Michigan's Adaptive Management Plan to Reduce Phosphorus Loading into Lake Erie

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EGLE
MICHIGAN DEPARTMENT OF
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On the cover: *center - Great Lakes map highlighting Lake Erie in dark blue, with image of the Detroit River mouth in the background (adapted from Michigan Sea Grant)*

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This document has been prepared by the state's Michigan Lake Erie Domestic Action Plan (DAP) Team, a senior management working group from the Michigan Quality of Life Departments including Environment, Great Lakes, and Energy; Agriculture and Rural Development; and Natural Resources. Deserving of acknowledgment is the tremendous technical support by agency staff who have assisted with the development and implementation of the Plan. We would also like to acknowledge and thank our stakeholders who provided important input and feedback into the development process.

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EXECUTIVE SUMMARY

Lake Erie, Michigan's warmest and shallowest Great Lake, has experienced impacts from harmful algal blooms (HABs) fueled by excess phosphorus and other factors in the Western Lake Erie Basin, and a Central Basin hypoxic or "dead zone" at the bottom of the lake, where dissolved oxygen is depleted during the summer and fall. The causes are complex and binational natural resource agencies are working to fully understand them. Specific ecosystem goals, actions needed, and frameworks for measuring progress toward meeting the ecosystem improvement goals have been set through the Great Lakes Water Quality Agreement, Annex 4 (Nutrients) Subcommittee.

Who Is Doing the Work? Michigan's Role in Addressing HABs & Hypoxia

In February 2018, the state released the Michigan Lake Erie Domestic Action Plan (DAP) that provided the road map for reducing phosphorus entering Lake Erie by 20 percent by 2020, and 40 percent by 2025. The state of Michigan's DAP Team agencies play critical management and technical roles in achieving Annex 4 goals, along with supporting internal policy development.

- The Department of Agriculture and Rural Development oversees or facilitates agricultural conservation programs that contribute to nonpoint source (NPS) nutrient load reductions under a variety of federal and state programs, including Michigan Agricultural Environmental Assurance Program (MAEAP).
- The Department of Environment, Great Lakes, and Energy, Water Resource Division, has responsibility for permitting point sources, monitoring tributary nutrient loads, and assisting partners with the watershed planning and implementation efforts.
- The Department of Natural Resources monitors fish and wildlife habitats and populations and works with partners to protect and restore them in Lake Erie and associated tributaries.

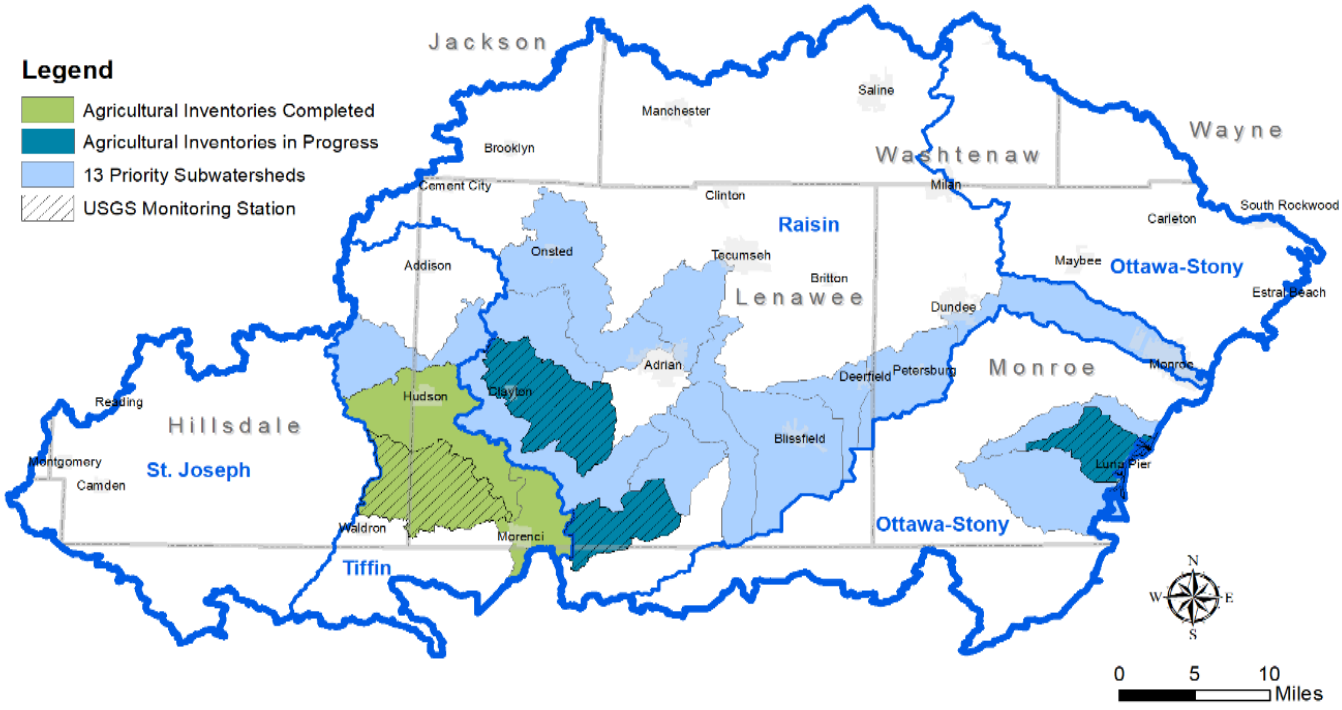
The DAP Team is transitioning from a "passive" to "active" adaptive management process to meet DAP goals. Active adaptive management provides for the use of scientific outcomes and experimentation to guide the best direction for achieving the phosphorous reductions in the basin. The DAP Team is using the Taking Action on Lake Erie website to provide more frequent updates on progress, and will be developing joint annual progress reports and two-year work plans, along with five-year DAP updates that will capture lessons learned, spell out commitments of responsible agencies and key partners. Tracking progress through these efforts will also help align funding, other resource needs, and research with agency management commitments. This regular and predictable planning, assessment, and reporting cycle, with feedback from a WLEB science-based advisory group, is designed to give managers and stakeholders more confidence and empowerment in the collaborative process of tackling Lake Erie's nutrient issues together.

What is The Nonpoint Source Challenge?

As a result of point source reductions from wastewater treatment plants, Michigan has met the aspirational goal of a 20 percent phosphorus load reduction by 2020. Beyond the need to maintain key wastewater treatment facilities in compliance with their reduced phosphorus effluent limits, it will be necessary to focus on NPS management actions in the River Raisin Watershed and Upper Maumee Watersheds to meet the 2025 DAP goals. Historical random efforts to implement NPS BMPs have not been successful at meeting our 2025 goals.

Where & How to Meet the Challenge? Focusing Conservation in the Right Places

To meet the NPS challenge, the DAP Team believes a more focused and accelerated activities are necessary at localized and subwatershed levels to better understand the current conditions on the landscape and focus on the implementation of BMPs to reduce agricultural nonpoint source pollution delivery to Lake Erie. The state is planning and implementing agricultural inventories in 13 priority subwatersheds in the Bean Creek and River Raisin Watersheds. Additional U.S. Geological Survey water quality gaging stations have been installed in key subwatersheds to assess this more targeted BMP implementation approach and to better detect changes at the subwatershed level (see hatched subwatershed in graphic below).



Michigan's Western Lake Erie Basin 13 priority agricultural inventory subwatersheds, including completed and in progress projects. [Note: The Tiffin River Watershed is known as the Bean Creek Watershed in Michigan.]

The Agricultural Inventory process, first developed by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), uses a modeling component, a desktop analysis component, and a field-by-field inventory of cropping systems on agriculture fields, to collect and organize specific land use data for evaluating and prioritizing sites that have the potential to address existing resource concerns that influence water quality. This data and prioritization of sites will be used to further refine the local watershed management planning process and be used by Conservation District staff to help prioritize BMP implementation and engage landowners on opportunities to implement BMPs to address agricultural nonpoint source pollution concerns on the land.

The following implementation actions are ranked in order of importance and will serve as the foundation of the NPS reduction strategy for Michigan's WLEB Watersheds:

- Improve nutrient management (i.e., 4R practices – right source, right rate, right time, right place).
- Increase acreage using cover crops.
- Increase acreage under no-till and/or reduced tillage.
- Increase miles of riparian buffers/filter strips along critical reaches/drains.
- Expand use of water quantity management.
- Develop whole-farm conservation systems.
- Promote wetland protection/restoration to reduce nutrient loads.

Next Steps

The adaptive management cycle is an iterative process. The state is in the initial set-up phase, which will take some time to fully implement. While regulatory options are limited, the DAP Team is committed to the adaptive management process outlined in this plan and are actively working with partners to strategically focus planning and implementation actions using existing programmatic technical and financial assistance, supporting new innovative approaches and partnerships, and accelerating comprehensive conservation planning through MAEAP and other land management programs. The state agencies are relying on support and input from many others to adapt to changing conditions, unexpected results, new research findings, and new opportunities that arise as we seek to improve Lake Erie for the benefit of people and ecosystems.

INTRODUCTION

Lake Erie is Michigan's warmest and shallowest Great Lake, which contributes to its vulnerability to algal blooms and dissolved oxygen depletion. Michigan, along with the other states in the Lake Erie Watershed (Figure 1) and the province of Ontario, are engaged in a collaborative effort with industry, businesses, agriculture, and residents to reduce nutrient inputs to the lake and address negative ecosystem impacts including harmful algal blooms (HABs) in the WLEB, hypoxia (i.e., low dissolved oxygen) in the Central Basin, and nuisance *Cladophora* growth in the Eastern Basin. Since 2013 when the Great Lakes Water Quality Agreement (GLWQA) went into effect, the Parties to the GLWQA (i.e., the federal governments of Canada and the United States [U.S.]), have worked with state and provincial jurisdictions to determine specific ecosystem goals and actions needed to create a framework for measuring progress toward meeting the ecosystem improvement goals. An important component of this binational process was for each jurisdiction to develop a domestic action plan or DAP.

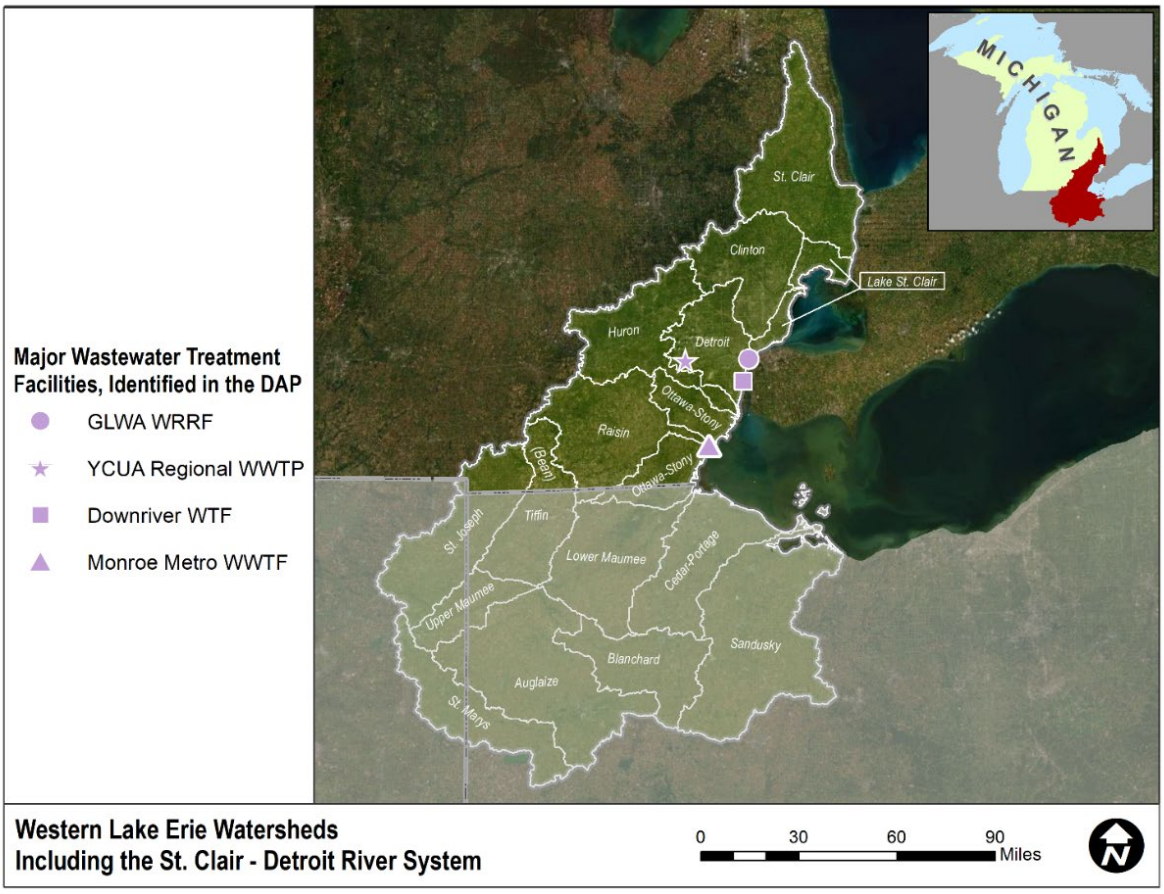


Figure 1. The DAP point sources are shown by symbols on the graphic. The Southeast Michigan watershed areas contributing to the St. Clair-Detroit River System and Western Lake Erie (dark green) are superimposed on a satellite image; Ohio and Indiana watershed areas are shown in lighter green. Ontario watershed areas are not distinguished.

Michigan released its DAP in 2018 (State of Michigan, 2018), which was drafted by the DAP Team, consisting of senior management staff from the Michigan departments of Agriculture and Rural Development (MDARD); Natural Resources (DNR); and Environment, Great Lakes, and Energy (EGLE). The DAP outlined Michigan-specific programmatic tactics and 10 task-oriented objectives for reducing phosphorus entering Lake Erie from Michigan's waters by 40 percent by 2025. The Michigan DAP and the other jurisdictions' DAPs informed the development of the U.S. Environmental Protection Agency (USEPA) Action Plan for Lake Erie (2018) and the Lake Erie Binational Phosphorus Reduction Strategy (GLWQA Nutrients Annex Subcommittee, 2019). When taken together, these plans outlined the binational, federal, state, regional, and local actions and priorities for meeting the overall ecosystem goals for Lake Erie set forth under the GLWQA, as well as identifying gaps in knowledge or data that posed challenges.

Each of the DAPs refer to the use of an adaptive management approach for implementation, which consists of a structured process for:

1. Considering alternative ways to meet environmental objectives.
2. Moving forward with thoughtful actions based on the current state of knowledge.
3. Monitoring to learn about the impacts of implemented management actions.
4. Using the resulting information to update knowledge, to guide future research and monitoring, and to adjust management actions.

The DAP Team chose to produce a separate adaptive management plan to serve as a companion document to the DAP. The process of developing the Plan offered the opportunity to develop a process to guide management decisions, actions, and policy development. Michigan's adaptive management framework will work in two ways: 1) to evaluate the outcomes of deliberate, measured actions taken to reduce phosphorous; and 2) to develop and implement scientifically driven projects to address gaps and uncertainties in current approaches to reducing phosphorous delivery to Lake Erie.

Adaptive management starts with understanding how the system works and assessing the problem (Williams et al., 2009). The purpose of this Plan is to provide status update on ecosystem conditions and current management actions being taken in Michigan's portion of the Lake Erie Basin, to outline the initial set-up phase of move from "passive" to "active" adaptive management, and to identify agency and partner tactics for optimizing and accelerating phosphorus loading reduction to Lake Erie over time. This approach is a learning-based management framework that recognizes uncertainties that are inherent in managing complex social and environmental systems.

The state and the DAP Team cannot achieve the necessary phosphorus reduction targets alone. Residents, business owners, agriculture, and other industries – all stakeholders – must be engaged, encouraged, and supported to implement the actions that will result in a healthier Lake Erie. The framework will incorporate transparency in the planning and implementation processes so that management decisions are made with input from affected and interested stakeholders. Specifically, the intended audience for this Plan includes federal, state, and local agriculture and natural resource agency managers and staff; local partner organizations assisting producers with conservation practices; environmentalists; urban and rural communities supporting wastewater

treatment plants that are named in the DAP; and representatives of other groups that are part of the solution.

Michigan's approach to managing nutrient loads is governed by several agreements, including the 2012 GLWQA (Annex 4 – Nutrients), the 2015 Western Lake Erie Collaborative Agreement (Collaborative Agreement) that set the phosphorus reduction time-bound commitments for 2020 and 2025, the 2018 Michigan DAP, and Governor Whitmer's 2019 Executive Directive No. 2019-14, which reaffirmed the state's commitment to achieving the 40 percent phosphorus reduction goals by 2025 that were set forth under the GLWQA and the Collaborative Agreement.

Based on 2008 load calculations determined through the Annex 4 process, Michigan estimated phosphorus loading reduction goals needed from the following tributaries and associated watersheds by 20 percent by 2020, and 40 percent by 2025 (**Table 1**). **These are the Annex 4 phosphorus target load reductions that Michigan is using to formally track progress. Through the adaptive management process, however, the DAP Team will develop additional watershed-based goals/metrics to track watershed management planning, BMP implementation and tracking, and surface water monitoring efforts.**

Table 1. Phosphorus load reduction goals reproduced from the 2018 Michigan DAP.

Priority Objective (4)	2008 TP Target Baseline Load (1)	20 Percent Reduction Amount (by 2020)	40 Percent Reduction Amount (by 2025)	Target Load
Detroit River TP load (at mouth)	1,261	252	504	756
River Raisin TP Load (at monitoring location) (5)	172 (0.157 mg/l)	34 (0.031)	69 (0.063)	103
River Raisin Spring TP load (at monitoring location)	83 (0.148 mg/l)	17 (0.030)	33 (0.059)	50 (0.089)
River Raisin Spring SRP Load (3)	N/A	N/A	N/A	N/A
MI Maumee TP Load (2)	267	53	107	160
MI Maumee SRP Load (3)	N/A	N/A	N/A	N/A
Total Michigan Load Allocation	1,883	377	753	1,130

1. Based on 2008 load estimated by Annex 4. The 2008 TP Target Baseline Load numbers for the Raisin come from Heidelberg University's River Raisin monitoring station data.
2. Based on percentage of land use in Michigan's portion of the Maumee River.
3. No Soluble Reactive Phosphorus (SRP) loading estimate for the River Raisin or the Maumee River. Research is needed and concentrations may currently be low for the River Raisin.
4. Concentration in parenthesis is a flow weighted mean concentration.
5. Values at monitoring location on the River Raisin will be used to provide an entire watershed value.

The most substantial progress to date, relative to a 2008 baseline, has been reduction of point source loads via upgrades to wastewater treatment facilities, especially those of the Great Lakes Water Authority (GLWA) in Detroit (Figure 1). Based on actual and projected phosphorus reductions, the 2020 goal of 20 percent load reduction has been met but reducing nutrient loads from Michigan toward 2025 targets will be more difficult (Figure 2).

Overall, if the rate of NPS load reduction is not sufficient to meet the goals by 2025, slower reductions will result in shifting of the target timeline into the future (red arrows in Figure 2 with decreasing slopes). Note that part of the overall target reduction was not assigned to a particular source in the DAP. Besides the greater challenges of reducing NPS loading relative to point source reductions, additional factors such as weather variability and flooding can overwhelm the positive signal of NPS management actions that might have otherwise been detected in tributary monitoring. Michigan will continue to work through the Annex 4 process to identify and agree upon potential SRP metrics. Discussions are also ongoing through Annex 4 about how changes in the entire WLEB will be monitored, tracked, and reported. Improving understanding of the human and ecological processes that influence nutrient loading is a priority focus of the adaptive management process.

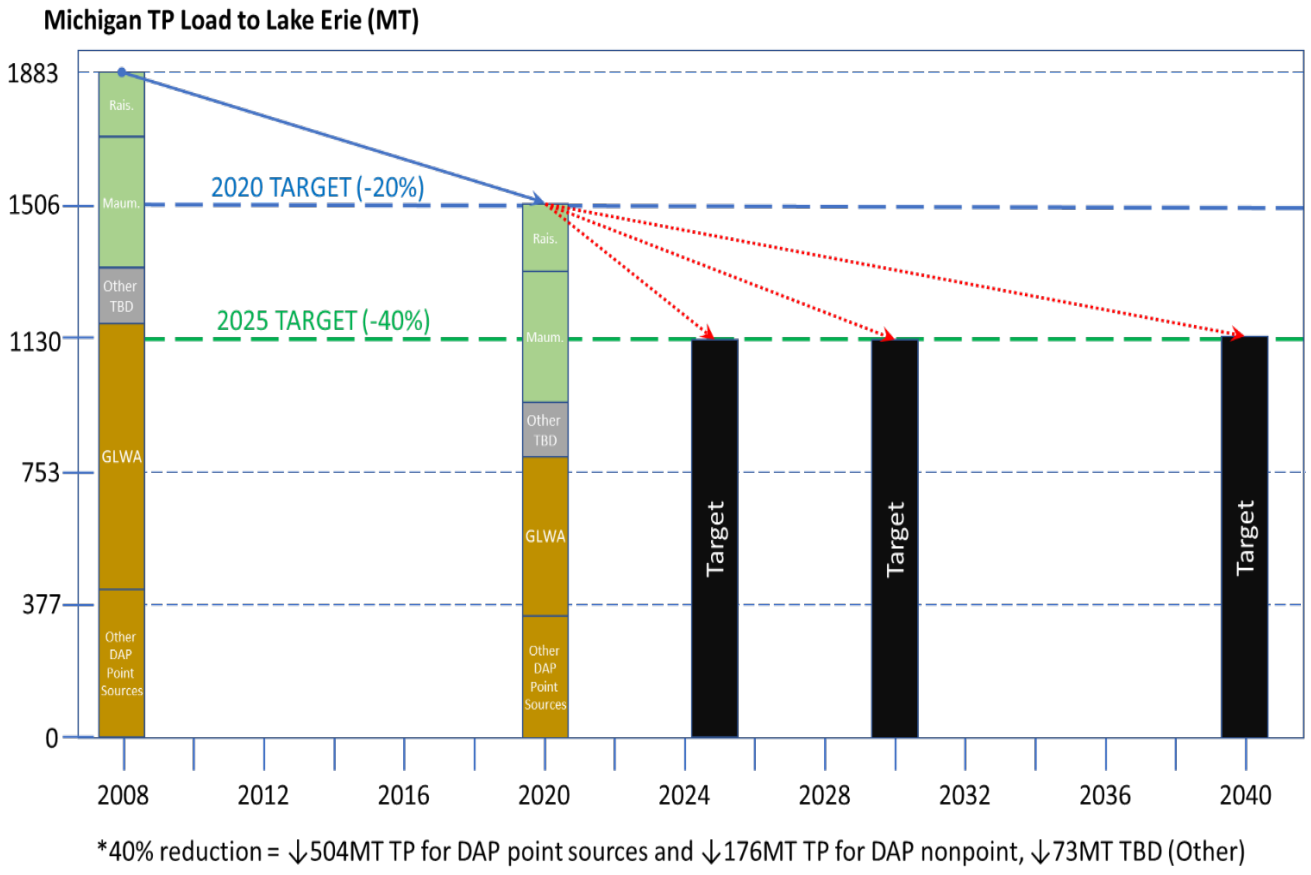


Figure 2. Estimated past and future P loading reduction over time to Lake Erie from Michigan. Load reduction targets were set by the Annex 4 Objectives and Targets Task Team (2015).

