop some project-based and overall conservation practice implementation-based estimates of anticipated load reductions. This will not be a definitive way of determining whether these subwatersheds will achieve their targets, due to the uncertainty involved in developing the estimates. However, this can serve as a check on watershed model estimates and water quality monitoring-based tracking.

Reporting

In recent years a robust and diverse set of reporting mechanisms have been developed to allow stakeholders various ways to access reporting on Lake Erie status, management actions, completed work, new and existing programs, funded projects, forecasting, and planning. These include periodic reporting documents, public meetings, press releases, and online resources. There has been a considerable amount of web resource build-out. Key portals for Ohio's efforts include binational.net[30] and ErieStat[31] for Annex 4 Subcommittee products, NOAA GLERL[32] for in-lake monitoring, the Ohio DAP[33] and Water Monitoring Summary[34] resources, and the H2Ohio website[35]. Throughout this document we have provided links to these and additional web-available resources in the relevant sections.

Ohio is committed to working with U.S. EPA as the lead U.S. agency for the GLWQA to coordinate and provide progress tracking information for Annex 4 purposes in a consistent and timely manner. Ohio specific information that we report to the Annex 4 Subcommittee includes management actions underway and completed, significant individual projects of regional interest, point source monitoring data, and stream monitoring data if conducted by Ohio agencies. Ohio also coordinates with USGS and Heidelberg University to ensure consistency in reporting stream monitoring data. Ohio participates in the Annex 4 Subcommittee Adaptive Management Team five-year evaluation, annual webinars, and other public forums such as the Great Lakes Public Forum which is held every three years. Ohio also provides information used in the GLWQA Triennial Progress Report of the Parties which is published every three years. The current Triennial Progress Report was issued in June 2022 and the next report will be issued in 2025[36].

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[29] List and link to online map at ***https://epa.ohio.gov/divisions-and-offices/surface-water/reports-data/approved-nine-element-nonpoint-source-implementation-strategies-in-ohio.***

[30] ***https://binational.net/annexes-issues/a4/***

[31] Also known as Lake Erie Algae – Blue Accounting. See: ***https://www.blueaccounting.org/issue/eriestat/***

[32] ***https://www.glerl.noaa.gov/res/HABs_and_Hypoxia/***

[33] ***https://lakeerie.ohio.gov/planning-and-priorities/02-domestic-action-plan***

[34] ***https://lakeerie.ohio.gov/planning-and-priorities/03-wms/wms***

[35] ***https://h2.ohio.gov/***

[36] ***https://binational.net/category/prp-rep/***

Ohio EPA is responsible for publishing a publicly available biennial Ohio Integrated Water Quality Monitoring and Assessment Report[37]. This report is sent to U. S. EPA to satisfy the Clean Water Act's Section 303(d) requirement for a prioritized list of impaired waters. Lake Erie assessment units are included in this report. The next Integrated Report will be released in 2024.

Ohio has also produced a printable annual Water Monitoring Summary that tracks a limited amount of monitoring results against the Annex 4 targets and an associated Expanded Lake Erie Tributary Nutrient Load Monitoring Report that includes more complete information[38]. The Summary is a short, four-page fact sheet that can be distributed in hard copy form at various in-person events throughout the year. Work is underway at Heidelberg University using an ODHE-HABRI grant to analyze data acquired from additional monitoring stations at subwatershed gages and determine how best to utilize and report the new information. We expect to further develop these resources within the next year or two and integrate this annual reporting with the proposed Maumee Watershed Nutrient TMDL reporting cycle.

As a part of the H2Ohio initiative, progress is reported to the public at via an online dashboard[39]. Metrics reported via this dashboard include extent of adoption of agricultural BMPs (number of acres, number of adopters), number and type of completed wetlands projects, number and type of Ohio EPA infrastructure projects completed (HSTS, lead removal) and progress toward the actual phosphorus load targets. Most of these metrics are available cumulatively by county. The H2Ohio program also produces an Annual Report each year which is available on the H2Ohio web portal.

The state agencies will continue to highlight key phases and successful projects through news releases. In addition to agency news outlets, H2Ohio specific releases are posted at the h2.ohio.gov website.

Additional reporting mechanisms may be developed with stakeholder input as described below in the section on Public Involvement. For example, OLEC provides recorded materials from Ohio DAP workshops on our YouTube channel[40].

Research

Research is a critical part of Adaptive Management. In a system as complex as Lake Erie and its watershed, there are many uncertainties. In addition to exploring fundamental questions around nutrient fate and transport in the watershed, nutrient cycling in the lake, toxicity and algal biology, there are also critical research questions about protecting public health and the magnitude and timing of system response to management actions.

Ongoing Research

A primary source of research direction and funding in Ohio has been the work of Ohio's Department of Higher Education (ODHE). The chancellor of ODHE has been and will continue to work through representatives from the University of Toledo, Ohio Sea Grant, and The Ohio State University to solicit critical needs and knowledge gaps from state agencies. ODHE is now providing funding through the Harmful Algal Bloom Research Initiative (HABRI)[41] for applied research at Ohio universities. Many HABRI projects seek to understand both how phosphorus and other elements like nitrogen affect algal blooms, and how runoff can be reduced without negative impacts on farmers and other industries. Other projects focus on the public health impacts of toxic algal blooms, ranging from drinking water issues to food contamination.

Research to evaluate progress includes watershed modeling, research on effectiveness of best management practices, paired watershed studies, survey work, and research on in-lake and in-stream processes.

Watershed models are a critical part of the Adaptive Management cycle for nutrient reduction in Lake Erie. Existing models have been valuable in evaluating alternative practices and scenarios upon which nutrient reduction strategies can be based. Researchers at the Ohio State University, USDA-NRCS, USEPA, USGS, other universities, and private contractors maintain watershed models of the Maumee River for various research purposes. We anticipate that work

[37] ***https://epa.ohio.gov/divisions-and-offices/surface-water/reports-data/ohio-integrated-water-quality-monitoring-and-assessment-report***.
[38] See ***https://lakeerie.ohio.gov/planning-and-priorities/03-wms/wms***.
[39] See ***https://h2.ohio.gov*** for list of reporting metrics which will direct to the online tool for each metric.
[40] See ***https://www.youtube.com/@OhioLakeErie/***.
[41] See resources at ***https://ohioseagrant.osu.edu/research/collaborations/habs***.

will continue to refine the accuracy and precision of these models and enhance their ability to be predictive of system response to management actions.

There has been and continues to be work done to better understand the effectiveness of various best management practices using field scale research on BMPs. USDA-ARS is maintaining the existing edge of field research network which is looking at several types of BMPs using paired fields with and without a practice installed. Using HABRI funds, work is being done to study two-stage ditch effectiveness over time. There are also projects underway to study the effectiveness of phosphorus filters, especially looking at different types of fiter media that will optimize phosphorus retention.

The H2Ohio Wetland Monitoring Program is funded by the Ohio Department of Natural Resources (ODNR) and led by a team of scientists from six Ohio universities through the Lake Erie and Aquatic Research Network (LEARN). Its mission is to independently assess the ability of wetland restoration projects to reduce nutrients and improve water quality. Researchers visited 45 H2Ohio wetland projects in 2022 and collected data reflecting nutrient function. In addition, H2Ohio Wetland Monitoring Program researchers obtained a $3 million grant from the US EPA Great Lakes Restoration Initiative and $250,000 in funding from Ohio Department of Higher Education (ODHE) Harmful Algal Bloom Research Initiative (HABRI) to enhance researchers' capacity to not only directly assess individual wetlands, but to synthesize nutrient reduction/water quality benefits across different wetland types and geographies. More information about the program's progress, including a public webinar, can be found at ***https://lakeerieandaquaticresearch.org/research/learn-initiatives/h2ohio-wmp/***.

NRCS is providing funds for two separate projects using paired watersheds in the Maumee River where one small (HUC12) watershed is paired with a nearby watershed with similar land use and soil characteristics. Water monitoring will be conducted at each watershed to compare and contrast the effects of building out maximum BMPs in one watershed with the other used as a control. This intermediate condition between edge of field and watershed-wide effects has been less well studied as it is expensive and presents challenges in site location and recruitment of participating producers.

A recently awarded project with multiple partners, led by OSU researchers with funding from NRCS, will study BMP implementation in paired watersheds including directed, in-depth survey work to further explore barriers to BMP implementation for producers and look at ways to reduce or remove these barriers. Survey research can provide insight into incentives for adoption of practices as well as projecting likely adoption rates. Demonstration projects, such as working farms in the Blanchard River watershed, have also been useful to encourage adoption of BMPs.

Researchers at USGS and OSU are studying the fate and transport of phosphorus within streams. This set of projects will look at whether the stream network itself is a source or sink of phosphorus. This is an important area of research that will further inform efforts to manage DRP.

Field Prioritization Research Concept

There is an open question about whether the state could accelerate progress by prioritizing implementation at the field or even subwatershed level. Previous model project research (Scavia and Martin) has suggested that prioritizing locations with higher phosphorus yield can improve the performance of phosphorus reduction efforts, given an equivalent total percentage actively implemented. We know from prior work (e.g. Duncan et al. 2017) that fields with higher soil test phosphorus (STP) tend to have higher nutrient losses. These STP data are very closely held by farmers and landowners as business confidential information, and there are state and federal laws that limit access to these data. Thus, the state has significant challenges to utilizing this factor as a phosphorus yield/risk identification tool.

A new approach to this problem in Ohio could be similar to what Michigan is doing with their Agriculture Inventory System, in which they have constructed an overlay model of the Raisin River watershed. This model uses publicly accessible data such as location relative to streams, cropping system, slope, size of field, etc. to rate each field with a runoff risk factor that is a proxy for nutrient loss. This model does not use STP, as the challenges in acquiring those data are the same as in Ohio. A model like this is suitable for rating fields by phosphorus loss risk, but these types of data are available watershed-wide and so could be used uniformly across the watershed.

In the case of the Maumee River, which has an enormous area, such a model could be piloted for significant subwatersheds (e.g. Blanchard River) and perhaps tied to gaging station data for water quality. Ohio already has a phosphorus yield based map for the Maumee (see Appendix A). These data could also inform a phosphorus loss overlay model for the Maumee River watershed. Other data that might be informative would be the BMP mapping (including a tile drain network map) developed for the H2Ohio SWAT model project currently underway. Once developed, the overlay model of higher risk fields could then suggest areas where more effort could be prioritized.

Ohio proposes to make this concept a topic of research and testing during the coming DAP cycle.

A related question that would need to be addressed as part of such research would be an analysis of its cost-effectiveness as an approach, knowing that it is likely to take longer, be less likely to persist, and may be somewhat more costly to incentivize despite its potential increase in effectiveness.

Technology Assessment Program

In support of efforts to address HABs, state agencies are often presented with emerging technologies for reducing nutrient loading and reducing HABs. Since these technologies are typically innovative, proprietary, and span multiple scientific disciplines, state agencies alone are not best positioned to evaluate the efficacy and feasibility of these technologies.

To evaluate these technology proposals, the H2Ohio Technology Assessment Program (TAP)[42] was implemented. The TAP has identified promising new technologies. Ohio EPA is working towards validating those technologies and facilitating demonstration projects to determine their effectiveness at scale.

Public Involvement and Advisory Mechanisms

The Western Basin of Lake Erie Collaborative Framework and the Ohio DAP were developed with input through meetings and conversations with various stakeholder groups and state agencies, individually and collectively. We appreciate the time and effort from our local partners who not only meet with the state to discuss the Ohio DAP and related work, but also conduct their own efforts that are federally and privately funded. OLEC maintains a table of actions by these partners and stakeholders as a companion piece to the Ohio DAP which is available on the Ohio DAP website.

Ohio will continue to hold occasional conferences or workshops specifically to address the Ohio DAP actions and outcomes. Since 2020, OLEC has conducted two online workshops to report on status of Lake Erie and its watershed, management actions underway and planned, and completed actions. We intend to explore ways to expand this effort, perhaps as a hybrid online/in-person event in the future.

The state will continue to engage interested stakeholders through ad hoc meetings. Meetings will cover a range of topics related to meeting the goals of the Ohio DAP, and stakeholders may provide recommendations to OLEC about specific questions or issues that should be discussed in a broader group setting.

OLEC maintains a list of interested stakeholders and uses this list to send email notifications for public workshops, public notice of documents posted for review, and updates to web resources. Interested stakeholders who are not already receiving these emails should contact OLEC to be added to this list (dap@lakeerie.ohio.gov).

Conclusions and Projections

Model Projections

The Adaptive Management process includes making predictions about expected outcomes based on proposed actions. Watershed modeling efforts have shown that implementation levels for proposed actions will have to increase basin wide to achieve the 40 percent load reduction target from Annex 4.

A multi-university team of modeling experts has developed, calibrated, and validated six watershed computer models to determine which conservation practices are most likely to lead to target reductions in phosphorus runoff from the Maumee River watershed into Lake Erie (Scavia et al., 2016[43], Martin et al. 2019[44]). The models were then used to

[42] A more detailed description of the TAP and list of initial ten technologies identified is available at ***https://h2.ohio.gov/ohio-epa/***.
[43] Scavia, D. et al. 2016. Informing Lake Erie Agriculture Nutrient Management via Scenario Evaluation. Water Center, University of Michigan. ***http://graham.umich.edu/water/project/erie-western-basin***.
[44] Martin, J. et al. 2019. ibid.

evaluate how adoption of conservation measures over time would impact overall water quality. Meaningful engagement of a diverse advisory group provided important guidance for the project. Results indicated that widespread adoption of practices will be necessary, as many scenarios required multiple management practices across at least half the farm fields in the Maumee watershed, so this mix-and-match approach will be essential to achieving the 40 percent reduction goal.

Separately, the NRCS 2016 Conservation Effects Assessment Project (CEAP) report[45] estimated that 95 percent of cropland acres would have to be affected by a suite of BMPs to achieve a 43 percent reduction in total phosphorus. This work showed that no single conservation solution will meet the needs of each field and farm. Rather, comprehensive field-scale conservation planning and systems are needed to accommodate the differences across farm fields. Another key finding from this work was that additional progress in nutrient and erosion control will depend on advancements in precision technologies.

Through a combination of funding from HABRI and H2Ohio, the state has sponsored further work using one of the existing watershed models of the Maumee River to evaluate potential outcomes from H2Ohio. This work is intended to evaluate both the practices that have been funded, and the overall program projected results and timeline. Results are expected to be consistent with prior work in that widespread adoption of practices will continue to be necessary. It is hoped that this effort will provide a more realistic time frame in which to expect measurable results at the Maumee River at Waterville gage.

These modeling efforts clearly show that every farm throughout the watershed has a role to play in achieving the load reduction targets. There are different ways to reach the target loads, but in all cases the adoption rates of the nutrient reduction practices will need to be more widespread than they are currently in 2023. If program expansion remains at the current rate of uptake, it will be very important to continue the programs for the duration required to achieve high rates of practice adoption and encourage adopters to maintain them, or, to increase the rate of adoption to achieve results in a shorter time frame.

Estimated Load Reductions

State agencies working on H2Ohio are producing estimates of load reductions based on the number of practices adopted, wetlands constructed, and other actions implemented.

ODA continues to estimate phosphorus reductions through implemented Best Management Practices (BMP) on the field. Because the growing season in Ohio begins in spring and extends into the winter, ODA does not yet have complete and verified data for 2022, but based on the 2022 data that is available, ODA estimates that agricultural producers have reduced overall phosphorus runoff by 232,000 pounds, an increase from the 200,000 pounds in 2021. Considering the BMPs currently enrolled for 2023, ODA estimates that this number could increase to over 317,000 pounds over the next year.

Through ODNR's efforts, H2Ohio wetlands that are already built or in the construction process are projected to reduce phosphorus loading to Lake Erie tributaries by over 119,000 pounds per year. These wetlands will also reduce nitrogen losses and sequester carbon, as well as provide 11,221 acres of habitat.

Ohio EPA invested H2Ohio dollars as well as other funds for nutrient management in Lake Erie in wastewater infrastructure improvements. The benefits to improving large-scale wastewater facilities and home sewage treatment systems are largely human health related. Through Ohio EPA's projects, a total of 400 pounds of phosphorus runoff was prevented.

The calculated potential phosphorus load reduction for 2023, once projects and practices are constructed and completed, is 449,500 pounds of phosphorus, an increased reduction of 161,100 pounds from 2022. Please see the H2Ohio Annual Report 2023[46] for additional details.

[45] USDA NRCS, 2016 Effects of Conservation Practice Adoption on Cultivated Cropland Acres in Western Lake Erie Basin, 2003-06 and 2012. ***https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcseprd889806.pdf.***

[46] Posted at ***https://h2.ohio.gov/***

Managing Expectations

Ohio has more work to do. Each agency remains focused and committed to ensuring water quality through streamlined BMPs for producers, wetland restoration, community-based actions, and watershed planning. With continued effort and investment, the phosphorus entering Lake Erie is continuing to decrease, but the impact of continuing implementation of H2Ohio and other actions will take years before it is fully realized. The Lake Erie watershed in Ohio consists of over 7 million acres. The Maumee River alone has over 4 million acres in Ohio. While some progress has been made in the years since the Collaborative Agreement was first signed, monitoring data in the rivers and satellite data showing HABs in the lake indicate that there is still a long way to go to meet the targets that have been set.

We anticipate that the response in the rivers and lakes will continue to be slow because of the need for widespread changes to reduce nutrient losses in agricultural landscapes. H2Ohio has been stunningly successful in its initial phases, reaching about one third of all agricultural acreage in the Western Basin with Voluntary Nutrient Management Plans (VNMPs). Furthermore, ODA's goals are to enroll 2 million acres across the H2Ohio area by the end of 2025, which would be approximately 50 percent of the cropland in the WLEB.

Despite this significant effort, research predicts that 70 percent or more of the cropland in the WLEB is needed to reach the target reductions. To participate in H2Ohio, producers must develop and implement a VNMP. Producers are also encouraged to implement other best management practices, which increase the effectiveness of the VNMP and load reduction impact. ODA encourages all producers who have not done so already to explore how the VNMP can improve their conservation efforts and reduce their environmental footprint.

Even with broad support for the concepts behind nutrient reduction, changes in agricultural practices need time to be integrated, and installation of natural features such as wetlands takes time to move through the proposal, design, and construction phases. Education and outreach and the changes in behavior that they are intended to promote also take time to roll out. Even if fully re-imagining Lake Erie's watershed was complete, it would still take time and resources to re-engineer the landscape accordingly.

In addition to the time needed to make these changes, it remains uncertain whether the installation of practices and changes in land management will result in immediate effects, or if there is some lag time for nutrients already in the soils and moving through the system to be removed. This is an area of ongoing research.

Despite these challenges, the State of Ohio feels that the resources and focus provided by H2Ohio should continue to accelerate the progress we have been making toward achieving the Annex 4 and Ohio DAP goals for nutrient reduction, and ultimately, a healthier Lake Erie.

Appendix A: Developing Subwatershed (HUC12) Far-Field Targets for the Maumee River Watershed

Distribution of baseline nonpoint source loads by sources and assigning target nonpoint source loads

A1 Introduction

At over 4 million acres, the Maumee River watershed as a whole is not a practical size to plan nonpoint source nutrient reduction. The efforts need to be based on individual actions by farmers, property owners and local officials at a finer scale, for example at the size of an agricultural field. Therefore, to be effective, it is necessary to bridge the gap between the total phosphorus (TP) loadings from the entire Maumee River watershed and smaller HUC12 subwatersheds. Loads are needed at the HUC12 scale to develop 9-element Nonpoint Source Implementation Strategies (NPS-IS) to guide actions in the absence of NPS-IS. These plans are the critical link between Maumee River watershed loading targets and implementable projects developed by local stakeholders. For this edition of the DAP, updates to these HUC12 loadings have been made to synchronize them to the Maumee Nutrient TMDL's nonpoint source total phosphorus load allocation.

A2 Methods

Ohio EPA completed a Nutrient Mass Balance Study in 2016 and 2018 that broke down existing TP loads into three broad categories: nonpoint source, point source [covered by National Pollutant Discharge Elimination System (NPDES) permit], and household sewage treatment systems (HSTS) (Ohio EPA, 2016 and 2018). At the statewide level this information has served to broadly define the role of the landscape runoff and wastewater treatment facilities in phosphorus loading. However, the study did not break down landscape to define the role of agricultural, developed and natural areas in total loading. The following methods are the evolution of what Ohio EPA used in the Nutrient Mass Balance Study. This refined method details a way to first identify the role of different components of nonpoint sources in the Nutrient Mass Balance Study and then to distribute those loads to the smaller HUC12 watershed units.

In addition to the new information added in the method, the components have been renamed to better reflect their legal definitions and to be consistent with the Maumee Watershed Nutrient TMDL. The component that is identified as nonpoint source in the Nutrient Mass Balance Study includes loads from permitted stormwater, such as municipal separate storm sewer systems (MS4) and some categories of industrial stormwater. Those permitted sources are legally defined as point sources. This method removes that permitted stormwater load from the overall nonpoint source load and renames this updated load as the "nonpoint source landscape load".

A2.1 Pour Point Load Estimation

Central to this modified nutrient mass balance method is a monitoring point, herein the pour point, where near-continuous data is collected by the National Center for Water Quality Research (NCWQR; see Works Cited section for a data download link). The pour point on the Maumee River is at Waterville, OH (USGS Gage No.: 04193490). Water quality data are collected one to three times daily, resulting in the ability to calculate an accurate annual load at that location. Streamflow is continuously measured at this location by the United States Geological Survey (USGS).

The load calculated at this point is the sum of daily loads based on the product of USGS daily flow and NCWQR daily nutrient concentrations. Flows were missing on some dates within the period of record. To address these gaps, flows were estimated using linear interpolation if the time period was less than three days; otherwise that period was excluded from the initial estimate. The dates when concentration data was missing (for example, ice cover) were excluded from the initial load estimate. To account for the days that were missing load (due to either flow or concentration gaps), a ratio of the USGS annual flow to sum of daily flow reported with NCWQR monitoring is used to adjust the annual nutrient load.

A2.2 Overall Loading Calculation

Equation 1 shows the overall loading calculation. The load discharged by wastewater treatment facilities are within the regulatory authority of Ohio EPA and represented as WT in equation 1. In addition to waste treatment facilities, loads from combined sewer overflows (CSOs) are also regulated by Ohio EPA. HSTS contributions are estimated separately. The landscape derived loads are separated into two categories: load calculated upstream (UPST) from the pour point and load calculated downstream (DST) of the pour point. The landscape loading terms include loads from agricultural, developed and natural lands. The landscape load at this point still includes the permitted stormwater loads. Those permitted loads are removed in an additional step to result in the landscape nonpoint source load. These components of loading are presented schematically in Figure A1. Details of how all these sources were determined are explained in the following sections of this report.

$$Total\ Load = WT + CSO + HSTS + Landscape_{UPST} + Landscape_{DST}\ (1)$$

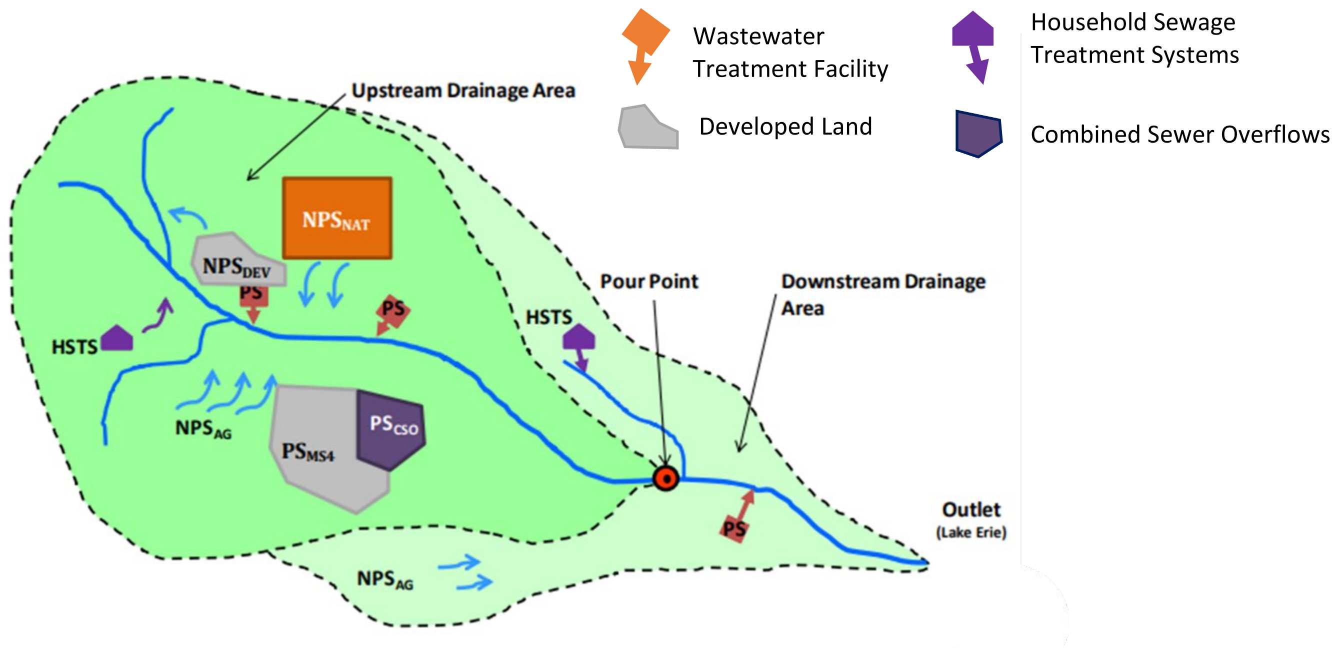

Figure A1: Schematic of sources represented in modified nutrient mass balance.

A2.3 Loads from Wastewater Treatment Facilities

Wastewater treatment facilities report operational data to Ohio EPA. All facilities are required to report flow volume. Phosphorus is reported at each facility dependent on factors such as its reasonable potential of elevated concentrations and facility size. The varied reporting from different facilities requires that loads be estimated using a method which is flexible and can account for missing data. Equation 2 estimates the generic loading from a wastewater treatment facility.

$$Annual\ Load = Q(in\ MG) * [TP] * cf\ (2)$$

In Equation 2, Q represents a facility's flow volume in million gallons (MG). The *cf* term, equal to 3.78451, is a conversion factor used to convert the product of MG and milligrams per liter into kilograms.