DETROIT RIVER AND POINT SOURCE LOADING REDUCTIONS

Low-concentration, high-volume nutrient loads from the Detroit River, which includes upstream inputs from Lake Huron, the St. Clair River, as well as the Thames River in Canada, flow along the north side of the WLEB, and eventually to the Central Basin. These nutrients drive production of biomass (e.g., algae and vegetation) that sinks to the bottom of the Central Basin and drives hypoxia as it decays (Figure 2). While the Detroit River is a large source of phosphorus to Lake Erie, because of the low concentration, seasonal consistency, and basin circulation, it is not a significant influence on Western Basin HABs (Verhamme et al. 2016).

Detroit River phosphorus originates from a complex set of binational sources (Appendix D). Canadian sources include the agricultural watersheds that discharge to Lake St. Clair (i.e., Sydenham River and Thames River), and point sources from Sarnia to Windsor. Several recent research reports and papers have been published on loading and nutrient cycling in parts of this system, along with management implications (Maccoux et al., 2016; Bocaniov and Scavia, 2018; Burniston et al., 2018; Scavia et al., 2019a and 2019b).

TAKING ACTION ON LAKE ERIE

Michigan has reduced phosphorus limits at four key wastewater treatment facilities that discharge over 90 percent of the total phosphorus load to the Detroit River and Lake Erie. Meeting permit limits helped achieve Michigan's goal of reducing nutrient impacts from point sources that are affecting hypoxia in the Central Basin.

The State of Michigan commitments in the 2018 DAP for nutrient loading reductions in the Detroit River were focused on point source load reductions, under the National Pollutant Discharge Elimination System (NPDES) regulatory permit program, at three sites (Figure 1): the GLWA Wastewater Resource Recovery Facility (WRRF) in Detroit, the Downriver Utility Wastewater Authority (DUWA) WWTP, and Ypsilanti Community Utility Authority (YCUA) Wastewater Treatment Plant that discharges to the Rouge River (a Detroit River tributary). These point sources were selected for inclusion in the DAP because they discharged over 90 percent of the Total Phosphorus (TP) point source load from Michigan to the Detroit River and Lake Erie, and when permit limits were met, would achieve Michigan's goal for reducing nutrient impacts from point sources that are affecting hypoxia in the Central Basin.

In addition to required wastewater NPDES permits, the facilities are required to have an NPDES permit for the management of biosolids (i.e., solid waste leftover after treatment) generated at the facility. The communities that these facilities serve are also required to have MS4 NPDES permits to reduce the discharge of pollutants in stormwater to surface waters of the state. An MS4 is a system of drainage (e.g., roads, storm drains, pipes, and ditches) that is not a combined sewer or part of a wastewater treatment plant. As of February 2020, the wastewater treatment facilities, and the communities they service follow their required NPDES permits. Efforts are underway in all communities to reduce overall stormwater discharges by implementation of green infrastructure projects and other actions that decrease urban runoff and increase infiltration and evaporation of precipitation.

NONPOINT SOURCE CHALLENGES

Beyond the need to continue to keep the wastewater treatment facilities in compliance with their reduced phosphorus effluent limits, it will be necessary to focus on NPS management actions in the River Raisin Watershed and Upper Maumee River Watersheds in order to meet 2025 goals. The Annex 4 process determined 2008 as the base year for phosphorus loads from which to measure progress. However, due to the lack of baseline monitoring in Michigan's portion of the WLEB, specific targets for the TP and SRP loading in Michigan's portion of the Maumee River Watershed and SRP in the River Raisin Watershed (Table 1) were not set, but data from recently installed gage stations are being assessed annually. The following two sections describe phosphorus load reduction planning and implementation efforts currently underway in the River Raisin and the Upper Maumee River Watersheds. Additional actions thought to be conducive to adaptive management are further described in the Program Tactics and Selected Management Actions for Measurement and Investigation section below.

Phosphorus Load Reduction Actions in the River Raisin Watershed

The River Raisin Watershed is considered a high priority watershed for the State of Michigan (Figure 3). River Raisin nutrient loads, which have Annex 4 TP targets but not SRP targets (Table 1), are primarily from NPS, but also include some point sources, the largest of which is the Monroe Metro Wastewater Treatment Facility (WWTF). While small relative to Maumee River loads, the River Raisin inputs are locally important for HAB initiation and impacts to impaired Michigan waters of Lake Erie. In November 2016, the former Michigan Department of Environmental Quality (now EGLE) included the WLEB on the 2016 303(d), Impaired Waters list submitted to the USEPA (State of Michigan, 2018). This impairment listing was based on repeated, widespread, and persistent cyanobacteria blooms along Michigan's Lake Erie shoreline. More information on Michigan's approach to addressing this impairment is found in Appendix C.

The conditions in Lake Erie are documented by monitoring data along Michigan's shoreline and through satellite imagery. The blooms in Michigan's waters of the WLEB were determined to be excessive/nuisance conditions indicating ecological imbalance in the vicinity of the mouth of the River Raisin. Heidelberg University's National Center for Water Quality Research has monitored and analyzed River Raisin annual and spring TP loads and SRP loads since 1999. Analysis of data from 2019 indicates that an apparent declining trend from 2008 to 2016 that was reported in the 2018 DAP did not continue, while TP loads have increased since then, or at least returned to approximately the long-term average (Figure 4). The loss in CREP acreage (Stubbs, 2019) that occurred from 2013 through 2016 (Figure 5), due to reduced funding and other factors, may have contributed to these results (Stubbs, 2019). More rigorous analysis of other contributing factors, such as increased flows over this interval, would also need to be conducted to draw any definitive conclusions (Choquette et al., 2019).

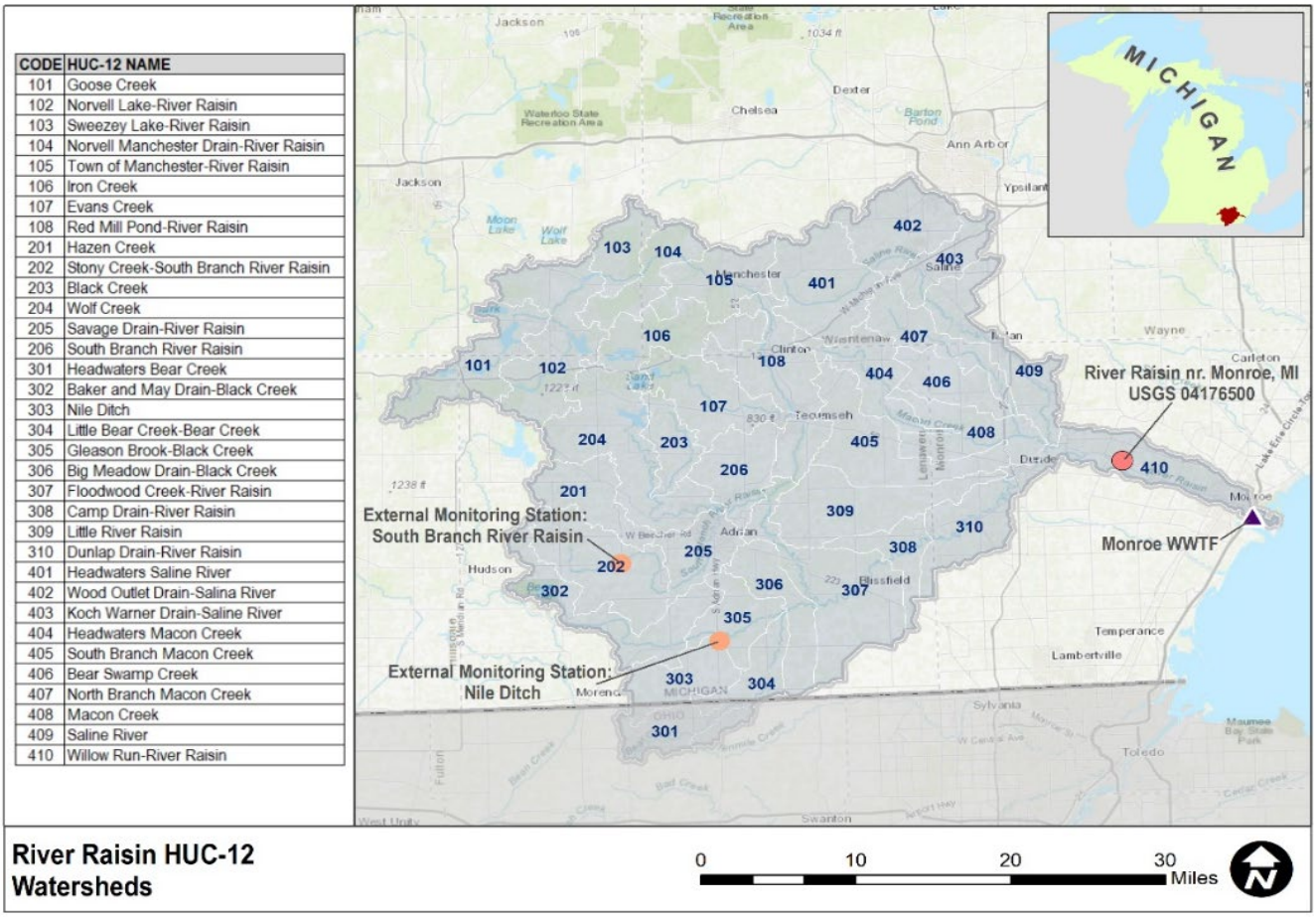


Figure 3. River Raisin Watershed map showing HUC-12 subwatersheds, monitoring locations, and Monroe WWTF location.

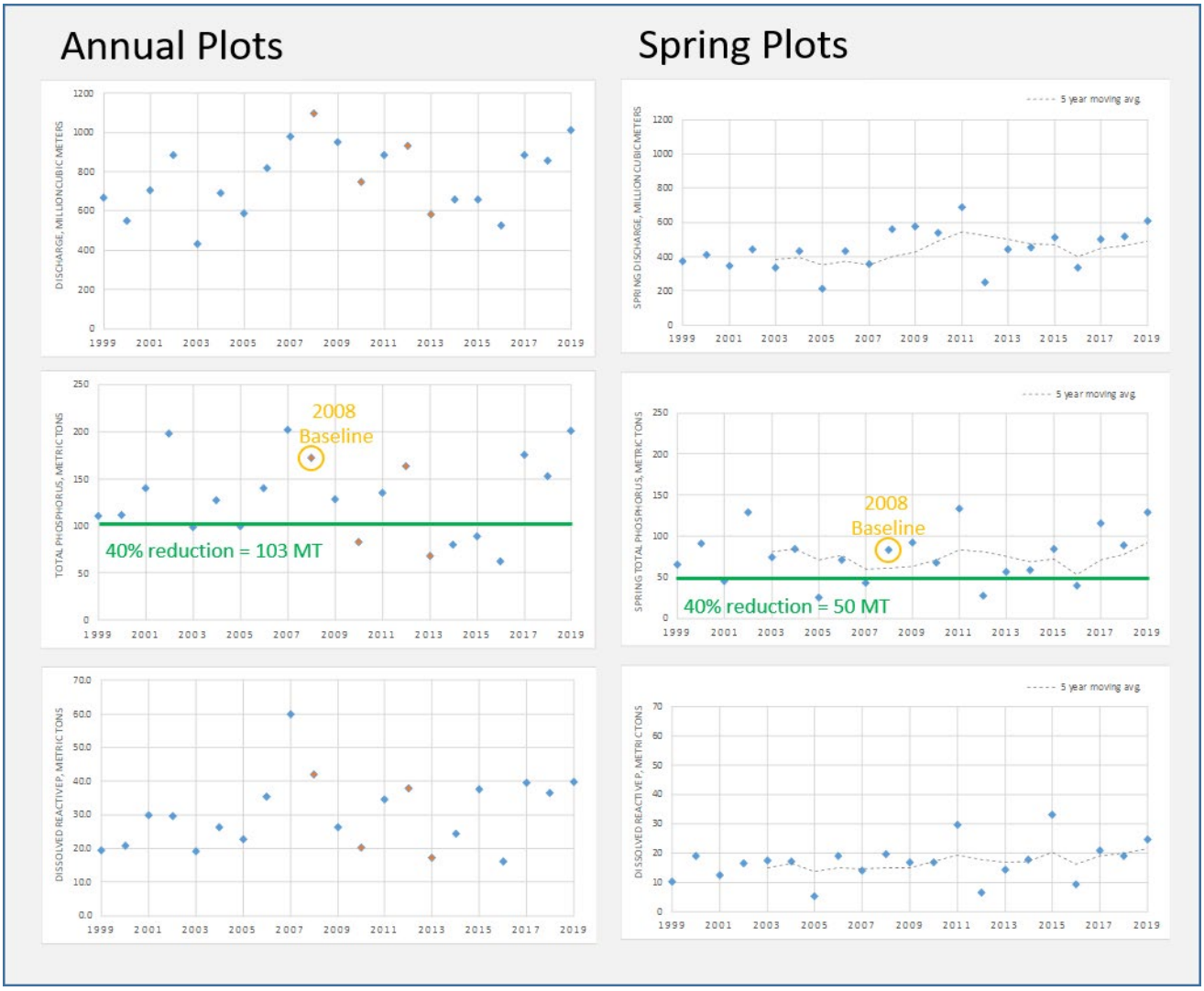


Figure 4. River Raisin annual (left) and spring (right) flow (top), TP loads (middle), and SRP loads (bottom). Note the steady to slightly increasing trend over the last 20 years in both annual loads and spring loads. Green 40 percent reduction goal lines for TP in metric tons (MT) are from the 2018 DAP. Data are from the Heidelberg University monitoring station and USGS stream gage in Raisinville Township upstream of Monroe.

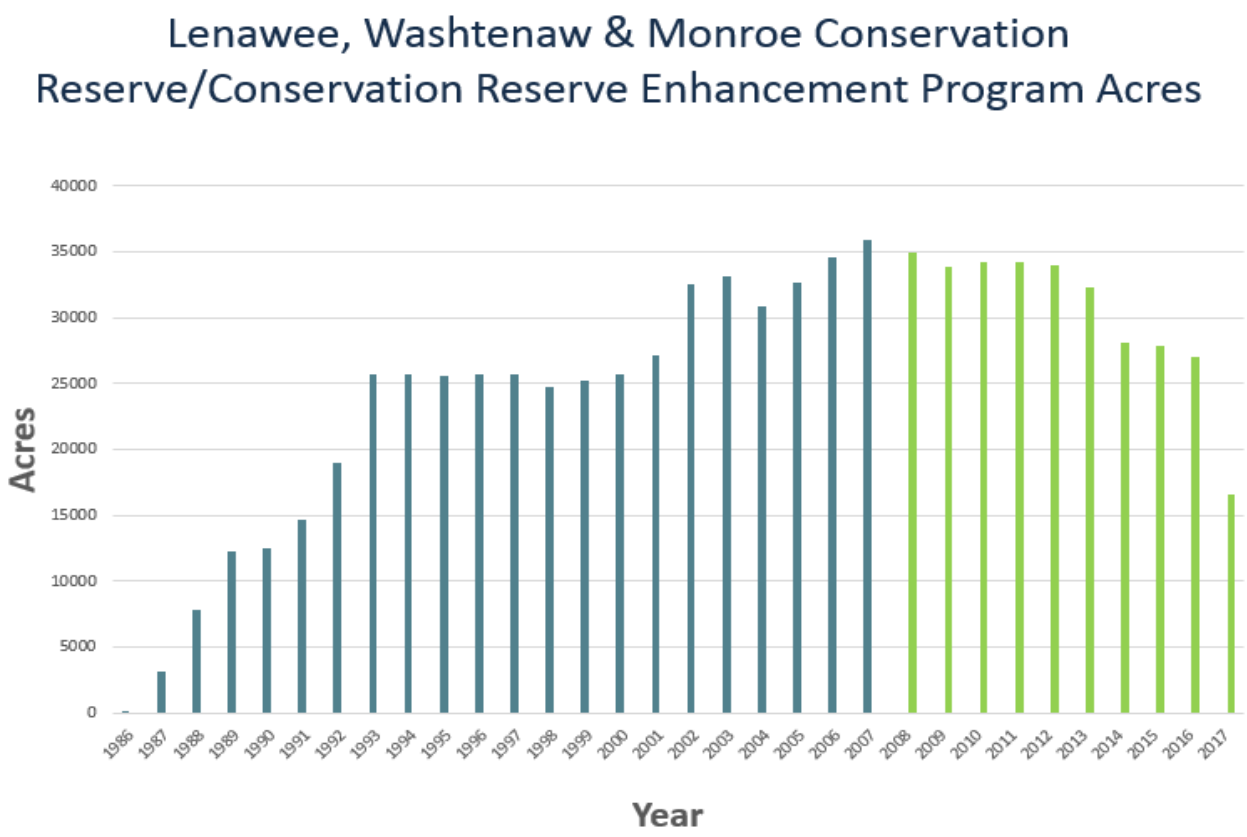


Figure 5. Acreage in the CRP and CREP programs in River Raisin counties declined from 2013-2017, which may have contributed to the recent increase in annual and spring TP loads shown in Figure 4 above due to expected increased runoff from cultivation of former CRP and CREP fields. Blue bars indicate CRP/CREP program acres for each year prior to the 2008 phosphorus load reduction base year, and green bars indicate program acres from 2008 and beyond.

An assessment was conducted to estimate agricultural BMP adoption rates needed to achieve the 40 percent annual and spring TP load reduction targets relative to 2008 loading conditions for the River Raisin Watershed. The purpose of this assessment was neither to prescribe a specific suite of BMP adoption nor to serve in place of a regulatory mechanism for prescribing source load allocations. Rather, it was meant to demonstrate the magnitude of TP load reductions that can be realized with aggressive but still reasonable levels of BMP adoption in the River Raisin Watershed.

The annual TP load target for the River Raisin at the Heidelberg University monitoring station in Raisinville Township is 103 MT (Figure 4), which represents a reduction of 69 MT from the 2008 load of 172 MT. A variety of resources were used to evaluate alternatives for achieving these load reductions from agricultural NPS, including a recent U.S. Geological Survey (USGS) study that estimated TP load source contributions (Robertson and Saad, 2019) and several watershed modeling studies that evaluated agricultural nutrient reduction practices. The USGS study also estimated the relative proportion of the total load contributed by agricultural inputs (i.e., inorganic fertilizer and manure), urban land, natural sources (i.e., forest, grassland, atmospheric deposition, natural weathering, wildlife), and municipal wastewater discharges.

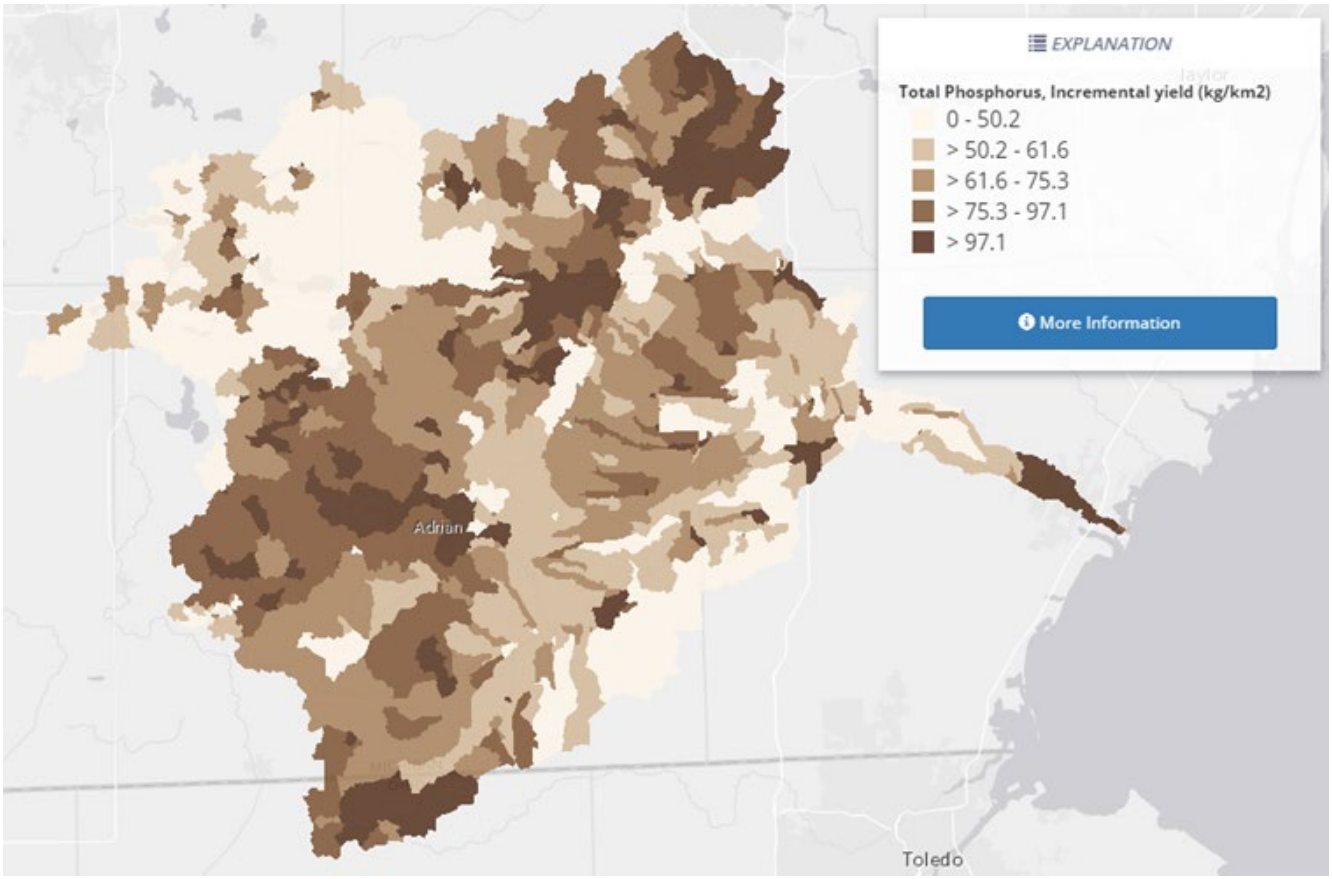


Figure 6. Map of River Raisin subwatershed areas showing differences in TP yield per unit area of land, based on results from the USGS SPARROW model using 2012 data (Robertson and Saad, 2019; image from online map viewer: https://sparrow.wim.usgs.gov/sparrow-midwest-2012/). Darker shading indicates areas expected to lose the most TP per acre on an annual basis. These areas are likely to show the greatest impacts on TP loss from BMP implementation.

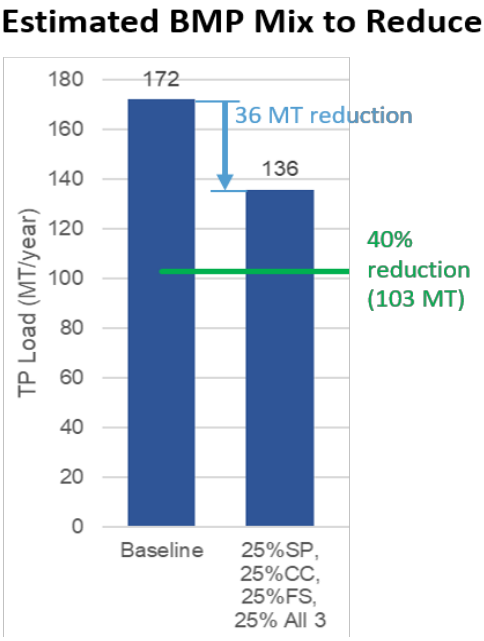
To demonstrate the potential impact of agricultural BMPs on TP load reductions, the 2008 annual and spring loads were apportioned into four source categories using the results of the Robertson and Saad (2019) study. Because point source discharges are relatively stable from year to year and NPS will vary with precipitation, the NPS categories were scaled proportionally to achieve the equivalent 2008 load of 172 MT while holding the point source contribution estimate constant (i.e., 12.9 MT/year). The same approach of source contributions estimated for the annual load was then applied to the 2008 spring load of 83 MT.

The resulting 2008 TP loads attributable to agricultural sources in the watershed was 95 MT or 55 percent of the annual load, and 46 MT or 56 percent of the spring load. To achieve the TP load reduction goals of 69 MT annually and 33 MT during March-July only by implementation of agricultural BMPs would require elimination of 73 percent of the 2008 annual agricultural load and 71 percent of the 2008 spring agricultural load. The next step in this assessment involved deriving average TP removal efficiencies for three common practices, including cover crops, subsurface fertilizer placement, and filter strips, to determine to what extent those load reductions could be achieved by hypothetical levels of BMP adoption.

Several watershed models have been developed, calibrated, and applied over the last decade to assess agricultural nutrient management strategies in the River Raisin Watershed and other watersheds in the Lake Erie basin. Several Soil and Water Assessment Tool (SWAT) models of the River Raisin Watershed have been developed including one published by Muenich et al. (2017) from the University of Michigan, among other university and federal agency research models. Numerous recent watershed model applications in the Lake Erie basin investigated the impact of agricultural practices like those used in this assessment in other watersheds, particularly the Maumee River Watershed (e.g., Martin et al., 2021). The effectiveness of agricultural practices reported in many of these studies was reviewed and consolidated into the values shown in Figure 7.

Several hypothetical BMP adoption scenarios were constructed using the above information on reduction efficiencies and catchment scale agricultural TP yield estimates from Robertson and Saad (2019) to demonstrate potential load reductions toward meeting the Annex 4 and DAP targets. An important assumption in the combination scenario result shown in Figure 7 was the ability to "target" catchments with relatively higher TP yields (Figure 6) according to several model assessments. There was general agreement among various model-based estimates of areas of relatively high vs. low sediment and TP yields. Because of the potential for relatively high surface runoff of sediment-bound phosphorus, areas of the watershed with high erosion rates tend to also have high TP yields. The combination scenario (Figure 7) hypothetically implemented the combination of stacked BMPs (placement + cover crops + filter strips) on agricultural land with the highest TP yields, and individual BMPs on land with relatively lower TP yields.

The combination scenario, representing reasonable yet aggressive levels of BMP adoption, suggested that approximately 36 MT of the 69 MT annual load reduction goal could be achieved. **No scenario resulted in achieving the annual or spring goals through agricultural practice adoption only.** Even 100 percent adoption of the three stacked BMPs (removal efficiency of 60 percent) is not sufficient to achieve the 73 percent TP reduction needed from agricultural sources to reach a watershed-wide TP reduction of 69 MT. This analysis indicates that the remaining load reduction of 33 MT will have to come from some combination of additional targeted BMP adoption in the River Raisin Watershed (e.g., more fields with at least two BMPs) and non-agricultural TP source reductions (e.g., addressing failing septic systems).



Agricultural BMP	Abbrev.	TP removal efficiency
Subsurface fertilizer placement	SP	20%
Cover crops	CC	25%
Filter strips	FS	35%
Subsurface fertilizer placement + cover crops + filter strips	SP+CC+ FS	60%

Figure 7. Results of analysis of River Raisin TP load reductions that can be achieved based on a reasonable but aggressive combination scenario of targeted BMP placement on 25 percent of the agricultural land in the watershed (combination of three BMPs), and additional placement of single BMPs on the rest of the agricultural land. The table shows estimated TP removal efficiencies based on published values that were used in the assessment. Values for individual and combined BMP efficiencies are shown as a percentage of the TP loss that would occur without BMPs.

Phosphorus Load Reduction Actions in the St. Joseph River and Bean Creek Watersheds

The Michigan areas of the Upper Maumee Basin includes the East and West Branches of the St. Joseph River Watershed (Figure 8) and the Bean Creek Watershed (Figure 9). Currently, these watersheds do not have specific target phosphorus load reductions under Annex 4 or the DAP (Table 1). They were listed as priority watersheds by Annex 4, even though they likely contribute relatively small TP and SRP loads, because they are part of the larger Maumee River Watershed, which is the major source of phosphorus that drives WLEB HABs (Verhamme et al., 2016).

However, Michigan, Indiana, and Ohio have committed to increasing monitoring of the Upper Maumee tributaries to better define their loading contributions. For example, Michigan has collected multiple rounds of samples at up to 19 stations in the Upper Maumee River watershed in 2016 through 2018. This kind of monitoring does not allow a high-resolution load to be calculated but it does make it possible to determine relative loads from subwatersheds (EGLE and LimnoTech, 2020). Michigan continues to work with Indiana, Ohio, USEPA, and USGS to determine baseline water quality conditions and will develop targets once baseline conditions have been established.

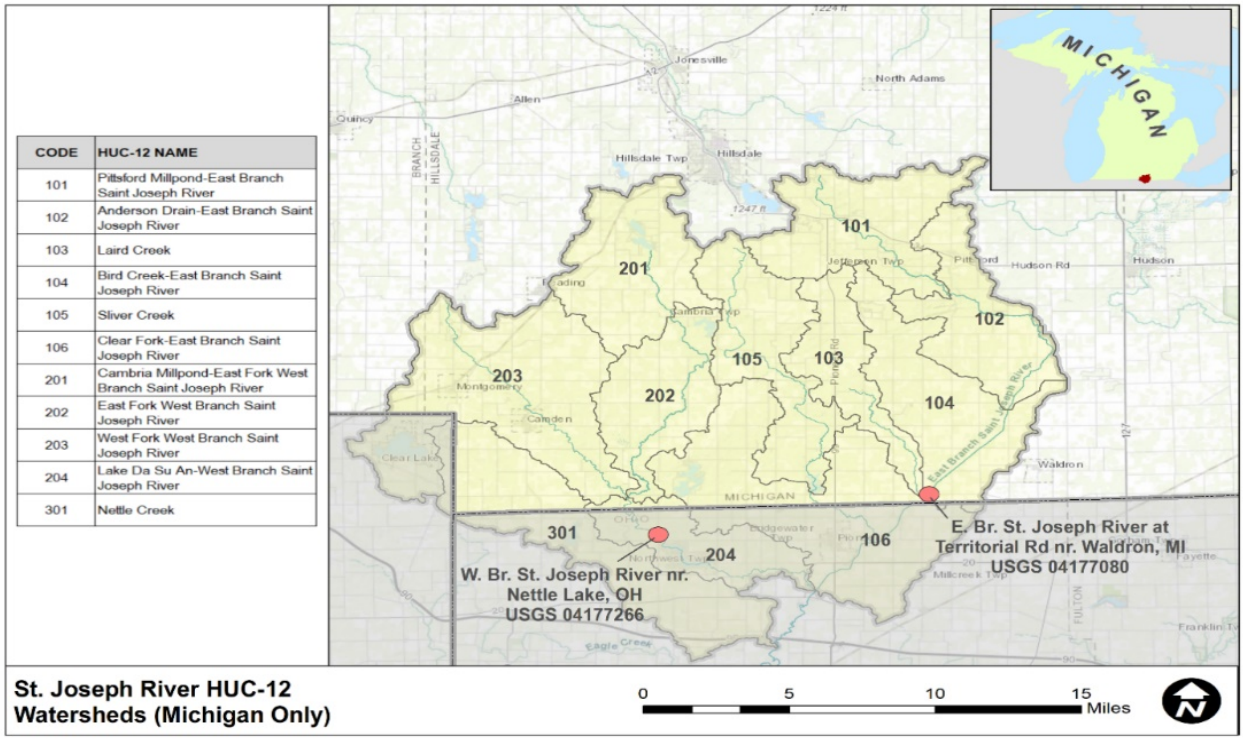


Figure 8. Upper Maumee River – St. Joseph River Watershed map showing HUC-12 subwatersheds and monitoring station locations.

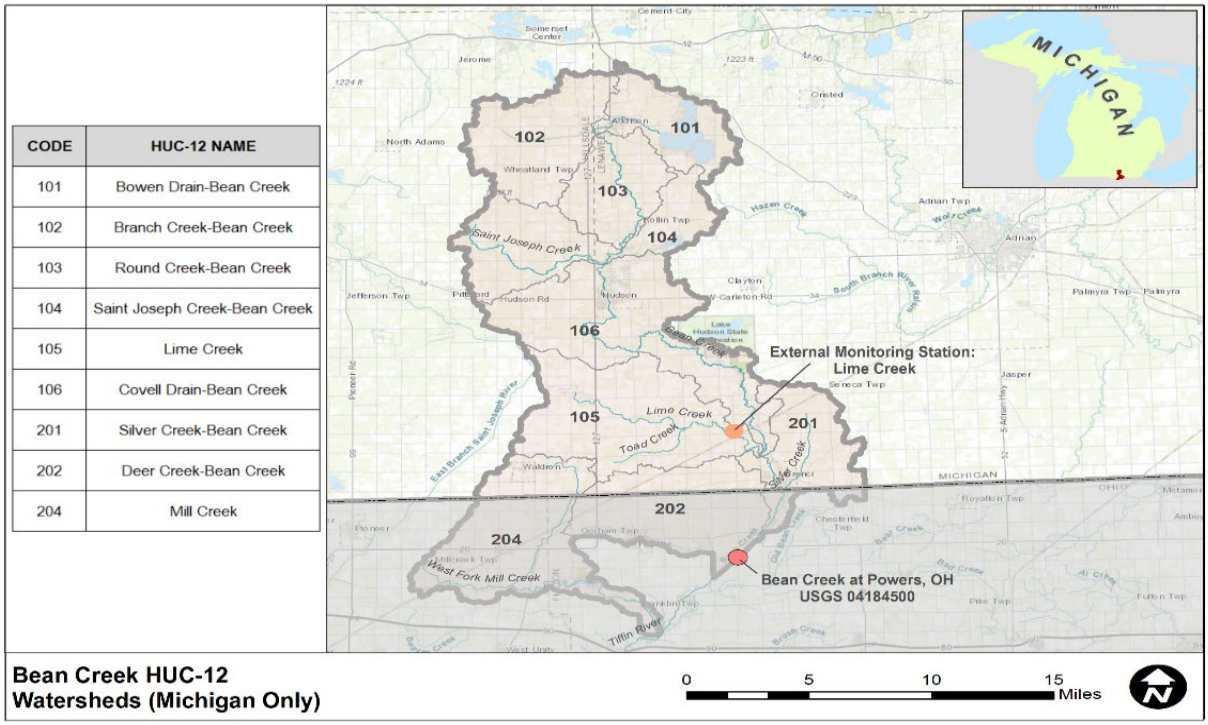


Figure 9. Upper Maumee River – Bean Creek Watershed map showing HUC-12 subwatersheds and monitoring station locations.

MICHIGAN'S ADAPTIVE MANAGEMENT FRAMEWORK

The 2018 DAP calls for the state to implement an "active" adaptive management approach at two levels: the Michigan-specific level and the binational Lake Erie basin level, through the GLWQA Annex 4 process. The goal of the adaptive management approach is to use a science-driven approach to improve the effectiveness of actions, accelerate progress, enhance coordination with partners, and leverage resources to gain water quality improvements in the system. Below is a diagram of the general steps in the adaptive management cycle (Figure 10). **The DAP Team began the process of establishing this framework in 2021.**

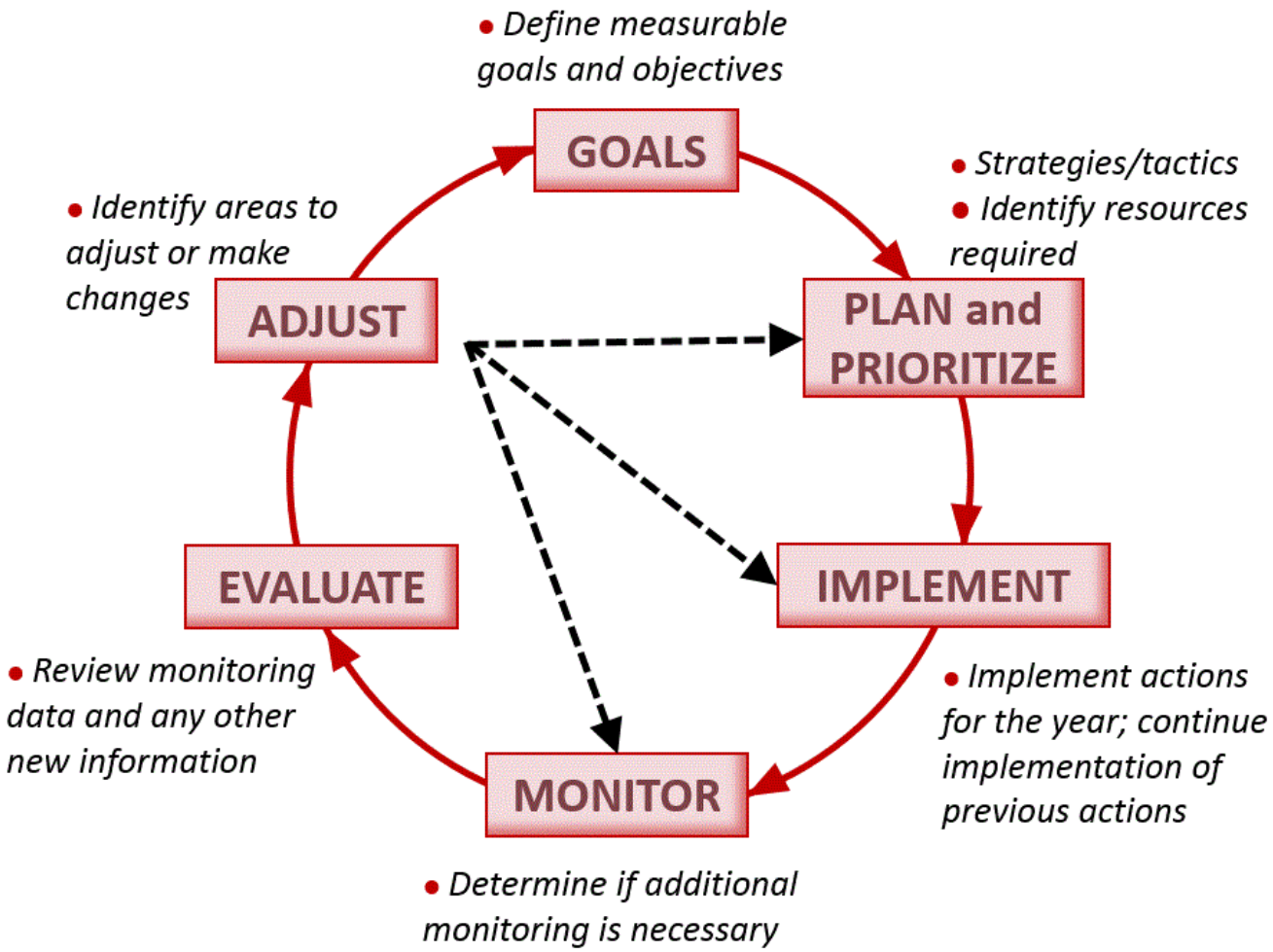


Figure 10. Adaptive management process diagram modified from the Michigan DAP (2018). Source: National Academies Press; original figure adapted from a Department of Interior source (see Williams et al., 2009).

DAP Team and Advisory Group Roles and Responsibilities

Coordination through the DAP Team agencies provides critical management and technical roles in achieving Annex 4 goals, along with supporting internal policy development. EGLE-WRD has responsibility for permitting point sources, monitoring tributary nutrient loads, and assisting partners with the watershed planning and implementation efforts. MDARD oversees or facilitates agricultural conservation programs that contribute to NPS nutrient load reductions under a variety of federal and state programs, including MAEAP. The DNR manages and monitors fish and wildlife habitats and populations in Lake Erie and associated tributaries and works with partners to protect and restore fish and wildlife populations and habitat. To be most effective in the implementation of the Michigan DAP and the adaptive management framework, it was important to define these roles and responsibilities. Figure 11 identifies where the DAP Team will seek opportunities to engage internal and external subject matter experts and stakeholders through a structured decision-making process that is based on the six core elements of the adaptive management cycle (Figure 11).

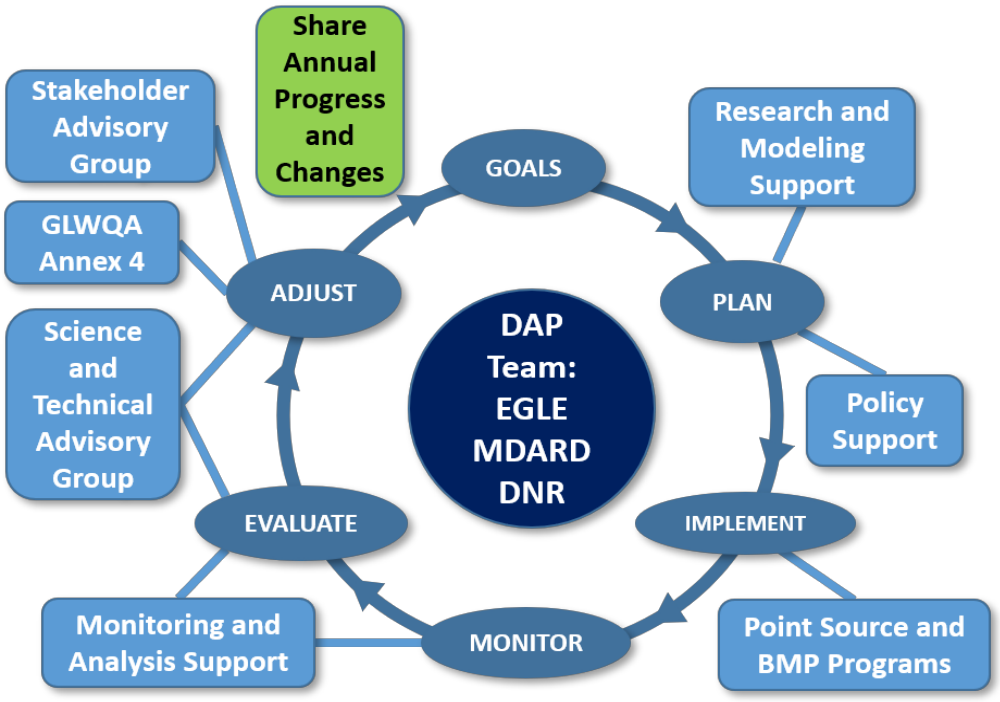


Figure 11. Proposed conceptual governance and support structure for Michigan DAP adaptive management cycle. Note that some support and advisory components, roles, and commitments are currently under development and subject to change.

Michigan's state agencies cannot meet DAP goals and commitments alone. The DAP Team will form an external, science based WLEB stakeholder advisory group and seek input from other experts as needed to provide stakeholder feedback and technical input throughout the adaptive management process but will look for the bulk of support during the "evaluate" and "adjust" phases (Figure 11). The DAP Team will support the formation of a broader stakeholder advisory body by working with partners to identify and confirm sector engagement and points of contact, seek nominations for representatives where necessary, draft structural components and mandates for the group, and secure resources for long-term structural support. Formalizing a structured adaptive management framework and process, including stabilizing funding and management of technical data (e.g., monitoring, modeling, and research), internal and external policy efforts, and outreach and engagement with technical and advisory groups will provide the structure and information to allow learning to take place and provide transparency in the process.

Transparency, rigor, and timely analysis by state agencies and their technical support teams, as well as careful tracking of hypotheses, management alternatives, and uncertainty will provide a pathway for effectiveness and efficiency in achieving the goals or altering direction as necessary. Plans for oversight by a formally structured and balanced advisory body including a broad array of WLEB external stakeholders is in development to assure accountability, enhance engagement and communication, and inform consideration of important external viewpoints in agency analysis and resulting decisions. The adaptive management process being developed by the State of Michigan is also nested within the larger adaptive management activities of the GLWQA Annex 4 Subcommittee that includes other states, U.S. federal agencies, and Canadian representatives.

Program Tactics and Selected Management Actions for Measurement and Investigation

During the development of this Plan, the 2018 DAP Task Tracking Table was updated and is included in Appendix A to show all the various agency programs and efforts being planned or implemented to address the phosphorus issue. Some program tactics are longer term such as the Long-Term Control Plan Program (LTCP) elements to address CSOs in the city of Detroit. Nonpoint source focus areas include drainage water management (DWM), nutrient management plans at the farm-scale, improved manure management, increased creation of riparian buffers, expansion of cover crop planting, reversal of declining CRP/CREP acreage, and increasing MAEAP enrollment.

More focused implementation of NPS activities to increase impact will be possible at the subwatershed scale (HUC-12 or smaller) as agricultural inventories at the HUC-12 subwatershed level are completed and/or updated (Figure 12), but mechanisms to take advantage of this resource-intensive process will need to be developed. Incorporation of innovative tile drainage management or treatment systems will be reviewed in the future to determine their relative cost and effectiveness. For example, the effectiveness of phosphorus-optimal wetlands that are being installed in Ohio is being looked at as a possible model for Michigan. The DNR, in partnership with Ducks Unlimited, is actively pursuing the creation of a pilot agriculture wetland restoration project in the WLEB to reduce phosphorus contributions to the watershed.

The following sections describes six adaptive management priority tasks that are being planned, implemented, and tracked by the state to gain additional knowledge, fill research gaps, and accelerate actions to achieve the 40 percent reduction by 2025. As described above, target load reduction metrics in Table 1 are what Michigan is using to formally measure and track progress, and through the adaptive management process, the DAP Team will develop additional watershed-based goals/metrics to track watershed management planning, BMP implementation and tracking, and surface water monitoring efforts.

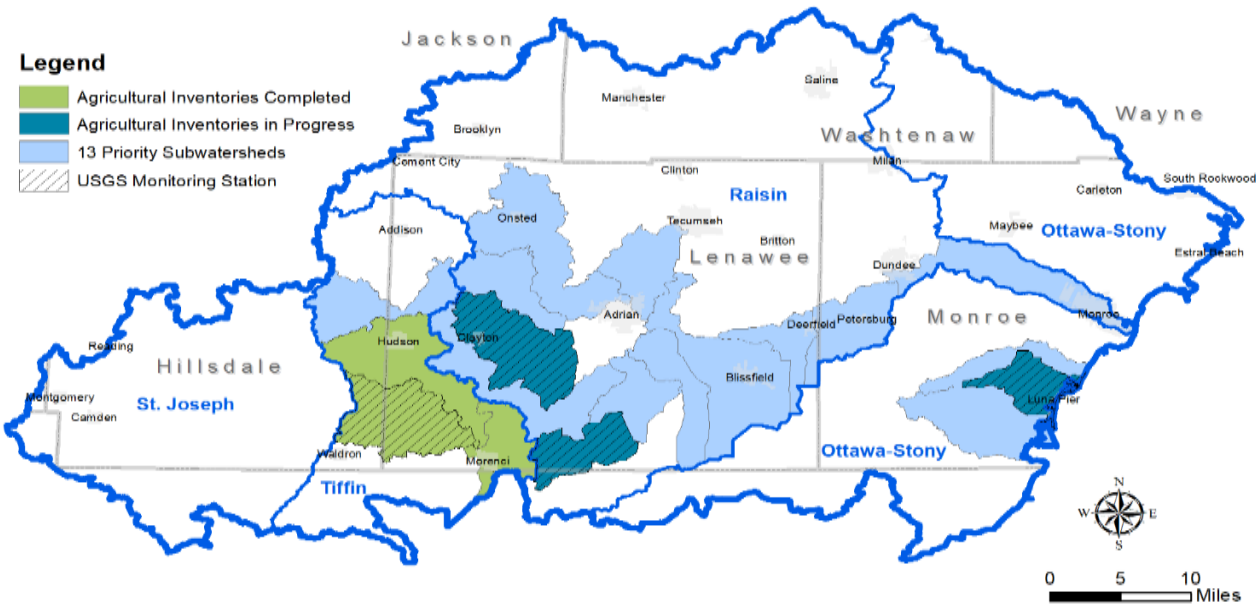


Figure 12. Michigan's Western Lake Erie Basin 13 priority agriculture inventory subwatersheds, including completed and in progress. Hatch marked subwatersheds have USGS monitoring stations. [Note: The Tiffin River Watershed is known as the Bean Creek Watershed in Michigan.]