The TP concentration denoted $[TP]$ in Equation 2, must be estimated from either reported data or assumptions based on similar facilities. Within the Maumee River watershed, wastewater treatment facilities are generally accounted for in two categories: public facilities and industrial facilities. The public facilities are further broken down into subcategories: major (≥1.0 million gallons per day facility design flow (mgd)), significant minor (≥0.5 mgd and <1.0 mgd), minor (≥0.1 mgd and <0.5 mgd), package plant (<0.1 mgd) and controlled discharge lagoons (any size).

To estimate the phosphorus concentration, each facility is placed into one of four groups depending on the type of plant and available phosphorus monitoring data. The groups and approaches for calculating phosphorus concentrations are: 1) industrial facilities reporting phosphorus concentrations – use the median concentration of phosphorus reported during the calculation period; 2) industrial facilities not reporting phosphorus concentrations – use similar facilities or other means to estimate phosphorus concentrations; 3) sewage treatment facilities reporting phosphorus concentrations – use the median phosphorus concentration from the calculation period; and 4) sewage treatment facilities not reporting phosphorus concentrations – use the median phosphorus concentration from similar facilities. Nutrient concentrations estimated for five classes of municipal effluent and are presented in Table A1.

Table A1: Facility classes by design flow.

Group	Type	Design Flow (mgd)	Median Concentration of Group (mg/L)
Industrials	All Industrial Permits	--	N/A
Major Municipal	Sewage Treatment	≥ 1.0	0.54
Significant Minor Municipal	Sewage Treatment	0.5 to 1.0	1.72
Minor Municipal	Sewage Treatment	0.1 to 0.5	2.07
Controlled Discharge	Sewage Treatment	Varies	1.92
Package Plant	Sewage Treatment	< 0.1	3.54

Wet-weather events often result in increased wastewater flows within collection networks, either by design in combined sewer communities or inflow and infiltration. The result of increased flows is reduced treatment at the plant (usually a bypass of secondary treatment), wastewater bypasses at the plant headworks (raw bypasses), overflows of combined sewers (CSOs) and overflows of sanitary sewers (SSOs). SSOs typically report occurrences but not volume. Therefore, SSOs are excluded from the analysis unless flow volumes are reported. This report uses a wet weather loading nutrient concentration of 0.73 mg/L for TP, the median concentration of 131 samples reported from September 2014 to August 2017 by two Ohio sewer districts that are required to monitor TP at select CSO outfalls in their NPDES permit. When bypasses go through primary treatment, 15 percent removal is assumed by Ohio EPA to account for settling and sludge removal. This value is set to be greater than the 6 percent removal from septic tanks but not as high a removal rates observed when fine solids are removed via extended settling and/or anaerobic digestion.

The Maumee River watershed includes wastewater treatment facilities that are outside of the State of Ohio. Data on monthly loads were available from the Integrated Compliance Information System (ICIS) maintained by U.S. EPA. These monthly loads were summed for each facility within the watershed and are reported in the lumped out-of-state (OOS) load. Facilities identified as controlled dischargers were excluded from the OOS analysis because using the data maintained in ICIS results in a gross overestimation of discharge volume. This is because ICIS averages the discharge of only days a discharge occurred. No associated count of days that discharge occurred is reported. Due to this being a very small fraction of the OOS wastewater load, it is more practical to not include this source. This load contains a CSO load estimate where the overflow volumes are reported, and combined sewer systems were assumed to have the same concentration as those within Ohio.

A2.4 HSTS Loads

The population served by HSTS is estimated using a spatial analysis of census data (U.S. Census Bureau, 2010), combined with an assessment of populations that are likely served by sewer systems of NPDES permitted facilities. The populations served by NPDES permitted wastewater treatment facilities are estimated using two methods. The first method is that census designated places (CDPs) are assessed as sewered or not. The second method is applied to NPDES permitted sewage treatment facilities that are not associated with a CDP. In this case, the population served by the facilities is estimated by determining the average flow for facilities associated primarily with households and then dividing by 70.1 gal/day/person (Lowe et al., 2009). Facilities serving mobile home parks and subdivisions were included in the latter approach while facilities serving highway rest stops and recreation facilities were excluded. The HSTS population is then estimated to be the remaining population when NPDES served CDP population and non-CDP NPDES served population are subtracted from the total population of the watershed.

Equation 3 explains this overall method.

$$Load_{HSTS} = Pop_{HSTS} * Nut_{Yield} * \left[percentPop_{\text{onsite, working}} * DR_{\text{onsite, working}} + percentPop_{\text{onsite, failed}} * DR_{\text{onsite, failed}} + percentPop_{discharge} * DR_{discharge} \right] \quad (3)$$

where,

Pop_{HSTS} = Total population served by HSTS in watershed (persons)

$\text{Nut}_{\text{Yield}}$ = Annual yield of nutrient per person $\left(\frac{\frac{\text{lb}}{\text{year}}}{\text{person}}\right)$

$\text{percentPop}_{\text{onsite, working}}$ = percent of population served by onsite working HSTS

$\text{DR}_{\text{onsite, working}}$ = nutrient delivery ratio for onsite working systems

$\text{percentPop}_{\text{onsite, failed}}$ = percent of population served by onsite failing HSTS

$\text{DR}_{\text{onsite, failing}}$ = nutrient delivery ratio for onsite failing systems

$\text{percentPop}_{\text{discharge}}$ = percent of population served by discharging HSTS

$\text{DR}_{\text{discharge}}$ = nutrient delivery ratio for discharging systems

The per capita nutrient yield in household wastewater was determined by literature review. A study by Lowe and others (2009) reported a median nutrient yield as 0.511 kg-P/capita/year. In a similar effort to this mass balance study, the Minnesota Pollution Control Agency (MPCA) estimated the annual per capita nutrient yield to be 0.8845 kg-P/capita/year (Wilson and Anderson, 2004). The MPCA study used estimated values based on different household water use activities while the Lowe study reported statistics on data measured on actual systems. The Lowe study median concentrations were used because the methodology uses actual sampling data of septic tank effluents.

Phosphorus delivery ratios for three different system types were also estimated by literature review. One system type is properly operating soil adsorption systems. In these systems, wastewater percolates through the soil matrix where physical, chemical and biological processes treat pollutants. Phosphorus is usually considered to be effectively removed in these systems. Beal and others (2005) reviewed several studies and reported several findings including: >99 percent P removal; 83 percent P removal; and slow P movement to ground water. In a nutrient balance study, MPCA assumed that HSTS with soil adsorption systems removed phosphorus at 80 percent efficiency (Wilson and Anderson, 2004). For this study, 80 percent efficiency will be used because the studies reviewed by Beal used fresh soil columns and did not consider a reduction in efficiency with system age.

Another category of systems included in the mass balance study is soil adsorption systems that are failing to function as designed. Failure of systems is caused by a myriad of problems, so literature values are not available for phosphorus removal. For this method, the assumption is made that failing systems still involve some level of soil contact; therefore, TP removal will be in between the value of a direct discharge and a soil adsorption system. The value used for this study is 40 percent TP removal for failing soil adsorption systems, or half that is assumed for properly working systems.

A third group of HSTS is systems that are designed to discharge directly to a receiving stream. These systems use mechanical treatment trains to treat wastewater and discharge directly to streams. Like septic tanks, they are designed to remove suspended solids, but sludge removal is limited to periodic pumping. Lowe et al. (2009) studied septic tank influent and effluent and determined that there was a six percent reduction in TP. This study will use the same six percent reduction observed by Lowe and others (2009).

The final component needed to estimate HSTS loading is the relative proportion of system types, split into three categories: 1) working soil adsorption systems; 2) failing soil adsorption systems; and 3) systems designed to discharge. The Ohio Department of Health (ODH) is tasked with regulating the treatment of household sewage. In

2013, ODH published the results of a survey of county health departments in 2012 as an inventory of existing HSTS in the state by Ohio EPA district (Table A2). The Maumee River watershed is in the northwest district.

The Toledo Metropolitan Area Council of Governments (TMACOG) refined the Ohio portion of the HSTS estimate from Ohio EPA's Nutrient Mass Balance Study (TMACOG, 2018). Study improvements included refined sewershed areas for NPDES facilities and completing HSTS loading estimates at the HUC12 subwatershed scale. The improvements for the Ohio portion of the HSTS load are incorporated into this study.

Table A2: Proportions of total HSTS systems grouped into categories for Ohio's Nutrient Mass Balance Study. Adapted from the 2012 ODH statewide inventory (ODH, 2013).

Ohio EPA District	Working Soil Adsorption (%)	Failing Soil Adsorption (%)	Discharging (%)
Northwest	41.5	26.5	32
Northeast	44	27	29
Central	42.8	25.2	32
Southwest	64	14	22
Southeast	61.2	10.8	28

A2.5 Loading from the Landscape

Central to calculating the load from the landscape is the pour point load described in section A2.2 above. The calculation of the load from the landscape upstream of the pour point is the total load at the pour point minus the wastewater treatment facilities and HSTS loads upstream of the pour point. The landscape load calculated at this point includes loads contributed by all land uses. This subsection explains how the lumped landscape load is empirically broken down to different land use types.

Using land use to break down total loading from the landscape is based on the concept that there are unique and important differences in loads from different parts of the landscape. To do this in the context of an empirical mass balance, a ratio of the loads from different parts of the landscape is defined. Field scale data from different land uses is needed to define the contributions of different land use types. A review of literature was completed to summarize field scale data for different land uses. Land use was lumped into three broad categories discussed below: 1) agricultural land, 2) developed land and 3) natural lands. These uses were aggregated from the 2011 National Land Cover Database (NLCD) (USGS, 2014), as shown in Table A3.

Table A3: Land use recategorization from NLCD land use types to broader landscape mass balance groups.

NLCD Land Use Type	Mass Balance Group
Cultivated Crops	Agriculture
Hay/Pasture	Agriculture
Developed, High Intensity	Developed
Developed, Low Intensity	Developed
Developed, Medium Intensity	Developed
Developed, Open Space	Developed
Emergent Herbaceous Wetlands	Natural
Evergreen Forest	Natural
Deciduous Forest	Natural
Herbaceous	Natural
Open Water	Natural
Shrub/Scrub	Natural
Woody Wetlands	Natural
Mixed Forest	Natural

The purpose of the literature review is to index yields from the three broad landscape categories to each other, as described below in section A2.5.4 by Equations 4 through 6. The range of values from each category within the landscape will vary, however the emphasis here is on the average. Variation within these categories is complex and the data may not be available at an appropriate spatial scale. For example, soil test phosphorus and tillage practices vary across small areas but are summarized at the county or zip code level. In practice, a coarser method is more appropriate at the HUC12 watershed scale, while further detail can be added when developing NPS-IS plans for HUC12 subwatersheds.

Some of land area used in the landscape calculations are covered by one or more type of the NPDES permitted stormwater programs. The phosphorus loads from those areas are removed to result in the NPS landscape load after the initial landscape load calculations are made. This is described further in section A2.6.2.

A2.5.1 Agricultural Lands

Agriculture comprises nearly 78 percent of the landscape in the Maumee River watershed with approximately 93 percent of that area represented by cultivated crops. The abundance of the agricultural land means that its contribution weighs heavily into the average load conveyed to the pour point near the Maumee River outlet. Edge-of-field monitoring networks and modeling efforts have been employed to improve knowledge of nutrient loss from agricultural fields in Ohio. Much of this research is led by the U.S. Department of Agriculture (USDA) Soil Drainage Research Unit (SDRU) at The Ohio State University. A recent study spanning water years 2012 – 2015 summarized edge-of-field phosphorus loading from 38 field sites throughout the corn belt region of Ohio. The study reports an average annual TP yield for this period of 1.1 lbs./acre (Peace et al., 2018). USDAs Natural Resources Conservation Service Conservation Effects Assessment Program (NRCS-CEAP), estimated an annual average of 1.9 lbs./acre of TP loss at the edge of agricultural fields based on the 2012 conservation condition (NRCS, 2016). The NRCS-CEAP effort used modeling results to describe phosphorus losses across the broader landscape than can be represented in the monitoring network. The results for annual loss observed by the SDRU edge-of-field data collection ranged from ~0.1 - ~4 lbs./acre (Peace et al., 2018) were within the distribution of the NRCS-CEAP modeling effort. An earlier report by the Ohio Lake Erie Phosphorus Task Force II (Ohio Phosphorus Task Force II, 2013) estimated an average annual loss of TP yield of 2.05 lbs./acre from cultivated cropland after a review of the literature.

A2.5.2 Developed Lands

Developed lands are defined by the amount of impervious surface that they represent (Table A4). Within the Maumee River watershed approximately 11 percent of the landscape is classified as developed land. Approximating the percent imperviousness as the center of each class and the relative proportions of each class developed land is approximately 27 percent impervious in the Maumee River. Across the pervious-impervious landscape nutrient loads are described by stark differences in the volume of runoff and nutrient concentrations in the runoff.

Research pertinent to Ohio has been carried out on developed land in the upper Midwest and the Northeast. Some of the studies were executed to quantify the impact of removing phosphorus from lawn fertilizers, an action that has since been largely implemented in Ohio. In a Wisconsin study TP loss from turf grass plots were 0.05 – 0.61 lbs./acre/year over three monitoring years, 2005-2007 (Bierman et al., 2010).

The primary impact of impervious areas within the developed landscape is increased runoff. Data from U.S. EPA's Nationwide Urban Runoff Program showed the lowest event mean TP concentrations on commercial land when compared to other developed land uses, except for open spaces (U.S. EPA, 1999). However, this is compounded by increases in runoff as the amount of impervious area increases. As imperviousness increases in commercial and industrial areas, runoff volumes exceed 50 percent of observed rainfall compared to <10 percent for lawns (Bannerman et al., 1993; U.S. EPA, 1999). The same studies reported mean TP concentrations that were approximately 2.5 times greater for lawns when compared to streets and 5-10 times greater when compared to parking lots. Annual loads across the developed landscape start to balance across the landscape as concentrations are elevated in low runoff areas and lower in higher runoff areas.

Table A4: NLCD land use classes for developed land (adapted from USGS, 2014) and the percentage of each class within the Maumee River watershed's developed land.

Class	Description	% of Maumee
21	Developed, Open Space- areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses and vegetation planted in developed settings for recreation, erosion control or aesthetic purposes.	55
22	Developed, Low Intensity- areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20 percent to 49 percent of total cover. These areas most commonly include single-family housing units.	30
23	Developed, Medium Intensity -areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50 percent to 79 percent of the total cover. These areas most commonly include single-family housing units.	10
24	Developed, High Intensity-highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80 percent to 100 percent of the total cover.	5

A2.5.3 Natural Lands

Natural lands are grouped as areas within the watershed that are generally not managed with nutrient inputs (Table A3). Most of the research on the natural landscape has been focused on enhancing the capacity of natural lands to serve as nutrient and sediment sinks. However, across the broader landscape natural lands represent a wide variety of landforms that serve as sources and sinks. While the distribution of loads from agricultural and developed lands were always reported as positive loads, natural lands are represented by a distribution of both positive and negative loads. Without adequate monitoring data to compare with other land uses, a small positive bias of about 0.1 lbs./acre/year is assumed for natural lands.

A2.5.4 Landscape Loading Summary

The literature supports the assumption that agricultural lands are the highest yielding of the three defined categories. Annual agricultural loads reported in the region ranged from 1.1 – 2.05 lbs./acre/year on average. Developed land had results that were <0.1 – 0.6 lbs./acre/year on turfgrass and similar values from the impervious landscape, albeit due to increased runoff at lower concentrations. The natural landscape is not well described with field scale monitoring data across the diverse natural landscape, but a small positive load of 0.1 lbs./acre/year is assumed. The ratio that is used to define the relative contributions at the pour point are that agricultural land yields twice as much per acre as developed land (1:0.5) and agricultural land yields 10x as much per acre as natural lands (1:0.1). Small changes in these ratios will not result in large changes in the breakdown of the total load because the equations are constrained by the large proportion of the landscape represented by agricultural production.

Equations 4 through 6 define the relative contribution of the landscape load at the pour point.

$$\frac{Landscape_{up}}{Area_{up}} = \frac{Landscape_{AG}}{Area_{AG}} + \frac{Landscape_{DEV}}{Area_{DEV}} + \frac{Landscape_{NAT}}{Area_{NAT}} \quad (4)$$

$$Landscape_{DEV} = Landscape_{AG} * 0.5 \quad (5)$$

$$Landscape_{NAT} = Landscape_{AG} * 0.1 \quad (6)$$

Note that each component in Equation 4 is normalized by area, signifying that these are yields, not total loads. $Landscape_{up}$ and $Area_{up}$ indicates the landscape load and area upstream of the pour point, respectively. Agricultural, developed and natural land areas are denoted AG, DEV and NAT, respectively.

The series of equations gives the relative load from each sector at the pour point that can then be used to estimate the load downstream of the pour point from the nonpoint source. To do this, the upstream loads are converted into yields for each land use. Then the yield is used to determine the nonpoint source downstream by assuming the same yield from the upstream area applies to the downstream area for each component of the landscape. This calculation is necessary because it is not possible to measure load directly due to the lake influence on the river downstream of the pour point.

A2.6 Distribution of Watershed Nonpoint Source Load to HUC12s and counties

Once loads are defined at the larger watershed scale there are several factors that should be considered in order to distribute landscape loads to the HUC12 subwatersheds. Three factors are considered in this distribution methodology: 1) hydrology, 2) land use (including permitted stormwater) and, 3) HSTS population.

A2.6.1 Hydrology - Accounting for Discharge in HUC12 Distributed Loads

Streamflow normalized to the watershed size has been shown to differ at the HUC8 scale in the Maumee River watershed. In a report, "*Methodology for Connecting Annex 4 Water Quality Targets with TMDLs in the Maumee River Basin*" (TetraTech, 2018), the authors showed a 26 percent difference in streamflow between the St. Marys and Tiffin rivers' HUC8s based on gaging stations located within each watershed. Because these differences are observed, it is important to consider the impact that differences in flow from different regions within the Maumee River watershed impact loading.

Flow and concentration combine to compute the total load, therefore, areas that have a greater discharge volume will have more load even when concentrations are the same. When total load is the primary concern, as is the case for the Lake Erie, concentration is reported as the flow weighted mean concentration (FWMC). The FWMC gives more weight to concentrations when discharge is high. Another way it can be described is as flow normalized concentration. It is equivalent to the total load (mass) divided by the total discharge (volume). The purpose of accounting for varying discharge across the larger Maumee River watershed is to account for regional influences of geology, climate and other factors can influence the total discharge.

Since there is ample monitoring of stream discharge an empirical method was developed to understand how discharge varies in the Maumee River watershed. The USGS maintains a stream gaging network and discharge data is available for download via the National Water Information System (NWIS) website (USGS, 2016). Several steps were taken to turn the point discharge record for these gaging locations into a raster grid of discharge.

The first step was selecting what gages within the region would be used for the spatial interpolation. Gages needed to contain at least 14 years of springtime (March-July) discharge between 2002-2016 to be selected. Gages were also screened out if they were regulated in some way, for example, a dam controlled the discharge upstream of the gaging location. Using these criteria, a total of 36 gages were selected within and near the Maumee River watershed (Figure A2).

Then USGS's StreamStats tool (Ries et al., 2017) was used to define the contributing watershed for each 36 gages. The watersheds were exported as a shapefile and loaded into ESRI's ArcMap program. Michigan streams were not supported with a StreamStats application so watersheds for gaging stations that were in Michigan were delineated using the ArcHydro toolbox in ArcMap 10. Once the basins were in ArcMap, they were projected into Ohio State Plane South. Some basins were nested, meaning a watershed was geographically within another. To address this the nested area was removed from the larger watershed. The result was that each gage's watershed was independent from the others. A centroid point was created for each of the basins.

Then, for each watershed, the discharge associated with the corresponding gage was downloaded from the USGS NWIS site into a spreadsheet. There were three basins that did not contain a full discharge record between 2002-2016. These gages went through a record extension process to extrapolate to the entire period. With complete records the springtime average discharge over the 14-year period (2002-2016) was calculated. The average discharge was then converted to a total volume. When a gaging station had upstream nested stations, the volumes discharged from the nested watersheds were subtracted, so the volume associated with a watershed was not counted more than once. The total volume was then normalized by watershed area by converting it to a water yield, as depth in inches, over the watershed area.

In the final step the water yield was paired with the centroids that were created for each basin in ArcMap. A spatial interpolation tool (Kriging) was used in ArcMap to create a 38 ft Raster grid of water yield across the entire Maumee River watershed. Using zonal statistics, the average yield was calculated for each HUC12 subwatershed (Figure A2). The ratio of each HUC12's average yield and the total watersheds average yield is used to determine the hydrologic weighting factor (HWF). Each HUC12 subwatershed's HWF is used to adjust the whole watershed phosphorus yields for each land use category. The HWFs range from 0.87 to 1.14.

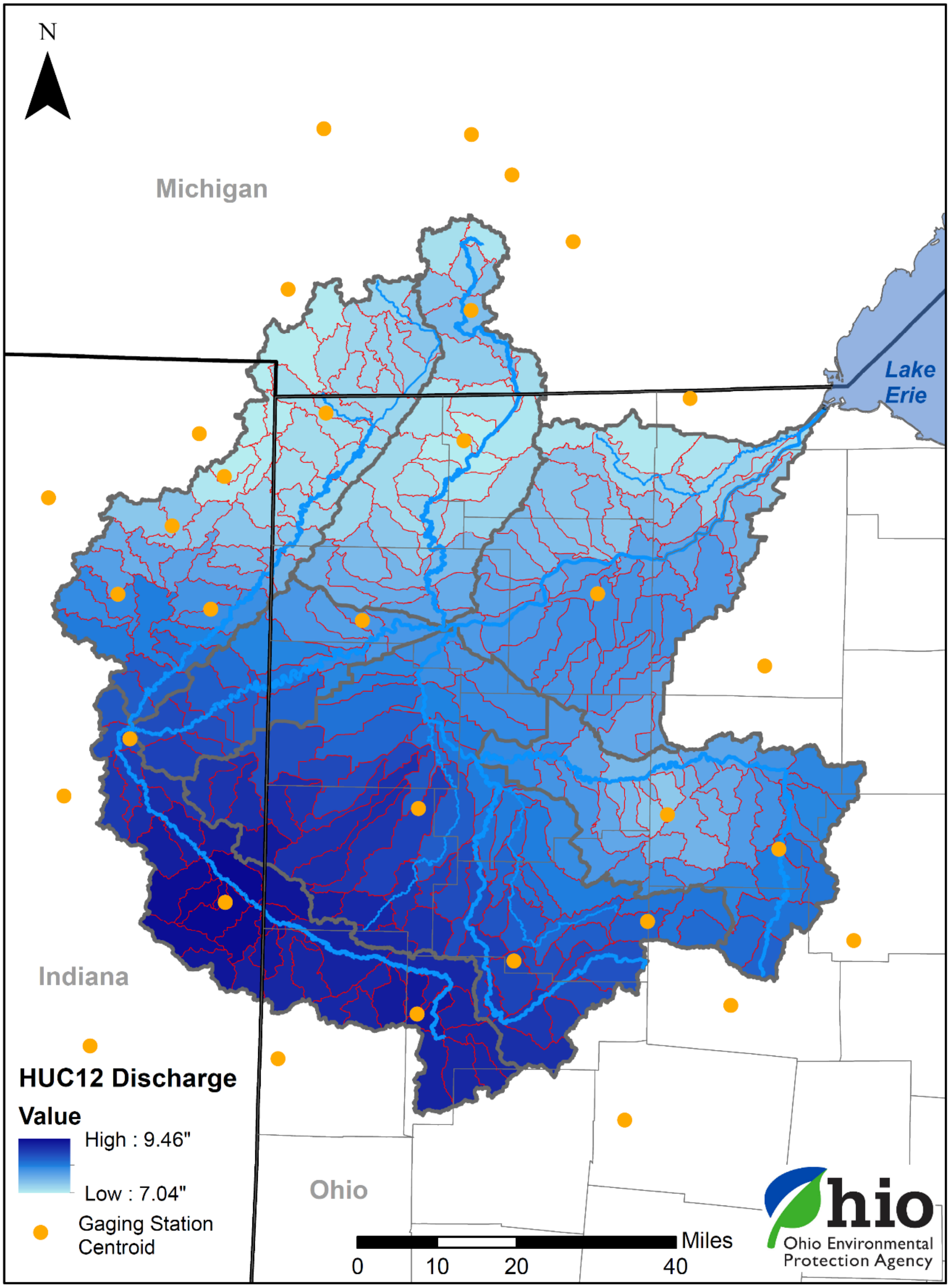

Figure A2: HUC12 average (2002-2016) springtime (March-July) water yield in the Maumee River watershed in inches. The values are interpolated from the centroid of 36 gaging stations within and surrounding the watershed. Note, four gage centroids are not shown due to being just outside of the map extent (three in the east and one in the west).

A2.6.2 Land Use - Accounting for Land Use in HUC12 Distributed Loads

A mass balance method that does not include land use factors would assume all HUC12 subwatersheds contribute at the same rate. However, agricultural land yields greater phosphorus loss than developed land followed by natural lands, as explained in section A2.5. By capturing these differences within each HUC12, realistic base loads and resulting targets can be calculated for each HUC12.

In some HUC12 watersheds where natural and/or developed land dominate the landscape, the overall HUC12 phosphorus yield is relatively lower than agriculture heavy HUC12s. Without this accounting method these HUC12 watersheds might already be considered as meeting a target based on the 40 percent reduction of the 2008 base yield that applies to the entire Maumee River watershed. This would result in a situation where less load would be available to be reduced in these areas. Then, HUC12 subwatersheds with the most agriculture would have to implement relatively more load reduction based on the Maumee River watershed wide loading rate in order to balance out the total reduction required. This method avoids this situation by allowing for more equitable reduction expectations throughout the greater watershed.