POINT SOURCE LOADING REDUCTIONS

Point Source Loading Reductions Priority Tasks (details in Appendix A):

- Maintain the phosphorus reductions achieved in the GLWA discharge due in part to the more stringent TP effluent limits placed in the NPDES permit in 2013 (Task 1).
- Achieve reductions in phosphorus discharged from the DUWA and continue reductions at YCUA WWTP (Task 2).

Point Source Loading Reductions Planning: The Annex 4 target for the Detroit River loading requires the state to reduce TP by 504 MT (Table 1).

Point Source Loading Reductions Implementation: To meet this target, the DAP calls for maintaining more stringent NPDES TP effluent limits for the three key WWTPs that discharge to the Detroit River (Tasks 1 and 2), that the communities in the WWTPs service areas maintain compliance with Municipal Separate Storm Sewer System (MS4) and biosolid permits, and for the GLWA to achieve their Long-term CSO Control Program. To date, these WWTPs are complying with NPDES-related permits, and the GLWA is meeting their Long-term CSO Control Program.

Point Source Loading Reductions Tracking: Completed through NPDES Program DMRs and the NPDES permit term with information available through MiWaters.

POINT SOURCE LOADING REDUCTION ADAPTIVE MANAGEMENT PROJECT:

EGLE will partner with the GLWA to design and fund a study to evaluate SRP discharge quality as a function of the level of municipal treatment, including secondary treated, primary treatment, CSO Retention Treatment Basins, and untreated CSOs (Task 4f).

Working hypothesis: Improving understanding of P speciation in effluent may make it possible to optimize treatment operations and seasonal approaches to reduce SRP versus TP.

Point Source Loading Reductions Contingencies/Alternative Hypotheses: The influence of Detroit River loads on winter/spring diatom productivity and linkages to hypoxia is unclear; current treatment plant design may not allow for adjustments that can substantially or affordably change bioavailability of phosphorus; phosphorus speciation may not have much influence on important lake phenomena, or this may be hard to measure.

Nonpoint Source Watershed Management Planning and Implementation

NPS Watershed Management Priority Tasks (details in Appendix A):

- Identify priority areas in Michigan's portion of the Maumee River Watershed for P reductions. Identify and implement priority actions to reduce P loads from Michigan's portion of the Maumee River Watershed (Task 3).
- Support and invest in research to better understand the causes of HABs, including invasive mussels and SRP, and how these factors increase/decrease HAB events (Task 4).
- Use research and field demonstrations to identify the suite of BMPs that work collectively to reduce both TP and SRP at the field implementation level (Task 5).
- Implement P control actions in the River Raisin Watershed to achieve the target load reductions (Task 6).

TAKING ACTION ON LAKE ERIE

Focus conservation within key HUC-12 subwatersheds that contribute disproportionate amounts of pollutant load to water quality impairments or concerns.

Agricultural Inventory Planning: The Annex 4 NPS-related targets are to reduce spring total and SRP loads from the River Raisin Watershed and Michigan's portion of the Maumee Watershed by 40 percent. To meet these ambitious NPS reductions, the state must better understand the current conditions to focus implementation of BMPs to reduce agriculture nonpoint source pollution delivery to Lake Erie. To fill this data gap, the MDARD and EGLE are planning and implementing Agricultural Inventories in high priority HUC-12 watersheds within Bean Creek and River Raisin (Figure 12). The Bean Creek Agricultural Inventories, described in more detail below, will be used as a model to implement inventories in all of Michigan's 52 HUC-12 subwatersheds in Michigan's portion of the WLEB.

Agricultural Inventory Implementation: The Agricultural Inventory, first developed by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), is a multiple year process that uses a modeling component, a desktop analysis component, and a field-by-field inventory of cropping systems on agriculture fields. This multi-pronged effort is used to collect specific land use data and prioritize sites that have the potential to address existing resource concerns that impact water quality. This data and prioritization of sites will be used to further refine the local watershed management planning process and be used by Conservation District staff and MAEAP technicians to help prioritize BMP implementation and engage landowners on opportunities to implement BMPs.

After the data-driven screening analysis, the following implementation actions, ranked in order of importance, will serve as the foundation of the NPS reduction strategy for the Bean Creek Watershed:

- Improve nutrient management (particularly by implementing 4R practices – right source, right rate, right time, and right place),
- Increase acreage using cover crops,
- Increase acreage under no-till and/or reduced tillage,
- Increase miles of riparian buffers/filter strips along critical reaches/drains,
- Expand use of water quantity management,
- Develop whole-farm conservation systems, and
- Promote wetland protection/restoration to reduce nutrient loads.

The critical area analysis uses a tiered approach. The first tier prioritizes HUC-12 subwatersheds based on EGLE monitoring data, land use composition, and the strategic vision provided in EGLE's NPS Program Plan. A multi-scale framework then identifies those locations within key HUC-12 subwatersheds that contribute disproportionate amounts of pollutant load to water quality impairments or concerns. The second tier incorporates field inventory information based on priority concerns and implementation opportunities. Fields of interest were identified where the risk of nutrient and/or sediment loss is greater, or disproportionate pollutant loads could potentially be contributed to streams resulting in water quality impairments or concerns. This enabled an evaluation of sources at a level detailed enough to identify critical agriculture fields and describe specific actions/responsibilities, which will have a greater impact on overall restoration efforts.

Field-by-field survey data and desktop analyses were used to identify fields where there may be a higher risk of nutrient loss to streams. An example of the results of this type of analysis are shown in Figure 13, with fields prioritized based on distance from streams, average field slope, flow accumulation pathways, cropping, fall tillage, and spring residue. Field-by-field surveys helped "bridge the gap" from desktop analyses of GIS data by describing current practices and highlighting fields where BMPs are already being implemented.

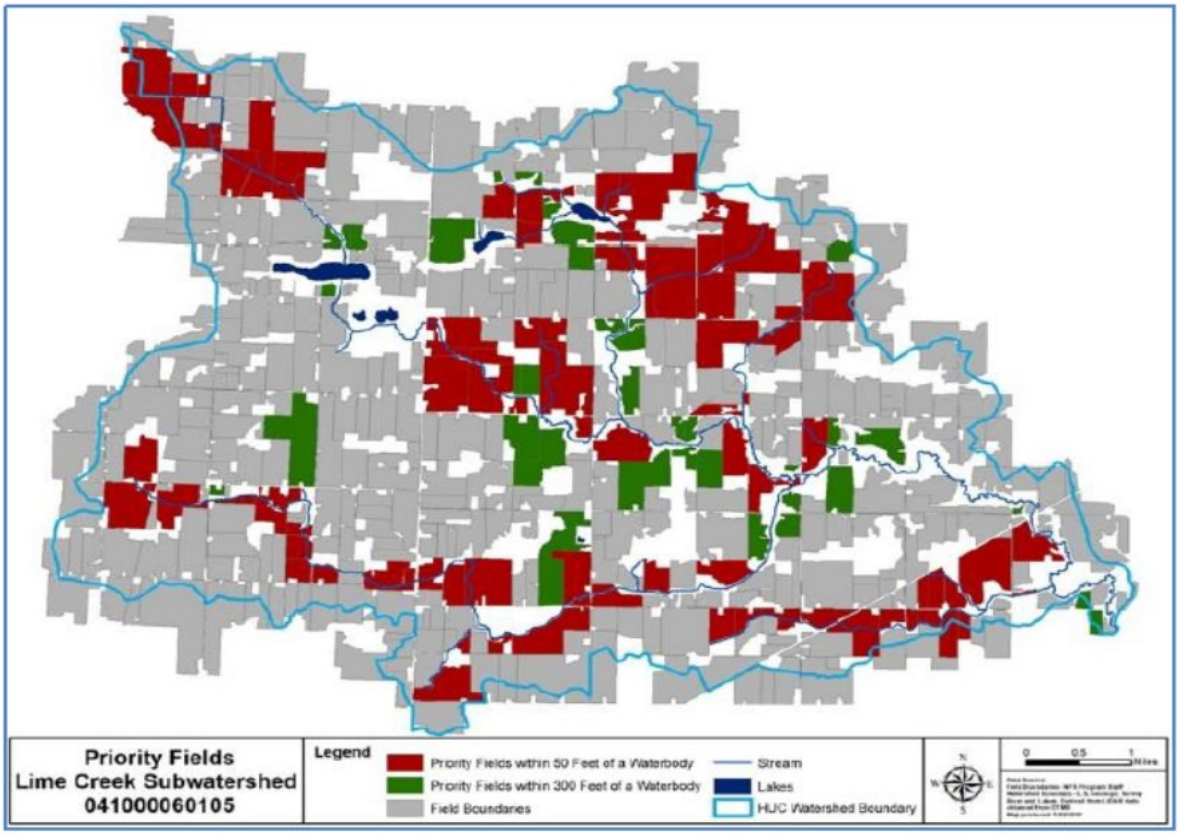


Figure 13. Desktop analyses describing potential risks were combined with tillage and residue field-by-field survey data to identify priority fields where implementation projects could help improve water quality (Blonde and Cleland, 2019). Red fields are within 50 feet of a waterbody, and green fields are fields within 300 feet of a waterbody.

Agricultural Inventory Tracking: EGLE NPS Program grant funded projects will be tracked by the NPS project database, Erb Family Foundation funded projects will be tracked by grant reporting, and cumulatively track progress using the Great Lakes Watershed Management System (GLWMS).

Drainage Water Management (DWM) Planning: Although controlled drainage has been documented to reduce phosphorus transport off fields, research for SRP reduction with controlled drainage is limited in Michigan's portion of the WLEB.

ADAPTIVE MANAGEMENT PROJECTS:

The Agricultural Inventory process will provide a more focused approach to BMP planning and implementation, including:

- Conduct Agricultural Inventories in priority HUC-12 sub-watersheds in the Bean Creek (Task 3i) and River Raisin (Task 6g) Watersheds.

Working hypothesis: Higher resolution Agricultural Inventories will make it possible to more effectively place and fund BMPs.

DWM Implementation: The MDARD, EGLE, Michigan State University (MSU) and partners are currently investigating the effectiveness of controlled drainage in Lenawee County at two on-farm sites with varying soil types. This research will determine the effectiveness of this practice in reducing nutrient load at the field scale.

DWM Tracking: EGLE NPS Program grant funded projects will be tracked by the NPS project database, MDARD funded projects will be tracked by the MAEAP database, and cumulatively track progress using the GLWMS.

Anaerobic Digester Planning: Anaerobic digesters provide a source of renewable energy while reducing nutrient run-off from current land application of manure. Southeast Michigan has 14 large livestock operations, in addition to hundreds more smaller livestock operations. Creation of a commercial anaerobic digester would benefit the environment and create energy for the grid.

Anaerobic Digester Implementation: There is an opportunity to further explore the cost and impact, both economically and environmentally, of creating a pilot project for a commercial anaerobic digester in southeast Michigan.

CREP Planning: The MDARD has received $5.0 million in General Fund to reinstate CREP to address algal blooms in the WLEB, Saginaw Bay, and Lake Macatawa Watersheds. Of this amount, $4.4 million in one-time funding will be used to leverage as much as $45 million in federal USDA funding for the installation and management of effective conservation practices that are proven to reduce nutrient run-off from agricultural fields or filter nutrients before they enter a water course feeding into the WLEB over the next 15 years.

Gaps in knowledge around the most effective suite of BMPs to reduce nutrients are still a problem. The following are research-oriented adaptive management projects:

- Implement a study to evaluate the effectiveness of DWM control practices installed to reduce tile line discharges of nitrates, TP and SRP (Task 5e).
- Determine the feasibility of implementing a regional commercial biodigester in the WLEB (Task 5h).
- Based on prior evidence of an association between decreased CREP acreage and increased P loads, MDARD will work with agricultural partners to reinstate CREP in the WLEB and look for associated water quality improvements, among other actions to further reduce agricultural NPS issues (Task 5g).

Working hypothesis: The combination of approaches under investigation will identify multiple cost-effective practices and combinations to further reduce NPS P loads, including multiple benefits from certain practices (e.g., renewable power generation from biodigesters).

CREP Implementation: MDARD will employ Michigan State University Extension (MSUE) and the local Conservation Districts, which are trusted organizations among Michigan producers, to conduct outreach and recruitment, while utilizing the expertise of the existing specialists at MDARD, NRCS, and Farm Services Agency for implementation, metric development, and monitoring. Implementation of CREP will be prioritized in the River Raisin and Upper Maumee River watersheds.

TAKING ACTION ON LAKE ERIE

Invest in the CREP in Michigan and implement effective conservation practices that are proven to reduce nutrient run-off from agricultural fields before they enter a water course feeding into the WLEB.

CREP Tracking: CREP will be tracked via the MAEAP database, and cumulatively track progress using the GLWMS.

NPS Watershed Management Contingencies/Alternative Hypotheses: External factors such as precipitation patterns and commodity prices may counteract the impact of BMP placement optimization; cultural or other barriers to adoption may prevent implementation of inventory knowledge; rapid change in practices may cause inventories to become outdated rapidly; privacy concerns may create obstacles to inventory data collection and use; remote sensing approaches (satellite, drone, or aircraft imaging) and other methods may be a more effective and affordable monitoring approach than ground-based methods.

Michigan Agriculture Environmental Assurance Program (MAEAP)

MAEAP Priority Tasks (details in Appendix A):

- Maintain and expand partnerships to provide valuable technical and financial assistance to farmers. Continue expanded CD MAEAP technical assistance levels through 2017 and beyond (Task 7).
- Increase and maintain MAEAP practice implementation for long-term water quality improvement (Task 8).

MAEAP Planning: The MAEAP is MDARD's primary tool for working with agriculture stakeholders in the WLEB and throughout the state. The MAEAP is an innovative, proactive statewide program that helps farms of all sizes, and all commodities voluntarily minimize agricultural pollution risks. MAEAP technicians focus on recommending a suite of conservation practices and BMPs that will address the needs of a specific site. A variety of factors can impact the selection of conservation practices and effectiveness of a BMP including but not limited to soil type, slope, and current farm management.

MAEAP Implementation: To incentivize conservation actions and BMP implementation, cost-share funding is available through a variety of federal, state, and local programs. Once a farmer has completed the management practices identified for environmental risk on their farm, they can request third party verification of environmental practices implemented by MDARD staff. Farms can be verified in several "systems," Farmstead, Cropping, Livestock or Forest, Wetlands, and Habitat corresponding to the risk assessment tools used by MAEAP technicians. At the time of reverification, the farm must meet current program standards.

ADAPTIVE MANAGEMENT PROJECTS:
To better understand how MAEAP is being adopted across the WLEB priority watersheds, MDARD is proposing to specifically identify and track the number of BMPs implemented in the following:

- Bean Creek Watershed (Task 3f)
- St. Joseph River Watershed (Task 3g)
- River Raisin Watershed (Task 6e)

Focusing on tracking progress made in these watersheds will assist the MDARD with setting quantifiable MAEAP goals and focus additional MAEAP efforts in areas of greatest environmental risk.

Working hypothesis: Using the MAEAP model in a more targeted effort will improve the adoption rate that results in improved water quality.

TAKING ACTION ON LAKE ERIE

- Increase MAEAP enrollment in the River Raisin, Bean Creek, and St. Joseph River Watersheds.
- Continue to reevaluate, target, and improve MAEAP to be more protective of Michigan's water quality standards, including but not limited to, the requirement for enough NPS BMPs to prevent significant nutrient runoff from MAEAP participating farms.

In 2021, MAEAP began operation of a new database which was designed to allow better tracking of conservation practices that have been implemented on verified farms, as well as farms that have not reached the point of verification. The system will allow searches to be refined down to the level of a HUC-12 watershed, allowing for more specificity in measurement of BMPs in the WLEB on farms working with the program.

MAEAP Tracking: MDARD will use the MAEAP database, and cumulatively track progress using the GLWMS.

MAEAP Contingencies: MAEAP program marketing, incentives, or staffing may be insufficient to result in substantial net impacts on phosphorus loading; external factors such as higher commodity prices or changing land ownership may make MAEAP enrollment and verification more difficult.

Improve and Increase Outreach to the Public and Farmers

Outreach to the Public and Farmers Priority Tasks (details in Appendix A):

- Improve and increase outreach to the public and farmers to promote understanding of the basin and good conservation practices by initiating new targeted outreach campaigns, workshops, field demonstrations and information sharing (Task 9).

Outreach to the Public and Farmers Planning: It will be important to provide an opportunity for stakeholders to engage in the adaptive management process through the establishment of an external, science-based WLEB stakeholder advisory group. A defined stakeholder community is, in fact, deliberately and directly engaged in the learning-based framework and approach. Since the 4th quarter of 2020, the DAP Team through contractual arrangements with LimnoTech, conducted phone surveys with regional experts, stakeholder advisory board members from Michigan Cleaner Lake Erie through Action and Research (MICLEAR) Partnership and state agency staff concerning the adaptive management framework, stakeholder engagement structures and processes, governance and the research and development of social indicators. All of this contributed to the below supporting tasks related to outreach and engagement.

Outreach to the Public and Farmers Implementation: The DAP team will work with partners to formalize a broadened and balanced external stakeholder advisory body, with lessons and key attributes from MICLEAR's experience in mind. Formal partnerships with Erb Foundation and MSUE will be explored to support and facilitate the formation of this group. Important gaps for research and information that were identified during the interviews will be highlighted for partners to consider. A limited term group of human dimensions experts will be convened to explore and recommend social metrics for the adaptive management process. Human dimensions in the context of natural resource management refers to understanding attitudes, behaviors, and preferences of stakeholders to improve management and conservation of public lands and waters managed by the state.

Outreach to the Public and Farmers Tracking: The DAP Team will seek the advice from human dimensions experts on how best to track outreach and engagement efforts, but may use surveys, webinar participation, and other methods to track public and farmer perceptions.

Outreach to the Public and Farmers Contingencies: Insufficient or uneven resources and inconsistency of staffing may interfere with the ability to build needed relationships and commitments; changing administrations can destabilize programs; insufficient transparency may hinder ability or willingness of stakeholders to commit time or provide valuable input. Metrics that can engage stakeholder communities and demonstrate progress toward goals of value to them could energize contributors and create momentum and goodwill to overcome delays, misunderstandings, or inconsistencies in resources.

Adaptive Management Projects

The DAP Team will establish an external WLEB stakeholder advisory group to provide input and feedback on the adaptive management process.

- Establish an external, science-based WLEB stakeholder advisory body to provide input and feedback on the adaptive management process (Task 9e).
- Develop social-based metrics with assistance from social science experts to better understand public and farmer perception (Task 9d).

Working hypothesis: An improved external advisory structure for DAP implementation and evaluation will increase trust, collaboration, investment, and sustained adoption of practices.

Wetland Restoration, Riparian Buffers, and Green Infrastructure

Wetland Restoration, Riparian Buffers, and Green Infrastructure Priority Tasks (details in Appendix A):

- Promote wetland restoration and land management initiatives to reduce phosphorous loading (Task 10).

Wetland Restoration Planning: Functional wetlands, riparian buffers and other green infrastructure provide exceptional ecosystem services and can assist in mitigating nutrient runoff through biological filtering. Case studies in the Mississippi River Basin (Kalcic et al., 2018) and Ontario (Institute for Wetland and Waterfowl Research, 2020) have shown that restored wetlands improve water quality, recharge groundwater, and can provide important recreational opportunities. Implementing wetland restoration, riparian buffers, and other types of green infrastructure practices in agricultural dominated landscapes to intercept run-off is an important area of research.

Wetland Restoration Implementation: Based on a technique developed by the U.S. Fish and Wildlife Service, EGLE developed the Landscape Level Wetland Functional Assessment (LLWFA) to help identify priority areas for wetland protection and restoration using watershed location and wetland function.

TAKING ACTION ON LAKE ERIE

Seek funding to invest in the landscape to restore and develop highly functional wetlands to prevent phosphorous from entering Lake Erie to prevent harmful algal blooms and support ecosystem services.

The DNR, in partnership with Ducks Unlimited, has conducted a site prioritization analysis and used the LLWFA and other GIS tools to develop a 'suitability model' for potential locations. This model included the LLWFA information, parcel and land-owner information, LiDAR and associated indices, terrain, hydrologic characteristics, soil types, land cover, priority areas, and protected lands, among others.

These various datasets were overlaid with the parcel information and, based on the site selection criteria, were calculated, and applied a numerical rank directly to the parcels from 'least' to 'greatest' potential for water quality benefits.

Site selection criteria considered for the agriculture wetland restoration project include, but are not limited to:

- Potential water quality benefits
- Proximity and alignment with ditches and subsequent receiving waters
- Sub-watershed listed on the 2020 Integrated Report 303(d) impairment list
- Watershed size
- Watershed land cover type
- Hydric soils
- Plat/multiple ownership
- Proximity to state wildlife areas

A web mapping application was developed that included the model results and all datasets used as inputs for the model. This mapping application allows the users to interact with the data, apply custom filters and sub-selections, and evaluate sites with current aerial imagery to further refine site selection and targeted outreach. Over 2,100 sites were initially identified as potential locations for wetland restoration, and these were further evaluated by the partner team for suitability. Over 40 sites were identified as potential candidates for wetland restoration and landowners have been contacted.

In addition to the DNR's agriculture wetland restoration pilot project, the LLWFA was developed for the Michigan portion of the Bean Creek Watershed, which helped summarize status and trends of wetlands and their functions (Blonde and Cleland, 2019). This information is now being used to identify locations of current and potentially restorable wetlands that may serve as nutrient and sediment sinks and can be targeted for implementation actions (Figure 14).

Wetland Restoration Tracking: This project is in the pilot phase. EGLE NPS Program grant funded projects will be tracked by the NPS project database, MDARD funded projects will be tracked by the MAEAP database, and cumulatively track progress using the GLWMS.

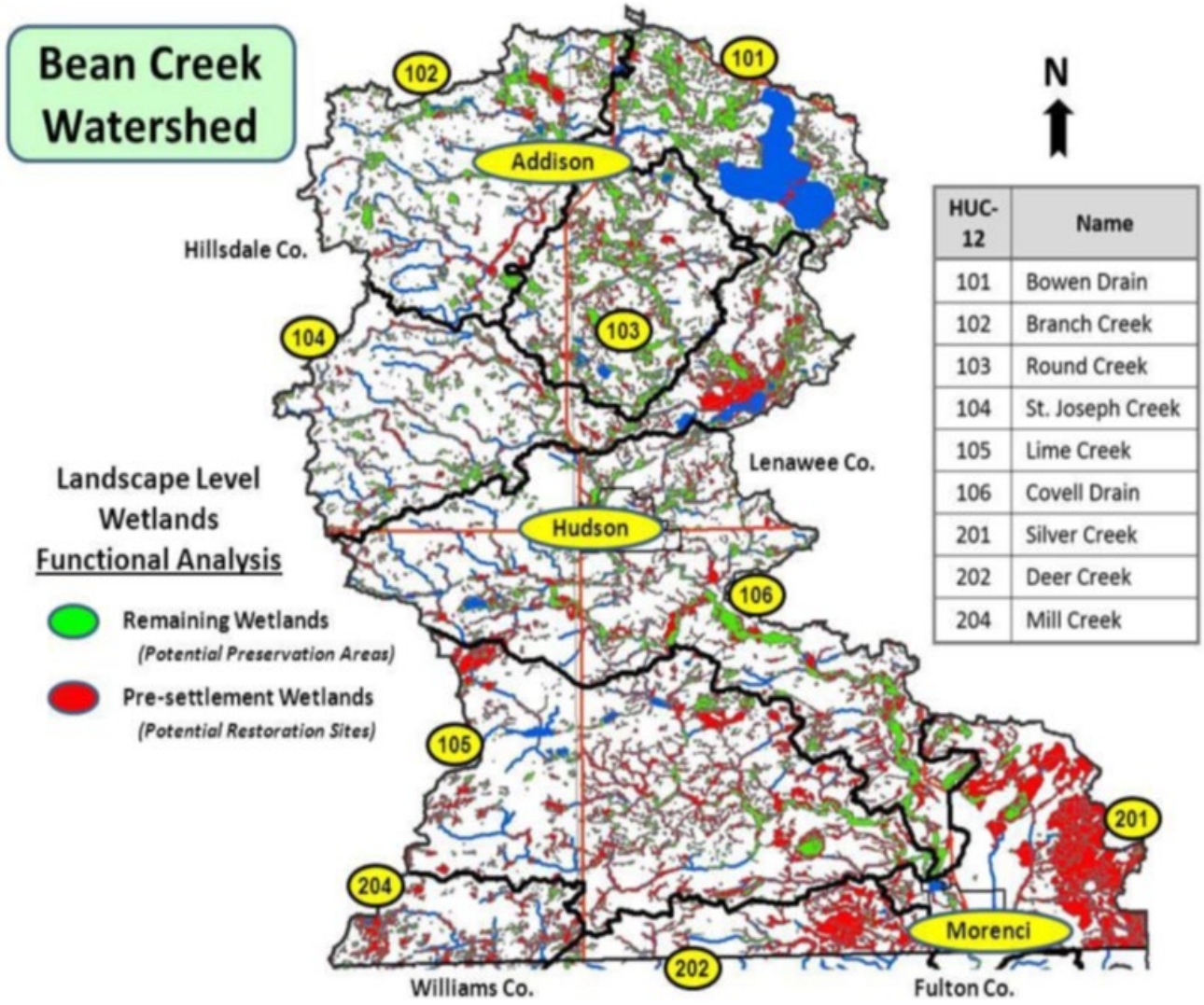


Figure 14. Landscape Level Wetland Functional Assessment included in the Bean Creek Watershed Plan that is being used to identify wetland loss and potential restoration areas (Blonde and Cleland, 2019).

Drain Easement Purchase Pilot Planning: Many producers in the WLEB currently farm up to the county and intercounty drain system with little to no buffer between the field planting and public drainage system. MDARD is interested in implementing a Saline River Watershed drain easement pilot project within Washtenaw County. The Saline River Watershed is a subwatershed of the River Raisin Watershed. This project will build off successful piloted drain easement projects implemented in Monroe and Saginaw counties to purchase drain easements with the requirement of the installing buffer strips within the drain easement.

Drain Easement Purchase Pilot Implementation: This pilot project would purchase drain easements stipulating the installation of buffer strips, which would lower sediment and phosphorus inputs into the waterways. These drain easements would be officially recorded, and the easements would be held by the Washtenaw County Water Resources Commissioner's Office.

Drain Easement Purchase Pilot Tracking: Existing research regarding vegetative buffers will be used to estimate sediment load reduction. The calculated sediment reduction will be based on the width and length of buffer strips installed, along with the drainage area contributing to each buffer. If there are opportunities to do physical monitoring of specific buffer strips, beyond inspection and maintenance, they will be considered on a case-by-case basis. MDARD will track implementation via the MAEAP database, and cumulatively track progress using the GLWMS.

ADAPTIVE MANAGEMENT PROJECTS:

Develop innovative strategies to enhance wetland restoration, green infrastructure, and other land management planning and implementation efforts in Southeast Michigan (Task 10a).

- Construct agriculture wetland restoration pilot in the WLEB (Task 10e).
- Implement a Saline River Watershed Drain Easement Purchase pilot to incentivize drain setbacks (Task 6k).

Working hypothesis: Wetland and buffer restoration sites of sufficient size to achieve substantial P reductions and other benefits (habitat, carbon storage) can be identified, appropriate land can be acquired, and sufficient funds for construction/maintenance/monitoring will be available, and restored sites will consistently capture and retain P as expected.

TAKING ACTION ON LAKE ERIE

Install a gage station in the Saline River, a tributary in the River Raisin Watershed, to monitor water quality improvements as a result of the drain easement purchase pilot project.

Wetland Restoration, Riparian Buffers, and Green Infrastructure Contingencies: Cost benefits considering total benefits (habitat, P retention, carbon storage) will be sufficient to justify investments. If restored wetlands do not prove to be a cost-effective means of reducing phosphorus loads, they may still have sufficient co-benefits to justify their creation. Related programs being implemented in Ohio at a larger scale will be important to watch for lessons learned and best practices. Sufficient monitoring will need to be conducted to quantify phosphorus-related benefits over time, and to determine which maintenance practices are necessary to prevent switching of wetlands from sinks to pulsed sources over time.

Approach to Evaluation

As part of the adaptive management process, the projects described above will be evaluated during and after completion based on available data, metrics, and qualitative information provided by project managers and participants. The evaluation process will consider the original working hypothesis, contingencies, and alternative hypotheses, along with input from the external WLEB stakeholder advisory group and other subject matter experts, as appropriate. Based on these evaluations, lessons learned about what worked well and potential areas for improvement will be compiled to inform planning in the next adaptive management cycle.

RESEARCH AND MONITORING TO REDUCE UNCERTAINTIES

Uncertainties are defined as gaps in our knowledge. There are multiple sources of uncertainty that apply to an adaptive management process of this magnitude including: 1) inadequate scientific understanding of phosphorus cycling and climate change impacts, 2) rapidly evolving technologies and information about the relative effectiveness and cost of various agricultural engineering practices to mitigate phosphorus loss, 3) social and economic factors like changing interstate and binational governance structures, and 4) fluctuating agricultural commodity prices. Along with structuring mitigation investments as hypothesis-driven exercises designed with opportunities for learning built in, developing a systematic approach to reducing uncertainty about processes and management actions is a key element of an adaptive management approach.

The MDARD, EGLE, and DNR staff, as part of the state's DAP Team, will use expert judgement and seek additional expertise when necessary to identify and reduce uncertainties over time. Building from the influence diagram workshop and the review of the conceptual models for Lake Erie (Appendix D), the DAP Team will be able to better categorize uncertainties (e.g., effectiveness, costs, relationships) and use the information to prepare and, where necessary, refine working hypotheses related to selected adaptive management projects and programs, and/or management actions. Monitoring and research elements of the adaptive management process that will be used to support evaluation are described below.

Research on Soil Test Phosphorus Levels and Manure Application Rates

Current guidelines for determining manure application rates to crop fields, are based on the soil test phosphorus levels in each crop field and the amount of phosphorus in the manure. When soil test phosphorus levels reach 75 parts per million (ppm) (Bray P1), the amount of manure phosphorus that can be applied becomes limited based on crop phosphorus removal rates. Once soil test phosphorus levels reach 150 ppm (Bray P1), manure and its associated phosphorus, can no longer be applied to the crop field.

The concern with allowing crop field soil phosphorus levels to build up to 150 ppm is that the level is four to five times the agronomic phosphorus level that is necessary to grow corn, soybeans or wheat, and the increased risk of phosphorus loss to surface waters, when soil phosphorus levels can be built up that high. The current 75-150 ppm soil test phosphorus levels are applied to all soil types across the state. However, it is known that certain soils can bind up less phosphorus and therefore making phosphorus more susceptible to being lost from the soil and potentially impacting water quality. Also, it is not known if the 75-150 ppm standard took into consideration soluble phosphorus and phosphorus discharges from tile lines.

TAKING ACTION ON LAKE ERIE

If the literature search shows that Michigan's standards are not protective of water quality, the results of the research will be used to establish standards that are protective of Michigan's water quality standards.

Given these unknowns related to what variables were considered to establish the standard and the fact that the standard is four to five times the necessary agronomic phosphorus rates, the state will be conducting a literature review to research what limits other states and Canada use for soil phosphorus limits. Specifically, the state is interested in understanding what data, research, and variables each of those jurisdictions utilize to set their limits. In addition to reviewing other jurisdictions guidelines, EGLE staff will be researching what data and variables were used to set Michigan's standards. If the literature search shows that Michigan's standards are not protective of Michigan's water quality standards, the results of the research will be used to establish standards that are protective of Michigan's water quality standards.

Watershed Research

Additional research to scale edge-of-field results (Daniels et al., 2018) to subwatershed and watershed scales (Bosch et al., 2011), including results of runoff measurements and tile drain measurements from drainage water management (DWM) would be useful. Research to more closely link BMPs to their impacts in the watersheds of interest would also be valuable. For example, HUC-12 agricultural inventories are being completed in the Bean Creek Watershed at the field scale. This detailed information is being used to strengthen a watershed model that can be used to help optimize BMP placement and impact. MDARD and EGLE are also collaborating with MSU to conduct a five-year research project in the River Raisin Watershed monitoring effectiveness in reducing nutrient loads from farmland with tile drainage systems.

Research on BMPs and In-Lake Processes

New publications are also expected soon on whole-lake biogeochemical modeling of Lake Erie, Central Basin hypoxia, HAB toxin production drivers, effectiveness of BMPs such as DWM, and investigations of Lake Huron loads to Lake Erie. As noted in the DAP, additional factors beyond nutrient loading from Michigan watersheds and point sources influence Lake Erie water quality and biological conditions. Therefore, it will be important to distinguish the strength of the full set

of drivers to determine whether impacts of implementation of BMPs in Michigan would be expected to be distinguishable in Lake Erie ecosystem responses. Additional discussion on in-lake processes is found in Appendix C.

Research on Other Watershed Processes

Despite recent research (Scavia et al., 2019), questions remain about phosphorus loading and processing in southern Lake Huron, the Thames River (Ontario), and the St. Clair-Detroit River System. The interaction of phosphorus in the Detroit River plume with spring diatom production, and summer hypoxia and cyanobacteria blooms are also not well studied. Lastly, the diversity of cyanobacteria in river mouths and how they are linked with open lake blooms is somewhat elusive at present.

Although a variety of agricultural BMPs are widely used, their effectiveness at reducing phosphorus loading is not routinely well constrained in models, and region-specific performance data and barriers to adoption are often lacking. The role of legacy phosphorus (Sharpley et al., 2013; Muenich et al., 2016) in overall loading to Lake Erie is an area of active research (LimnoTech, 2017; Osterholz et al., 2020; Guo et al., 2021). Phosphorus that is already in fields and tributary sediments may delay ecosystem recovery, even after BMPs are widely adopted (King et al., 2017). Analysis of 2019 loading data suggested that loads were lower than what would have been expected given the wet spring and high flows (Guo et al., 2021). Other recent field and stream sediment studies have produced results that seem inconsistent with these observations (e.g., Osterholz et al., 2020; Williamson et al., 2020). Research to reconcile these results continues.

Research on Climate Change

The Midwest Region chapter of the Fourth National Climate Assessment highlighted several trends that have the potential to influence phosphorus loading to Lake Erie and ecological impacts in the lake. Several researchers have identified statistical trends of increasing spring rainfall, runoff, and nutrient loading in Lake Erie watersheds (Stow et al., 2019; Williams and King, 2020). Warmer lake temperatures and longer summers with changing weather patterns are expected to produce more toxic algal blooms and more intense hypoxia in Lake Erie (Perello et al., 2017; Jankowiak et al., 2019).

Some researchers have proposed that shifting baselines may necessitate adjustments to nutrient loading targets even before they are achieved (Baker et al., 2019). Others have pointed out that under scenarios of longer growing seasons and more winter precipitation falling as rain rather than snow, agricultural nutrient losses in spring may decline, partially mitigating other negative climate change impacts on Lake Erie (Culbertson et al., 2016, Kalcic et al., 2019). Uncertainty related to net climate change impacts in the coming years is an important factor that is aligned with taking an adaptive approach in management of the system.

Finally, Michigan agency staff participate actively in research communities related to Lake Erie issues including the HABs Collaborative and the Invasive Mussel Collaborative. Staff also interact with NOAA's multi-university Cooperative Institute for Great Lakes Research, which is coordinated by the University of Michigan. Participating in these forums offers agency staff the opportunity to learn about new research before it is published and to communicate state management priorities

to the research community. Michigan staff also shares information with local advisory groups including the MAEAP WLEB Partnership (i.e., MDARD working group consisting of conservation districts, MAEAP technicians, NRCS staff, and River Raisin Watershed Council, and other partners), farmer-led conservation groups, other agricultural partners, and eventually will engage a broadened science-based WLEB stakeholder advisory group.

Research on Policy Development and Regulatory Approaches

Current regulatory authority under both the federal Clean Water Act and the state's Part 31 of the Natural Resources and Environmental Protection Act are limited for controlling agricultural nonpoint source pollution. However, the DAP Team will continue to explore new policies, regulations, and laws to reduce these sources. Implementing new regulatory restrictions on agricultural nonpoint pollution will require additional administrative and/or legislative actions.

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The DAP Team will continue to explore new policies, regulations, and laws to reduce agricultural nonpoint source pollution.

Watershed Monitoring

Water quality monitoring, including biological monitoring of fish and other aquatic organisms, is a critical component of the adaptive management process because data generated can be used to assess progress toward selected objectives and targets. Beyond in-state monitoring programs, the DAP Team will need to work through the Annex 4 process to develop the binational operational monitoring and modeling infrastructure and resources to support ongoing evaluation of changing watershed conditions and Lake Erie responses to nutrient reduction investments. This will be a critical component of assessing progress toward achieving the GLWQA nutrient reduction targets and Lake Erie ecosystem restoration goals.

Tributary monitoring should be sensitive enough to detect change. For example, initial results of finer spatial scale water quality monitoring (e.g., EGLE and LimnoTech, 2020), which has been conducted in recent years in the River Raisin and Maumee tributaries, indicate that there is a need for more measurements through the year in some locations to capture phosphorous loading from the spring freshet and storm events. Continuous nutrient measurement devices, water quality sondes and cost-effective water quality sensors can measure proxies for nutrients are being deployed by various organizations in the WLEB. Another important component of effectively using monitoring data for adaptive management is integrating data sets across locations and data types (e.g., water chemistry, BMP implementation, stream, and river/lake biology) through modeling and other synthesis approaches to extract the greatest amount of information and value from these data sets.

CONCENTRATED ANIMAL FEEDING OPERATION PERMIT AND GENERALLY ACCEPTED AGRICULTURAL AND MANAGEMENT PRACTICES

There is continued concern over animal feeding operations and the management of manure from those enterprises in Michigan's portion of the WLEB. In the 2020 Concentrated Animal Feeding Operation (CAFO) permit, EGLE set new limits on livestock manure spreading, which has been an active area of research in the Great Lakes Region (Long et al., 2019; LimnoTech, 2017; International Joint Commission, 2018). The 2020 CAFO permit limits land application on frozen and snow-covered ground and eliminates surface application during the months of January, February, and March. These months precede a time of year when runoff to surface waters is greatest. This approach also helps to ensure that the nutrients in the waste can be properly placed and used by crops. The permit made changes to the weather forecasting requirements as well to better prevent land application before rain events.

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- The 2020 CAFO Permit requires increased manure storage capacity, vegetative buffers, and manure application setbacks from surface waters.
- Improve the collaboration and governance of the GAAMP review committees by offering additional trainings, information sharing, and technical support.
- During the next evaluation, GAAMPs should be redesigned to ensure they are protective of Michigan's water quality standards and will prevent the runoff of excessive nutrients to Michigan's surface waters.

The permit also incorporates additional water quality protections by having CAFOs either use the Michigan Phosphorus Risk Assessment or putting in place both a 35-foot vegetative buffer and a 100-foot setback from surface waters. The additional practices of buffers and setbacks will further prevent waste and reduce associated phosphorus from entering surface waters. Along with this, the allowable soil phosphorus levels for land application were lowered to limit the fields on which additional waste can be applied and therefore helping to lower the potential source amount of phosphorus. That source includes both the legacy soil phosphorus and additional phosphorus inputs. Further reductions were implemented in nutrient Total Maximum Daily Load (TMDL) watersheds as well. The permit also provided guidance for additional pollutant reductions in non-nutrient TMDLs as they relate to animal agriculture (e.g., *E. coli*).

In addition to the field practice enhancements, additional monitoring, reporting, and tracking of waste requirements were added to the permit. This will help EGLE better understand locations and quantities of waste being land-applied as well as connecting the data to areas where water quality standards are not being met. The changes also provide greater transparency regarding tracking of the waste, as is done with other regulated wastes.

The *Generally Accepted Agricultural and Management Practices (GAAMP) for Manure Management and Utilization* is another agriculture management tool. GAAMPs are reviewed annually, and the most recent update was released in January 2021. The Manure Management GAAMPs are reviewed and developed through a Task Force including individuals from EGLE, MDARD, MSUE, MSU College of Agriculture and Natural Resources, Farm Bureau, USDA, and other stakeholders. This collaborative effort allows the GAAMPs to identify the management practices used to mitigate nuisance conditions to the environment and the public. The GAAMPs are reviewed by a Task Force of experts in that area of agricultural production and approved by the MDARD Agricultural Commission each year. While GAAMPs are 'generally accepted' as standards for practices in the area of focus, they are not BMPs. They are in place to provide both nuisance reduction as well as being protective of the environment. The frequency of review and approval allows for rapid adoption of new standards as the science develops. While conformance to the GAAMPs is not required by law, doing so affords certain protections as described under Michigan's Right to Farm Act. These conditions apply to all commercial farming operations regardless of enterprise.

PERFORMANCE MEASURES AND BENCHMARKS

Setting goals and measuring progress toward goals relative to benchmarks is a critical component of adaptive management. Through the establishment of the adaptive management process, the DAP Team recognized that metrics previously reported out in the 2018 DAP will need to be revisited through the lens of the adaptive management framework. The DAP Team will work closely with agency technical experts and the WLEB stakeholder advisory group to review the existing metrics, and where necessary, refine them or establish different metrics.

The ability to track implementation of management actions and link them to associated positive impacts within an adaptive management framework will make it possible to make informed and timely adjustments to strategic approaches moving forward. While progress has been made in meeting nutrient reduction goals with the aim of improving Lake Erie water quality and ecosystems, much work remains. The State of Michigan is committed to working effectively across agencies and with partners to achieve program goals.

The state will also continue to work through the Annex 4 process to understand how best to measure progress in areas where there are no SRP targets set. Watershed management planning efforts include important performance measures and benchmarks that can be used to track progress at the watershed level. Nonpoint source measures and benchmarks at finer scales, such as HUC-12 or smaller subwatersheds, are also in development to link monitoring results closely with field scale management. Specifically, Agricultural Inventory projects that are currently underway in the Bean Creek and River Raisin watersheds will help inform the process of establishing the appropriate indicators with metrics and focused BMP implementation.

SCHEDULE AND REPORTING PROGRESS FOR THE ADAPTIVE MANAGEMENT PLAN

In approximately March of each year, a draft annual report will be released covering management activities, monitoring and modeling results, relevant research results since the last report, nutrient load reduction progress, and lessons learned during the previous water year (Table 2). Two-year work plans will be prepared each year and synchronized with the state and federal fiscal calendars (Appendix B). Many work plan components will require external budgetary and timeline commitments beyond state agencies. One goal of all internal and external communications will be enhanced coordination and synergy within state government, and effective incorporation of innovation and helpful feedback into the evaluation and implementation processes. The Michigan DAP will be revised every five years, with the next revision due in 2023. The DAP update will replace the annual report in 2023, and every fifth year thereafter.

The commitments and approaches outlined in this Plan will initially be communicated within one or more formal and informal structures such as standing internal and external support groups, regular public meetings, press releases, forums and webinars, social media posts, and website updates. Targeted briefings with key stakeholders and impacted groups, including with MDARD's MAEAP WLEB Partnership, Lake Erie/St. Clair Citizens Fishery Advisory Committee, and Annex 4 will also continue. Geographically focused monitoring teams, including watershed and lake elements, will continue to be implemented. Other partners or programs that will be engaged include MSUE, the Conservation Districts, the Lenawee Conservation District Center for Excellence, and the Raisin River Farmer-Led Watershed Conservation program, among others. Regular and predictable reporting cycles, with feedback built in, will give stakeholders confidence in the process, and allow collaborators in other jurisdictions to hear about progress, lessons learned, and new research results that could benefit their own missions.

In addition to reporting out to key stakeholders groups, the DAP Team will regularly update the Taking Action on Lake Erie website, which provide more information to the general public related to the DAP and the Adaptative Management Plan implementation efforts. Information will also be shared on the Great Lakes Commission Blue Accounting ErieStat website. The DAP Team is also exploring the use of the Great Lakes Watershed Management System to cumulatively track BMP implementation efforts in the Bean Creek and River Raisin Watersheds, which may include a progress tracking dashboard that will be publicly accessible.

ADDITIONAL FUNDING AND OTHER RESOURCES

The DAP Team will continue to seek additional funding and other resources to best meet the goals of both the DAP and this Plan in collaboration with local, state, and federal partners. This additional support is necessary to achieve the actions listed in Appendix A: DAP Task Tracking Table and the two-year work plans. Tracking progress through these efforts will help align funding, other resource needs, and research with agency management commitments. This regular and predictable planning, assessment, and reporting cycle, with feedback from a WLEB stakeholder advisory group, is designed to give managers and stakeholders more confidence and empowerment in the collaborative process of tackling Lake Erie's nutrient issues together.

Table 2. DAP and Adaptive Management Reporting Timeline, including annual progress updates, two-year work plans, and the 2023 DAP update.

2018	2019	2020	2021	2022	2023	2024	2025
MI DAP Developed	DAP Progress Update		DAP/AM Progress Update	DAP/AM Progress Update	DAP Update	DAP/AM Progress Update	DAP/AM Progress Update
Taking Action on Lake Erie Website			DAP Progress Update	DAP Progress Update		DAP Progress Update	DAP Progress Update
		Draft Adaptive Mgmt. Plan	Final Adaptive Mgmt. Plan				
			Two-Year Work Plan* →				
				Two-Year Work Plan* →			
					Two-Year Work Plan* →		
						Two-Year Work Plan* →	

*Two-year work plans will be revised each year, as the second year will contain projections.

OUTREACH AND ENGAGEMENT

Public understanding of the importance of Lake Erie's issues and the actions that are being taken to improve conditions in the lake is a critical component of a successful program. Public perception, including by the wastewater treatment plant communities and agricultural producers in the watersheds that have been prioritized in the DAP, ranges from highly engaged and well-informed, to disengaged or even skeptical. Recent survey research by Wilson et al. (2018) found that willingness of farmers to adopt BMP practices was highly dependent on two factors: 1) the confidence of farmers in their ability to implement practices, and 2) the degree of farmer's belief in the effectiveness of the practices at reducing nutrient loss and improving local water quality. Both issues can be addressed by more effective outreach, including more and better training, and improved communication of research results concerning the impacts of practices on water quality.