To capture the variation in land use for each HUC12, the NLCD (USGS , 2014) dataset was analyzed using GIS software. The data were projected into the State Plane South and then summed to the HUC12 subwatersheds (Figure A3). Since data is not available to differentiate the phosphorus loss from different components of the detailed land use categories in the NLCD, land use is again grouped into the three categories described above in section A2.5.

Ninety-five of the HUC12s have at least some of their area covered by NPDES permitted stormwater. A GIS analysis developed for the Maumee Watershed Nutrient TMDL delineated the spatial areas covered by permitted MS4s, individually permitted facilities, and general permitted facilities. For this DAP update, the amount of permitted stormwater area within each HUC12 is summed from the TMDL's delineations. This area is subtracted from the developed land total within each HUC12 prior to the load calculation explained in the next sub-section.

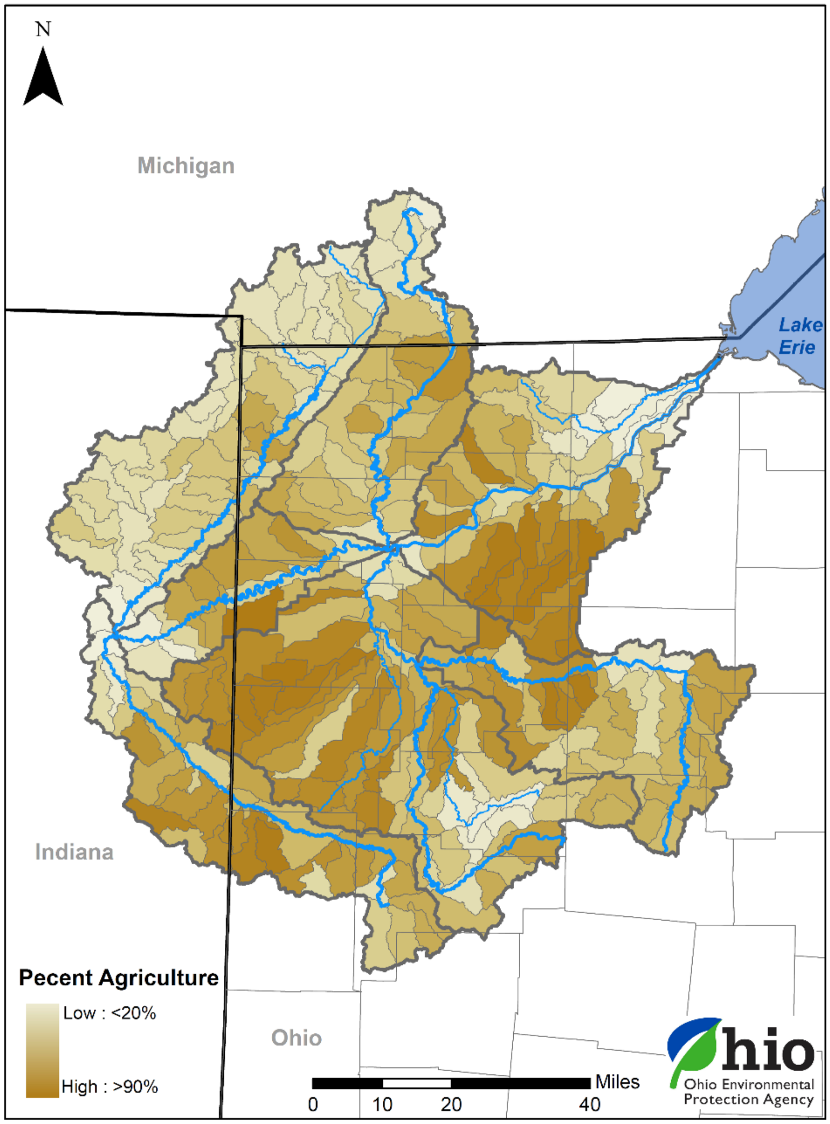

Figure A3: Percent agricultural land use by HUC12 in the Maumee River watershed.

A2.6.3 Distributing HUC 12 Loads – Combining Hydrology and Land Use

The two sub-sections above outline how hydrology and land use are considered for distributing HUC 12 loads. Equation 7 shows how the two are combined. Note that the "Maumee yield" used for each of the three land use categories is a single value determined when balancing the loads for the entire watershed. The Maumee yield values are presented in Section A3 Results, below. Equation 8 shows an example HUC12 of these calculations. The numbers values used for this example can all be found in the results section (note that only two significant digits are retained in the actual load results).

$$HUC12\ LOAD_{AG,\ DEV,\ NAT} = [\ (Maumee\ Yield_{AG} * HUC12\ Area_{AG}) + (Maumee\ Yield_{DEV} * HUC12\ Area_{DEV\text{-}non\text{-}permitted\ stormwater}) + (Maumee\ Yield_{NAT} * HUC12\ Area_{NAT})\ ] *\ Hydrologic\ weighting\ factor \qquad (07)$$

Example Platter Creek – HUC12: 04100005 02 06

$$10{,}491\ pounds_{AG,\ DEV,\ NAT} = [\ (0.85\ pounds/acre_{AG} * 12{,}266\ acres_{AG}) + (0.42\ pounds/acre_{DEV} * 741\ acres_{DEV}) + (0.09\ pounds/acre_{NAT} * 870\ acres_{NAT})\ ] *\ 0.97 \qquad (08)$$

A2.6.4 HSTS - Accounting for HSTS in HUC12 Distributed Loads

In addition to an estimate of population in Ohio's portion of the Maumee River watershed, TMACOG provided population estimates for all HUC12s in Ohio (Figure A4). This population estimate is described in section A2.5 above. The HUC12 population estimates were used directly to distribute the total HSTS TP load for Ohio to the HUC12s where it originated. For this DAP update, the TP load from the discharging HSTS are not included in the presentation of the existing loads below, nor factored into the target calculations. This is because the State of Ohio has an NPDES general permit for discharging HSTS. As explained in the Maumee Watershed Nutrient TMDL, all of these types of systems are expected to eventually be covered by the general permit.

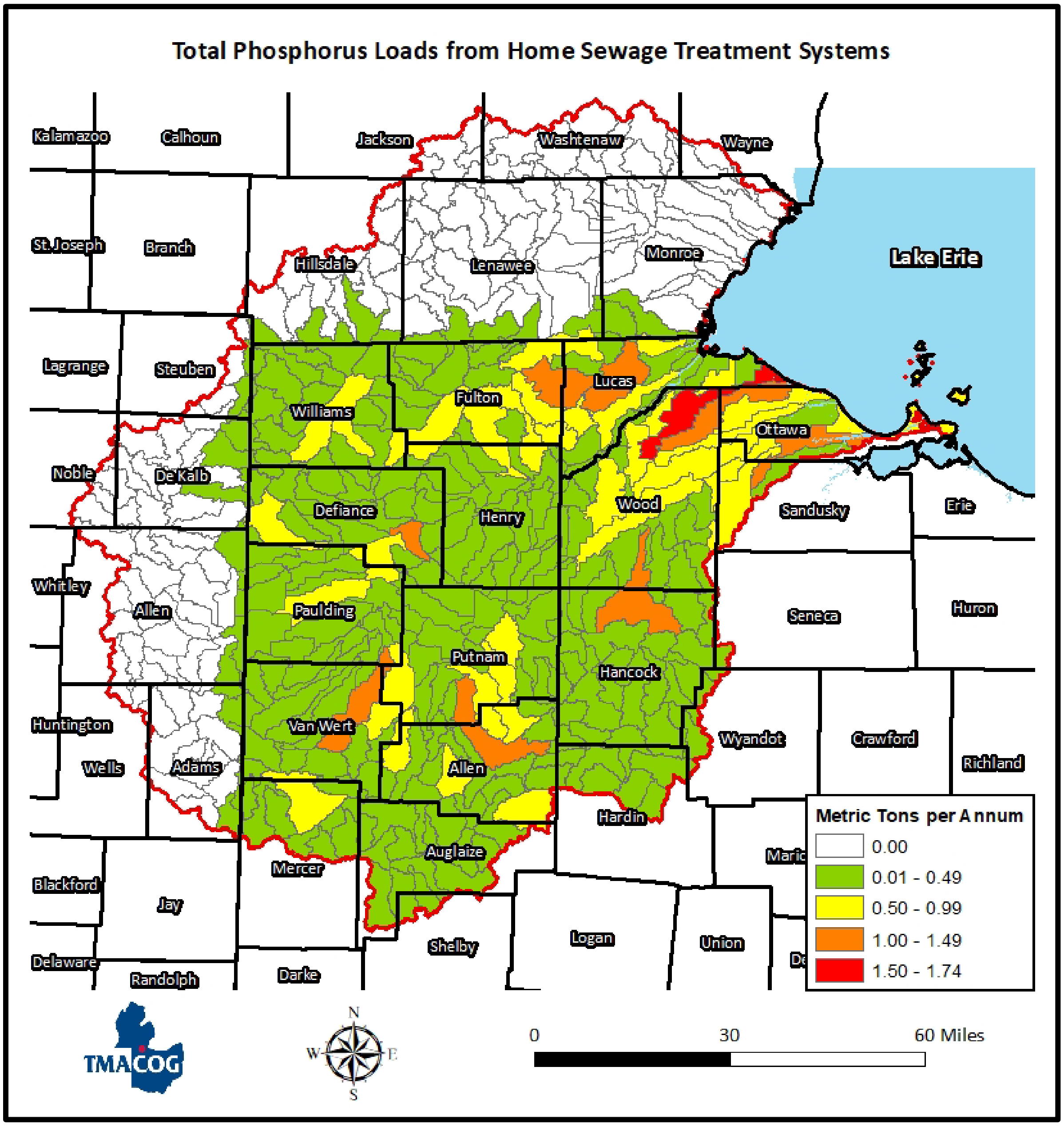

Figure A4: Phosphorus loads from HSTS for HUC12 watersheds. (TMACOG, 2018).

A3 Results

Using the modified nutrient mass balance method, the nonpoint source loads for the Maumee River watershed from within Ohio's borders are summarized in Figure A5. This figure shows the load in three nonpoint source land categories and non-permitted HSTS for the existing condition for the spring 2008 baseline period. The major loading source at nearly 94 percent of Ohio's total contribution in spring 2008 is agricultural land. Nonpoint source developed land (4 percent), unpermitted HSTS (~1 percent), and natural land (~1 percent) sources contribute the remaining TP load. Expressed as TP yields for spring 2008 areas with land uses of agricultural, developed and natural exported 0.85, 0.42 and 0.09 pounds per acres, respectively. While the existing loads for developed land have changed due to the removal of permitted stormwater, these yields have not changed in this DAP update.

Figure A5 also shows the nonpoint source TP target load for the Maumee River watershed from within Ohio's borders. This is the load, 555.9 metric tons (1,225,506 pounds), is the spring season nonpoint source load allocation from the Maumee Watershed Nutrient TMDL. It equates to a 45 percent reduction needed from the baseline for the nonpoint sources of TP. While the TMDL's load target is based on the Annex 4 recommended TP target, this reduction is greater than the about 40 percent reductions associated with the Annex 4 targets. The additional nonpoint source reductions were identified as the most cost effective and equitable means to achieve the loading reductions required by the TMDL. The implementation strategy for nonpoint sources includes both additional management of agricultural land as well as restoring wetlands and stream channels to increase to serve as phosphorus sinks.

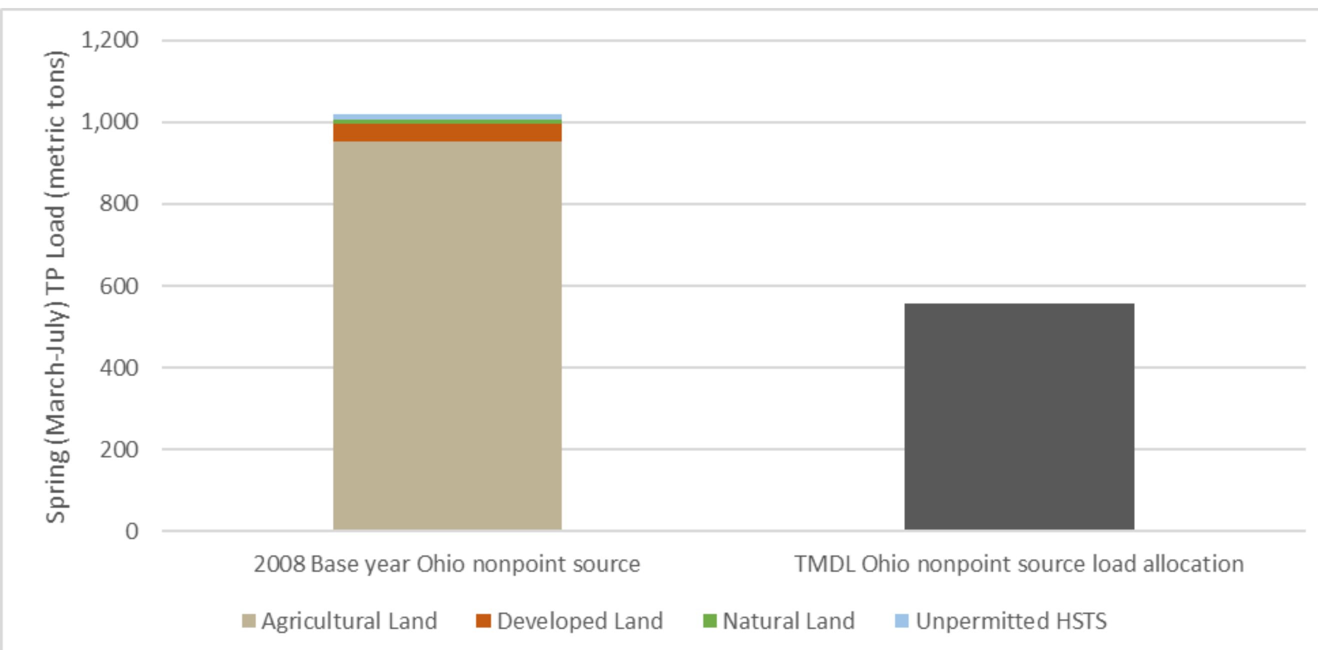

Figure A5: Ohio's portion of the Maumee River watershed spring nonpoint source TP loading by major source category in the 2008 base year and TMDL nonpoint source load allocation.

The Maumee River watershed includes seven HUC8 watersheds. Within Ohio, these watersheds encompass 194 HUC12 subwatersheds. Following the methods outlined in this appendix, the Maumee River watershed nonpoint source TP loads were distributed to the HUC12 subwatersheds. When these loads are converted to yields using the contributing area of the HUC12 watersheds the effect of the method is clear. Areas with more agriculture and more streamflow have higher springtime loading in the 2008 base year than areas with less agriculture and less streamflow (Figure A6). For example, there are several HUC12s in the southern part of the watershed that, while in a higher streamflow area part of the watershed (Figure A2), have lower landscape nonpoint source phosphorus yields than the surrounding areas. This is likely due to a decrease in agriculture (Figure A3) associated with the developed land in the urbanized area around the city of Lima.

Spring nonpoint source loads for the base year of 2008 and the corresponding nonpoint source targets for each HUC12 are shown in Tables A5 through A11. Each table outlines the results for one of the seven HUC8s and only loads from Ohio are included. Since the permitted stormwater and permitted HSTS loads are not included in these calculations for this DAP update, loads have changed for nearly all of these HUC12s from the last version of the DAP. The HUC12s that have permitted stormwater have base year developed loads (italicized) presented on Tables A5 through A11.

The nonpoint source target for each HUC12 is calculated as the product of 1) each HUC12's proportion its baseline spring nonpoint source load and the sum of all HUC12s baseline nonpoint source loads and 2) the entire watershed's spring nonpoint source load allocation. For example, the Platter Creek HUC12 (04100005 02 06) has a baseline nonpoint load of 10,573 pounds and the sum of the entire watershed's baseline nonpoint source load is 2,246,369 pounds. This results in 0.47067 percent of the watershed's baseline load. The product of that proportion and the whole watershed load allocation (1,225,508 pounds) is the nonpoint source target load (5,768 pounds) for the Platter Creek HUC12.

This target calculation assumes that loads from natural areas will not receive reductions. This is because these land areas are generally unmanaged and nutrient reduction from them is not expected.

On Tables A5 through A11 load results greater than 100 pounds are shown with two significant digits. Results under 100 pounds are noted as less than 100. This is to reflect the level of precision when calculating yields bound by research that generally reports results with two significant digits. It is important to note that these load targets are provided as a means to assist in nonpoint source pollution reduction planning, implementing, and tracking. While these HUC12 targets are based on the TMDL's load allocation, they should not be considered codified HUC12 TMDL allocations. The HUC12s that can reduce more phosphorus than their targets outline will most likely be needed to make up for HUC12s that do not achieve target reductions.

Tables A12-18 provide more information that went into the HUC12 calculations. Like the preceding set of tables, each table includes all of the Ohio HUC12s for a HUC8. Each table includes the land use area for the three categories used in this method. The developed land use area only includes land that is unpermitted by the various stormwater NPDES permitting programs. The HWF used for each HUC12 is next presented. The HUC12-specific land use yields are then given for each of the three land use categories. (These values can also be calculated by multiplying the whole Maumee River watershed yields by the specific HUC12s HWF. For instance, if a HUC12 has an HWF of 1.10 then that value would be multiplied by the whole-Maumee agricultural yield of 0.85 pounds/acre to come up with 0.94 pounds/acre for agriculture land in that HUC12.) The last column on Tables A12-18 shows the whole HUC12 2008 spring season nonpoint source phosphorus yield. This is the value determined by summing up all of the phosphorus from the unpermitted land uses and the unpermitted HSTS, then dividing that value by the HUC12 unpermitted land area. The whole HUC12 yield is also the value shown on Figure A6's map overlaid with the MS4 permitted areas.

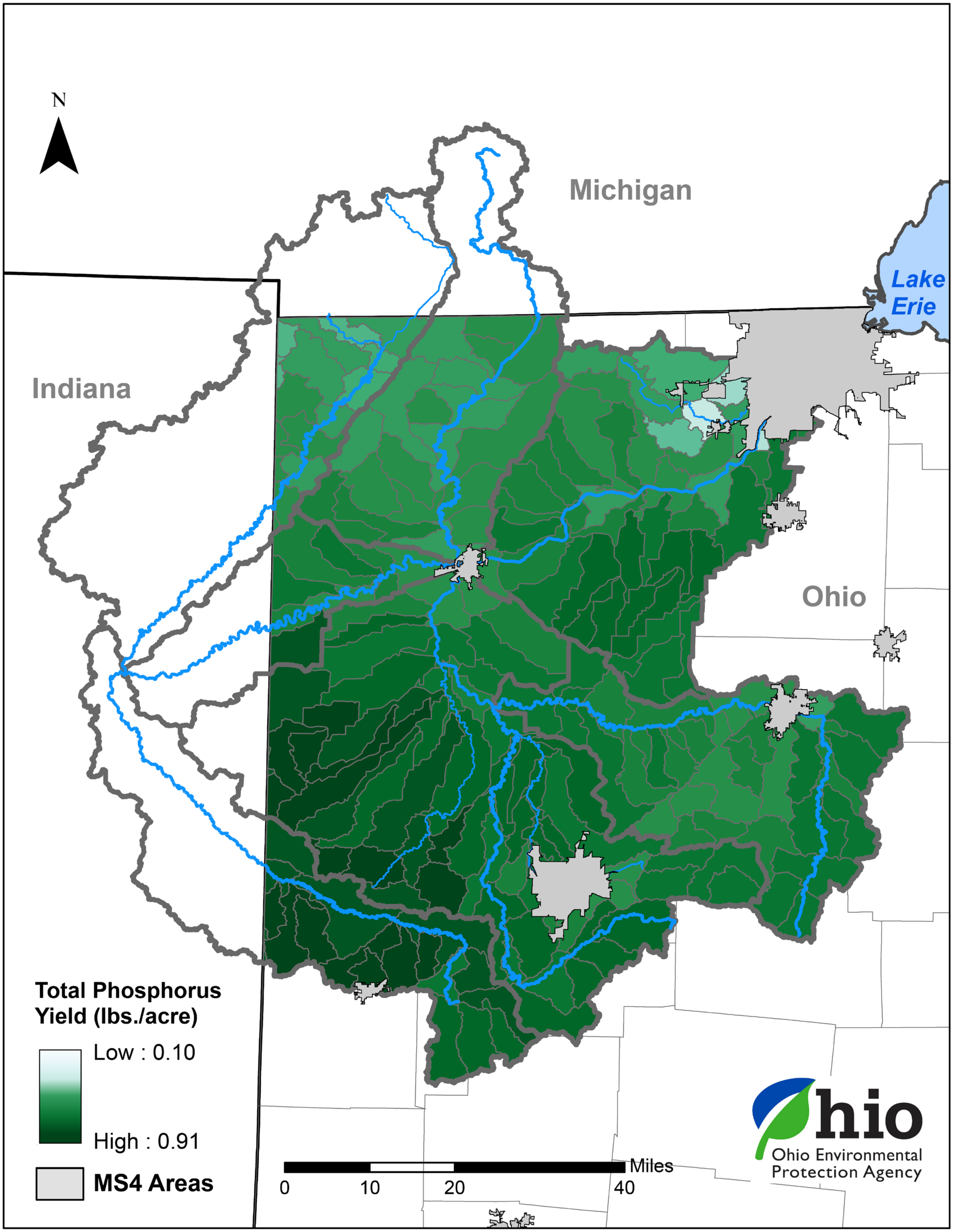

Figure A6: Nonpoint source TP yield from the landscape and unpermitted HSTS by HUC12 in the Maumee River watershed for the spring 2008 base condition overlaid with MS4 areas.

Table A5: Nonpoint source total phosphorus loadings for HUC12s within the St. Josephs River HUC8 (Ohio contributions only) for the spring 2008 base condition and nonpoint source targets.

St. Josephs River – 04100003 (all loads in pounds)						
	2008 Spring Season Baseline					
HUC12	Agricultural Land	Developed Land (unregulated)	Natural Land	Ohio HSTS (onsite)	Nonpoint source Total	Nonpoint Source Target
01 04	150	<100	<100	<100	160	<100
01 06	9,600	460	150	110	10,000	5,700
02 04	4,600	310	200	<100	5,200	2,900
03 01	8,300	400	160	<100	8,900	4,900
03 02	3,400	*250*	<100	<100	3,700	2,000
03 03	14,000	580	220	130	15,000	7,900
03 04	6,800	*700*	190	110	7,800	4,300
03 05	9,200	*380*	<100	<100	9,700	5,300
03 06	5,400	170	<100	<100	5,800	3,100
04 02	2,700	<100	<100	<100	2,900	1,600
04 05	860	<100	<100	<100	930	510
04 06	2,500	<100	<100	<100	2,700	1,500
05 01	10,000	270	110	<100	10,000	5,700
05 02	1,300	<100	<100	<100	1,400	740
05 03	6,800	*530*	110	<100	7,500	4,100
05 05	5,200	130	<100	<100	5,500	3,000
05 06	510	<100	<100	<100	540	290

Table A6: Nonpoint source total phosphorus loadings for HUC12s within the St. Marys River HUC8 (Ohio contributions only) for the spring 2008 base condition and nonpoint source targets.

St. Marys River – 04100004 (all loads in pounds)						
	2008 Spring Season Baseline					
HUC12	Agricultural Land	Developed Land (unregulated)	Natural Land	Ohio HSTS (onsite)	Nonpoint source Total	Nonpoint Source Target
01 01	8,300	220	120	<100	8,800	4,800
01 02	14,000	*710*	190	150	15,000	8,400
01 03	11,000	450	120	110	12,000	6,300
01 04	16,000	*1,500*	160	190	18,000	9,600
01 05	9,100	360	<100	<100	9,600	5,200
01 06	6,900	*1,100*	110	100	8,200	4,400
02 01	6,700	220	<100	<100	7,000	3,800
02 02	12,000	*470*	<100	110	13,000	6,900
02 03	6,300	*120*	<100	<100	6,600	3,600
02 04	13,000	460	<100	<100	13,000	7,200
02 05	22,000	670	240	<100	23,000	12,000
03 01	14,000	370	<100	<100	14,000	7,900
03 02	16,000	490	<100	<100	17,000	9,200
03 03	30,000	*1,500*	340	260	32,000	17,000
03 04	6,300	210	<100	<100	6,600	3,600
03 05	5,700	300	<100	<100	6,100	3,300
04 01	13,000	450	140	100	14,000	7,500
04 04	590	<100	<100	<100	620	340

Table A7: Nonpoint source total phosphorus loadings for HUC12s within the Upper Maumee River HUC8 (Ohio contributions only) for the spring 2008 base condition and nonpoint source targets.

Upper Maumee River – 04100005 (all loads in pounds)						
	2008 Spring Season Baseline					
HUC12	Agricultural Land	Developed Land (ununregulated)	Natural Land	Ohio HSTS (onsite)	Nonpoint Source Total	Nonpoint Source Target
02 01	16,000	440	<100	<100	16,000	8,900
02 02	6,000	*590*	<100	100	6,800	3,700
02 03	11,000	*270*	110	130	11,000	6,300
02 04	19,000	*870*	180	240	21,000	11,000
02 05	6,400	480	120	<100	7,100	3,900
02 06	10,000	*300*	<100	<100	11,000	5,800
02 07	8,000	400	<100	100	8,600	4,700
02 08	9,600	*170*	250	<100	10,000	5,500

Table A8: Nonpoint source total phosphorus loadings for HUC12s within the Tiffin River HUC8 (Ohio contributions only) for the spring 2008 base condition and nonpoint source targets.

Tiffin River – 04100006 (all loads in pounds)						
	2008 Spring Season Baseline					
HUC12	Agricultural Land	Developed Land (unregulated)	Natural Land	Ohio HSTS (onsite)	Nonpoint Source Total	Nonpoint Source Target
02 01	1,300	<100	<100	<100	1,400	750
02 02	9,300	*350*	<100	<100	9,800	5,300
02 03	14,000	440	<100	150	15,000	8,100
02 04	13,000	440	170	110	13,000	7,400
02 05	5,900	220	<100	<100	6,200	3,400
03 01	12,000	*640*	100	<100	12,000	6,800
03 02	7,200	270	<100	<100	7,500	4,100
03 03	13,000	*970*	100	160	14,000	7,700
04 01	10,000	*510*	200	250	11,000	6,200
04 02	13,000	710	140	140	14,000	7,500
04 03	11,000	*1,300*	<100	100	13,000	7,000
04 04	7,300	180	130	<100	7,700	4,200
05 01	18,000	*860*	260	250	19,000	10,000
05 02	27,000	*1,400*	200	350	29,000	16,000
05 03	9,800	*570*	150	<100	11,000	5,800
05 04	12,000	*490*	220	130	13,000	7,100
06 01	14,000	370	180	<100	15,000	8,100
06 02	11,000	430	150	110	12,000	6,600
06 03	8,400	*420*	130	110	9,000	4,900
06 04	7,400	*340*	180	140	8,100	4,400

Table A9: Nonpoint source total phosphorus loadings for HUC12s within the Auglaize River HUC8 (Ohio contributions only) for the spring 2008 base condition and nonpoint source targets.

Auglaize River – 04100007 (all loads in pounds)						
	2008 Spring Season Baseline					
HUC12	Agricultural Land	Developed Land (unregulated)	Natural Land	Ohio HSTS (onsite)	Nonpoint Source Total	Nonpoint Source Target
01 01	21,000	*680*	220	260	22,000	12,000
01 02	8,100	330	<100	<100	8,600	4,700
01 03	14,000	*550*	210	170	15,000	8,200
01 04	17,000	*760*	220	140	18,000	9,900
01 05	9,700	*1,700*	140	150	12,000	6,400
02 01	15,000	*530*	180	170	16,000	8,500
02 02	4,400	*350*	<100	<100	4,900	2,700
02 03	14,000	490	210	190	15,000	8,100
02 04	14,000	*870*	180	160	15,000	8,200
03 01	10,000	380	130	<100	11,000	5,900
03 02	14,000	*780*	110	120	15,000	8,300
03 03	9,800	550	170	150	11,000	5,800
03 04	7,200	340	110	<100	7,700	4,200
03 05	4,600	<100	180	130	4,900	2,700
03 06	5,600	<100	210	200	6,000	3,300
04 01	4,300	400	120	170	5,000	2,700
04 02	6,600	<100	200	390	7,100	3,900
04 03	5,800	250	140	120	6,300	3,400
04 04	4,300	*<100*	<100	160	4,500	2,500
04 05	6,800	280	<100	<100	7,200	3,900
04 06	10,000	*330*	<100	<100	11,000	5,800
05 01	27,000	*490*	360	450	29,000	16,000
05 02	19,000	*920*	<100	230	20,000	11,000
05 03	10,000	*420*	<100	170	11,000	5,800
06 01	10,000	340	<100	<100	11,000	5,700
06 02	14,000	*550*	<100	<100	15,000	8,100
06 03	11,000	420	<100	<100	12,000	6,400
06 04	28,000	*1,400*	140	240	30,000	16,000
07 01	8,600	420	<100	<100	9,100	4,900
07 02	27,000	1,000	120	170	28,000	15,000
07 03	21,000	*730*	<100	130	22,000	12,000
08 01	30,000	1,200	110	440	32,000	18,000
08 02	7,800	280	<100	<100	8,100	4,400
08 03	18,000	*890*	<100	170	19,000	10,000
08 04	18,000	*2,200*	<100	160	20,000	11,000
08 05	8,300	260	<100	<100	8,700	4,700
08 06	6,500	250	<100	<100	6,900	3,800
09 01	15,000	500	<100	<100	15,000	8,300
09 02	7,500	*260*	<100	<100	7,800	4,300
09 03	13,000	*1,200*	<100	220	15,000	8,000
09 04	10,000	480	<100	110	11,000	5,900
09 05	9,900	390	110	100	10,000	5,700
09 06	6,500	270	<100	<100	6,900	3,800
09 07	7,200	390	120	<100	7,800	4,300
10 01	8,400	330	<100	<100	8,700	4,800
10 02	14,000	420	<100	<100	14,000	7,700
10 03	11,000	310	<100	<100	11,000	6,000

Auglaize River – 04100007 (all loads in pounds)							
	2008 Spring Season Baseline						
HUC12	Agricultural Land	Developed Land (unregulated)	Natural Land	Ohio HSTS (onsite)	Nonpoint Source Total	Nonpoint Source Target
10 04	25,000	810	110	110	26,000	14,000
10 05	10,000	*280*	120	<100	11,000	5,700
11 01	21,000	720	250	160	22,000	12,000
11 02	18,000	*810*	130	120	19,000	10,000
11 03	4,900	*200*	130	<100	5,400	2,900
12 01	5,600	130	<100	<100	5,800	3,200
12 04	260	<100	<100	<100	270	150
12 05	20,000	850	<100	130	21,000	12,000
12 06	22,000	*1,200*	250	210	24,000	13,000
12 07	8,800	310	<100	<100	9,200	5,000
12 08	13,000	*460*	140	<100	13,000	7,300
12 09	12,000	*130*	360	260	13,000	7,100

Table A10: Nonpoint source total phosphorus loadings for HUC12s within the Blanchard River HUC8 for the spring 2008 base condition and nonpoint source targets.

Blanchard River – 04100008 (all loads in pounds)						
	2008 Spring Season Baseline					
HUC12	Agricultural Land	Developed Land (unregulated)	Natural Land	Ohio HSTS (onsite)	Nonpoint Source Total	Nonpoint Source Target
01 01	11,000	380	140	<100	11,000	6,300
01 02	9,100	590	<100	120	9,900	5,400
01 03	16,000	690	170	110	17,000	9,200
01 04	13,000	*650*	<100	<100	14,000	7,600
01 05	17,000	800	190	<100	18,000	9,800
02 01	13,000	*560*	110	<100	14,000	7,700
02 02	18,000	730	160	130	19,000	10,000
02 03	10,000	350	140	<100	11,000	5,900
02 04	12,000	*480*	110	130	13,000	7,000
02 05	3,800	*320*	120	<100	4,300	2,400
03 01	12,000	620	150	<100	13,000	6,800
03 02	13,000	*810*	220	120	14,000	7,600
03 03	7,100	*200*	<100	<100	7,400	4,000
03 04	12,000	*990*	160	200	13,000	7,200
04 01	6,400	310	<100	<100	6,900	3,700
04 02	6,100	290	<100	<100	6,600	3,600
04 03	6,400	*700*	<100	120	7,300	4,000
04 04	6,000	*660*	<100	<100	6,800	3,700
04 05	11,000	*560*	110	120	12,000	6,300
05 01	8,300	330	<100	<100	8,800	4,800
05 02	19,000	880	210	190	20,000	11,000
05 03	6,200	170	<100	<100	6,400	3,500
05 04	6,800	*180*	<100	<100	7,000	3,800
05 05	6,900	170	<100	<100	7,200	3,900
05 06	19,000	*690*	<100	110	19,000	11,000
06 01	21,000	*840*	110	250	22,000	12,000
06 02	12,000	*1,100*	100	380	13,000	7,200
06 03	11,000	370	<100	120	11,000	6,200
06 04	5,900	230	<100	100	6,300	3,400
06 05	18,000	700	210	170	19,000	10,000

Table A11: Nonpoint source total phosphorus loadings for HUC12s within the Lower Maumee River HUC8 for the spring 2008 base condition and nonpoint source targets.

Lower Maumee River – 04100009 (all loads in pounds)	2008 Spring Season Baseline					
HUC12	Agricultural Land	Developed Land (unregulated)	Natural Land	Ohio HSTS (onsite)	Nonpoint Source Total	Nonpoint Source Target
01 01	7,900	210	<100	<100	8,200	4,500
01 02	10,000	370	<100	<100	11,000	5,800
01 03	19,000	770	<100	130	20,000	11,000
01 04	18,000	570	<100	100	19,000	10,000
01 05	11,000	350	<100	<100	12,000	6,500
01 06	6,100	260	<100	<100	6,500	3,500
02 01	4,900	*<100*	130	540	5,500	3,000
02 02	11,000	*390*	<100	<100	12,000	6,400
02 03	16,000	710	270	140	17,000	9,300
02 04	13,000	*690*	<100	150	13,000	7,400
02 05	10,000	*770*	<100	110	11,000	6,000
02 06	8,800	*700*	<100	<100	9,700	5,300
02 07	6,700	*640*	140	<100	7,600	4,100
03 01	9,000	380	120	200	9,700	5,300
03 02	16,000	*1,100*	210	350	18,000	9,700
04 01	12,000	*340*	<100	100	12,000	6,600
04 02	21,000	*1,400*	130	340	23,000	12,000
04 03	12,000	540	100	160	13,000	6,800
05 01	10,000	430	<100	<100	11,000	5,900
05 02	12,000	410	<100	<100	13,000	7,100
05 03	8,200	250	<100	<100	8,600	4,700
05 04	16,000	*720*	<100	160	17,000	9,400
05 05	12,000	*630*	<100	<100	13,000	6,800
05 06	11,000	340	<100	<100	11,000	6,200
05 07	11,000	310	<100	<100	11,000	6,200
05 08	11,000	*260*	<100	<100	12,000	6,400
05 09	7,400	330	<100	<100	7,900	4,300
05 10	9,200	580	190	140	10,000	5,500
06 01	21,000	*840*	100	240	22,000	12,000
06 02	8,300	*580*	190	180	9,200	5,000
06 03	5,300	*<100*	<100	180	5,500	3,000
07 01	18,000	*680*	400	510	19,000	10,000
07 02	11,000	*580*	170	400	12,000	6,500
07 03	2,100	*<100*	520	270	2,900	1,600
08 01	5,600	480	380	400	6,800	3,700
08 02	9,600	*350*	150	170	10,000	5,600
08 03	2,400	*<100*	410	570	3,400	1,900
08 04	5,900	*<100*	190	390	6,500	3,500
09 01	9,900	*<100*	<100	310	10,000	5,600
09 02	1,800	*<100*	<100	230	2,100	1,100
09 03	1,800	*<100*	270	110	2,200	1,200
09 04	<100	_0*_	170	<100	220	120

* Permitted stormwater area covers this entire HUC12 resulting in no developed land area producing nonpoint sources of phosphorus.

Table A12: Unregulated land use area, total phosphorus hydrologic weighting factor (HWF), and resulting nonpoint source total phosphorus yields for HUC12s within the St. Josephs River HUC8 (Ohio contributions only) for the spring 2008 base condition. The whole HUC12 yield is the sum of loads from the three land use categories and HSTS loads, divided by the total area.

St. Josephs River – 04100003								
	Area in Acres			Hydrologic Weighting Factor	HUC12 Specific NPS TP Yield in pounds per acre			
HUC12	Agricultural Land	Developed Land (unregulated)	Natural Land		Agricultural Land	Developed Land	Natural Land	Whole HUC12
01 04	196	5	57	0.91	0.77	0.39	0.08	0.62
01 06	12,670	1,217	1,903	0.90	0.76	0.38	0.08	0.65
02 04	6,079	823	2,541	0.90	0.76	0.38	0.08	0.55
03 01	10,999	1,050	2,003	0.89	0.75	0.38	0.08	0.63
03 02	4,455	671	1,010	0.89	0.76	0.38	0.08	0.60
03 03	18,075	1,535	2,789	0.89	0.75	0.38	0.08	0.65
03 04	9,011	1,852	2,453	0.89	0.76	0.38	0.08	0.59
03 05	12,215	1,011	1,071	0.89	0.75	0.38	0.08	0.68
03 06	7,174	453	1,153	0.89	0.76	0.38	0.08	0.66
04 02	3,627	243	1,132	0.87	0.74	0.37	0.08	0.58
04 05	1,154	88	451	0.88	0.74	0.37	0.08	0.55
04 06	3,311	217	434	0.90	0.76	0.38	0.08	0.67
05 01	13,037	717	1,439	0.90	0.76	0.38	0.08	0.69
05 02	1,675	97	154	0.92	0.78	0.39	0.08	0.71
05 03	8,715	1,371	1,358	0.92	0.78	0.39	0.08	0.65
05 05	6,555	322	1,015	0.94	0.80	0.40	0.08	0.69
05 06	631	15	141	0.96	0.81	0.41	0.08	0.68

Table A13: Unregulated land use area, total phosphorus hydrologic weighting factor (HWF), and resulting nonpoint source total phosphorus yields for HUC12s within the St. Marys River HUC8 (Ohio contributions only) for the spring 2008 base condition. The whole HUC12 yield is the sum of loads from the three land use categories and HSTS loads, divided by the total area.

St. Marys River – 04100004								
	Area in Acres			Hydrologic Weighting Factor	HUC12 Specific NPS TP Yield in pounds per acre			
HUC12	Agricultural Land	Developed Land (unregulated)	Natural Land		Agricultural Land	Developed Land	Natural Land	Whole HUC12
01 01	8,814	472	1,238	1.12	0.95	0.47	0.10	0.83
01 02	15,099	1,499	1,934	1.12	0.95	0.47	0.10	0.83
01 03	11,445	954	1,201	1.12	0.95	0.47	0.10	0.85
01 04	16,605	3,237	1,661	1.12	0.95	0.48	0.10	0.82
01 05	9,587	761	926	1.12	0.95	0.47	0.10	0.85
01 06	7,157	2,233	1,087	1.13	0.96	0.48	0.10	0.78
02 01	6,926	462	529	1.13	0.96	0.48	0.10	0.88
02 02	12,443	976	909	1.13	0.96	0.48	0.10	0.88
02 03	6,679	253	604	1.12	0.95	0.47	0.10	0.87
02 04	13,364	968	746	1.11	0.94	0.47	0.10	0.88
02 05	23,104	1,425	2,489	1.11	0.94	0.47	0.10	0.85
03 01	14,740	781	446	1.12	0.95	0.47	0.10	0.91
03 02	17,064	1,028	790	1.12	0.95	0.47	0.10	0.89
03 03	31,412	3,133	3,493	1.12	0.95	0.48	0.10	0.84
03 04	6,605	446	424	1.13	0.96	0.48	0.10	0.89
03 05	5,882	625	666	1.14	0.97	0.48	0.10	0.85
04 01	13,547	942	1,431	1.14	0.96	0.48	0.10	0.86
04 04	615	51	53	1.13	0.95	0.48	0.10	0.86

Table A14: Unregulated land use area, total phosphorus hydrologic weighting factor (HWF), and resulting nonpoint source total phosphorus yields for HUC12s within the Upper Maumee River HUC8 (Ohio contributions only) for the spring 2008 base condition. The whole HUC12 yield is the sum of loads from the three land use categories and HSTS loads, divided by the total area.

Upper Maumee River – 04100005								
	Area in Acres				HUC12 Specific NPS TP Yield in pounds per acre			
HUC12	Agricultural Land	Developed Land (unregulated)	Natural Land	Hydrologic Weighting Factor	Agricultural Land	Developed Land	Natural Land	Whole HUC12
02 01	17,899	987	212	1.04	0.88	0.44	0.09	0.85
02 02	6,874	1,361	980	1.03	0.87	0.44	0.09	0.73
02 03	12,835	625	1,272	1.01	0.85	0.43	0.09	0.78
02 04	23,165	2,106	2,145	0.98	0.83	0.42	0.09	0.75
02 05	7,587	1,126	1,328	1.00	0.85	0.42	0.09	0.71
02 06	12,266	732	870	0.97	0.82	0.41	0.09	0.76
02 07	9,624	950	1,079	0.98	0.83	0.42	0.09	0.74
02 08	11,508	400	2,963	0.98	0.83	0.42	0.09	0.67

Table A15: Unregulated land use area, total phosphorus hydrologic weighting factor (HWF), and resulting nonpoint source total phosphorus yields for HUC12s within the Tiffin River HUC8 (Ohio contributions only) for the spring 2008 base condition. The whole HUC12 yield is the sum of loads from the three land use categories and HSTS loads, divided by the total area.

Tiffin River – 04100006								
	Area in Acres				HUC12 Specific NPS TP Yield in pounds per acre			
HUC12	Agricultural Land	Developed Land (unregulated)	Natural Land	Hydrologic Weighting Factor	Agricultural Land	Developed Land	Natural Land	Whole HUC12
02 01	1,742	104	129	0.89	0.75	0.38	0.08	0.69
02 02	12,364	941	1,080	0.89	0.75	0.38	0.08	0.68
02 03	18,957	1,188	1,179	0.88	0.75	0.37	0.08	0.70
02 04	17,035	1,162	2,228	0.89	0.75	0.38	0.08	0.66
02 05	8,007	589	649	0.87	0.74	0.37	0.08	0.67
03 01	15,638	1,720	1,369	0.87	0.74	0.37	0.08	0.66
03 02	9,513	710	869	0.89	0.75	0.38	0.08	0.68
03 03	17,259	2,589	1,291	0.88	0.75	0.37	0.08	0.67
04 01	13,707	1,336	2,556	0.90	0.76	0.38	0.08	0.64
04 02	16,246	1,786	1,713	0.93	0.79	0.40	0.08	0.70
04 03	14,521	3,411	995	0.91	0.77	0.39	0.08	0.67
04 04	9,122	450	1,553	0.94	0.80	0.40	0.08	0.69
05 01	23,227	2,272	3,349	0.89	0.76	0.38	0.08	0.66
05 02	35,899	3,606	2,514	0.90	0.76	0.38	0.08	0.70
05 03	12,728	1,483	1,839	0.91	0.77	0.38	0.08	0.66
05 04	15,440	1,246	2,646	0.93	0.79	0.40	0.08	0.68
06 01	17,628	909	2,151	0.95	0.81	0.40	0.08	0.72
06 02	14,129	1,053	1,839	0.95	0.81	0.40	0.08	0.71
06 03	10,334	1,046	1,598	0.95	0.81	0.40	0.08	0.69
06 04	9,087	833	2,154	0.97	0.82	0.41	0.08	0.66

Table A16: Unregulated land use area, total phosphorus hydrologic weighting factor (HWF), and resulting nonpoint source total phosphorus yields for HUC12s within the Auglaize River HUC8 (Ohio contributions only) for the spring 2008 base condition. The whole HUC12 yield is the sum of loads from the three land use categories and HSTS loads, divided by the total area.

	Auglaize River – 04100007							
	Area in Acres				HUC12 Specific NPS TP Yield in pounds per acre			
HUC12	Agricultural Land	Developed Land (unregulated)	Natural Land	Hydrologic Weighting Factor	Agricultural Land	Developed Land	Natural Land	Whole HUC12
01 01	23,261	1,500	2,341	1.07	0.90	0.45	0.09	0.82
01 02	8,756	721	948	1.09	0.92	0.46	0.10	0.82
01 03	15,520	1,208	2,274	1.07	0.91	0.46	0.09	0.79
01 04	18,229	1,611	2,273	1.11	0.94	0.47	0.10	0.82
01 05	10,445	3,579	1,413	1.10	0.93	0.47	0.10	0.76
02 01	16,018	1,148	1,876	1.08	0.92	0.46	0.09	0.82
02 02	4,678	745	898	1.10	0.93	0.47	0.10	0.77
02 03	15,146	1,064	2,215	1.09	0.92	0.46	0.10	0.81
02 04	15,330	1,911	1,880	1.07	0.91	0.45	0.09	0.79
03 01	11,596	855	1,409	1.04	0.88	0.44	0.09	0.78
03 02	16,390	1,794	1,280	1.02	0.87	0.43	0.09	0.78
03 03	11,072	1,239	1,895	1.05	0.89	0.44	0.09	0.75
03 04	8,302	794	1,218	1.02	0.87	0.43	0.09	0.75
03 05	5,150	0	1,992	1.05	0.89	0.45	0.09	0.69
03 06	6,385	0	2,264	1.04	0.88	0.44	0.09	0.70
04 01	4,797	878	1,306	1.07	0.90	0.45	0.09	0.72
04 02	7,351	0	2,141	1.05	0.89	0.45	0.09	0.75
04 03	6,425	566	1,503	1.06	0.90	0.45	0.09	0.74
04 04	4,935	0	746	1.03	0.88	0.44	0.09	0.80
04 05	7,688	629	295	1.04	0.88	0.44	0.09	0.83
04 06	11,704	760	701	1.03	0.87	0.44	0.09	0.81
05 01	31,876	1,133	4,047	1.02	0.86	0.43	0.09	0.78
05 02	22,442	2,192	796	0.99	0.84	0.42	0.09	0.79
05 03	11,662	976	495	1.02	0.86	0.43	0.09	0.81
06 01	10,645	715	830	1.12	0.95	0.47	0.10	0.86
06 02	14,921	1,165	669	1.12	0.94	0.47	0.10	0.88
06 03	11,966	900	699	1.10	0.93	0.47	0.10	0.86
06 04	31,858	3,051	1,571	1.06	0.89	0.45	0.09	0.83
07 01	9,268	911	159	1.09	0.93	0.46	0.10	0.88
07 02	28,891	2,203	1,250	1.10	0.93	0.47	0.10	0.88
07 03	22,985	1,609	476	1.07	0.91	0.46	0.09	0.87
08 01	33,113	2,628	1,168	1.08	0.92	0.46	0.09	0.87
08 02	8,156	591	471	1.13	0.95	0.48	0.10	0.88
08 03	18,684	1,903	982	1.11	0.94	0.47	0.10	0.87
08 04	19,115	4,819	796	1.10	0.93	0.47	0.10	0.82
08 05	9,310	575	614	1.06	0.90	0.45	0.09	0.83
08 06	7,399	581	934	1.03	0.88	0.44	0.09	0.77
09 01	15,548	1,063	663	1.10	0.93	0.47	0.10	0.88
09 02	8,151	560	178	1.08	0.92	0.46	0.09	0.88
09 03	14,496	2,676	780	1.07	0.91	0.45	0.09	0.82
09 04	11,563	1,101	795	1.03	0.88	0.44	0.09	0.80
09 05	11,421	908	1,256	1.02	0.87	0.43	0.09	0.77
09 06	7,594	627	524	1.01	0.86	0.43	0.09	0.78
09 07	8,342	892	1,324	1.03	0.87	0.43	0.09	0.74

Auglaize River – 04100007								
	Area in Acres				HUC12 Specific NPS TP Yield in pounds per acre			
HUC12	Agricultural Land	Developed Land (unregulated)	Natural Land	Hydrologic Weighting Factor	Agricultural Land	Developed Land	Natural Land	Whole HUC12
10 01	8,978	713	94	1.10	0.93	0.47	0.10	0.89
10 02	14,510	906	449	1.10	0.94	0.47	0.10	0.89
10 03	11,647	686	118	1.08	0.91	0.46	0.09	0.88
10 04	27,722	1,829	1,251	1.04	0.88	0.44	0.09	0.83
10 05	11,713	641	1,301	1.01	0.86	0.43	0.09	0.76
11 01	25,276	1,708	2,866	0.99	0.84	0.42	0.09	0.75
11 02	21,353	1,910	1,478	1.00	0.85	0.42	0.09	0.77
11 03	5,933	488	1,514	0.98	0.83	0.42	0.09	0.68
12 01	5,847	268	211	1.13	0.96	0.48	0.10	0.91
12 04	273	19	23	1.11	0.94	0.47	0.10	0.86
12 05	22,145	1,870	941	1.07	0.91	0.45	0.09	0.85
12 06	25,314	2,807	2,767	1.03	0.87	0.44	0.09	0.77
12 07	10,236	728	444	1.01	0.86	0.43	0.09	0.81
12 08	15,047	1,077	1,594	1.00	0.85	0.43	0.09	0.74
12 09	14,547	310	4,185	0.99	0.84	0.42	0.09	0.67

Table A17: Unregulated land use area, total phosphorus hydrologic weighting factor (HWF), and resulting nonpoint source total phosphorus yields for HUC12s within the Blanchard River HUC8 for the spring 2008 base condition. The whole HUC12 yield is the sum of loads from the three land use categories and HSTS loads, divided by the total area.

Blanchard River – 04100008								
	Area in Acres				HUC12 Specific NPS TP Yield in pounds per acre			
HUC12	Agricultural Land	Developed Land (unregulated)	Natural Land	Hydrologic Weighting Factor	Agricultural Land	Developed Land	Natural Land	Whole HUC12
01 01	12,388	864	1,529	1.04	0.88	0.44	0.09	0.77
01 02	10,300	1,329	933	1.05	0.89	0.44	0.09	0.79
01 03	18,320	1,571	1,906	1.03	0.87	0.44	0.09	0.78
01 04	15,200	1,502	1,098	1.02	0.87	0.43	0.09	0.79
01 05	19,599	1,861	2,180	1.01	0.86	0.43	0.09	0.76
02 01	15,657	1,315	1,222	1.01	0.85	0.43	0.09	0.77
02 02	21,016	1,723	1,776	1.00	0.85	0.43	0.09	0.77
02 03	12,001	834	1,556	1.00	0.85	0.42	0.09	0.75
02 04	14,565	1,152	1,329	0.99	0.84	0.42	0.09	0.76
02 05	4,532	767	1,391	0.99	0.84	0.42	0.09	0.64
03 01	13,723	1,456	1,673	1.00	0.85	0.43	0.09	0.74
03 02	15,452	1,959	2,525	0.98	0.83	0.41	0.09	0.70
03 03	8,727	505	907	0.95	0.81	0.40	0.08	0.73
03 04	14,481	2,436	1,849	0.96	0.81	0.41	0.08	0.70
04 01	7,610	730	843	0.99	0.84	0.42	0.09	0.75
04 02	7,402	690	1,079	0.98	0.83	0.42	0.09	0.71
04 03	7,691	1,683	1,017	0.98	0.83	0.42	0.09	0.70
04 04	7,466	1,649	774	0.95	0.80	0.40	0.08	0.68
04 05	13,308	1,381	1,313	0.96	0.81	0.41	0.08	0.72
05 01	10,366	816	1,087	0.95	0.80	0.40	0.08	0.72
05 02	23,980	2,207	2,558	0.94	0.80	0.40	0.08	0.71
05 03	8,029	427	208	0.91	0.77	0.39	0.08	0.74
05 04	8,710	452	443	0.92	0.78	0.39	0.08	0.73
05 05	8,703	434	311	0.94	0.79	0.40	0.08	0.76
05 06	23,410	1,739	1,200	0.94	0.79	0.40	0.08	0.74
06 01	25,666	2,019	1,257	0.98	0.83	0.42	0.09	0.78
06 02	14,262	2,667	1,222	0.96	0.82	0.41	0.08	0.73
06 03	13,114	879	474	0.98	0.83	0.42	0.09	0.79
06 04	7,117	554	440	0.98	0.83	0.42	0.09	0.78
06 05	21,107	1,641	2,426	1.00	0.85	0.42	0.09	0.75

Table A18: Unregulated land use area, total phosphorus hydrologic weighting factor (HWF) and resulting nonpoint source total phosphorus yields for HUC12s within the Lower Maumee River HUC8 for the spring 2008 base condition. The whole HUC12 yield is the sum of loads from the three land use categories and HSTS loads, divided by the total area.