Social metrics to track such things as farmer and public perception can be developed to assist with the long-term tracking and analysis of this type of information. It is recognized that research in this area requires social science expertise and partnerships with universities and nonprofit organizations. Fortunately, social metric or social indicator research, is underway in various communities in the WLEB region (Pearsall et al., 2012; Wilson et al., 2018; Wilson et al., 2019; Liberati et al., 2020). Additionally, national efforts in coastal communities have produced a fairly robust set of recommendations for social, behavioral, economic, and cultural indicators that are valued by communities, enhance stakeholder engagement, and improve decision making to increase resiliency (Smith et al., 2013; Lovelace et al., 2013; Lee et al., 2013; Yoskowitz, et al., 2019).

The State of Michigan will continue to engage through a WLEB stakeholder advisory group as in previous years through such efforts as the MICLEAR Partnership. The MICLEAR Partnership was an effort that resulted in enhanced relationships and improved understanding by regional leaders concerning the diverse array of efforts across the landscape to improve the long-term water quality of the WLEB. Perhaps most importantly, that partnership succeeded in an initial effort to bring together stakeholders and develop on the ground educational experiences for farmers and other citizens.

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The DAP Team will form a WLEB stakeholder advisory group that will include all stakeholder sectors in a balanced manner to advise the state on aspects of the adaptive management process.

Stakeholder engagement efforts undertaken in recent months have identified additional groups to engage, and topics of increasing importance for information, research and analysis, and communication. The DAP Team will continue to work with partners to support a refreshed and broadened WLEB stakeholder advisory group to continue and focus these efforts. This will include a formal proposed membership structure, mandate, plus administrative, logistical and facilitation support. This effort is expected to include all stakeholder sectors in a balanced manner from the following groups: farmers and agricultural support services; environmental, conservation and recreation; urban, equity and environmental justice; water and energy utility; corporate, coastal business and economic development; and regional watershed groups consistent with targeted efforts under Annex 4.

The goals of the WLEB stakeholder advisory group, while still retaining a focus on the long-term water quality of the WLEB, will promote general understanding and relationship-building among and across sectors, but will be expected to engage and advise the state on aspects of the adaptive management process. This will include reviewing information from the DAP Team and state agencies with an expectation that the advisory body will provide recommendations on decision points, investments, communication needs, research gaps, engagement, and communication priorities. In addition, the advisory group will be expected to recommend communication products for the state to support, propose and support permanently structured on

the ground and water educational experiences for a wide variety of WLEB citizens, and highlight concerns and priorities in a problem-solving discussion.

The state is expected to provide resources and partial support, along with clear communication expectations, feedback in a reasonable timeframe concerning the work of the advisory body, and best efforts to seek, engage and retain a diverse membership and representation of stakeholders across the region. Finally, the state will determine the most efficient and impactful engagement structure and process with this new WLEB stakeholder advisory group while remaining open to considering new and/or additional department engagement as needs and resources are identified.

NEXT STEPS

The adaptive management cycle is an iterative process. The state is in the initial set-up phase, which will take some time fully implement. Nevertheless, the DAP Team continues to advance focused work to achieve the phosphorus reduction targets by 2025 and is committed to working across agencies and with partners to achieve them. The ability to specifically track implementation of management actions through an adaptive management framework will improve the State's ability to adjust our strategic actions. The state agencies are relying on support and input from many others to adapt to changing conditions, unexpected results, new research findings, and new opportunities that arise as we seek to improve Lake Erie for the benefit of people and ecosystems.

APPENDIX A – MICHIGAN'S DAP TASK TRACKING TABLES

Task 1: Maintain the Phosphorous reductions achieved in the GLWA discharge due in part to the more stringent TP effluent limits placed in the NPDES permit in 2013.

Task No.	Task	Who	Milestone &Timeline(s)	Agency Reporting Source & Frequency	Status & Projections	Contingencies
1a	Achieve TP limits of 0.7 mg/l monthly average, and 0.6 mg/l growing season average (April – Sept.), as required at the main secondary treated outfall at the WWTP.	EGLE	Completed through NPDES Program DMRs and the NPDES permit term.	EGLE MiWaters, Monthly	Completed. GLWA is complying with NPDES permit.	Michigan will work through its compliance and enforcement process to address systemic non-compliance.
1b	Achieve TP limits of 1.5 mg/l monthly average as required at the two wet weather outfalls at the WWTP.	EGLE	Michigan will work through its compliance and enforcement process to address systemic non-compliance.	EGLE MiWaters, Monthly	Completed. GLWA is complying with NPDES permit.	Michigan will work through its compliance and enforcement process to address systemic non-compliance.
1c	Participate on monthly calls/meetings between EGLE and GLWA to ensure compliance with effluent limits and to discuss any issues.	EGLE, GLWA	Monthly call frequency reassessed annually.	EGLE, Monthly	Ongoing. Continues to provide a good forum to discuss challenges and progress.	N/A
1d	Correct untreated CSOs.	EGLE, GLWA	Completion of CSO projects through the NPDES permit term.	EGLE CSO, SSO, and RTB Discharge Report, Annual	Ongoing. GLWA meeting Long-term CSO Control Program.	Michigan will assess the Long-term CSO Control Program schedule during each permit re-issuance.

Task No.	Task	Who	Milestone &Timeline(s)	Agency Reporting Source & Frequency	Status & Projections	Contingencies
1e	Implement MS4 Program in Southeast Michigan.	EGLE, GLWA	Completed through the 5-yr NPDES Program cycle.	EGLE MiWaters, Annual	Ongoing.	Michigan will work through its compliance and enforcement process to address systemic non-compliance.
1f	Implement Biosolids permits.	EGLE, GLWA	Completed through the NPDES permit term.	EGLE MiWaters, Annual	Completed. GLWA is meeting the RMPs required by the provisions of the facilities NPDES permit.	Michigan will work through its compliance and enforcement process to address systemic non-compliance.
1g	Participate on the Annex 4 (Nutrient) Subcommittee's Adaptive Management Task Team to understand the relative contribution of the Lake Huron nutrient load to the St. Clair-Detroit River System and the Central Basin of Lake Erie.	EGLE, MDARD	Incorporate relevant Annex 4's Adaptive Management information into the DAP and AM Plans; as new information becomes available; Timeline TBD by Annex 4.	New information will be reflected in the 2023 DAP	Recently formed Adaptive Management Team will collaborate and coordinate with state and provincial jurisdictions on shared adaptive management efforts.	Continue to participate in the Annex 4 process and will determine whether to course correct based on Michigan data.

Task 2: Achieve reductions in P discharged from the DUWA WWTP and continue reductions at YCUA WWTP.

Task No.	Task	Who	Milestone & Timeline(s)	Agency Reporting Source & Frequency	Status & Projections	Contingencies
2a	Reissue NPDES permit with TP limits of 0.7 mg/l monthly average, and 0.6 mg/l growing season average (April – Sept.), at the treated outfall at the WWTP.	EGLE, DWUA	Completed through the 5-yr NPDES Program cycle.	EGLE MiWaters, Monthly	Completed. DUWA is complying with NPDES permit.	Michigan will work through its compliance and enforcement process to address systemic non-compliance.
2b	Achieve more stringent TP limits required by permit schedule by 2020 for DWUA WWTP.	EGLE, DWUA	Completed through NPDES Program DMRs and the NPDES permit term.	EGLE MiWaters, Monthly	Completed. DUWA is complying with NPDES permits.	Michigan will work through its compliance and enforcement process to address systemic non-compliance.
2c	Achieve the TP 0.6 mg/l growing season average permit effluent limit at the tertiary treated outfall at the YCUA WWTP, as required in its NPDES permit.	EGLE, YCUA	Completed through NPDES Program DMRs and the NPDES permit term.	EGLE MiWaters, Monthly	Completed. YCUA is complying with NPDES permit.	Michigan will work through its compliance and enforcement process to address systemic non-compliance.
2d	Continue to implement MS4 programs in Down River Communities.	EGLE, Wayne County	Completed through the 5-yr NPDES Program cycle.	EGLE MiWaters, Annual	Ongoing. Down River Communities will be issued MS4 NPDES permits.	Michigan will work through its compliance and enforcement process to address systemic non-compliance.

Task No.	Task	Who	Milestone & Timeline(s)	Agency Reporting Source & Frequency	Status & Projections	Contingencies
2e	Continue to implement DWUA WWTF Biosolids permit.	EGLE, DWUA	Completed through the NPDES permit term.	EGLE MiWaters, Annual	Ongoing. DWUA WWTF currently landfills all sludge. The WWTF is currently in design for a project to construct a biosolids dryer facility to produce Class A biosolids (anticipated to be completed in 2022).	Michigan will work through its compliance and enforcement process to address systemic non-compliance.
2f	Continue to implement MS4 programs in YCUA Communities.	EGLE, YCUA	Completed through the 5-yr NPDES Program cycle.	EGLE MiWaters, Annual	Ongoing. YCUA Communities meeting MS4 NPDES permits.	Michigan will work through its compliance and enforcement process to address systemic non-compliance.
2g	Continue to implement YCUA Biosolids permits.	EGLE, YCUA	Completed through the NPDES permit term.	EGLE MiWaters, Annual	Ongoing. YCUA is meeting RMP that is required by the provisions of the facilities NPDES permit.	Michigan will work through its compliance and enforcement process to address systemic non-compliance.

Task 3: Identify priority areas in Michigan's portion of the Maumee River Watershed for P reductions. Identify and implement priority actions to reduce P loads from Michigan's portion of the Maumee River Watershed.

Task No.	Task	Who	Milestone & Timeline(s)	Agency Reporting Source & Frequency	Status & Projections	Contingencies
3a	Develop and implement 2016 monitoring plans.	EGLE	Developed cursory monitoring program for the Bean Creek and St. Joseph River; 2016.	N/A	Completed. Helped to refine where additional monitoring was needed to fill gaps.	N/A
3b	Develop and implement 2017 monitoring plan, including SRP, in coordination with IN and OH.	EGLE	Monitoring began April 2017 and concluded in the Spring of 2018.	N/A	Completed. Helped to refine where additional monitoring was needed to fill gaps.	N/A
3c	Conduct additional monitoring as appropriate to evaluate P reduction success and identify additional target areas for reduction.	EGLE, USEPA, USGS, OH, IN	EGLE continues to work on a coordinated monitoring plan for the Maumee River watershed; 2020-2022.	New information will be reflected in the 2023 DAP Update	Ongoing. Four new gage stations have been installed in the Bean Creek and River Raisin Watersheds.	Continue funding to support continuous monitoring.
3d	Develop WMP for the Bean Creek Watershed.	EGLE	EGLE grant awarded to Hillsdale County CD to develop 319-approved WMP; 2018-2019.	EGLE - NPS Program Website, Annual	Completed. EGLE approved WMP in August 2019. Priority implementation activities are eligible for Section 319 and CMI funding.	Updates to the WMP will be sought as new information becomes available.
3e	Implement priority BMPs in critical areas identified in the EGLE-approved Bean Creek WMP.	EGLE, Hillsdale CD, interested partners	The WMP outlines 2-, 7- and 15-year milestones for a suite of agricultural BMPs (see table 36 in WMP), Annual.	EGLE - NPS Program Website, Annual	Priority activities are eligible for Section 319 and CMI funding.	Continued funding to support implementation of the WMP.

Task No.	Task	Who	Milestone & Timeline(s)	Agency Reporting Source & Frequency	Status & Projections	Contingencies
3f✓	Identify and track the number of MAEAP verified acres out of total cropping acres in the Bean Creek Watershed.	MDARD	Measure acreage in MAEAP verified farms as a percent of total farmland acres, Annual.	MDARD Legislative Report and MAEAP Database, Annual; New information will be reflected in the 2023 DAP Update	New in 2020. This project has been selected as part of the Adaptive Management process conducive to adaptive management.	Completion of MAEAP database.
3g	Conduct Agricultural Inventories in priority HUC-12 sub-watersheds in the St. Joseph River Watershed.	EGLE, Hillsdale CD, interested partners	Conduct agricultural inventories is a priority for NPS Program funding, Annual.	EGLE - NPS Program Website, Annual; New information will be reflected in the 2023 DAP Update	New in 2020. This project is in development.	Local capacity, funding to complete agriculture inventory phases of process.
3h✓	Identify and track the number of MAEAP verified acres out of total cropping acres in the St. Joseph River Watershed.	MDARD	Measure acreage in MAEAP verified farms as a percent of total farmland acres, Annual.	MDARD Legislative Report, MAEAP Database, Annual; New information will be reflected in the 2023 DAP Update	New in 2020. This project has been selected as part of the Adaptive Management process conducive to adaptive management.	Completion of MAEAP database.
3i✓	Conduct Agricultural Inventories in priority HUC-12 sub-watersheds in the Bean Creek Watershed.	EGLE, MDARD, Hillsdale and Lenawee CDs, interested partners	Projects to conduct agricultural inventories in the Bean Creek Watersheds is a priority for funding for the EGLE NPS Program; Erb Family Foundation funding projects; 2020-2025	EGLE - NPS Program Website; New information will be reflected in the 2023 DAP and Annual AM Plan Update	New in 2020. This project has been selected as part of the Adaptive Management process conducive to adaptive management.	Local capacity, funding to complete agriculture inventory phases of process.
3j	St. Joe WLEB Phosphorus Reduction.	MSU Extension	Implementation project to cost-share on no-till, cover crops, saturated buffer, and high-level nutrient management; 2021–2023.	EGLE - NPS Program Website, Annual; New information will be reflected in the 2023 DAP Update	New in 2021.	Contract will be increased if certain milestones are meet.

✓ = Project identified as conducive to adaptive management and selected as part of the Adaptive Management process.

Task 4: Support and invest in research to better understand the causes of HABs, including invasive mussels and SRP, and how these factors increase/decrease HAB events.

Task No.	Task	Who	Milestone & Timeline(s)	Agency Reporting Source & Frequency	Status & Projections	Contingencies
4a	Participate in the Great Lakes HAB Collaborative.	EGLE, GLC	HAB Collaborative produces outreach materials to inform jurisdictions and public on HAB state of science and management, Annual.	HAB Collaborative Website updates; Quarterly Newsletters	Ongoing. EGLE staff currently serves on the HAB Collaborative steering committee.	N/A
4b	Implement two HAB research grants: Detection of toxin-producing cyanobacteria development of HAB hazard maps, and development of smartphone app to detect HABs.	EGLE	EGLE research awarded grants in 2016.	New information will be reflected in the 2023 DAP	Completed.	N/A
4c	Conduct Zequanox pilots as needed.	EGLE, Marone Labs	Pilot completed in 2014.	N/A	Completed.	N/A
4d	Participate in the Invasive Mussel Collaborative and support research to better understand the role of invasive mussels in nutrient cycling and cyanobacteria blooms.	EGLE, GLC	Invasive Mussel Collaborative produces outreach materials to inform jurisdictions and public on state of science and management; Annual.	New information will be reflected in the 2023 DAP	Ongoing. Agency staff continue to track information produced by the Invasive Mussel Collaboration.	N/A

Task No.	Task	Who	Milestone & Timeline(s)	Agency Reporting Source & Frequency	Status & Projections	Contingencies
4e	Participate on Annex 4 Subcommittee.	MDARD, EGLE	Annex 4 Subcommittee meets monthly via conference calls and two face-to-face meetings; Annual.	Annex 4 Subcommittee Webinar, quarterly; GLEC meeting, Annual	Ongoing. The Annex 4 Subcommittee recently formed an Adaptive Management Team.	Clear understanding of jurisdictional roles and responsibilities.
4f✓	Design and fund a study to evaluate SRP discharge quality as a function of level of municipal treatment, including secondary treated, primary treated, CSO Retention Treatment Basins, and untreated CSOs.	EGLE, GLWA	Discussions will begin in 2021. Project timeline has not been determined.	New information will be reflected in the 2023 DAP	Ongoing. This project has been selected as part of the Adaptive Management process conducive to adaptive management.	Current treatment plant design may not allow for adjustments that can substantially or affordably change bioavailability of phosphorus.

Task 5: Utilize research and field demonstrations to identify the suite of BMPs that work collectively to reduce both TP and SRP at the field implementation level.

Task No.	Task	Who	Milestone & Timeline(s)	Agency Reporting Source & Frequency	Status & Projections	Contingencies
5a	Implement new MAEAP reporting and planning database to better track the cumulative impact of conservation practices across the watershed and county scale.	MDARD	MDARD refined the database used to track MAEAP acres and BMPs within the WLEB; Annual.	MDARD Legislative Report, Annual; MAEAP Database, Annual	Ongoing. Due to delays in the first phase of development, implementation of this system was pushed back March 2022.	Completion of MAEAP database.
5b	Expand MAEAP database through the addition of a spatial mapping decision-based tool to enable MAEAP technicians to demonstrate to farmers sensitive areas that are conducive to BMP installation.	MDARD	FY18 creation of spatial mapping decision-based tool. Implementation began in FY2021.	MDARD Legislative Report, Annual; MAEAP Database, Annual	Ongoing. Due to delays in the first phase of development, implementation of this system was pushed back March 2022.	Completion of MAEAP database.
5c	Implement spatial mapping decision-based tool upgrades to database with MAEAP technicians.	MDARD	FY19 rolled-out tool to MAEAP technicians. Implementation began in FY2021.	MDARD Legislative Report, Annual; and MAEAP Database, Annual	Ongoing. Due to delays in the first phase of development, implementation of this system was pushed back March 2022.	Completion of MAEAP database.
5d	Pursue new data and information about ecosystem dynamics, BMPs, and monitoring strategies through ongoing communications partners.	MDARD, EGLE, MDNR, interested partners	Agency staff annually review, identify, and participate in research-oriented workshops, meetings, and conferences, Annual.	New information will be reflected in the 2023 DAP	Ongoing. In 2019, agency staff participated in the planning of a binational, federally led Lake Erie Cooperative Science and Monitoring Initiative.	Covid engagement restrictions.

Task No.	Task	Who	Milestone & Timeline(s)	Agency Reporting Source & Frequency	Status & Projections	Contingencies
5e✓	Design and implement a study to evaluate the effectiveness of DWM control practices installed to reduce tile line discharges of nitrates, TP and SRP.	MDARD, EGLE, MSU	Effective DWM BMPs are understood, first water year calibration of the system, second water year evaluation of practices has begun, 2018-2023.	New information will be reflected in the 2023 DAP	Ongoing. In 2020, project completed the calibration phase. This project has been selected as part of the Adaptive Management process conducive to adaptive management.	Data latency, quality assurance/quality control issues.
5f	Issue pass-through grants to reduce sediment and nutrient loads from the WLEB by implementing priority BMPs from approved WMPs.	EGLE, local partners	Issue NPS pass-through grant request for proposals, Annual.	EGLE NPS Program Website, Annual	Ongoing. Three new grant funded projects focused on the WLEB were announced during the summer of 2019.	Local capacity, adequate financial and technical assistance.
5g✓	Reinstate CREP in the WLEB.	MDARD, EGLE, CDs, MSUE	Promote outreach, recruit enrollees, develop tracking metrics and monitor progress, Annual.	New information will be reflected in the 2023 DAP	New in 2020. This project has been selected as part of the Adaptive Management process conducive to adaptive management.	Secure funding from MI Legislature and NRCS.
5h✓	Determine the feasibility of implementing a regional commercial biodigester in the WLEB.	MDARD, EGLE, MSUE, interested partners	Creation of a commercial anaerobic digester would benefit the environment and create energy for the farm and/or grid. Project timeline has not been determined.	New information will be reflected in the 2023 DAP	New in 2020. This project has been selected as part of the Adaptive Management process conducive to adaptive management.	Permitting, determining site selection alternatives.

Task No.	Task	Who	Milestone & Timeline(s)	Agency Reporting Source & Frequency	Status & Projections	Contingencies
5i	Implement an additional 120 DWM controls to reduce tile line discharges from 3,300 acres of cropland per year for three years.	EGLE	EGLE currently has two open grants with tasks related to installation of tile line control structures, Annual.	EGLE- NPS Program Website, Annual	Ongoing. EGLE NPS Program grant funds were used to install a total of 566 tile line control structures, which allows for DWM on 15,037 acres of cropland in the River Raisin Watershed.	Local capacity, adequate financial and technical assistance.
5j	Soil test phosphorus literature review.	EGLE	Project timeline has not been determined.	New information will be reflected in the 2023 DAP	New in 2021.	N/A

Task 6: Implement P control actions in the River Raisin Watershed to achieve the target load reductions.

Task No.	Task	Who	Milestone & Timeline(s)	Agency Reporting Source & Frequency	Status & Projections	Contingencies
6a	Conduct forensic analysis to determine likely sources resulting in reductions.	EGLE	Completed February 2016.	N/A	Completed. New analyses have been reflected in the Adaptive Management Plan.	N/A
6b	Reissue the Monroe Metro WWTF permit with more stringent TP limits of 0.7 mg/l monthly average, and 0.6 mg/l growing season average (April - Sep), at the main secondary treated outfall at the WWTF.	EGLE	Completed April 2016 with revised TP limits completed in 2019. Completed through the 5-yr NPDES Program cycle.	EGLE MiWaters, Monthly	Completed. City of Monroe is complying with NPDES permit.	Michigan will work through its compliance and enforcement process to address systemic non-compliance.
6c	Continue to implement City of Monroe MS4 programs.	EGLE, City of Monroe	Completed through the 5-yr NPDES Program cycle.	EGLE MiWaters, Annual	Ongoing. City of Monroe is meeting MS4 NPDES permit.	Michigan will work through its compliance and enforcement process to address systemic non-compliance.
6d	Continue to implement City of Monroe Biosolids permits.	EGLE, City of Monroe	Completed through the NPDES permit term	EGLE MiWaters, Annual	Ongoing. City of Monroe is meeting RMP that is required by the provisions of the facilities NPDES permit.	Michigan will work through its compliance and enforcement process to address systemic non-compliance.

Task No.	Task	Who	Milestone & Timeline(s)	Agency Reporting Source & Frequency	Status & Projections	Contingencies
6e✓	Identify and track the number of MAEAP verified acres out of total cropping acres in the River Raisin Watershed.	MDARD	Measure acreage in MAEAP verified farms as a percent of total farmland acres; Annual.	New information will be reflected in the 2023 DAP	New in 2020.	Completion of MAEAP database.
6f✓	Fund updates to the approved River Raisin Watershed Management Plan.	EGLE, interested partners	EGLE-WRD will issue requests for proposals to update WMPs; Annual.	New information will be reflected in the 2023 DAP	Ongoing. Agricultural Inventories component has been selected as part of the Adaptive Management process.	Local capacity to update WMP, funding to complete phases of ag inventory process.
6g✓	Conduct Agricultural Inventories in priority HUC-12 sub-watersheds in the River Raisin Watershed.	EGLE, Hillsdale CD, interested partners	Projects to conduct agricultural inventories in the St. Joseph River and Bean Creek Watersheds are a priority for funding; Annual.	EGLE- NPS Program Website, Annual; New information will be reflected in the 2023 DAP	New in 2020.	Funding and technical support to complete agriculture inventory phases of process.
6h	River Raisin Nutrient Management Cost Share.	Lenawee CD	Implementation project to cost share on high-level nutrient management practices to reduce phosphorus losses from cropland; 2019-2022.	EGLE - NPS Program Website, Annual; New information will be reflected in the 2023 DAP Update	New in 2021.	Local capacity, adequate financial and technical assistance.
6i	Upper River Raisin Conservation Easement.	Legacy Land Conservancy	Implementation project to purchase conservation easements on eight parcels, totaling 102 acres and 4,750 feet of frontage on the River Raisin; 2019-2022.	EGLE - NPS Program Website, Annual; New information will be reflected in the 2023 DAP Update	New in 2021.	Local capacity, adequate financial and technical assistance.