Lower Maumee River – 04100009								
	Area in Acres				HUC12 Specific NPS TP Yield in pounds per acre			
HUC12	Agricultural Land	Developed Land (unregulated)	Natural Land	Hydrologic Weighting Factor	Agricultural Land	Developed Land	Natural Land	Whole HUC12
01 01	9,515	491	202	0.99	0.83	0.42	0.09	0.80
01 02	12,259	881	314	0.98	0.83	0.42	0.09	0.79
01 03	22,168	1,830	872	0.99	0.84	0.42	0.09	0.78
01 04	21,269	1,359	566	0.99	0.84	0.42	0.09	0.80
01 05	13,643	834	318	0.99	0.84	0.42	0.09	0.81
01 06	7,271	625	927	0.98	0.83	0.42	0.09	0.73
02 01	5,882	0	1,531	0.98	0.83	0.41	0.09	0.70
02 02	13,718	954	703	0.97	0.82	0.41	0.08	0.77
02 03	19,077	1,711	3,090	0.98	0.83	0.42	0.09	0.71
02 04	15,724	1,728	839	0.94	0.80	0.40	0.08	0.74
02 05	12,757	1,951	580	0.93	0.79	0.40	0.08	0.72
02 06	10,879	1,716	940	0.96	0.81	0.41	0.08	0.72
02 07	8,193	1,557	1,638	0.97	0.82	0.41	0.08	0.67
03 01	12,033	1,018	1,523	0.88	0.75	0.37	0.08	0.67
03 02	20,801	2,814	2,590	0.92	0.78	0.39	0.08	0.68
04 01	14,694	850	571	0.93	0.79	0.39	0.08	0.75
04 02	26,699	3,536	1,600	0.92	0.78	0.39	0.08	0.71
04 03	14,902	1,359	1,250	0.93	0.79	0.39	0.08	0.72
05 01	12,257	1,026	483	0.98	0.83	0.42	0.09	0.78
05 02	14,991	977	89	0.98	0.83	0.42	0.09	0.81
05 03	9,869	601	220	0.99	0.84	0.42	0.09	0.80
05 04	20,056	1,773	278	0.96	0.81	0.41	0.08	0.78
05 05	14,254	1,520	231	0.98	0.83	0.41	0.09	0.78
05 06	13,345	837	306	0.96	0.82	0.41	0.08	0.78
05 07	13,184	733	192	0.99	0.84	0.42	0.09	0.81
05 08	13,653	620	529	0.99	0.84	0.42	0.09	0.79
05 09	8,925	809	1,000	0.98	0.83	0.41	0.09	0.74
05 10	11,299	1,408	2,261	0.96	0.82	0.41	0.08	0.68
06 01	25,418	2,029	1,202	0.98	0.83	0.41	0.09	0.77
06 02	10,162	1,432	2,294	0.96	0.81	0.41	0.08	0.67
06 03	6,490	0	1,048	0.96	0.81	0.41	0.08	0.72
07 01	23,641	1,818	5,277	0.88	0.74	0.37	0.08	0.62
07 02	14,227	1,513	2,227	0.90	0.76	0.38	0.08	0.66
07 03	2,733	0	6,593	0.91	0.77	0.39	0.08	0.31
08 01	7,085	1,232	4,659	0.93	0.79	0.39	0.08	0.53
08 02	12,089	879	1,823	0.94	0.80	0.40	0.08	0.70
08 03	3,218	0	5,371	0.88	0.75	0.37	0.08	0.39
08 04	7,719	0	2,352	0.90	0.76	0.38	0.08	0.64
09 01	12,364	0	605	0.94	0.80	0.40	0.08	0.79
09 02	2,329	0	405	0.92	0.78	0.39	0.08	0.75
09 03	2,303	0	3,395	0.92	0.78	0.39	0.08	0.36
09 04	53	0	2,148	0.89	0.76	0.38	0.08	0.10

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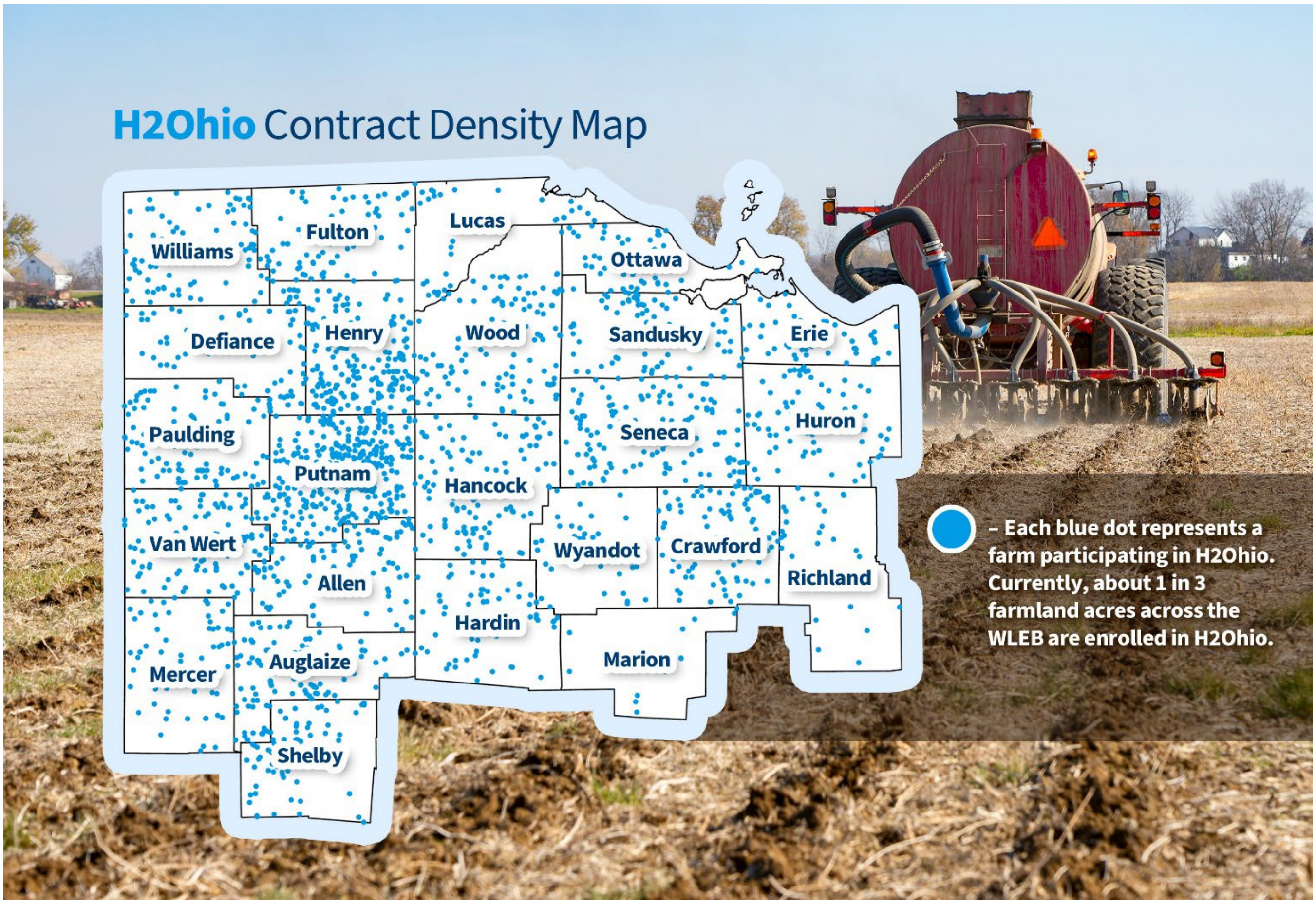
Appendix B: H2Ohio Agricultural Efforts

ODA has seen tremendous interest from Ohio's producers in H2Ohio. ODA's incentive program was first made available in the 14 counties of the Maumee River Watershed. Producers in this area have completed BMPs for two growing seasons and are implementing BMPs this year, which is H2Ohio's third growing season. In 2021, the remaining 10 counties of the Western Lake Erie Basin (WLEB) were eligible to enroll in H2Ohio practices.

H2Ohio has led to the development of Voluntary Nutrient Management Plans (VNMPs) that cover nearly 1.4 million acres in 24 counties across the WLEB. This represents nearly 35% of the total cropland in the H2Ohio project area.



ODA also incentivizes other BMPs that focus on water management practices that slow down the movement of water, like two-stage ditches and drainage water management structures, and land management practices that prevent erosion and nutrient loss, like cover crops and phosphorus placement. To date, more than 1.2 million acres have been enrolled into these other practices.

More than 2,400 producers enrolled in H2Ohio have developed or implemented 1.4 million acres of VNMPs. In addition, producers have implemented over 640,000 acres of additional BMPs across those fields. These practices are proven to have a positive impact on water quality by reducing nutrient runoff, improving nutrient application methods, reducing erosion, and promoting soil health. Below is a summary of acres completed for each BMP across the 14-county Maumee River Watershed H2Ohio project area:

2022 - Maumee Project Area - Completed Acres

County SWCD	VNMP Implementation	VRT Phosphorus Application	Subsurface Phosphorus Placement	Manure Incorporation	Conservation Crop Rotation	Overwintering Cover Crop
Allen	25,600	10,500	3,900	300	1,400	2,700
Auglaize	37,400	7,600	4,000	1,500	2,400	4,700
Defiance	57,000	9,300	7,100	2,300	1,700	9,500
Fulton	37,200	8,600	3,300	2,000	2,100	6,900
Hancock	55,800	27,500	5,600	600	2,500	12,400
Hardin	49,100	12,900	6,500	1,800	2,200	16,600
Henry	128,200	19,500	19,600	3,100	5,500	14,900
Lucas	12,600	3,800	4,400	100	600	2,700
Mercer	43,400	7,800	2,200	5,000	3,500	16,300
Paulding	51,400	2,200	10,700	4,300	3,000	11,800
Putnam	122,400	20,000	10,700	8,600	7,700	30,000
Van Wert	80,500	9,600	21,800	6,800	2,800	18,500
Williams	49,300	2,300	10,600	3,400	2,000	13,500
Wood	66,000	16,100	5,900	1,800	2,600	13,700
TOTAL	**815,900**	**157,700**	**116,300**	**41,600**	**28,500**	**11,300**

2023 Enrolled Acres in the Lake Erie Watershed

County SWCD	VNMP Implementation	VRT Phosphorus Application	Subsurface Phosphorus Place	Manure Incorporation	Conservation Crop Rotation	Overwintering Cover Crop
Maumee River	*Watershed*					
Allen	63,893	34,314	17,364	8,427	7,999	17,640
Auglaize	48,731	24,096	7,728	11,459	7,864	19,266
Defiance	56,878	28,961	15,186	5,675	6,970	25,453
Fulton	51,211	27,747	18,050	4,570	6,191	17,197
Hancock	63,811	45,315	16,550	3,076	8,317	31,609
Hardin	57,881	31,150	23,030	5,785	4,730	23,418
Henry	139,611	33,031	40,695	10,198	19,380	40,025
Lucas	14,854	8,444	5,312	668	1,663	3,734
Mercer	46,725	14,946	5,221	14,126	8,480	27,524
Paulding	103,537	40,026	39,672	30,415	18,204	56,118
Putnam	137,830	54,896	23,823	16,495	20,554	61,324
Van wert	94,233	31,970	33,373	14,392	7,743	36,458
Williams	56,724	30,587	14,191	13,661	9,759	24,383
Wood	64,972	35,277	25,478	5,889	14,579	27,602
TOTAL	**1,000,890**	**440,758**	**285,673**	**144,837**	**142,432**	**411,750**
County SWCD	**VNMP Implementation**	**VRT Phosphorus Application**	**Subsurface Phosphorus Place**	**Manure Incorporation**	**Conservation Crop Rotation**	**Overwintering Cover Crop**
WLEB						
Crawford	109,836	75,224	6,115	8,859	8,480	28,595
Erie	49,490	27,166	3,435	1,212	7,889	14,589
Huron	85,876	64,707	10,184	4,072	17,829	22,881
Marion	55,506	43,237	5,051	14,150	6,218	23,792
Ottawa	41,826	12,908	1,430	465	6,127	21,216
Richland	24,637	14,736	3,110	418	2,740	6,325
Sandusky	89,923	51,913	31,901	7,626	11,729	33,299
Seneca	70,786	54,547	12,251	4,545	13,271	37,852
Shelby	34,220	9,497	562	5,432	3,826	12,026
Wyandot	58,025	48,232	6,359	4,767	6,765	11,146
TOTAL	**620,127**	**402,167**	**80,398**	**51,544**	**84,873**	**211,719**

ODA has used experiences from the program roll-out and initial four years to adapt the H2Ohio agricultural BMP incentives. ODA will maintain the Voluntary Nutrient Management Plan (VNMP) as the foundation of the program. Practices will be streamlined for easier program enrollment and delivery. Practice requirements will be modified to provide producers more options to implement practices while maintaining nutrient reduction potential.

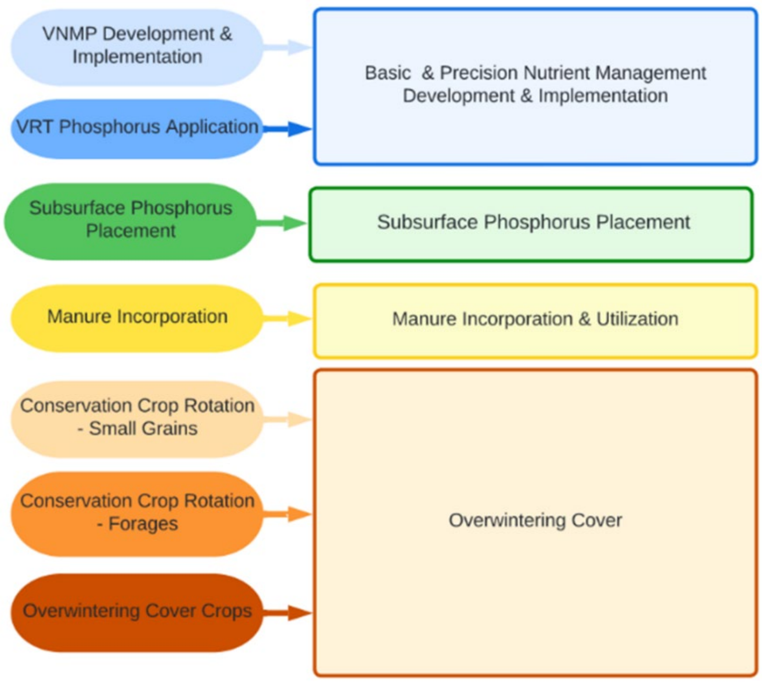


Figure B1: H2Ohio and SB 299 programs have been adjusted and recombined to streamline program delivery.

For more detailed and current information on the H2Ohio agricultural BMP incentive programs, please visit ***https://h2.ohio.gov/agriculture/***.

ODA's H2Ohio program was funded by the Ohio Legislature at $60 million per year for FY24-25. With this funding, ODA opened enrollment in the 14 counties of the Maumee River Watershed to offer new contracts to existing participants and to new producers who have not yet enrolled.

Additionally, ODA has contracted with MyFarms management software to custom-build a unique digital platform. This platform will help producers and their advisors with the creation of VNMPs and with H2Ohio's enrollment, certification, and verification processes.

With improvements to management software and streamlined BMP standards, ODA's goal is to grow the overall enrollment in the WLEB to 2 million acres by the end of FY25. Additionally, ODA anticipates offering new H2Ohio contracts to participants in the remaining 10 counties in the WLEB next year with a goal to increase state and federal enrollment in this project area to 750,000 acres through 2026.

Finally, ODA plans to expand H2Ohio incentives for development and implementation of VNMPs to producers outside of the WLEB with a goal to enroll 500,000 new acres.

Appendix C: Point Source Facilities in Ohio's Annex 4 Priority Watersheds

Beginning with the Great Lakes Water Quality Agreement (GLWQA) in 1972, it was acknowledged that municipal point source discharges contributed to the nutrient loadings to the lake. The early versions of the GLWQA recommended that all major wastewater treatment plants (WWTPs) discharging within the lake basin meet a 1.0 mg/L total phosphorus (TP) effluent concentration. By 1980, the affected WWTPs were implementing reduction efforts to a level that non-point sources became the major contributor of phosphorus loading to the lake. The majority of the WWTPs began treating for phosphorus using chemical additional of metal salts to precipitate out phosphorus and incorporate it into the biosolids at the end of the treatment process.

Coupled with the effluent controls at the major WWTPs were reductions in the phosphorus content in laundry detergents. Beginning in the late 1980s, Ohio began limiting the allowed amount of phosphorus in household and commercial laundry detergents. In 2010, Ohio became one of 16 states that also included a requirement that dishwasher detergent could not contain more than 0.5 percent phosphorus. Not only did these measures reduce the influent phosphorus concentration to the WWTPs but also reduced contributions from uncontrolled point sources such as combined sewer overflows (CSOs) and bypasses. It is also worthwhile to mention that in collaboration with the Ohio Lake Erie Phosphorus Task Force, the Scotts company has removed phosphorus as a component of residential lawn fertilizers. This effort has further reduced inputs from CSOs and municipal separate storm sewer (MS4) permitted storm water communities.

This appendix provides more details about how these and other efforts continue to reduce phosphorus discharges to Lake Erie.

NPDES – Permitted Discharges, Final Outfalls

There are a combined total of 1,236 permitted facilities in Ohio which discharge in the Lake Erie watershed. These facilities discharged a combined total of 452 metric tons annual average for water years 2017-2021. Table C1 breaks out these the NPDES permitted facilities and water years' 2017-2021 annual average total TP load for each Annex 4 priority tributary. The next nutrient mass balance study that Ohio EPA will publish in 2024 will update these values.

Table C1: Number of NPDES individual facility permits by Annex 4 Priority Watershed, with water year 2017-2021 total phosphorus average annual load from all permitted outfalls. This includes all facilities, public or private, that report discharge of total phosphorus.

Watershed		Number of Permitted Facilities	Total Phosphorus Load (MTA)
Annex 4 Priority Watersheds (State of Ohio)	Maumee	258	136
	Toussaint	55	4.2
	Sandusky	115	26
	Portage	42	13
	Huron	43	3
	Vermillion	29	2
	Cuyahoga	171	116
	Grand	86	7
Annex 4 Priority Total			
All Other Lake Erie Drainage		437	143
Total		**1236**	**452**

While municipal major WWTPs are required to achieve an effluent concentration of 1.0 mg/L in order to comply with their NPDES permits and as good environmental stewards, many treatment plants consistently perform well below this level. One reason for this is to remain in compliance throughout varying flow rates, operating conditions and process upsets. Statistically speaking, if one were to apply the same methodologies of reasonable potential to exceed the 1.0 mg/L limit as we do with other water quality criteria, a facility would need to achieve a long-term average concentration of 0.73 mg/L in order to remain in compliance 99 percent of the time.

Since 2017, Ohio EPA has been including permit conditions for wastewater treatment facilities to complete optimization plans. These plans have periodically identified potential optimization opportunities and permittees have submitted schedules to implement changes when appropriate. Ohio EPA has not required facilities to take on capital projects based on the findings of the plans; the emphasis was to identify low cost operational changes or cost saving opportunities. Many facilities demonstrated performance well beyond the level needed to achieve compliance, often well below 0.5 mg/L. As good environmental stewards these facilities had already worked to optimize performance and were not able to identify additional opportunities within the scope of this investigation.

Ohio EPA has been developing TMDLs since the early 2000's focused on local impairments in streams and rivers throughout the state. These impairments were based on biological criteria not attaining water quality standards. These criteria were then linked to excess nutrients through a causal analysis.

TMDLs were typically done for phosphorus, the most frequent limiting nutrient in fresh water, and point sources receive an allocation that when summed with other sources does not exceed the TMDL. Ohio does not have numeric criteria for phosphorus, so targets were identified – typically based on phosphorus concentrations at sites that were meeting biocriteria. However, the biocriteria demonstrate adequate performance over a range of phosphorus concentrations. To increase flexibility while working towards attaining biological water quality standards, Ohio EPA has used adaptive implementation. Adaptive implementation focuses resources on large magnitude, lower cost, reductions followed by a reevaluation of the biological conditions. Since there is some uncertainty in the targets, Ohio EPA pauses implementation once the biological water quality standards are attained.

While efforts to implement TMDLs have been underway since the early 2000's, in 2023 Ohio EPA developed its first farfield TMDL to address impairments identified in Lake Erie.

The remainder of this section provides details on how these efforts have impacted the point source loads in priority watersheds.

Treatment Facility Phosphorus Contributions and Progress in the Maumee River Watershed

In 2023, Ohio EPA, with collaboration from ODA and ODNR, completed the Maumee Watershed Nutrient TMDL. This project has a goal to reduce phosphorus loadings from the Maumee River in order to restore drinking water, aquatic life, and recreation uses in three areas within Lake Erie's western basin. The TMDL evaluated the existing contributions of treatment facilities and other sources in the watershed and the evaluation showed that Ohio's point sources contributed a small fraction of the phosphorus load, around 6-percent of the total phosphorus load from Ohio's portion of the watershed. In part, that small contribution was due to efforts of the municipalities and industries operating the facilities to minimize the phosphorus load. While some of these efforts were required to implement local TMDLs, many were driven by voluntary actions. The following examples highlight some of these efforts:

- In 2012, the Toledo Bayview WWTP changed where it added ferric chloride to chemically remove phosphorus. This allowed for better performance of the chemical reducing the total chemical needs while reducing phosphorus concentrations in the effluent. Currently the Toledo Bay View WWTP has a median phosphorus concentration of 0.45 mg/L. As the largest facility in Ohio's portion of the watershed, efforts by Toledo have a significant impact on the total load discharged by treatment facilities.
- Many facilities perform at levels well in excess of what is required to simply maintain compliance. Ohio EPA recognizes that many facilities cannot achieve this level of performance without significant investments and has not required these facilities to achieve the exceptional performance demonstrated. The following facilities have discharged median phosphorus concentrations at levels of control far exceeding permit requirements:
    - Bluffton WWTP: most recent factsheet shows a median phosphorus concentration of 0.13 mg/L
    - Ottawa WWTP: most recent factsheet shows a median phosphorus concentration of 0.2 mg/L
    - Bryan WWTP: most recent factsheet shows a median phosphorus concentration of 0.25 mg/L
    - Wauseon WWTP: most recent factsheet shows a median phosphorus concentration of 0.31 mg/L
    - City of St. Marys WWTP: most recent factsheet shows a median phosphorus concentration of 0.36 mg/L

- Local TMDLs have resulted in limits for several smaller wastewater treatment facilities and industrial facilities. The implementation of phosphorus removal technology at these facilities typically results in a 60 to 80-percent reduction in phosphorus loads. Other facilities either expanded due to growth or to implement wet weather controls resulting in a major designation, also resulting in the implementation of phosphorus controls.
    - The implementation of a TMDL to protect aquatic in local tributaries resulted in a limit of 1.0 mg/L for the treatment facilities serving Swanton and Delta.
    - The treatment facilities serving Ada, Leipsic, and Hicksville were expanded which resulted in it becoming a major facility which requires a limit of 1.0 mg/L.
    - The Lima Refinery and PCS Nitrogen have new limits based on the implementation of a local TMDL. The Lima Refinery discharges relatively low phosphorus concentrations but due to large flow rates contributed a significant load. The refinery implemented a water reuse project to improve management of other pollutants reducing its phosphorus load substantially. In addition to the new phosphorus limit PCS Nitrogen has reduced its use of phosphorus containing treatment additives. The permit requires the facility to continue to optimize the use of these additives while controlling corrosion in the cooling system.
- Facilities have been engaged in efforts to optimize treatment technologies.
    - Perrysburg's wastewater treatment facility has utilized old primary clarifier tanks to equalize anaerobic digester supernatant flows to lower peak nutrient loadings and possible bleed through to the effluent.
    - The Archbold wastewater treatment facility has worked with Ohio EPA's compliance assistance unit to implement operation changes to accomplish biological nutrient removal with operational changes.

The Maumee River Watershed Nutrient TMDL recognized both the existing level of control and the low relative contribution to the total phosphorus load to the Maumee River from treatment facilities. Weighing that information with the costs to increase treatment, facilities were allocated loads consistent with maintaining the actual load discharged in the 2008 condition that was defined as a baseline for Maumee River nutrient reductions. The resulting WLA is lower than the load that is currently authorized through discharge permits. Phosphorus controls were associated with the allocations for the largest facilities that make up approximately 85-percent of the total wasteload allocation. To ensure that discharge is maintained for these facilities, Ohio EPA developed a general permit that will measure the seasonal performance of the facilities against the WLA from the TMDL. Ohio EPA will continue to encourage optimization and implementation of better technology as facilities grow or re-invest in existing facilities.

Treatment Facility Phosphorus Contributions and Progress in the Toussaint River Watershed

The Toussaint River is the smallest area of any priority tributary in Ohio, draining less than 150 square miles. There are no major wastewater treatment facilities in the watershed. A TMDL developed in 2006 for local impairments in the watershed evaluated the impacts from treatment facilities. Genoa is served by the largest facility in the watershed and is designed to treat 0.6 MGD. The TMDL recommended a limit of 1.0 mg/L and in recent years the facility has been discharging median concentrations between 0.5-0.8 mg/L compared to 1.5-2.5 mg/L before phosphorus controls were implemented.

Treatment Facility Phosphorus Contributions and Progress in the Portage River Watershed

Ohio EPA's nutrient mass balance study identified that, from water years 2017-2021, an average of 6 percent of the annual phosphorus load in the Portage River watershed was discharge by treatment facilities. In part, that small contribution was due to efforts of the municipalities and industries operating the facilities to minimize the phosphorus load. While some of these efforts were required to implement local TMDLs, many were driven by voluntary actions.

- There are three major wastewater treatment plants in the Portage River watershed. Efforts at each of these facilities are highlighted below:
    - Bowling Green WWTP: The biological water quality standards for the North Branch Portage River were identified as impaired and a cause was determined to be excess phosphorus. While no TMDL was approved,

an evaluation determined lower phosphorus limits of 0.7 mg/L was appropriate as an adaptive implementation step to improve biological conditions.

- Fostoria WWTP: The most recent factsheet for the Fostoria WWTP shows a median phosphorus concentration of 0.42 mg/L. This level of performance shows optimization beyond what is needed to comply with the permit limit of 1.0 mg/L as a monthly average.
- Port Clinton: The most recent factsheet for Port Clinton shows a median phosphorus concentration of 0.15 mg/L. This is an exceptional level of performance demonstrating that the facility has been optimized to remove phosphorus.

- Local water quality evaluations have resulted in limits for several smaller wastewater treatment facilities and industrial facilities. The implementation of phosphorus removal technology at these facilities typically results in a 60 to 80-percent reduction in phosphorus loads. While no TMDL was approved, an evaluation determined lower phosphorus limits of 1.0 mg/L were appropriate for North Baltimore and Cygnet as an adaptive implementation step to improve biological conditions.

Treatment Facility Phosphorus Contributions and Progress in the Sandusky River Watershed

In Ohio EPA's nutrient mass balance study, the agency evaluates the Sandusky River and other tributaries to the bay as a common area, differing slightly from the priority tributary area. The study identified that 4-percent of the annual phosphorus load in the Sandusky River and other bay tributaries was discharged by treatment facilities of average from water years 2017-2021. In part, that small contribution was due to efforts of the municipalities and industries operating the facilities to minimize the phosphorus load. While some of these efforts were required to implement local TMDLs, many were driven by voluntary actions.

- There are four major wastewater treatment plants in the Sandusky River watershed, excluding the bay tributaries. Efforts at each of these facilities are highlighted below:
  - Bucyrus WWTP: The most recent factsheet for the Bucyrus WWTP shows a median phosphorus concentration of 0.32 mg/L. This is an exceptional level of performance demonstrating that the facility has been optimized to remove phosphorus.
  - Upper Sandusky WWTP: The most recent factsheet for the Upper Sandusky WWTP shows a median phosphorus concentration of 0.38 mg/L. This level of performance shows optimization beyond what was required to meet the limit of 1.0 mg/L as a monthly average. The Upper Sandusky WWTP now has a limit of 0.7 mg/L as a monthly average as implementation of the Upper Sandusky TMDL and a new treatment plant went online at the end of 2020.
  - Tiffin WWTP: The most recent factsheet for the Tiffin WWTP shows a median phosphorus concentration of 0.39 mg/L. This level of performance shows optimization beyond what was required to meet the limit of 1.0 mg/L as a monthly average.
  - Fremont WPCF: The most recent factsheet for the Fremont WPCF shows a median phosphorus concentration of 0.13 mg/L. This is an exceptional level of performance demonstrating that the facility has been optimized to remove phosphorus.
- A local TMDL has resulted in limits for the Carey WWTP. The limits became effective in 2022 with the completion of a new treatment facility. Prior to the effluent limits Carey had high effluent phosphorous concentrations with median concentrations greater than 4.0 mg/L. Based on the implementation of new technology the facility should realize more than an 80-percent reduction in effluent phosphorus concentrations.
- Facilities have been engaged in efforts to optimize treatment technologies.
  - Fremont's wastewater treatment facility, discharging to the Sandusky River watershed, recently completed upgrades to the facility in 2016. Biological nutrient removal capabilities were included in the upgrades and the facility continues minor process adjustments to achieve optimal effluent quality. Current phosphorus concentrations are ~41 percent lower than the former facility was able to achieve.

- The city of Crestline, in the Sandusky River watershed, will be implementing facility improvements to comply with the existing effluent limit in their NPDES permit. Preliminary reports have identified increased chemical feed rates as an interim solution with the possibility of constructing a new biological removal facility as a long-term solution.

Treatment Facility Phosphorus Contributions and Progress in the Huron River Watershed

In Ohio EPA's nutrient mass balance study, the agency evaluated the Huron River and identified that an average of 2 percent of the annual phosphorus load was discharged by treatment facilities from water years 2017-2021. In part, that small contribution was due to efforts of the municipalities and industries operating the facilities to minimize the phosphorus load. While some of these efforts were required to implement local TMDLs, many were driven by voluntary actions.

- There are three major wastewater treatment plants in the Huron River watershed. Each facility demonstrated exceptional performance for phosphorus removal which demonstrates the facilities have been optimized to remove phosphorus. The facilities and their performance are identified below:
    - Norwalk WWTP: The most recent factsheet for the Norwalk WWTP shows a median phosphorus concentration of 0.3 mg/L.
    - Huron Basin WWTP: The most recent factsheet for the Huron Basin WWTP shows a median phosphorus concentration of 0.22 mg/L.
    - Willard WWTP: The most recent factsheet for the Willard WWTP shows a median phosphorus concentration of 0.24 mg/L.
- Implementation of a local TMDL has resulted in limits for the Plymouth, Milan, and Monroeville WWTPs. Based on the implementation of new technology these facilities should have realized a 60 to 80-percent decrease in phosphorus loading.

Treatment Facility Phosphorus Contributions and Progress in the Vermillion River Watershed

In Ohio EPA's nutrient mass balance study, the agency evaluated the Vermillion River and identified that an average of 2 percent of the annual phosphorus load was discharged by treatment facilities from water years 2017-2021. In part, that small contribution was due to efforts of the municipalities and industries operating the facilities to minimize the phosphorus load. The Vermilion Water Pollution Control Facility is the only major wastewater treatment facility in the watershed. The facility shows an exceptional level of performance, and the most recent factsheet shows a median concentration of 0.22 mg/L. This level of control demonstrates that the facility has been optimized to remove phosphorus. The next largest treatment facility in the watershed is the New London WWTP which is designed to treat 0.6 million gallons per day and also has a phosphorus limit.

Treatment Facility Phosphorus Contributions and Progress in the Cuyahoga River Watershed

In Ohio EPA's nutrient mass balance study, the agency evaluated the Cuyahoga River and identified that an average of 43 percent of the annual phosphorus load was discharged by treatment facilities from water years 2017-2021. The relative point source loading is among the highest of the watersheds studied. The Cuyahoga River is one of the most urbanized watersheds in Ohio with more than 1,440 people/sq. mi., nearly four times greater than any other watershed in this study. It also has the highest natural areas of the watersheds in the study at 37 percent of the watershed. It is the home of Ohio's only national park as well as extensive local and state parks which preserve natural land covers. Even with the higher flow contribution of point sources relative to watershed size, the time-weighted mean concentration of total phosphorus (indicative of high low flow phosphorus concentrations) was lower than that of the Scioto and Great Miami rivers (Baker et al., 2006).

Implementation of the Cuyahoga River TMDL, which was completed in 2004, led to lower phosphorus limits at major wastewater treatment facilities in the watershed to address local impairments to water quality. Initial implementation efforts led to limits of 0.7 mg/L (monthly average) and efforts to focus on reductions from untreated discharges from combined sewer systems, especially in Akron.

In addition to implementation of lower permit limits many facilities perform at levels well in excess of what is required to simply maintain compliance. Ohio EPA recognizes that many facilities cannot achieve this level of performance without significant investments and has not required these facilities to achieve the exceptional performance demonstrated. The following facilities have discharged median phosphorus concentrations at levels of control far exceeding permit requirements:

- Bedford WWTP: most recent factsheet shows a median phosphorus concentration of 0.28 mg/L
- Bedford Heights WWTP: most recent factsheet shows a median phosphorus concentration of 0.32 mg/L
- Aurora Westerly WWTP: most recent factsheet shows a median phosphorus concentration of 0.20 mg/L
- Fishcreek WWTP: most recent factsheet shows a median phosphorus concentration of 0.10 mg/L
- Streetboro Hudson WWTP: most recent factsheet shows a median phosphorus concentration of 0.22 mg/L

Local water quality evaluations have resulted in limits for five smaller wastewater treatment facilities in the Cuyahoga River watershed. The implementation of phosphorus removal technology at these facilities typically results in a 60 to 80 percent reduction in phosphorus loads.

Treatment Facility Phosphorus Contributions and Progress in the Grand River Watershed

The Grand River was not studied in Ohio EPAs Mass Balance Study because phosphorus loading information is not available currently. However prior efforts form NCWQR show the phosphorus loading intensity is much lower than other tributaries studied. An analysis in Appendix F shows the Grand's TP concentration was regularly about a third of the other rivers while it was monitored from 1989-2006. This evaluation led Ohio to request the subcommittee consider alternative recommendations for the Grand River.

- There are three major wastewater treatment plants in the Portage River watershed. The status of phosphorus treatment at each of these facilities is discussed below:
  - Painesville Water Pollution Control Plant: The most recent factsheet shows a median phosphorus concentration of 0.52 mg/L.
  - Chardon WWTP: The most recent factsheet for Port Clinton shows a median phosphorus concentration of 0.31 mg/L. This is an exceptional level of performance demonstrating that the facility has been optimized to remove phosphorus.
  - Village of Jefferson WWTP: The Jefferson WWTP discharged a median phosphorus concentration of 0.37 mg/L from 2017-2021.
- Three of five wastewater treatment facilities discharging 0.1-1.0 MGD have phosphorus limits in their permits due to either local TMDLs or other local water quality evaluations. The implementation of phosphorus removal technology at these facilities typically results in a 60 to 80 percent reduction in phosphorus loads.

NPDES – Permitted Discharges, CSOs

Some communities have storm water outfalls that are regulated, which include CSOs and individual or general storm water permits. Overflows from combined sewers due to urban storm water are the primary source of untreated sewage discharges to Lake Erie. In the Lake Erie basin, 44 communities currently have CSOs. Ohio EPA's 2018 Nutrient Mass Balance Study reports that CSOs accounted for between 0.1 – 3.7 percent of the TP load exported from several Lake Erie watersheds from water years 2013 – 2017. For these years, the average CSO percentage of TP load was 0.5 percent in the Maumee River, 1.0 percent in the Portage River, 1.1 percent in the Sandusky River, 0.1 percent in the Vermillion River and 3.7 percent in the Cuyahoga River watersheds.

Ohio EPA works to control CSOs through provisions in NPDES permits and using orders and consent agreements when appropriate. The NPDES permits require CSO communities to implement nine minimum control measures. Requirements to develop and implement Long-Term Control Plans (LTCPs) are also included where appropriate. Billions of dollars have already been invested by communities to abate their CSO discharges. Details about CSOs can be found on Ohio EPA's website at: ***https://epa.ohio.gov/dsw/cso/csoindex.***

NPDES – Permitted Discharges, Storm Water Discharges

Storm water discharges are generated by runoff from land and impervious areas such as paved streets, parking lots and building rooftops during rainfall and snow events. Storm water can contain pollutants in quantities that could adversely affect water quality. Many storm water discharges are considered point sources and require coverage by the NPDES program. There are numerous storm water permits throughout the Lake Erie watershed. This includes 224 regulated MS4s, hundreds of facilities with individual NPDES permits that include storm water, and over 1,000 general industrial storm water permits. Additionally, thousands of general construction storm water permits in Ohio's portion of the Lake Erie watershed are open at any given time. The general permits and MS4 regulated areas can be viewed on an interactive map hosted by Ohio EPA[47].

Best management practices like green infrastructure and street sweeping can reduce nutrient loading from MS4 discharges. Ohio EPA is currently investigating opportunities to encourage MS4 communities to voluntarily sample for nutrients.

[47]Interactive map of permitted storm water communities is available at *http://oepa.maps.arcgis.com/apps/webappviewer/index.html?id=b680bd65d1874023ae6ec2f911acb841*.

Appendix D: Restoration Projects

This appendix details the specific actions of the Ohio Department of Natural Resources (ODNR) and provides updated project lists. For more information please see ***https://h2.ohio.gov/natural-resources/***.

ODNR has identified several different project types that will provide direct nutrient and sediment-reduction benefits to the Maumee River Watershed, Western Lake Erie Basin, Sandusky Bay and other watersheds throughout the state.

In-Water or Flow-Through Coastal Wetlands: One of the highest priorities is to place multiple flow-through, in-water coastal wetland restoration projects in the basin, particularly within the Maumee and Sandusky River mouths. The placement of these wetlands will include those that beneficially use dredged material and natural river flows to deliver sediment and nutrient-laden waters from the river into the wetlands. These projects will be designed, engineered and constructed at locations that maximize nutrient reduction benefits and improve fish and wildlife habitat.

Reconnecting Diked Wetlands: Many of the existing wetlands along the western basin shoreline are diked wetlands that are disconnected from Lake Erie and the adjacent tributaries and agricultural drainage channels that flow directly into the Lake. There is a desire to upgrade those wetlands with new innovative water control/fish access structures to reconnect the wetlands to the basin hydrology. These water control structures will allow the wetlands to continue to be managed for vegetation and waterfowl and will also provide the ability to divert surface water flow from upland areas into the wetlands to process sediments and nutrients before reaching the Lake.

Nature-Based Shoreline Wetlands: The addition of nature-based wetlands along the shoreline will be considered in areas where hardened shoreline protection is either absent or needs to be replaced. These wetlands may be constructed to include natural materials and/or beneficially use dredge materials to fill the cells to create new coastal wetlands. These nature-based shoreline projects control erosion, improve nearshore water quality by filtering water flowing from small tributaries and drainage channels flowing into Lake Erie.

Stream Buffers: The use of vegetative and/or forested buffers will be used where appropriate. Streamside trees, shrubs and native grasses prevent pollution from entering waterways, stabilize stream banks, provide food and habitat to wildlife, and keep streams cool during hot weather.

Nutrient Processing Wetlands and Surface Water Treatment Trains: Investments will be made in projects that treat nutrient-laden water derived from agricultural and urban lands using an engineered treatment train that consists of multiple wetland complexes. Scientists at Grand Lake St. Marys have developed a series of these wetlands and have reported phosphorus reductions up to 80 percent. Because of this success, ODNR has engineered wetland complexes where incoming water is captured upstream and pumped through the water control structure, then released into riparian or coastal wetlands designed to provide for sediment and nutrient reduction benefits. The water is then released through a water control structure or into a diked wetland where additional processing occurs before the water reaches the lake.

Stream Buffers, Riparian Restoration and In-field Wetlands: The use of vegetative and/or forested buffers and enhanced and/or restored riparian or in-field wetlands will be used where appropriate. These projects will be located within high phosphorus load areas in the Maumee and Sandusky River basins and combined with other best management practices (BMPs) to attain desired phosphorus reduction and water quality benefits. These projects will include planting streamside trees, shrubs or native grasses to prevent pollution from entering waterways, stabilize stream banks, and restore riparian fish and wildlife habitat that also improves water quality.

ODNR will pursue the following actions to implement projects that improve water quality within the Ohio Lake Erie basin, coastal and inland, as well as elsewhere in Ohio.

Lake Erie Coastal Zone

ODNR, in cooperation with local, state and federal agencies and using H2Ohio funding, will continue to fund and complete engineering and design work for potential in-water coastal wetland restoration projects in the western basin and Sandusky Bay that beneficially use dredged material and can help assimilate in-lake nutrients.

ODNR has completed two coastal wetland pilot projects recommended for Great Lakes Restoration Initiative funding by the U.S. Fish & Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NOAA), and U.S. Environmental Protection Agency (U.S. EPA) Great Lakes Coastal Conservation Working Group. These pilot projects reconnected existing degraded tributary and diked wetlands with Sandusky Bay resulting in restored nutrient processing functions and enhancing habitat connectivity with Sandusky Bay. These pilot projects serve as a template for the restoration of hydrologic connectivity of tributary and diked wetlands along the western basin shoreline of Lake Erie.

ODNR is using H2Ohio funds to renovate/enhance coastal diked wetlands to incorporate adjacent agricultural drainage where applicable and, if possible, installing fish passage structures which will (when Lake levels permit) allow free flow of lake water to the wetlands, thus improving water quality.

ODNR, through the Division of Wildlife, is working with partners to implement multiple wetland enhancement and restoration projects identified in the Sandusky Bay Initiative. These projects include the restoration of nature-based shoreline wetlands, creation of in-water wetlands and shallow shoals/islands to absorb wave energy and reduce sediment resuspension, and implementation of multiple projects to reconnect of tributary and diked wetlands to restore nutrient processing functions and enhance habitat connectivity with Sandusky Bay.

ODNR is and will continue to coordinate with and assist the USFWS/NOAA/U.S. EPA Great Lakes Coastal Conservation Working Group to develop and implement tools to identify potentially restorable wetlands for the western basin that incorporates landscape conservation design principles and goals, with a focus on restoring and conserving functional coastal wetlands that maximize sediment trapping and nutrient processing/reduction benefits. This has led to the development of multiple projects in targeted areas to reduce loading impacts in the western basin of Lake Erie.

ODNR, in cooperation with Ohio Sea Grant, has jointly funded projects to investigate and quantify nutrient processing and reduction benefits of coastal wetlands at the Old Woman Creek National Estuarine Research Reserve and other western basin wetlands through the H2Ohio Initiative. The information and data derived from these projects is assisting in the design and long-term management of on-the-ground nutrient and sediment reduction projects.

Lake Erie Conservation Reserve Enhancement Program Watersheds

The Lake Erie Conservation Reserve Enhancement Program (Lake Erie CREP) is a Federal program that provides 15 years of soil rental rate payments and cost share for the establishment of several different types of conservation practices on agricultural lands with a cropping history. ODNR, through the Division of Wildlife and its partners, are evaluating opportunities through the Lake Erie CREP to identify and develop projects in the eligible region that provide water quality benefits through enhancement and creation of riparian buffers and wetlands. These buffers may include planting streamside trees, shrubs or native grasses to prevent pollution from entering waterways; stabilization of stream banks, and the restoration of riparian fish and wildlife habitat structures that also improve water quality.

H2Ohio funds from ODNR are being used to incentivize the wetland restoration and wooded riparian buffer planting type projects by providing a one-time incentive payment of $2,000 per acre. This incentive payment is known as a water quality incentive payment. Thus, if a landowner is interested in planting a 4-acre wooded riparian buffer around a waterway on their property, they can receive:

- Cost share for establishing the practice through Lake Erie CREP.
- 15 years of incentivized soil rental rate payments through Lake Erie CREP.
- A $2,000 payment per acre on each of the 4 acres of the established practice, thus resulting in a one-time $8,000 H2Ohio incentive payment through the Ohio Department of Natural Resources (ODNR).

As of March 31, 2023, 153 landowners are participating in the program resulting in the restoration of 2,740 acres of wetlands and 94 acres of wooded riparian buffers. These projects are treating drainage from approximately 14,000 acres of watershed throughout the Lake Erie CREP area. Pending approval of the state budget July 1, 2023, the intention is to continue this incentivization structure in Lake Erie CREP and build a similar system into Scioto CREP offering $1500 per acre incentives for wooded riparian buffers and wetlands. The success of this effort is made possible through partnerships with Farm Service Agency, Natural Resource Conservation Service, Ohio Department of Agriculture, Ohio Soil and Water Conservation Districts, ODNR Division of Forestry, ODNR Division of Wildlife, Pheasants Forever and the United Stated Fish and Wildlife Service Partners for Fish and Wildlife Program.

For a landowner to participate in this program, they need to confirm eligibility with their local FSA office. If FSA determines they are eligible, they are automatically eligible to receive the water quality incentive bonus payment. For questions, contact Christina Kuchle, Wetland Habitat Program Administrator, Division of Wildlife: ***christina.kuchle@dnr.ohio.gov*** or 419-360-9448

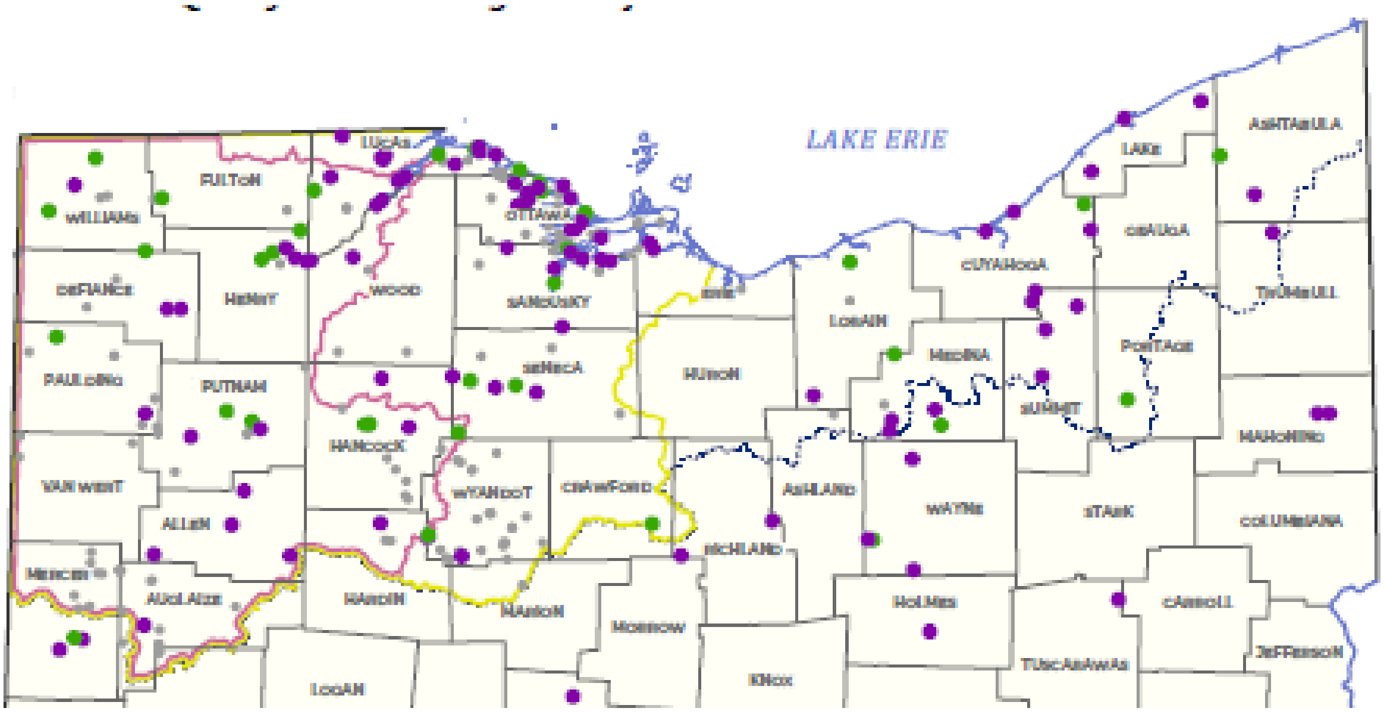


Figure D.1: Map of Lake Erie CREP region. Gray dots indicate the approximate location of projects receiving the $2,000 water quality incentive payment for either a Lake Erie CREP wetland or riparian buffer restoration.

Wetland Project Listing

This listing of ODNR wetland projects in the Lake Erie watershed was provided on August 30, 2023. More information about each project is available online by clicking on the project title. For the most up to date listing of projects, go to ***https://h2.ohio.gov/natural-resources/***.