Task No.	Task	Who	Milestone & Timeline(s)	Agency Reporting Source & Frequency	Status & Projections	Contingencies
6j	River Raisin Watershed Nutrient Reductions.	Lenawee CD	Implementation project to cost share on agricultural practices such as DWM, saturated buffers, and blind inlets; 2017-2021.	EGLE - NPS Program Website, Annual; New information will be reflected in the 2023 DAP Update	New in 2021.	Local capacity, adequate financial and technical assistance.
6k✓	Saline River Watershed Drain Easement Purchase Pilot.	MDARD, Washtenaw County Water Resources Commissioner, Washtenaw County CD, interested partners	Achieve permanent easements along a drain located in the Saline River Watershed; 2021-2023.	New information will be reflected in the 2023 DAP Update	New in 2020. This project has been selected as part of the Adaptive Management process conducive to adaptive management.	Dependent on EPA DAP funding.
6l	Develop WMP for Wolf Creek Subwatershed.	River Raisin Watershed Council, interested partners	Develop a new WMP for the Upper Wolf Creek watershed, a tributary of the River Raisin; 2021-2023.	EGLE - NPS Program Website, Annual; New information will be reflected in the 2023 DAP Update	New in 2021.	Local capacity to update WMP.

Task 7: Maintain and expand partnerships to provide valuable technical and financial assistance to farmers. Continue expanded CD MAEAP technical assistance levels through 2017 and beyond.

Task No.	Task	Who	Milestone & Timeline(s)	Agency Reporting Source & Frequency	Status & Projections	Contingencies
7a	Seek additional funding to assure the ongoing expanded levels of local MAEAP technicians in the WLEB.	MDARD, CDs	FY17 and each subsequent year, maintain technicians in the WLEB. Annually review the technical assistance need to expand, reduce, or target efforts.	MDARD Legislative Report, Annual	Ongoing. The MAEAP program provides seven grants to WLEB CDs. The 7 MAEAP technicians funded by those grants creates the highest technician density in the state to provide technical assistance to farmers.	Legislative support for continued funding of MAEAP.
7b	Strengthen partnerships with the agricultural community, including farming input providers and CCAs through the 4R Nutrient Stewardship Program, to encourage more farmers to take action to protect water quality.	MDARD, CDs, interested partners	Encourage grass roots farmer involvement in education, cost-share, and decision-making. Since FY17 promoted CCA incentive program to strengthen partnerships.	MDARD Legislative Report, Annual	Ongoing. MDARD and local CDs continue to work closely with technical service providers and CCA's to expand the reach of the program to farmers.	Local capacity, adequate funding to complete technical assistance.
7c	Partner with NRCS, MSUE, and other partners to offer training to MAEAP technicians.	MDARD, MSUE, federal, partners, interested partners	Staff trained in risk assessment tools, nutrient management, manure management system plans, knowledge of BMPs, communications, and landowner outreach; Annual.	MDARD Legislative Report, Annual	Ongoing. The MAEAP program provides optional and mandatory trainings to improve technician's skills and competencies. In 2019, six core trainings were held statewide.	Local capacity, adequate funding to complete training.

Task No.	Task	Who	Milestone & Timeline(s)	Agency Reporting Source & Frequency	Status & Projections	Contingencies
7d	Coordinate partnerships through quarterly MDARD MAEAP WLEB Partnership meetings to review technical assistance and resources available to farmers.	MDARD, CDs interested partners	Host four meetings per year. Debrief on local efforts to review who is doing what, success stories, and obstacles; Quarterly.	MDARD Legislative Report, Annual	Ongoing. The WLEB Partnership continues to meet quarterly to share information, opportunities, and success stories to help implement conservation practices on farms.	Covid engagement restrictions.
7e	Partner to identify and secure additional funding and cost share to provide opportunities to farmers.	MDARD, interested partners	Seek additional partnership opportunities to provide technical and financial conservation assistance; Annual.	MDARD Legislative Report	Ongoing. MDARD continues to pursue cost share to both farmers and technicians to increase BMP implementation.	Local capacity, adequate funding for cost share.
7f	Pursue and issue pass-through grants focused on farm conservation planning, livestock management strategies, and DWM strategies in the WLEB.	MDARD; EGLE, interested partners	MDARD pursues federal funding for BMP implementation, Annual; EGLE - NPS Program will release a request for proposals; Annual.	MDARD Legislative Report; Annual. EGLE – NPS Program Website; Annual	Ongoing. State agencies continue to pursue federal funds and continues to pass through funds annually.	Federal funds appropriated at the federal level.

Task 8: Increase and maintain MAEAP practice implementation for long-term water quality improvement.

Task No.	Task	Who	Milestone & Timeline(s)	Agency Reporting Source & Frequency	Status & Projections	Contingencies
8a	Identify and implement more incentives to expand participation in MAEAP through the MAEAP Advisory Council.	MDARD, MAEAP AC	Evaluate incentives and pilot projects; Annual.	MDARD Legislative Report, Annual.	Ongoing. The MAEAP AC has a standing Task Force that evaluates the program's direction, opportunities to expand the program, and provide input to the Council.	Covid engagement restrictions.
8b	Increase MAEAP cropland acres managed under NMPs.	MDARD, CDs	Increase total MAEAP NMP acreage on farms by 35,000 acres; Annual.	MDARD Legislative Report; Annual	Ongoing. MAEAP verified acres in the WLEB increased from 15,356 acres in FY17 to 33,108 acres in FY20.	Local capacity, adequate funding for cost share and technical assistance.
8c	Identify and track the number of farms eligible for reverification and discuss during local MAEAP goal-setting meetings.	MDARD, CDs	Maintain a minimum of 85 percent reverification rate for farms in the WLEB; Annual.	MDARD Legislative Report; Annual	Ongoing. MDARD and CDs continue to meet to determine the number of reverifications each year. This allows the program to maintain a reverification rate in excess of 85 percent.	Completion of MAEAP database.
8d	MAEAP technicians work one-on-one with farmers to provide technical assistance and identify environmental risks and recommend and prioritize BMP installation.	MDARD, CDs	Track number of risk assessments, BMPs installed, and acreage impacted; Annual.	MDARD Legislative Report; Annual; and MAEAP Database; Annual	Ongoing. CD technicians continue to provide one-on-one technical assistance to farmers working through the MAEAP process.	Local capacity, adequate funding for cost share and technical assistance.

Task No.	Task	Who	Milestone & Timeline(s)	Agency Reporting Source & Frequency	Status & Projections	Contingencies
8e	Increase farmers participating in MAEAP and track the environmental gains on both verified and non-verified farms; Reduce additional sediment entering the waters in the WLEB by 44,000 tons per year; reduce additional P loading by 46,000 pounds (21 MT)/year; and reduce additional N loading by 176,000 pounds (80 MT)/year.	MDARD, CD's	Increase number of program participants to 120 percent of FY17 level; Annual.	MDARD Legislative Report, and MAEAP Database, Annual	Ongoing. In FY20, there were 48 new verifications in WLEB counties, along with 34 reverifications.	Completion of MAEAP database, local capacity, adequate funding for cost share and technical assistance.

Task 9: Improve and increase outreach to the public and farmers to promote understanding of the basin and good conservation practices by initiating new targeted outreach campaigns, workshops, field demonstrations and information sharing.

Task No.	Task	Who	Milestone & Timeline(s)	Agency Reporting Source & Frequency	Status & Projections	Contingencies
9a	Work with the MAEAP Communications Work Group and partners to conduct targeted outreach to public and farmers to raise the awareness of the benefits of MAEAP.	MDARD, interested partners	MAEAP Communications Work Group meets six times a year and will annually review short and long-term communication goals. FY17-19 MDARD partner with Farmer-led conservation effort on targeted outreach analysis and campaign in WLEB.	MDARD Legislative Report, Annual; Communications Work Group reports to MAEAP AC, Bi-monthly	Ongoing. In 2019, the MAEAP Webpage was redesigned to be more user-friendly.	Updates to the MAEAP Webpage will be made as new information becomes available.
9b	Host six conservation sails in FY17 to help farmers experience the impact of land management decision on the waters of Lake Erie first-hand through water sampling and educational presentations.	Lenawee CD, interested partners	Reviewed attendance and impact of education to determine ongoing efforts, completed in FY17.	MDARD Legislative Report, Annual	Completed. Sails were conducted in 2017.	N/A
9c	Coordinate with partners to host on-farm field days, MAEAP Phase 1 educational events.	MDARD, CDs, MSUE, interested partners	Review attendance and impact of education to determine ongoing efforts; Annual.	MDARD Legislative Report and MAEAP Database, Annual	Ongoing. MDARD, MSUE and local CDs continue to host field days to demonstrate BMPs to farmers.	Covid engagement restrictions.

Task No.	Task	Who	Milestone & Timeline(s)	Agency Reporting Source & Frequency	Status & Projections	Contingencies
9d✓	Establish an external WLEB stakeholder advisory group to provide input and feedback on the adaptive management process.	EGLE, MDARD, DNR, interested partners	WLEB stakeholder advisory group will be formed in 2022.	New information will be reflected in the 2023 DAP and Annual AM Plan Update	New in 2020. This effort has been selected as part of the Adaptive Management process conducive to adaptive management.	Need to ensure adequate stakeholder representation, Covid engagement restrictions.
9e✓	Develop social-based metrics to better understand public and farmer perception.	EGLE, MDARD, DNR, interested partners	Implement surveys and additional outreach efforts such as public webinars, agency staff presentations at conferences, workshops, and other public engagement opportunities; Annual.	New information will be reflected in the 2023 DAP and Annual AM Plan Update	New in 2020. This effort has been selected as part of the Adaptive Management process conducive to adaptive management.	Creation of advisory committees, Covid engagement restrictions.

Task 10: Promote wetland restoration and land management initiatives to reduce phosphorous loading.

Task No.	Task	Who	Milestone & Timeline(s)	Agency Reporting Source & Frequency	Status & Projections	Contingencies
10a	Develop innovative strategies to enhance wetland restoration, and green infrastructure, and other land management planning and implementation efforts in Southeast Michigan.	EGLE, MDARD, DNR, SEMCOG, LUGs, NGOs, interested partners	Planning and implementing state, regional, and local planning, and implementation efforts; Annual.	New information will be reflected in the 2023 DAP and Annual AM Plan Update	Ongoing. Will continue to pursue federal and state funding.	Local capacity, adequate financial and technical assistance.
10b	Work with agency staff to review BMPs implemented on state managed lands in the WLEB.	DNR	Assess state managed lands in the WLEB to understand the types of BMPs are, or could be, implemented to protect water quality, in development.	New information will be reflected in the 2023 DAP and Annual AM Plan Update	Ongoing. Planning for review in development.	DNR GIS staff and funding availability to conduct project.
10c	Work with partners to pursue strategic conservation easements in coastal wetlands, riparian zones, and key wetland areas to improve groundwater infiltration, reduce runoff, and support diverse aquatic and terrestrial biota.	DNR, EGLE, interested partners	External and internal funding opportunities will be shared with interested partners; Annual.	New information will be reflected in the 2023 DAP and Annual AM Plan Update	Ongoing. A team of GIS staff are reviewing selection criteria and will begin evaluating potential sites with restoration potential.	Local capacity, adequate financial and technical assistance.
10d	Issue requests for proposals that place a priority on purchasing conservation easements to limit land use activities that are detrimental to water quality.	EGLE, interested partners	NPS Program's support conservation easement projects using pass-through grant request for proposals; Annual.	EGLE - NPS Program Website, Annual	Ongoing. In 2019, NPS Program funding was provided to local partners to implement conservation easements in the River Raisin Watershed.	Local capacity, adequate financial and technical assistance.

Task No.	Task	Who	Milestone & Timeline(s)	Agency Reporting Source & Frequency	Status & Projections	Contingencies
10e ✓	Implement an agriculture wetland restoration pilot in the WLEB.	DNR	The wetlands constructed will capture agricultural runoff and be open to the public for recreational activities; Project proposal submitted to the Michigan Natural Resources Trust Fund; 2021-2023.	New information will be reflected in the 2023 DAP and Annual AM Plan Update	New in 2020. This project has been selected as part of the Adaptive Management process conducive to adaptive management.	Permitting, determining site selection alternatives.
10f✓	Implement pilot green infrastructure projects in SEMI communities.	EGLE, SEMCOG, interested partners	Piloted green infrastructure projects are implemented on municipal lands; 2018-2021.	New information will be reflected in the 2023 DAP and Annual AM Plan Update	Ongoing through 2021 calendar year. A second proposal has been submitted to USEPA to expand the program through 2024. This project has been selected as part of the Adaptive Management process conducive to adaptive management.	Local capacity, adequate financial and technical assistance, permitting.
10g	Soil Testing to Reduce Agriculture's Nutrient Delivery (STRAND) in WLEB.	MDARD, CDs, interested partners	Promote program participation and encourage farmers to make informed decisions about nutrient applications to cropland based on scientifically derived values through soil tests; 2018-2022.	New information will be reflected in the 2023 DAP and Annual AM Plan Update	Ongoing through 2022 calendar year.	Local capacity, adequate financial and technical assistance.

Task No.	Task	Who	Milestone & Timeline(s)	Agency Reporting Source & Frequency	Status & Projections	Contingencies
10h	Resource Conservation Partnership Program Tri-State Collaboration.	MDARD, OH, IN, NRCS, NGOs, interested partners	Program will offer financial assistance through the NRCS Farm Bill by placing conservation best management practices on the ground and working with partners to educate landowners on the importance of soil health and decreased nutrient loading; 2021-2025.	New information will be reflected in the 2023 DAP and Annual AM Plan Update	New in 2021.	Local capacity, adequate financial and technical assistance.
10i	MI Clean Water Plan.	EGLE	The investment focuses on rebuilding Michigan's infrastructure and provides $500 million worth of funding to help local communities upgrade their drinking water and wastewater infrastructure, including $35 million for a Failing Septic System Elimination Program; Beginning FY22.	New information will be reflected in the 2023 DAP and Annual AM Plan Update	New in 2021.	Local capacity, adequate financial and technical assistance.

APPENDIX B – ADAPTIVE MANAGEMENT PLAN TWO-YEAR WORK PLAN (DRAFT)

Adaptive Management Plan Work Plan (2022 – 2023) Updated: 12/7/21

Action(s)	Proposed Responsible Parties	Challenges & Contingencies	Expected Completion Date (Calendar Yr, Quarter)
Develop annual cost estimate and identify dedicated funding source to support AM program.	DAP Team, agency leads	Agency budget process, COVID budget impacts.	2022, Q1
Confirm agency commitments and timelines for AM Plan implementation.	DAP Team, agency leads	Dependent on agency approval timelines and resources.	2022, Q2
Task 9d. Create outreach and engagement external WLEB stakeholder advisory group.	DAP Team	Need to ensure adequate stakeholder representation.	2022, Q2
Conduct virtual workshops, meetings, and webinars to review the Adaptive Management Plan, priority uncertainties, and proposed management options.	DAP Team, WLEB stakeholder advisory group	Creation of advisory committees, Covid engagement restrictions.	2022, Q4
Determine adequacy of current monitoring, modeling, and data management and analysis programs to support management decisions.	DAP Team	Staff capacity to review adequacy.	2022, Q4
Set clear priorities for science, research, and monitoring in the Bean Creek, St. Joseph River, and River Raisin Watersheds, and identify a mechanism for steering resources and funds to address these priorities as part of the structured AM process.	DAP Team, WLEB stakeholder advisory group	Creation of advisory groups and committees, developing prioritization process, data availability.	2022, Q4
Identify or refine specific metrics to track DAP progress.	DAP Team, WLEB stakeholder advisory group	Metrics that demonstrate progress toward goals can create momentum to overcome delays, misunderstandings, or inconsistencies in resources.	2022, Q4
Task 1g. Participate on the Annex 4 (Nutrient) Subcommittee's Adaptive Management Task Team.	EGLE	Clear understanding of jurisdictional roles and responsibilities.	2022, Q4
Task 3f. Identify and track the number of MAEAP verified acres out of total cropping acres in the Bean Creek Watershed.	MDARD	Completion of MAEAP database.	2022, Q4
Task 3g. Conduct Agricultural Inventories in priority HUC-12 sub-watersheds in the River Raisin and Bean Creek Watersheds.	EGLE, MDARD	Funding to complete agriculture inventory phases of process.	2024, Q4

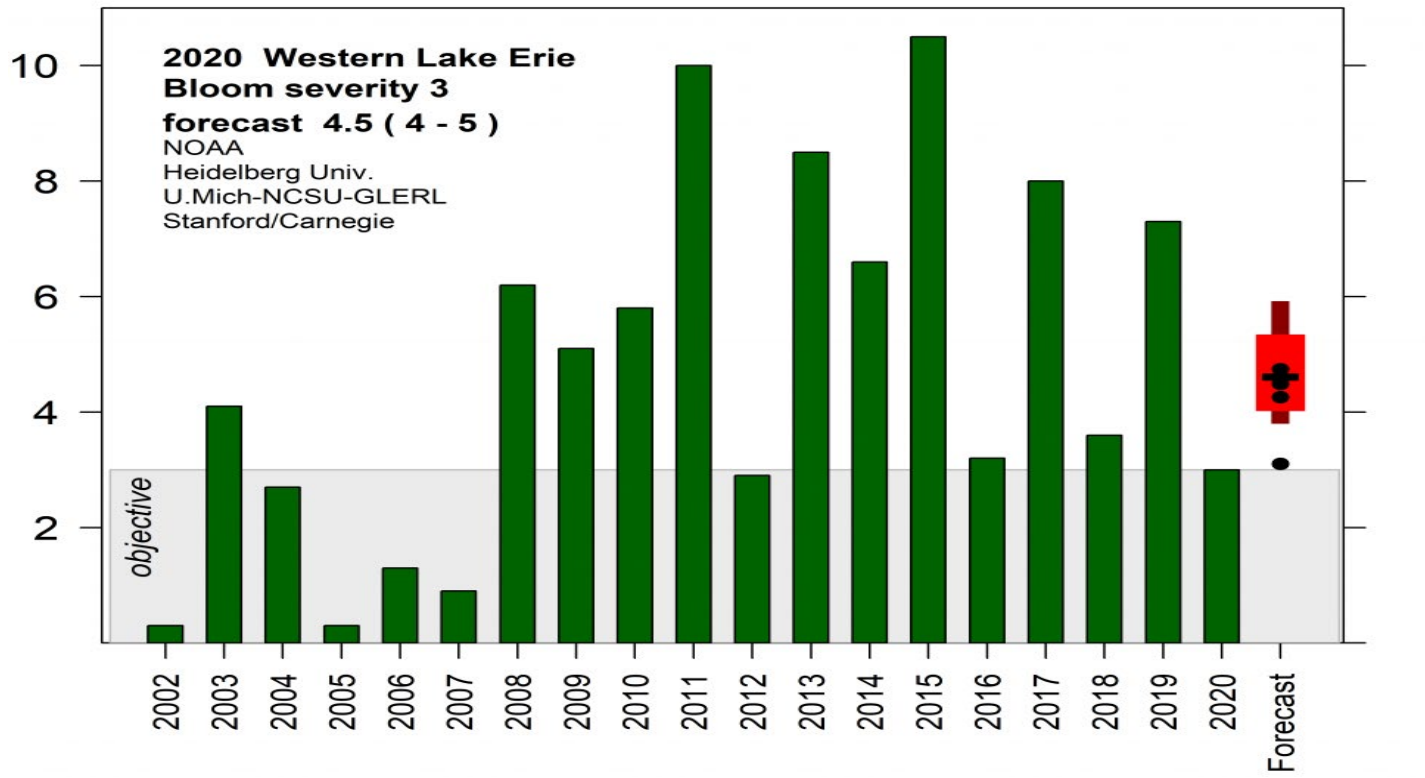
Action(s)	Proposed Responsible Parties	Challenges & Contingencies	Expected Completion Date (Calendar Yr, Quarter)
Task 3h. Identify and track the number of MAEAP verified acres out of total cropping acres in the St. Joseph River Watershed.	MDARD	Completion of MAEAP database.	2022, Q4
Task 4f. Design and fund a study to evaluate SRP discharge quality as a function of level of municipal treatment, including secondary treated, primary treated, CSO Retention Treatment Basins, and untreated CSOs.	EGLE, GLWA	Data availability, site selection, funding.	2023, Q4
Task 5e. Design and implement a study to evaluate the effectiveness of DWM control practices installed to reduce tile line discharges of nitrates, TP and SRP.	EGLE, MDARD, MSU	Data latency, quality assurance/quality control issues.	2024, Q4
Task 5g. Reinstate Conservation Enhancement Reserve Program in the WLEB.	MDARD	Secure funding from MI Legislature and NRCS.	2022, Q3
Task 5h. Determine the feasibility of implementing a regional commercial biodigester in the WLEB.	EGLE	Permitting, determining site selection alternatives.	2023, Q4
Task 6e. Identify and track the number of MAEAP verified acres out of total cropping acres in the River Raisin Watershed.	MDARD	Completion of MAEAP database.	2022, Q4
Task 6f. Fund updates to the approved River Raisin Watershed Management Plan, including support to conduct Agricultural Inventories on 12-digit HUC sub-watersheds.	EGLE	Local capacity to update WMP, funding to complete phases of ag inventory process.	2024, Q4
Task 6k. Fund Saline River Watershed Drain Easement Purchase Pilot	MDARD	Secure funding from EPA.	2023, Q4
Task 9d. Increase outreach to the public to promote understanding of the Lake Erie Basin ecosystem, good conservation practices, and progress being made to achieve nutrient reductions.	DAP Team, WLEB stakeholder advisory group, QOL Communication Teams	Covid engagement restrictions.	2023, Q4
Task 10e. Design and fund constructed wetland restoration pilot in the WLEB.	DNR	Permitting, determining site selection alternatives.	2023, Q4
Identify changing data needs and priorities for management.	DAP Team	Sustained funding of data collection and synthesis.	2022, Q4

APPENDIX C - STATUS OF THE ECOSYSTEM AND OTHER RELEVANT MANAGEMENT ACTIONS

Effective adaptive management of environmental restoration requires regular assessment of ecosystem, the state of management actions, expected direct results of management actions, and expected ecosystem outcomes. The work described in this Plan represents only a portion of the actions occurring under the DAP and across all state programs. These, in turn, are part of a larger effort by Michigan municipalities, businesses, conservation organizations, universities, private foundations, and individuals to restore the health of Lake Erie and its watershed by contributing to nutrient control efforts.

Western Lake Erie Basin

It is important to understand the components and processes operating to produce HABs in the WLEB (Appendix B). Understanding the relative magnitudes of the biomass pools and fluxes of nutrients and energy in the system can help with determining where management actions and monitoring systems might be effectively applied to reduce HABs. Satellite imaging indicates that blooms in the last five years have not reached the sizes of the 2011 or 2015 blooms, despite heavy spring rains in 2019 (Figure 1). One hypothesis to explain this result, which is consistent with tributary data, is that conditions were wet enough to prevent many fields from being planted or fertilized in spring of 2019, reducing the phosphorus mass available for transport to the lake (Guo et al., 2021).



Appendix C - Figure 1. Western Lake Erie algal bloom severity since 2002, including 2020 forecast (red box with dots) and actual values (green bar farthest to the right). Source: NOAA, 2020.

Western Lake Erie TMDL

There is ongoing interest in understanding Michigan's approach to addressing the nuisance algal conditions in open waters of Lake Erie by establishing a TMDL. Currently, EGLE does not believe a TMDL is the best way to achieve the goals set out in the larger Annex 4 process, including reducing the frequency of unacceptable nuisance algal blooms in Western Lake Erie. The problems being experienced in Lake Erie are due to multinational sources of nutrients. The multi-state and multi-national framework that the GLWQA established under Annex 4 offers a much more relevant process to address the shared issue of nutrient pollution rather than disparate state-based TMDLs and no unified multinational approach.