Project Title	Partner	Funding Source	Project Status
Maumee River Watershed, Inland			
Maumee - St. Joseph's River Confluence Wetland Restoration	Black Swamp Conservancy	H2Ohio	Complete
Rotary Riverside Preserve	Black Swamp Conservancy	H2Ohio, OWDA	Complete
Goll Woods Wetland Extension	ODNR – Natural Areas and Preserves	H2Ohio,	Complete
Springville Marsh Wetland Connection	ODNR – Natural Areas and Preserves	H2Ohio, OWDA	Complete
Oak Woods Nature Preserve	Hancock Park District	H2Ohio	Complete
Van Order Wetland & Forest Restoration	ODNR - Forestry	H2Ohio	Complete
The Weisgerber-Pohlman Nature Preserve	Black Swamp Conservancy	H2Ohio, OWDA	Complete
Clark Island Restoration: Design & Engineering	Toledo Lucas County Port Authority	H2Ohio	Incomplete
Defiance East River Drive	City of Defiance	H2Ohio	Incomplete
Blanchard River Floodplain Reconnection	Maumee Watershed Conservancy	H2Ohio	Complete
Sugarcamp 7 Blanchard Habitat Project	Private Landowner	H2Ohio	Complete
Otsego Schools, Wood County	Black Swamp Conservancy	H2Ohio	Complete
OSU Montpelier High-P Wetland	The Ohio State University	H2Ohio	Incomplete
Independence Dam Canal Reconnection & Wetland Creation	ODNR - Parks	H2Ohio	Incomplete
Bright Conservation Area Wetland Restoration	Hancock County Park District	H2Ohio	Complete
Andreoff Wetland Restoration	Ducks Unlmited	H2Ohio	Complete
City of St. Mary's Treatment Train	City of St. Mary's	H2Ohio, Clean Ohio	Incomplete
St. Joseph's River Wetland Restoration	Black Swamp Conservancy	H2Ohio	Complete
Oak Openings Preserve Expansion	Metroparks Toledo	H2Ohio, Clean Ohio	Complete
Maumee – Forder Bridge Riparian Restoration	Black Swamp Conservancy	H2Ohio	Complete
Western Lake Erie Basin, Coastal			
Maumee Bay State Park Wetland Reconnection	The Nature Conservancy, Ohio EPA, U.S. EPA	H2Ohio, EPA	Complete
Little Portage Nutrient Reduction and Coastal Wetland Reconnection	Ducks Unlimtied	H2Ohio	Incomplete
Bohling Marsh Wetland Reconnection	Ottawa SWCD	H2Ohio	complete
Darby Refuge Wetland Reconnection	Ottawa SWCD	H2Ohio	complete
Maggie Marsh Turtle Creek Bay Wetland Reconnection	Erie SWCD	H2Ohio	Complete
Navarre Marsh wetland restoration and Reconnection	Ducks Unlimited	H2Ohio, GLRI	Incomplete
Mallard Club Nutrient Reduction and Orchid Restoration	Ducks Unlimited	H2Ohio, USFWS, NAWCA	Incomplete
Pickerel Creek Floodplain Restoration	The Nature Conservancy	H2Ohio	Complete
Moxley Wildlife Area Wetland Reconnection Project	Ducks Unlimited	H2Ohio	Incomplete
Pickerel Creek East & Bayshore Access	The Nature Conservancy	H2Ohio	Incomplete

Rust Tract Wetland Restoration	Ducks Unlimited	H2Ohio, GLFWRA, USFWS, CREP	Complete
North Ridge Hunt Club Restoration	Ducks Unlimited	H2Ohio, GLFWRA	Complete
Toussaint Shooting Club Reconnection	Ottawa SWCD	H2Ohio	Incomplete
Racoon Creek Nature Based Barrier Wetland	The Nature Conservancy	H2Ohio	Incomplete
Sandusky Bay Coastal Wetland Reconnections/Restorations	Projects in development	H2Ohio, HLEF, GLRI	Incomplete
Cedar Point Causeway Wetland – Sandusky Bay	City of Sandusky, ODNR	HLEF, GLRI	Complete
Western Lake Erie Basin, Inland			
Sandusky River, Redhorse Bend Wetland Restoration	Black Swamp Conservancy	H2Ohio	Complete
Lucas County, Ford Two Stage Ditch	Lucas County Engineer	H2Ohio	Incomplete
Buehler Farms Treatment Wetlands	Ottawa SWCD	H2Ohio	Complete
Clary-Boulee-McDonald Nature Preserve	Seneca County Parks	H2Ohio	Complete
Sanford Agricultural Drainage Treatment Train Project	Erie SWCD	H2Ohio	Incomplete
Fruth Outdoor Center, Wetland and Riparian Restoration	Seneca County Parks	H2Ohio	Complete
Crawford Park District, Sandusky Headwaters Preserve Wetland Restoration	Crawford Park District	H2Ohio	Complete
Central Lake Erie Basin			
Martin's Run Wetland and Stream Restoration Project	City of Lorain	H2Ohio	Complete
Chagrin River & East Branch Corridor Restoration & Protection Project	Chagrin River Watershed Partners	H2Ohio	Incomplete
Headlands Dunes Coastal Wetland Restoration Project	ODNR – Parks and Watercraft	H2Ohio, GLRI	Complete
Madison Village Park Wetlands	Village of Madison	H2Ohio	Complete
Fosters Run Restoration	Cleveland Metroparks	H2Ohio	Complete
Trumbull Creek	Stream and Wetland Foundation	H2Ohio	Complete

HLEF = Healthy Lake Erie Fund, GLRI = Great Lakes Restoration Initiative, DU = Ducks Unlimited, GLFWRA = Great Lakes Fish & Wildlife Restoration Act
USDA = U.S. Department of Agriculture, EPA= Environmental Protection Agency, NAWCA=North American Wetland Conservation Act,
REP= Conservation Reserve Enhancement Program
USFWS = U.S. Fish and Wildlife Service

Appendix E: Lake Erie Tributary Nutrient Monitoring Strategy

This appendix describes the nutrient monitoring strategy for Lake Erie tributaries. Water quality monitoring in the basin has been a focus for decades. Two principal pour points, on the Maumee and Sandusky Rivers, have near continuous nutrient loading records dating to the early 1970s. These stations were pivotal in documenting loading trends and identifying loading targets for nutrients following the resurgence of algal blooms in the western Lake Erie basin (WLEB). Recent efforts have focused on refining the monitoring to get data at secondary and tertiary locations particularly in the Maumee Watershed. The refined monitoring considers the recommendations made in a 2015 report from the Northeast-Midwest Institute completed in conjunction with U.S. Geological Survey (USGS) (Betanzo, 2015).

The Maumee River watershed in Ohio is more than 4 million acres of diverse landscape superimposed by one dominant land use: row crop production. Producers use a variety of management practices to ensure the productivity of their crops while preventing the loss of soil and nutrients from their fields. In the previous effort for the Collaborative Framework, watershed resources were analyzed considering the available data in the watershed. These data sources included water quality monitoring data, water quality modeling results from a comprehensive SWAT modeling effort, geographic soil distributions, analysis of soil slope, land use data and livestock inventories. A comprehensive summary of these data sources and how they were used is detailed later in this appendix.

Until recently there were 16 sites within the WLEB and Sandusky River watersheds that had sufficient water quality and flow data for nutrient load calculations. These sites are maintained by both the National Center for Water Quality Research (NCWQR) at Heidelberg University and the USGS. Funds for the load monitoring stations are from federal, state and local governments as well as private enterprises. These stations were chosen to better understand the impact of loading from different regions within the WLEB and provide data for nutrient loading trends. However, many of these stations have been added since 2007 – yielding a relatively brief dataset for trends analysis. Refer to the monitoring strategy, Appendix B, of the previous version of Ohio's Domestic Action Plan (2020) for more information about the history and funding of these stations.

The amount of time needed to detect changes in water quality decreases with watershed size (Betanzo, 2015). Therefore, a special focus is on areas where monitoring exists at scales smaller than 50 mi^2. Seven of the sites in Table E1 fit into the <50 mi^2 category. These small monitored watersheds are termed "sentinel" watersheds in this report.

The reason for prioritization at sentinel watersheds in the basin is to understand more quickly if targets are being achieved and provide feedback to what actions are most effective.

Tables E1 and E2 outline list the monitoring stations draining to the WLEB/Sandusky River basin and central basin, respectively. These tables include the sampling agency and data collection timeframe. Figures E1 and E2 show maps of monitoring stations draining to WLEB and Sandusky/central basin, respectively. On Figure E1, stations currently being monitored by the states of Michigan and Indiana are noted in addition to the stations monitored by Ohio parties.

Table E1: List of existing load monitoring stations in the Western Lake Erie Basin and Sandusky Bay within Ohio.

Geographic location	Monitoring Program Name	Sampling Agency	Timeframe
Maumee River near Waterville	Heidelberg Tributary Loading Program	NCWQR	1/10/1975-9/30/1978; 10/13/1981-current
Maumee River near Waterville	GLRI	USGS	continuous 2011-current – misc. WQ to '67
Sandusky River near Fremont	Heidelberg Tributary Loading Program	NCWQR	10/2/1974-current
Portage River at Woodville	Heidelberg Tributary Loading Program	NCWQR	8/30/2010-current
Blanchard River near Findlay	Heidelberg Tributary Loading Program	NCWQR	7/9/2007-current
Tiffin River at Stryker	Heidelberg Tributary Loading Program	NCWQR	7/9/2007-current
Honey Creek at Melmore	Heidelberg Tributary Loading Program	NCWQR	1/28/1976-current
Eagle Creek above Findlay	GLRI/city of Findlay	USGS	August 2012-current
Maumee River at Antwerp	WLEB ODNR and WLEB Ohio EPA (continuous probes)	USGS	2013 to current – misc. WQ back to 1952
Tiffin River near Evansport	WLEB ODNR	USGS	2013-current
Blanchard River near Dupont	WLEB ODNR	USGS	2013-current – misc. WQ back to 1966
Ottawa River near Kalida	WLEB ODNR	USGS	2013-current – misc. WQ back to 1966
Auglaize River near Defiance	WLEB ODNR	USGS	2013-current – misc. WQ back to 1952
Maumee River near Defiance	WLEB ODNR	USGS	2013-current – misc. WQ back to 1952
Auglaize River near Fort Jennings	WLEB ODNR	USGS	2013-current – misc. WQ back to 1965
Little Auglaize River at Melrose	WLEB Ohio EPA	USGS	2015-current
Auglaize River near Kossuth	WLEB Ohio EPA	USGS	March 2017-current
St. Marys River near Willshire	WLEB Ohio EPA	USGS	March 2017-current
St. Joseph River near Newville	WLEB Ohio EPA	USGS	March 2017-current
Sentinel watershed monitoring stations (draining areas less than 50 square miles)			
Unnamed Trib to Lost Ck nr Farmer	Heidelberg Tributary Loading Program	NCWQR	10/1/1981-9/30/1993; 10/1/2007-current
Rock Creek at Tiffin	Heidelberg Tributary Loading Program	NCWQR	October 1982-current
Little Flatrock near Junction	WLEB Ohio EPA	USGS	March 2017-current
Platter Creek near Sherwood	WLEB Ohio EPA	USGS	March 2017-current
Wolf Creek near Toledo at Holland	Expanded Heidelberg Tributary Loading Program	NCWQR	Begin October 2017
S. Turkeyfoot Creek near Shunk	Expanded Heidelberg Tributary Loading Program	NCWQR	Begin October 2017
West Creek near Hamler	Expanded Heidelberg Tributary Loading Program	NCWQR	Begin October 2017

Table E2: List of existing load monitoring stations in the central Lake Erie basin within Ohio.

Geographic location	Monitoring Program Name	Sampling Agency	Timeframe
Sites in the Central Basin			
Cuyahoga River at Independence	Expanded Heidelberg Tributary Loading Program	NCWQR	1981-current
Vermillion River near mouth	GLRI	USGS	2011-current
Black River at Elyria	GLRI	USGS	2011-current
Old Woman Creek near Huron	NOAA	NOAA?	May 2016-current
Grand River near Painesville	GLRI	USGS	Begin 2017
Huron River at Milan	GLRI/Expanded Heidelberg Tributary Loading Program	USGS/ NCWQR	2014-current / Begin October 2017

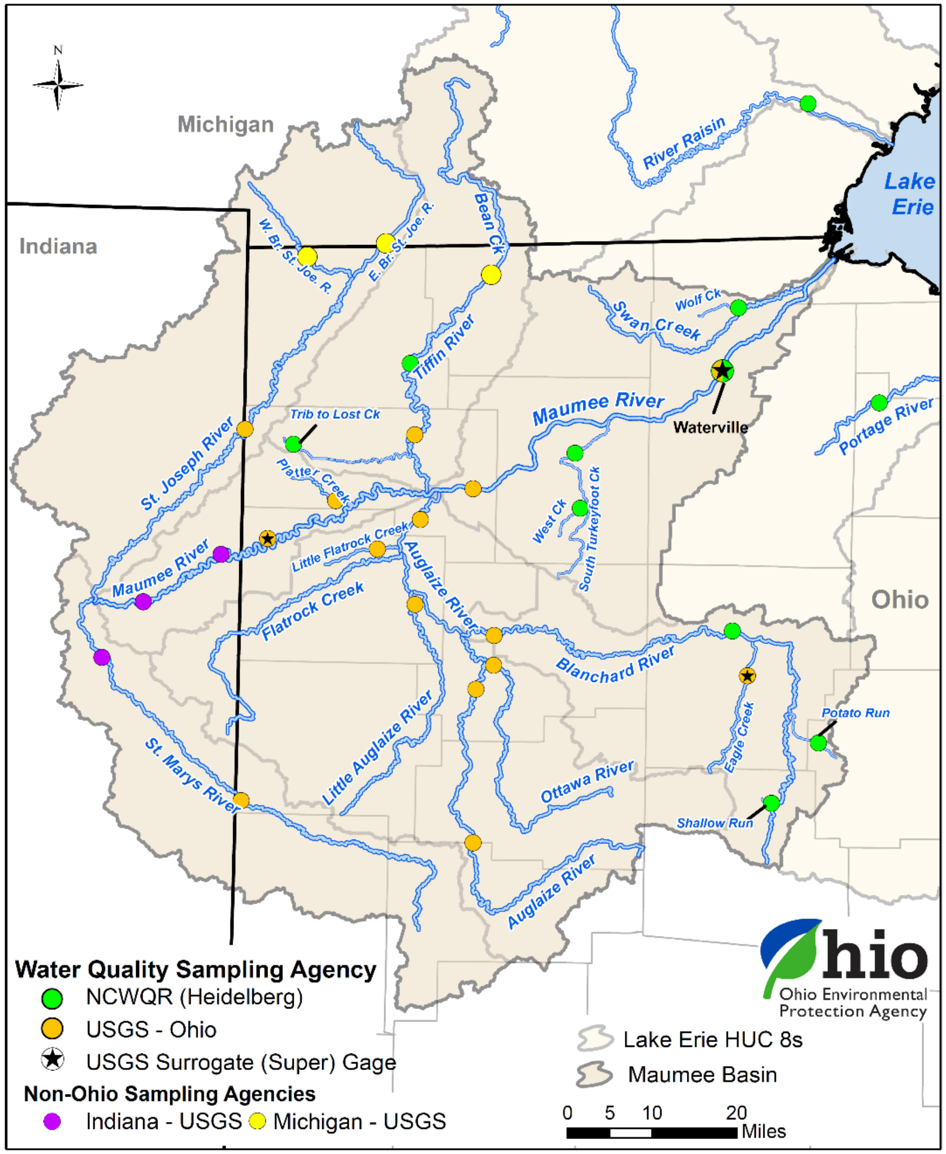


Figure E1: Existing load monitoring stations draining to the western Lake Erie basin.

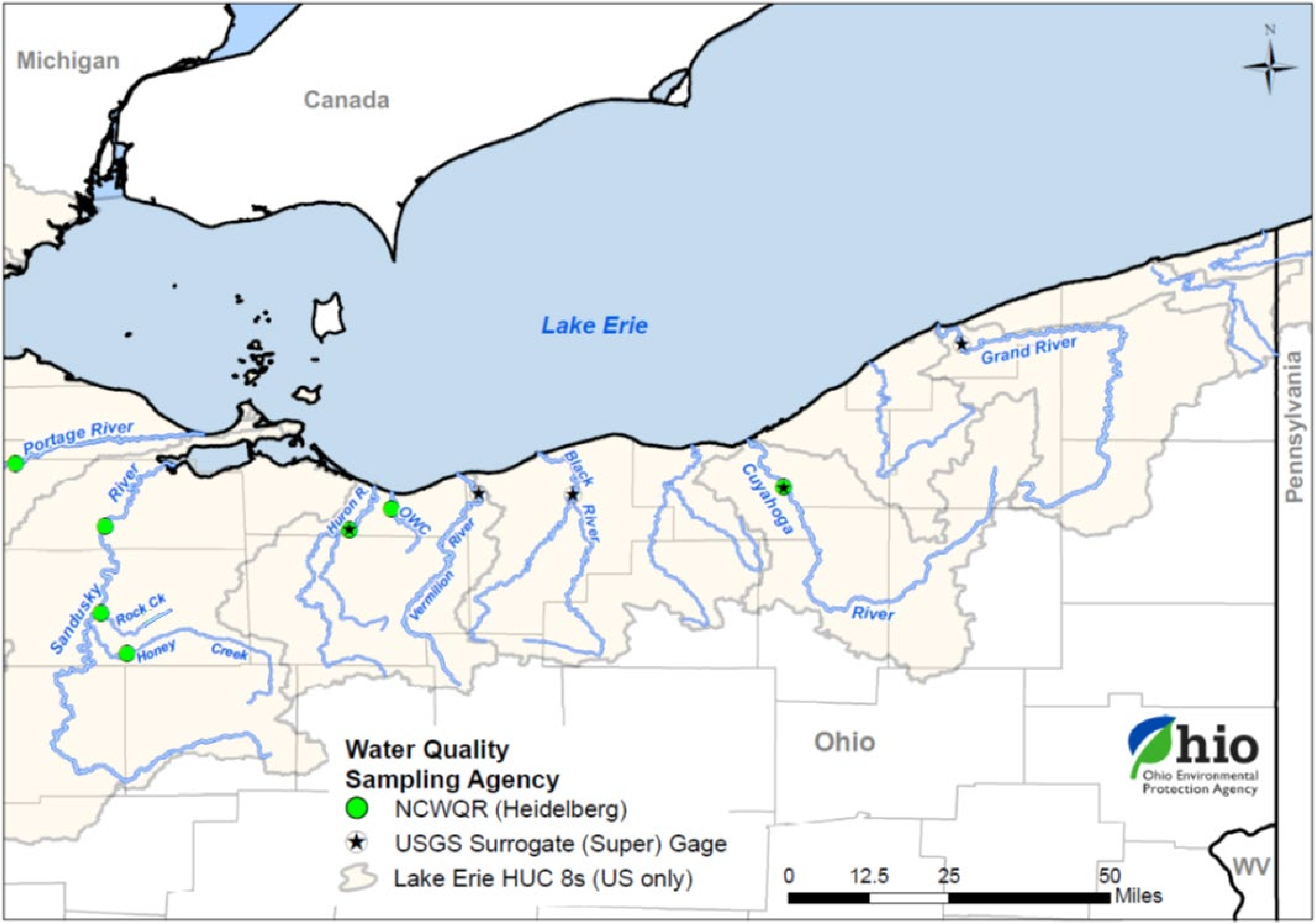


Figure E2: Existing load monitoring stations draining to the Sandusky Bay and central Lake Erie basins.

Sentinel Watersheds

A brief discussion of each sentinel watershed follows.

Unnamed Tributary to Lost Creek

This monitoring site drains a relatively small area that is less than five square miles within the Tiffin River watershed. Row-crop agriculture is the majority land use in this watershed, with some forest areas throughout; row crops do not dominate the land use as in many of the other sentinel watersheds. What makes this location unique is it has been monitored for greater than ten years. Among other reasons, this period of record could be useful in understanding hydrologic changes over time.

Little Flatrock Creek

Previous modeling efforts (Scavia, 2016) identified Little Flatrock Creek as a critical source area for dissolved reactive phosphorus (DRP). The influence of intense drainage practices and a high proportion of the land use dedicated to row crop agriculture were identified as the driving factors elevating DRP loading. Additionally, enhanced monitoring by Ohio EPA identified nutrient concentrations in Little Flatrock Creek that were consistently elevated above the three other sites monitored in the same program. Further, the size of Little Flatrock Creek (it drains 15 square miles at the monitoring location) makes it an ideal candidate for priority funding to assess watershed scale BMP implementation efforts on phosphorus loading.

Platter Creek

Manure management is often identified as an important component of phosphorus loading in the WLEB. Managing manure efficiently involves different challenges from using inorganic nutrients for row crop production. This can affect both the rate and timing of applications. Also, there is little watershed scale data that can be used to understand loadings in areas with higher portions of the land area being influenced by manure applications. Platter Creek has several large Concentrated Animal Feeding Operations (CAFOs) and is a good area to understand the influence of manure management on watershed loading. Further, the relatively small size of Platter Creek (it drains 19.5 square miles at the monitoring location) makes it an ideal candidate for priority funding to assess watershed scale BMP implementation efforts on phosphorus loading.

Wolf Creek

Wolf Creek differs from most of the focused monitoring areas because the land use is dominated by suburban development. While row crop agriculture dominates the greater basin and bears the largest share of the nutrient load, it is important to understand the role of the urban and suburban community. This subwatershed was also part of the Natural Resource Conservation Service's (NRCS) Regional Conservation Partnership Program (RCPP) and continued monitoring will serve to understand the influence of a different subset of BMPs on phosphorus loading in the Maumee Basin.

South Turkeyfoot Creek/West Creek

These two watersheds have been a part of the RCPP administered by NRCS. They are also representative of an area that has a very high portion of the land use dedicated to row crop agriculture. The soils are highly productive and generally respond well to tile drainage. Prior monitoring in the basin and its representativeness of a large segment of the agriculture in the basin are reasons for continuing the monitoring effort at these sites. The West Creek sampling station is nested within the South Turkeyfoot Creek Watershed. The understanding of scale and nutrient routing through the basin was a deciding factor in deciding to nest this gaging station. Further, the size of West Creek (it drains 15.5 square miles at the monitoring location) makes is an ideal candidate for priority funding to assess watershed scale BMP implementation efforts of phosphorus loading.

References

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Scavia, D., Kalcic, M., Logsdon Muenich, R., Aloysius, N., Boles, C., Confesor, R., DePinto, J., Gildow, M., Martin, J., Read, J., Redder, T., Robertson, D., Sowa, S., Wang, Y., Yen, H. 2016. "Informing Lake Erie Agriculture Nutrient Management via Scenario Evaluation." Water Center, University of Michigan. ***http://graham.umich.edu/water/project/erie-western-basin.***

Appendix F: Annex 4 Priority Tributary Targets

Introduction

Water year 2008 has been determined the baseline year by which to calculate the Annex 4 springtime HAB TP and DRP and annual TP hypoxia targets. U.S. EPA (2018) notes there is high confidence in the lake-wide and some tributary (e.g. Maumee and Sandusky) total loads for wy 2008. Both the Maumee and the Sandusky rivers were continuously monitored by Heidelberg's National Center for Water Quality Research (NCWQR) in 2008, and long before. However, several Annex 4 priority Lake Erie tributaries were not being continuously monitored in 2008. There have been various efforts to estimate 2008 phosphorus loads for these rivers with which to base reduction targets upon. The Ohio Domestic Action Plan 2020 (OLEC, 2020) included targets for the Portage River. This appendix presents loading information and recommends that the Annex 4 subcommittee re-evaluate phosphorus targets for the Ohio priority tributaries Toussaint, Portage, Huron, and Grand rivers.

Monitoring information availability

NCWQR began continuous water quality monitoring at the Portage River at Woodville OH USGS gage (number 04195500) in 2010. Data from this monitoring is available for the complete water years (wy) 2011 through 2022.

NCWQR began continuous water quality monitoring at the Huron River at Milan OH USGS gage (number 04199000) in 2018. Data from this monitoring is available for the complete wy 2018 through 2022.

Continuous water quality monitoring by NCWQR at the Grand River near Painesville OH USGS gage (number 04212100) occurred from 1989 to 2006. Regular nutrient monitoring of this river has not occurred since 2006.

The final Ohio priority Lake Erie tributary with Annex 4 recommended targets is the Toussaint Creek. This stream drains the smallest area of all Ohio priority tributaries; 143 square miles (ODNR, 2001). The next smallest priority tributary watersheds are the Huron, at 406 square miles, and the Portage, 581 square miles. There is no existing or previous USGS stream flow gage on the Toussaint Creek. In discussions with USGS, Ohio EPA has learned that due to an excessively long reach of regular lake-backwater conditions, stream gaging of the Toussaint would be much more costly than regular stream gaging. Ohio EPA did semi-regular stream discharge and water quality monitoring of Toussaint Creek and its largest tributary Packer Creek upstream of the zone believed to be impacted by backwater in 2017-2019. However, backwater conditions impacted this monitoring despite these efforts, most likely exacerbated by lake water levels much higher than long term averages during this period. The resulting information from the data collected is therefore of much reduced value compared to the tributaries with USGS stream discharge and NCWQR water quality monitoring.

Table F1 summarizes the period of time with high quality water available water quality monitoring information.

Table F1: Period of record of continuous water quality information (from NCWQR) for Annex 4 priority Lake Erie tributaries in Ohio.

River	Period of record
Maumee	1975-2022
Toussaint	No data available.
Portage	2011-2022
Sandusky	1975-2022
Huron	2018-2022
Grand	1989-2006

Target Considerations

Portage River

The Annex 4 targets document (Annex 4, 2015) uses a loading period that starts in 2002. Observations from the year 2008 were used for the baseline of reduction targets. Water quality monitoring of the Portage River with adequate frequency to estimate nutrient loads started in the 2011 spring season. However, stream discharge records are available for the Portage River back through 2002.

In the Ohio DAP 2020, Ohio EPA presented a method for Portage River reduction targets. The Maumee and Portage streamflow percentiles were compared for the period 2002-2017. The analyses suggested that the 2011 Portage River streamflow was a close enough equivalent to 2008 for its loads to be used as a basis for Portage River reduction targets. Load targets were set by applying a 40 percent reduction to the observed loads in that 2011 base year.

The base year of 2008 was identified because it represented a 90^{th} percentile condition. The Portage spring streamflow discharge for 2011 is the highest observed for 2002-2022 and is actually at the 100^{th} percentile. This resulted in a higher loading target. Using 2011 as the year on which to base targets in the Portage results in the Portage TP target having been met in all but one spring season 2012-2022, and the DRP target meets in seven of those eleven spring seasons. However, sufficient phosphorus pollutant reduction actions have not yet been documented in the Portage River watershed to justify considering that its targets are largely met.

Table F2 presents the streamflow rank and percentiles for the each of the 2002-2014 spring seasons of the Maumee, Portage, Sandusky, and Huron rivers. Note that this analysis does not includes the spring seasons for 2015 through 2017 like the previous evaluation. The 2015 spring season flows exceeded any in the 2002-2014 period for the Maumee. Dropping this year is appropriate for this application because the stream flows and loads are less similar to the period of record considered by the Annex 4 targets setting exercise. The Annex 4 Subcommittee has not yet proposed changing targets due recent observations of stream discharge. Table F2 shows that 2011 experienced the greatest streamflow for all rivers in this time frame (not including 2015).

Table F2: Spring streamflow rank and percentile in parenthesis for 13 of the Maumee, Portage, Sandusky, and Huron rivers. Highest flow is ranked 1 in each column.

Spring Season	Streamflow Rank (Percentile)			
	Maumee	**Portage**	**Sandusky**	**Huron**
2002	9, (33^{rd})	10, (25^{th})	9, (33^{rd})	11, (17^{th})
2003	2, (92^{nd})	3, (83^{rd})	4, (75^{th})	6, (58^{th})
2004	8, (42^{nd})	11, (17^{th})	5, (67^{th})	3, (83^{rd})
2005	12, (8^{th})	12, (8^{th})	12, (8^{th})	9, (33^{rd})
2006	11, (17^{th})	8, (42^{nd})	10, (25^{th})	12, (8^{th})
2007	10, (25^{th})	9, (33^{rd})	8, (42^{nd})	7, (50^{th})
2008	3, (83^{rd})	2, (92^{nd})	2, (92^{nd})	2, (92^{nd})
2009	7, (50^{th})	6, (58^{th})	11, (17^{th})	8, (42^{nd})
2010	4, (75^{th})	5, (67^{th})	6, (58^{th})	10, (25^{th})
2011	1, (100^{th})	1, (100^{th})	1, (100^{th})	1, (100^{th})
2012	13, (0)	13, (0)	13, (0)	13, (0)
2013	6, (58^{th})	4, (75^{th})	3, (83^{rd})	4, (75^{th})
2014	5, (67^{th})	7, (50^{th})	7, (50^{th})	5, (67^{th})

Table F3 shows the percentile rank for each of the rivers' spring seasons' streamflow in each year 2015-2022 based on the 2002-2014 spring season streamflow distributions (documented in Table F2). Given these flow statistics, 2017 appears to be a more appropriate baseline spring season for which to base phosphorus reductions. That season's flows ranks at the 89^{th} percentile of the 2002-2014 distribution which is in line with the Annex 4 baseline loading target settings work.

Table F3: Spring streamflow percentile rank for 2015-2022 of the Maumee, Portage, Sandusky, and Huron USGS gages using the 2002-2014 streamflow distribution.

	2002-2014 Streamflow Percentile Rank			
Spring Season	Maumee	Portage	Sandusky	Huron
2015	Exceeds	97th	86th	83rd
2016	27th	55th	25th	43rd
2017	94th	89th	66th	52nd
2018	44th	51st	33rd	42nd
2019	100th	97th	85th	73rd
2020	34th	33rd	30rd	62nd
2021	33rd	61st	32nd	55th
2022	43rd	51st	29th	47th

It is important to consider whether substantial phosphorus reductions had occurred prior to 2017 going back to 2008. Figure F1 presents the Portage spring TP and DRP loads for all spring seasons with available NCWQR data (2011-2022). Of the twelve seasons with continuous loading data for the Portage, 2017 had the third greatest TP and DRP loads. The Ohio Domestic Action Plan was not adopted by 2017, nor had H2Ohio started. The Annex 4 Subcommittee is currently evaluating flow-normalized trends for all Lake Erie tributaries with robust water quality monitoring, and the Portage is included (U.S. EPA, 2023). This analysis indicates that there is no evidence of phosphorus reductions due to recent actions in the Portage River to date.

Based on this information, Ohio proposes that 2017 be used as the baseline year for calculating updated Portage River targets. It is important to note that this proposal would lower the previously proposed targets by the state and the water year target included in the U.S. Action Plan (U.S. EPA, 2018).

Figure F1: Spring season TP (top) and DRP (bottom) loads for the Portage River.

Huron River

Only five years (2018-2022) of continuous water quality data exist for the Huron River. Like the Portage River, streamflow discharge has been gaged on the Huron for a much longer period of record. Tables F1 and F2 above, include stream flow statistics for the Huron River. Table F2 shows that the streamflow in years where water quality data exists, none fall within the 80th to 90th percentile used to justify the 2008 baseline conditions for Annex 4 targets.

Figure F2 below shows the TP and DRP flow weighted mean concentration (FWMC) for each spring season of the Maumee, Portage, Sandusky, and the Huron (2011-2022). For the five years of available data, the Huron's TP FWMCs appear to in line with these other water Lake Erie tributaries. However, the Huron's DRP FWMCs are notably lower. The average spring season DRP FWMC for the Maumee, Portage, and Sandusky in 2018-2022 is 0.08 mg/L and the Huron is 0.05 mg/L. Note that 0.05 mg/L is the DRP FWMC that corresponds to the Maumee River Annex 4 DRP load target.

Figure F2: Spring season TP (top) and DRP (bottom) FWMC for the Maumee, Portage, Sandusky, and Huron rivers, 2011-2022. Huron data only available 2018-2022.

The first line of investigation of the Huron's reduced DRP considers relative stream flows. Figure F3 (next page) shows each river's stream discharge normalized to its watershed area. A visual review of these results shows that the Huron's spring season stream flow is within the same range as the other tributaries.

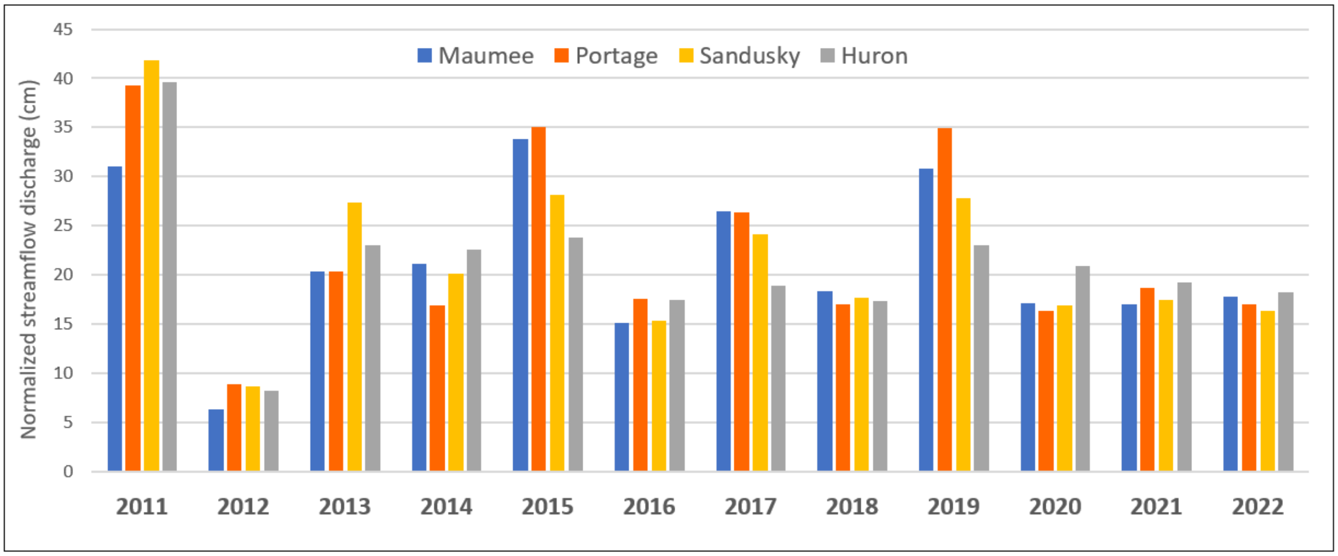

Figure F3: Spring season normalized streamflow discharge for the Maumee, Portage, Sandusky, and Huron rivers, 2011-2022.

Comparing nutrient loads to actual, non-normalized stream discharge is also a useful examination. Such a simple linear regression is regularly used to demonstrate that loads directly, and positively, respond to stream discharge (e.g., the critical source area review in the Maumee Watershed Nutrient TMDL report, Ohio EPA, 2023). Figure F4 shows DRP loads plotted against stream discharge for all four rivers considered here. Note that the bottom panel zooms into the lower aspect of both scales to present the Portage and Huron points in full resolution. The regression analysis of these data for the Maumee, Sandusky, and Portage show the expected strong correlation. The three streams R^2 statistic range from 0.86-0.87, with very similar slopes ranging from 0.092-0.107 (in the units as presented on Figure F4) and with reasonable predication residuals. Such a relationship is not observed for the Huron results, with an R^2 of 0.02. Despite only five seasons of observations, this suggests that the Huron DRP export may not behave in a similar fashion as the other streams.

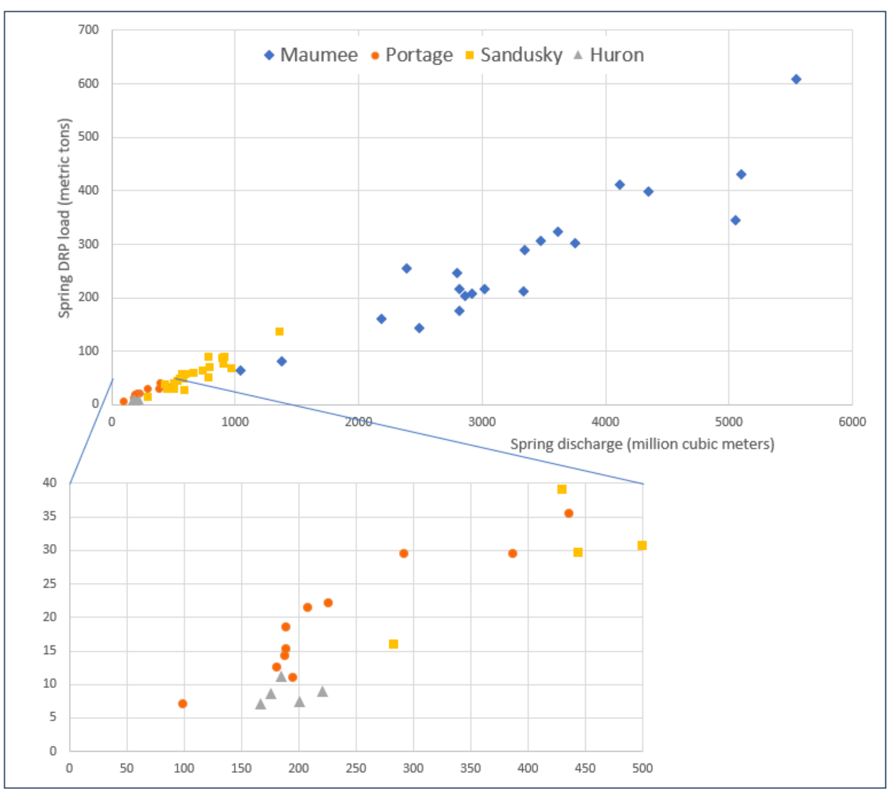

Figure F4: Spring season DRP loads plotted against stream discharge for the Maumee, Portage, Sandusky, and Huron, 2002-2022. Portage data available 2011-2022. Huron data available 2018-2022. Top panel full scale, bottom panel zoomed in to show all Portage and Huron points at greater resolution.

Further investigation into the nature of Huron's DRP export considers suspended solids. Figure F5 presents the FWMC of suspended solids for the four rivers. The Huron's suspended solids concentrations are visible greater than the other streams. The Huron's suspended solids FWMC five-year average is 263 mg/L compared to the average of the other three streams for 2018-2022 of 167 mg/L. A similar regression analysis as carried out for DRP loads versus discharge was developed for suspended solid loads versus discharge. That analysis, not shown in this appendix, found the Huron suspended solids to discharge to have better agreement than the DRP (R^2 of 0.23), but not as strong as the other streams (R^2 ranging from 0.64-0.79). Also, the Huron's regression slope was greater than the other streams, which is expected given its higher FWMCs.

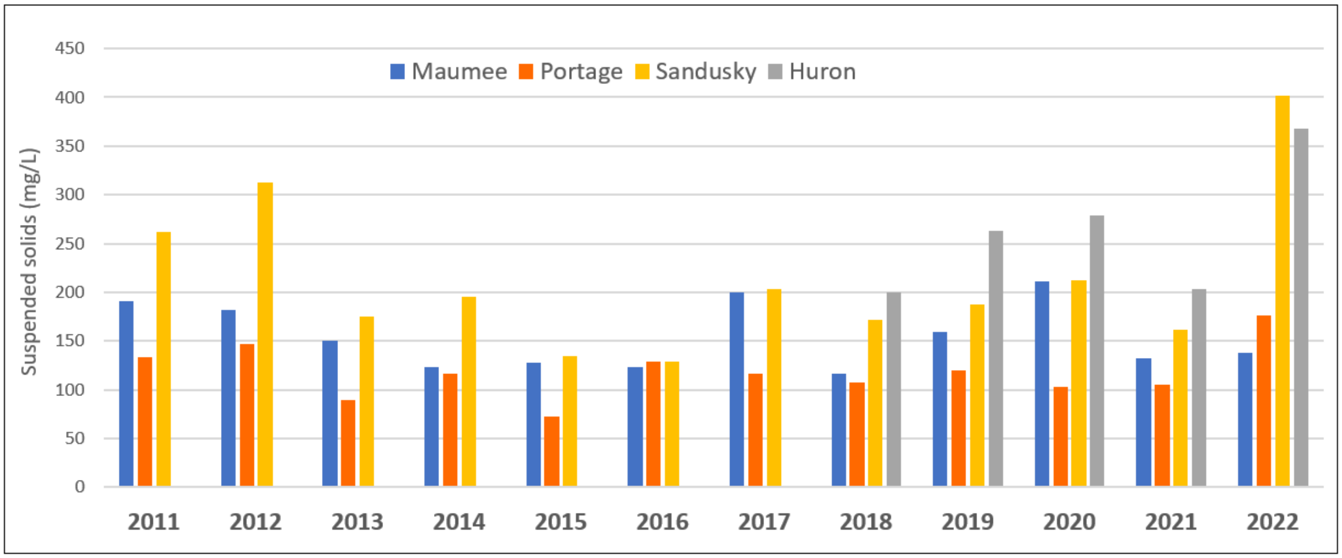

Figure F5: Spring season suspended solids FWMC for the Maumee, Portage, Sandusky, and Huron rivers, 2011-2022. Huron data only available 2018-2022.

Overall, the information presented here indicates that the Huron River's phosphorus export is of a different nature than the Maumee, Portage and Sandusky rivers. The similar TP concentrations but reduced DRP concentrations indicate that Huron exported phosphorus is relatively greater in the particulate form. The greater suspended solids in the Huron may indicate instream dissolved phosphorus sorption to fine particulates, especially in higher flow conditions that carry a large share of the total load. This phenomenon has been suggested in recent literature, see King, et al., 2022. These observations likely reflect differences in land use (e.g., percentage of natural lands) and geography (e.g., soils and slopes) compared to the other rivers.

The form of exported phosphorus is of great import when considering load reduction targets aimed at curbing downstream HABs. Phosphorus exported in the Huron more in the particulate form may indicate that less overall phosphorus reduction needs to occur compared to the other watersheds. It is recommended that more observations be conducted prior to setting numeric load reduction targets for the Huron River. Ideally, this improved understanding will suggest phosphorus reduction actions that do not unintentionally shift phosphorus exports from the particulate to dissolved form which may yield unintended consequences.

The U.S. Action Plan for Lake Erie (U.S. EPA, 2018) included a water year target of 123 metric tons TP for the Huron to address Central Basin hypoxia. This target applies to the entire watershed, therefore it cannot be compared to the loads at the pour point. Ohio's Nutrient Mass Balance has calculated the entire Huron watershed's TP load for wy 2018 through 2021. Of these four years, the Huron met the water year target in 2021 with a total watershed load of 118 metric tons (Ohio EPA, 2022).

Grand River

The Grand River drains a very different watershed than the Maumee and Sandusky rivers. The mouths of the Maumee and the Grand are over 100 miles (Euclidean distance) apart. The Grand drains to the Central Basin of Lake Erie while the Maumee River drains to the Western Basin of Lake Erie. The Sandusky River drains to the large Sandusky Bay which enters Lake Erie at the boundary of the Western and Central basins of Lake Erie.

The hydrology experienced by the Grand River varies greatly from the Maumee and Sandusky. NCWQR data exist for the Grand River for water years 1989 through 2006. Figure F6 shows the FWMC for each of those water years for the Maumee, Sandusky, and Grand rivers. Clearly the Grand River has much lower TP concentrations. As documented by Maccoux et al., 2016 and Rowland et al., 2021, TP reductions to Lake Erie stabilized in the early 1990s. In this time period an average TP FWMC for the Maumee, Sandusky, and Grand rivers were 0.37, 0.38, and 0.12 mg/L, respectively. The Grand's TP concentration was regularly about a third of the other rivers. Note that the TP FWMC corresponding to the Maumee River load target is 0.23 mg/L.

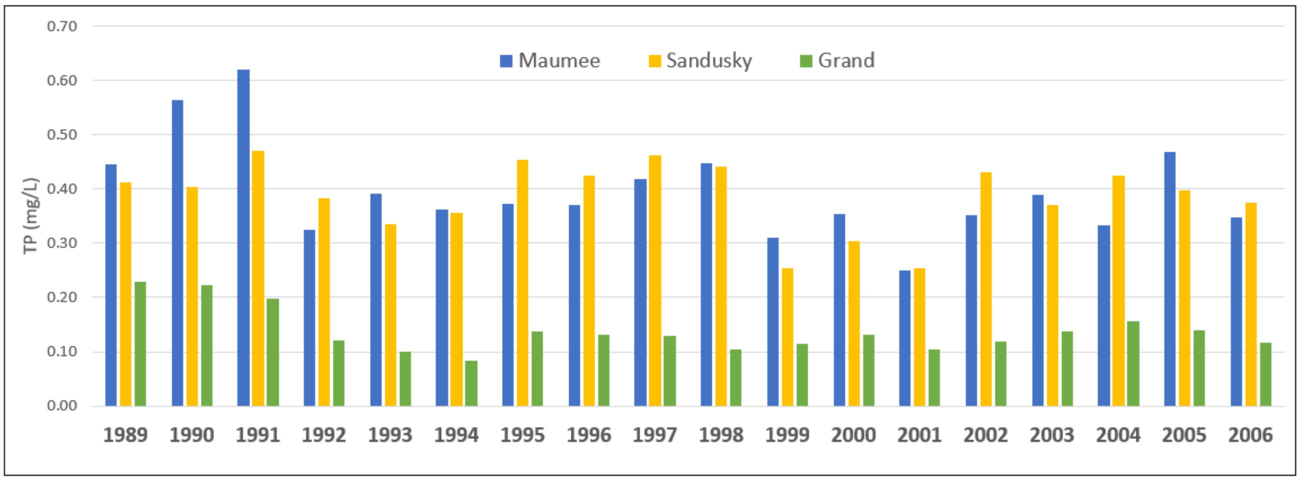

Figure F6: Water year TP FWMC for the Maumee, Sandusky, and Grand rivers, 1989-2006.

The hydrology of the Grand River watershed is also very different than the Maumee and Sandusky watersheds. Figure F7 compares each river's stream discharge normalized to its watershed area. On average the Grand drains about two thirds more water, per area, than each of the other rivers. A similar analysis to that presented in Figure F4 was carried out for the TP loads verses actual stream discharge for the Maumee, Sandusky, and Grand rivers for water years 1992-2006. As expected, TP load positively correlates with discharge for all three rivers (R^2 ranging from 0.82-0.90). Figure F8 plots this relationship for the Sandusky and Grand. It is evident that the Grand's TP load response to stream flow is subdued with a slope of 0.14, in the units used in Figure H8, compared to 0.49 for both the Maumee and Sandusky.

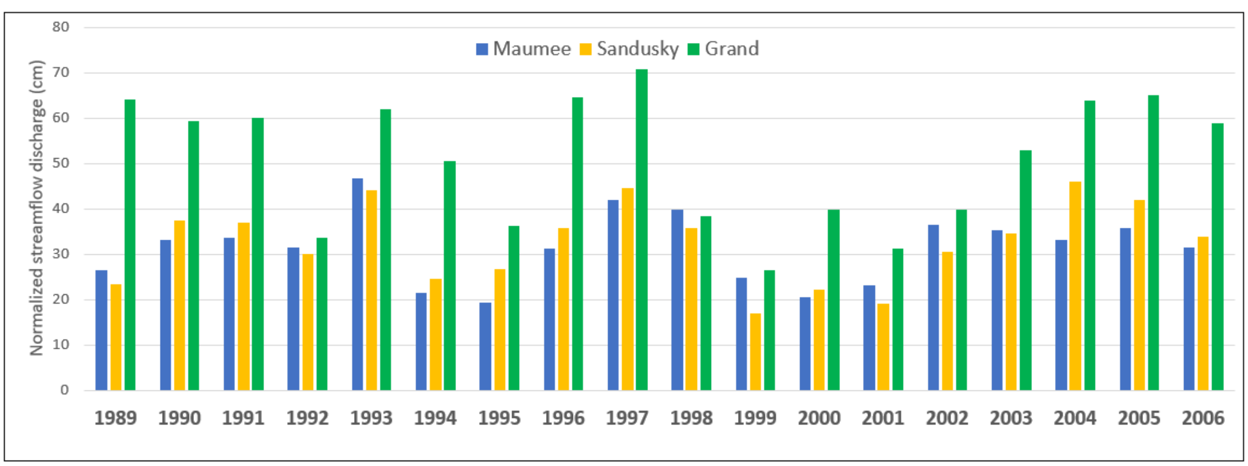

Figure F7: Water year normalized streamflow discharge for the Maumee, Sandusky, and Grand rivers, 1989-2006.

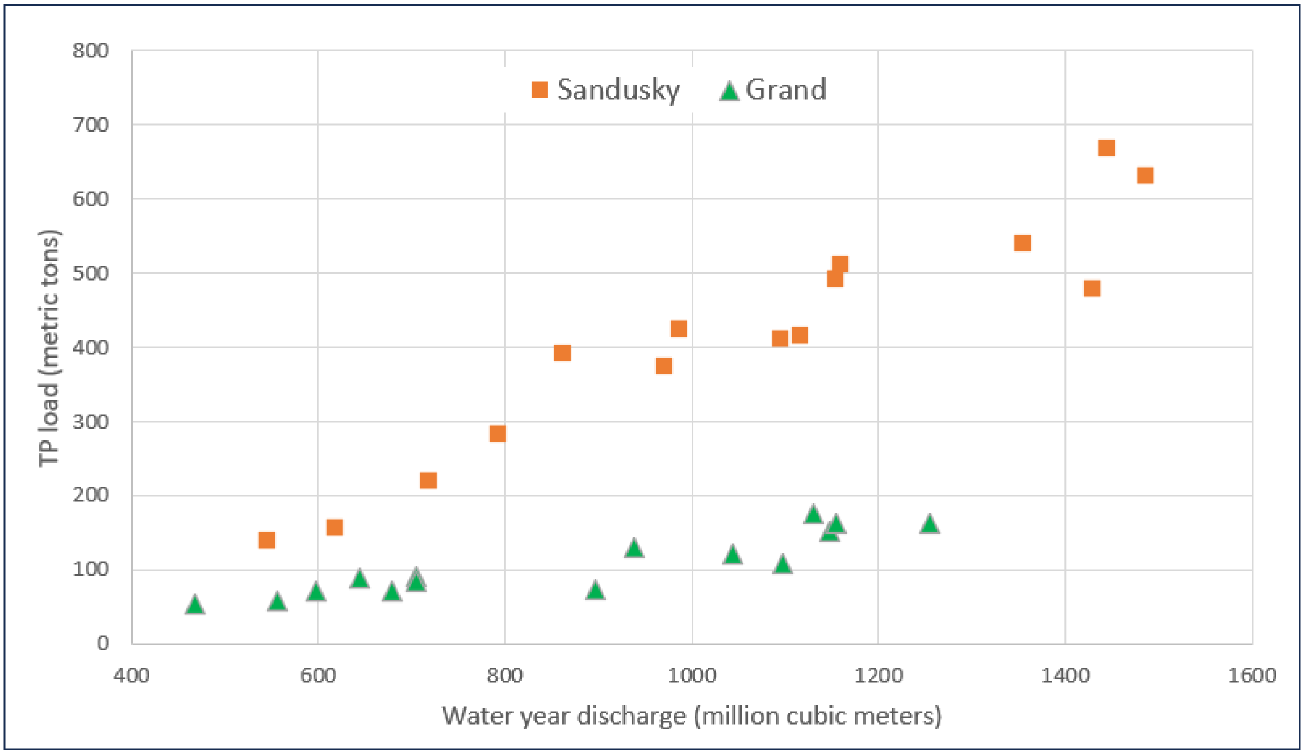

Figure F8: Water year TP loads plotted against stream discharge for the Sandusky and Grand, 1992-2006.

This information suggests that the Grand River, at least up until 2006, did not contribute an excessive amount of phosphorus to Lake Erie, especially as compared to the Maumee and Sandusky rivers. With an average TP FWMC of 0.12mg/L, an expectation of further phosphorus reduction from the Grand River to address Central Basin Lake Erie seasonal hypoxia may not be warranted. In fact, such an expectation may shift resources away that are clearly needed in the Lake Erie tributaries west of the Grand River. Therefore, Ohio requests that the Annex 4 subcommittee consider other recommendations for the Grand River. This could include support to bring back regular monitoring of the Grand, a reevaluation of the drivers of Central Basin hypoxia, and/or removing the Grand River as a priority tributary.

Summary of Annex 4 priority tributary targets recommendations

This appendix provides analysis to support developing updated/revised phosphorus targets for Annex 4 priority Lake Erie tributaries in Ohio that did not have robust monitoring in 2008. The following summarizes each tributary considered:

Toussaint: This is a very small watershed that has never had regular water quality monitoring. Due to its geographic placement, between the Maumee and Portage watersheds, it very likely contributes phosphorus at a relatively high rates. However, given its small watershed the overall phosphorus delivered is very minor compared to the other tributary watersheds considered. Furthermore, most Ohio pollution implementation reduction efforts aimed at western basin of Lake Erie tributary watersheds cover this watershed. Given these factors, and considering the difficulty in monitoring this watershed, Ohio recommends that the Annex 4 subcommittee remove this tributary from the priority list.

Portage: This appendix documents that the earlier Ohio DAP's proposed targets for the Portage were inappropriately high. This analysis proposes that using 2017 may be a more appropriate year/spring season to base a 40 percent phosphorus load reduction. In order to ensure that this is a sound approach, Ohio recommends that the Annex 4 subcommittee consider this information.

Were 2017 used as the base year for reductions, the TP target at the Portage River monitoring point for the water year would be 81 metric tons. The spring season targets at the monitoring point would be 69 and 18 metric tons for TP and DRP, respectively.

Huron: This appendix documents that the phosphorus export from the Huron watershed is different in nature than the other tributaries considered. Some analyses and concepts are proposed as to why this might be the case. Ohio recommends that the Annex 4 subcommittee examine this information and would like to work with the subcommittee to help better understand this watershed. This appendix asserts that this deliberation is prudent in order to avoid unintentionally increasing the dissolved portion of phosphorus export from the Huron watershed.

The existing water year TP target in the U.S. Lake Erie Action Plan (U.S. EPA, 2018) is adequate to maintain at this time.

Grand: Using water quality data that is several decades old, this appendix documents that the phosphorus exported from the Grand River watershed is much lower than other assessed tributaries. Estimates of recent Grand River TP loads are based on very sparse data. Ohio recommends the Annex 4 subcommittee consider supporting reinstating some level of regular monitoring of the Grand, a reevaluation of the drivers of Central Basin hypoxia, and/or removing the Grand River as a priority tributary. For the time being, the US Action Plan for Lake Erie (U.S. EPA, 2018) water year target of 99 metric tons of TP is appropriate.

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