Michigan could develop a TMDL that would incorporate the required nutrient reductions needed to meet the targets established for its portions of the WLEB. That would allow the State the regulatory authority to reduce contributions from NPDES permit facilities. However, to date, the Water Resources Division (WRD) of EGLE has identified the needed NPDES reductions from permitted point source facilities and those facilities are meeting the required reductions. Importantly, there seems to be a misconception that developing a TMDL for Michigan's portion of Western Lake Erie would provide more regulatory authority over the various NPS contributions. After an extensive review of existing Legislation, the state's current Rules governing NPS contribution, and discussions with the USEPA, EGLE has determined that a TMDL does not offer any additional NPS regulatory authority. At this time, true NPS nutrient reductions can only be achieved through voluntary measures under any approach.

One typical TMDL requirement is the development of nutrient loading estimates for permitted and nonpoint sources. EGLE's WRD is developing watershed planning projects that will identify NPS loading reduction targets down to the hydrologic unit code 12 (HUC-12) subwatershed scale. Those sources/loads will be targeted through the adaptive management process and progress towards implementing appropriate NPS reductions will be tracked through a tracking platform such as the GLWMS, as well as water quality monitoring in various locations in the subwatersheds.

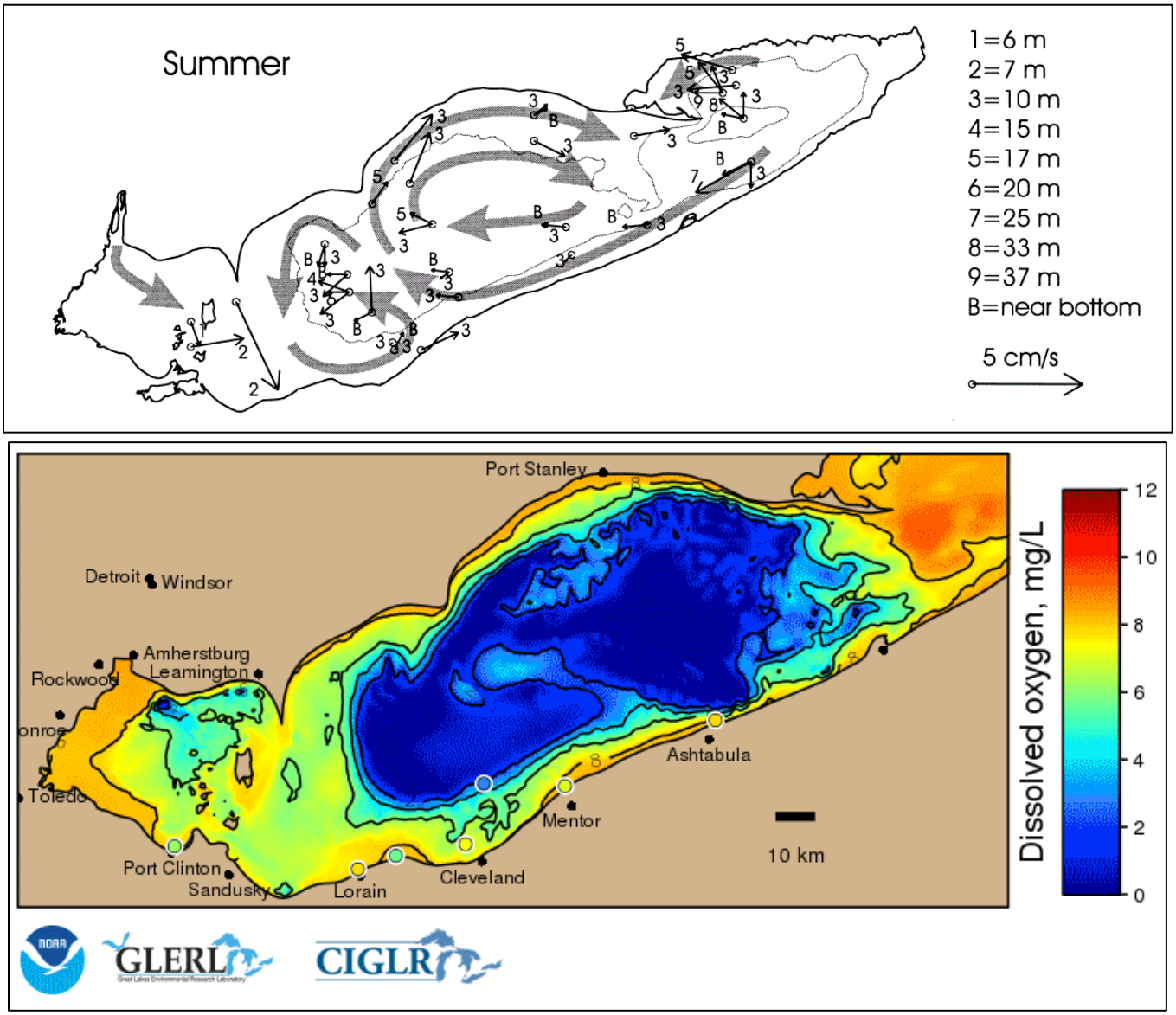
Finally, the WRD will be working with the USEPA to prepare the 2022 Integrated Report which will change the impairment listing for Lake Erie to Category 5 - Alternative. This category acknowledges that an alternative to a TMDL will be used to restore the designated use impairments. Around the country, the Category 5 - Alternative designation is typically used in situations where multiple partners are working on broad and often nonpoint source issues, like the nutrient pollution situation we have in Western Lake Erie.

Central Lake Erie Basin

Due to its depth, stratification, and annual deposition of phytoplankton biomass that consumes oxygen as it decays, the Central Basin of Lake Erie is subject to seasonal hypoxia (i.e., oxygen depletion) that typically reaches its greatest extent in late summer or early fall (Rowe et al., 2019). Algal biomass driving hypoxia comes from spring diatom blooms in the Western and Central Basins, which are driven to a greater extent by nutrient loading from the Detroit River than are Western Basin HABs (Rucinski et al., 2016), as well as from more localized loading from Central Basin tributaries and greenhouse effluent in the Leamington region of southern Ontario (Maguire et al., 2018).

Sediment oxygen demand and meteorological conditions that influence stratification are also important. Benthic organisms are eliminated by hypoxia in the summer, and fish feeding, and spawning are likely restricted. Biological impacts of hypoxia are a topic of active research (Stone et al., *in press*). The primary human impacts are on drinking water quality in Cleveland and other cities that draw drinking water from the Central Basin due to upwelling of low-oxygen water into intakes (Rowe et al., 2019). Because hypoxia is not detectable from satellites, the spatial and historical coverage of data on hypoxia extent and duration in the basin is much more limited than that of HABs data, although hypoxia has been studied more intensively than it had been previously beginning in approximately 2014.

Hypoxia forecasting models have become increasingly sophisticated (Rowe et al., 2019; Figure 2). Highly resolved annual delineations of hypoxic area or volume are not available. Research is needed on ways to detect changes in Central Basin hypoxia over time in response to nutrient loading reductions, as distinct from other factors such as variable weather conditions. A conceptual model diagram of the Central Basin is shown in Appendix B. Rowe et al. (2019) suggested that there is some evidence of greater oxygen demand on the western end of the Central Basin than on the eastern end, which could be linked to its proximity to the highly productive WLEB. More research and assessment through the Annex 4 process will help address knowledge gaps for the Central Basin.

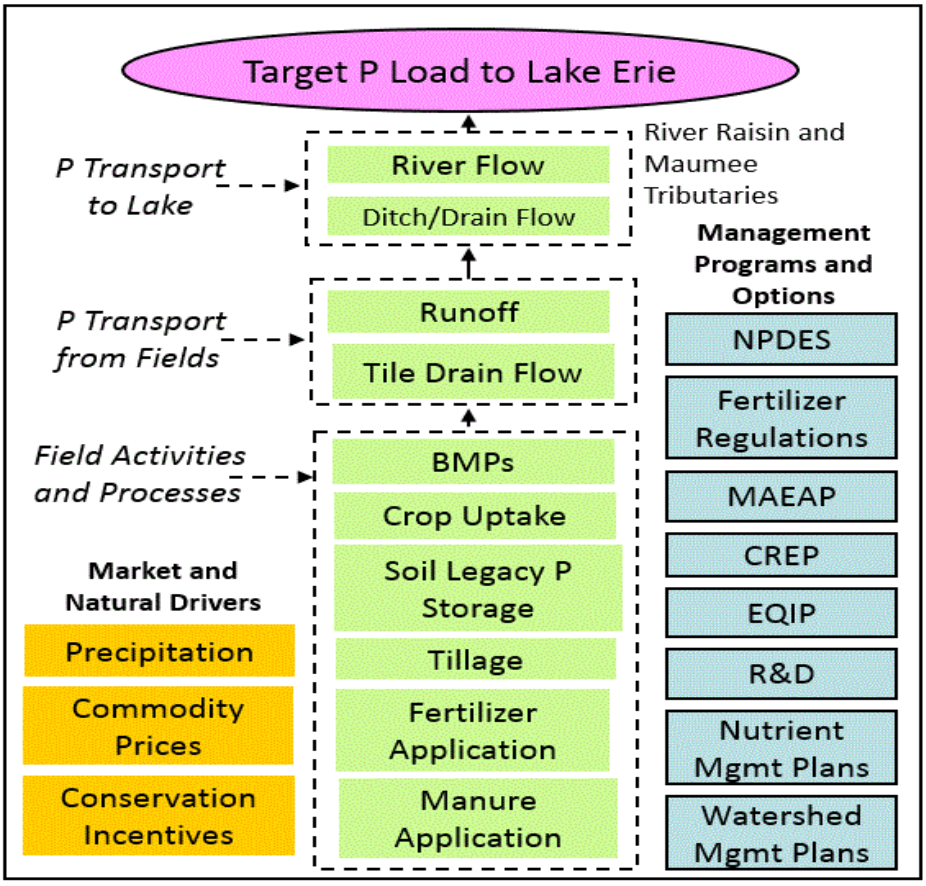


Appendix C – Figure 2. Top panel: Lake Erie average summer circulation (top panel, large arrows) showing transport of Detroit River discharge to Central Basin in lower left of panel (Beletsky et al., 1999). Bottom panel: Numerical model simulation of the low-oxygen area of central Lake Erie for 18 September 2018: https://noaaglerl.blog/tag/hypoxia/ . See Rowe et al. (2019) for more details on the model. Colored circles indicate locations of monitoring data, for comparison with model output. A conceptual diagram of Central Basin processes is included in Appendix B.

APPENDIX D – CONCEPTUAL MODEL DIAGRAMS

One way to keep track of refinements in understanding of how the ecosystem component's function is to develop and regularly revisit conceptual models of parts of the Lake Erie system. In preparation for developing this Plan, agency staff held an influence diagram workshop to "gather the givens" to clarify nutrient sources, review results of recent research on NPS loading, including recent findings related to Lake Huron nutrient inputs (Scavia et al. 2019a, 2019b), and consider how point source and NPS programs might be better quantified and enhanced to track and accelerate progress toward nutrient reduction goals (Scavia et al., 2016). Point sources to the Detroit River were also discussed briefly, but primary attention was concentrated on processes and programs identified in the below NPS loading influence diagram.

This NPS loading diagram shows linkages between the natural and human systems that control and influence conditions in Lake Erie, including State of Michigan programs and stakeholder activities. The conceptual models and influence diagrams that were developed as outputs of the workshop and the following status assessments of Michigan's portion of the Lake Erie Basin helped determine new projects and initiatives that were thought to address knowledge gaps and uncertainties, and that were also conducive to using an adaptive management approach.



Appendix B - Figure 1. Conceptual model diagram of the River Raisin and Upper Maumee River tributaries NPS phenomena and processes that influence nutrient loading from Michigan to Lake Erie. Nutrient movement (middle column, light green) is from fields to waterways to the lake (bottom to top). State management programs and options are shown in blue boxes (lower right), and external drivers are shown in orange boxes (lower left).

The following notes describe the elements shown in the preceding NPS influence diagram.

Field activities and processes

Basic agricultural practices include preparing fields for planting with various types of tillage (e.g., conventional, conservation, and no-till), planting, application of fertilizer and manure to supplement existing soil fertility, uptake of nutrients by crops and harvest, along with management practices to keep soil from eroding from fields and nutrients from leaving the fields in particulate or soluble forms.

P transport from fields

Eroded or soluble P leaves fields in surface runoff along the edges of fields, or percolates or flows through cracks and pores into tile drainpipes, into ditches, creeks, surface drains, or rivers.

P transport to lake

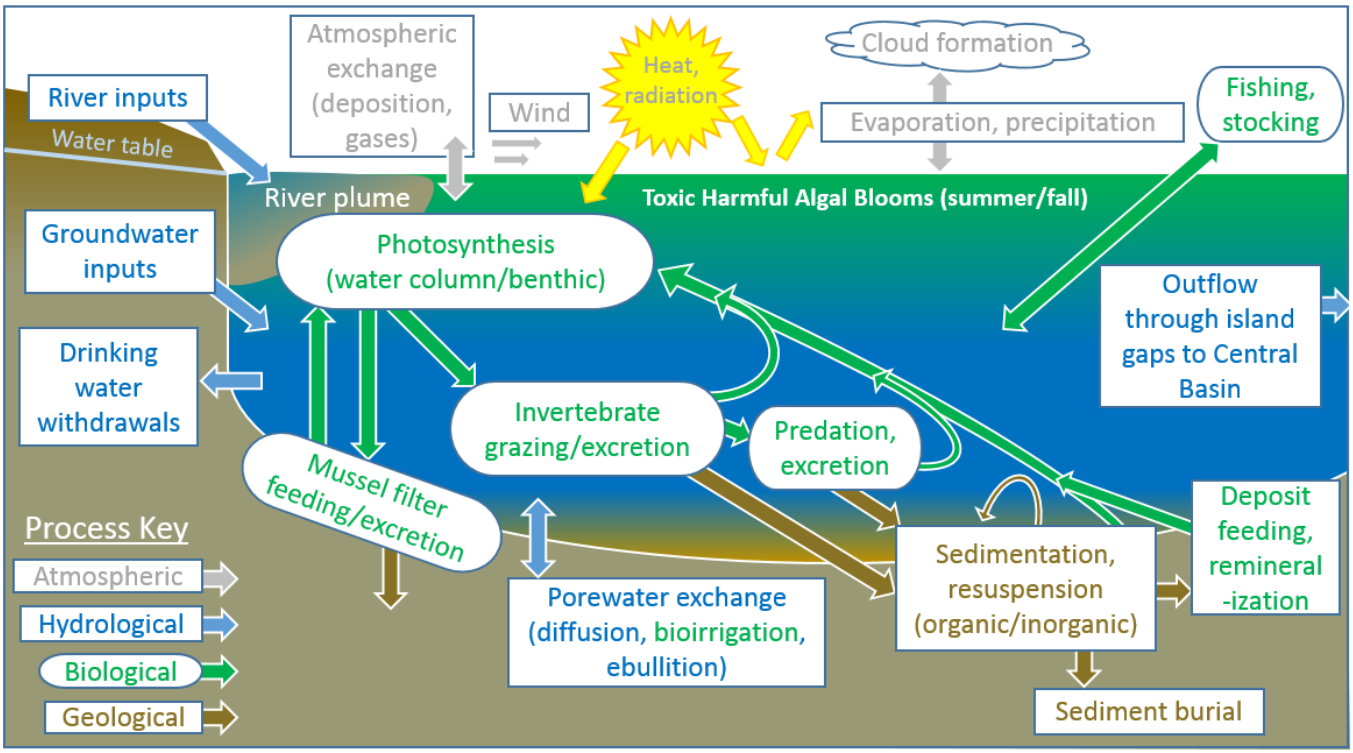
Smaller ditches and drains flow into larger rivers, carrying P-rich particles and soluble P, eventually reaching Lake Erie at the mouth of the River Raisin and the Maumee River in Ohio. Some P settles out along the way or is taken up by wetland plants and algae in the rivers.

Market and natural drivers

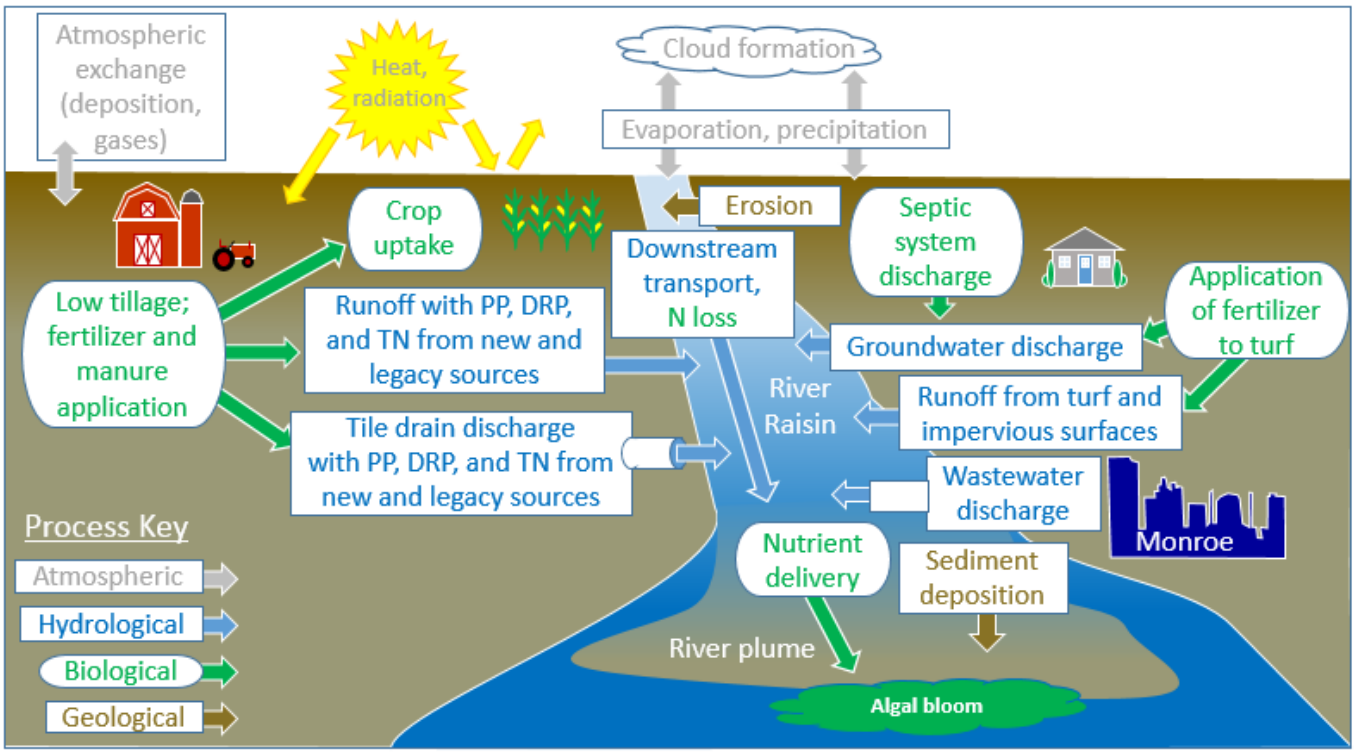
Factors external to the agricultural system can have moderate to major influences on how much P makes it Lake Erie in any particular year. The amount of snow in the winter and rain in spring influence the amount of runoff and tile drainage that leaves fields, and the amount of fertilizer than can be applied, if fields are too wet to plant. Changes in markets for crops and farm products due to national and international factors such as crop failures in other regions, trade agreements, and tariffs influence decisions about what is planted and how much fertilizer is applied in Michigan fields. The overall strength of the economy and prices of equipment, seeds, fuel, and fertilizer also influence these decisions. Conservation incentives beyond state and federal programs can also be a factor, including temporary or permanent conservation easements, or premium prices for crops grown in particular ways (e.g., organic or sustainable).

Management programs and options

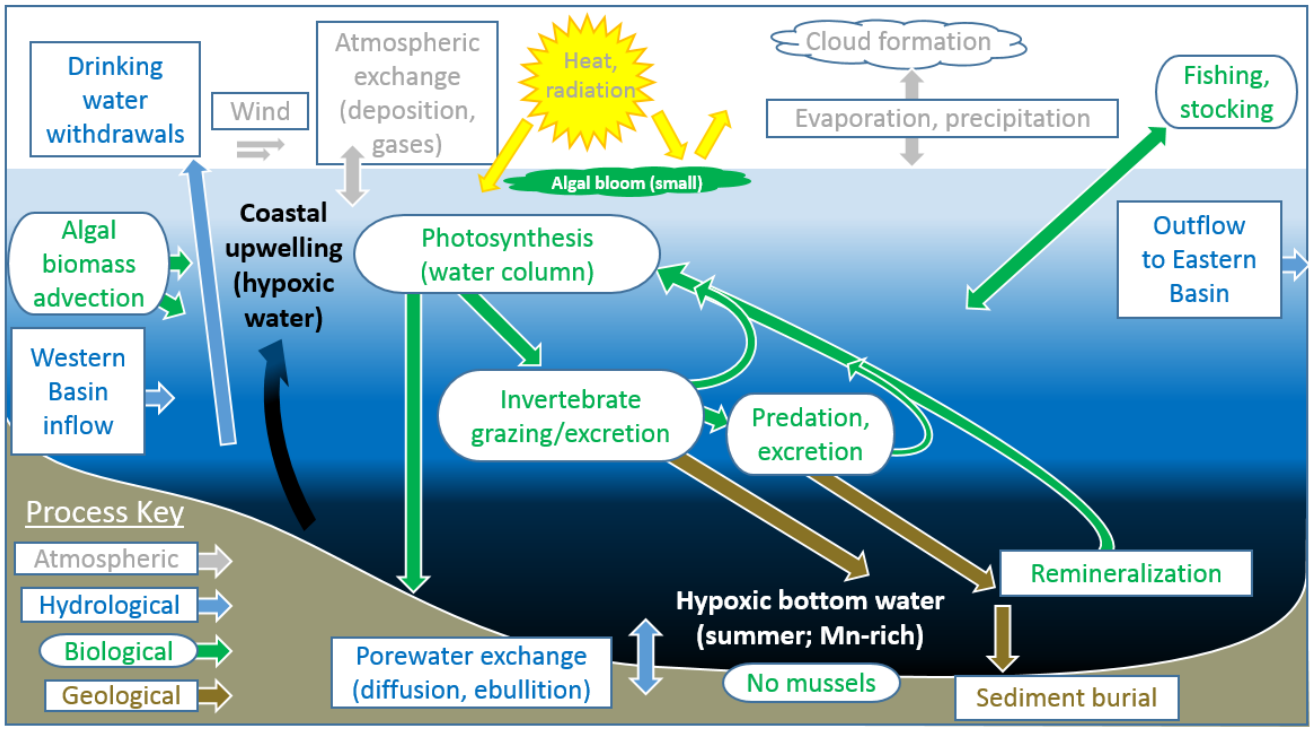
The State of Michigan, often in partnership with federal programs, employs a variety of voluntary and regulatory measures to produce desired reductions in nutrient loads from various sources. These include permit, payment, or technical assistance programs such as the NPDES for point sources, Environmental Quality Incentives Program (EQIP), CREP, MAEAP, fertilizer regulations or guidelines related to timing of applications and other factors (e.g., 4Rs), and requirements and support for preparation and implementation of nutrient management plans and watershed management plans. The State of Michigan also supports academic institutions and other organizations that perform research and development that applies to understanding nutrient cycling in watersheds and lakes and optimizing farming practices to minimize environmental impacts.



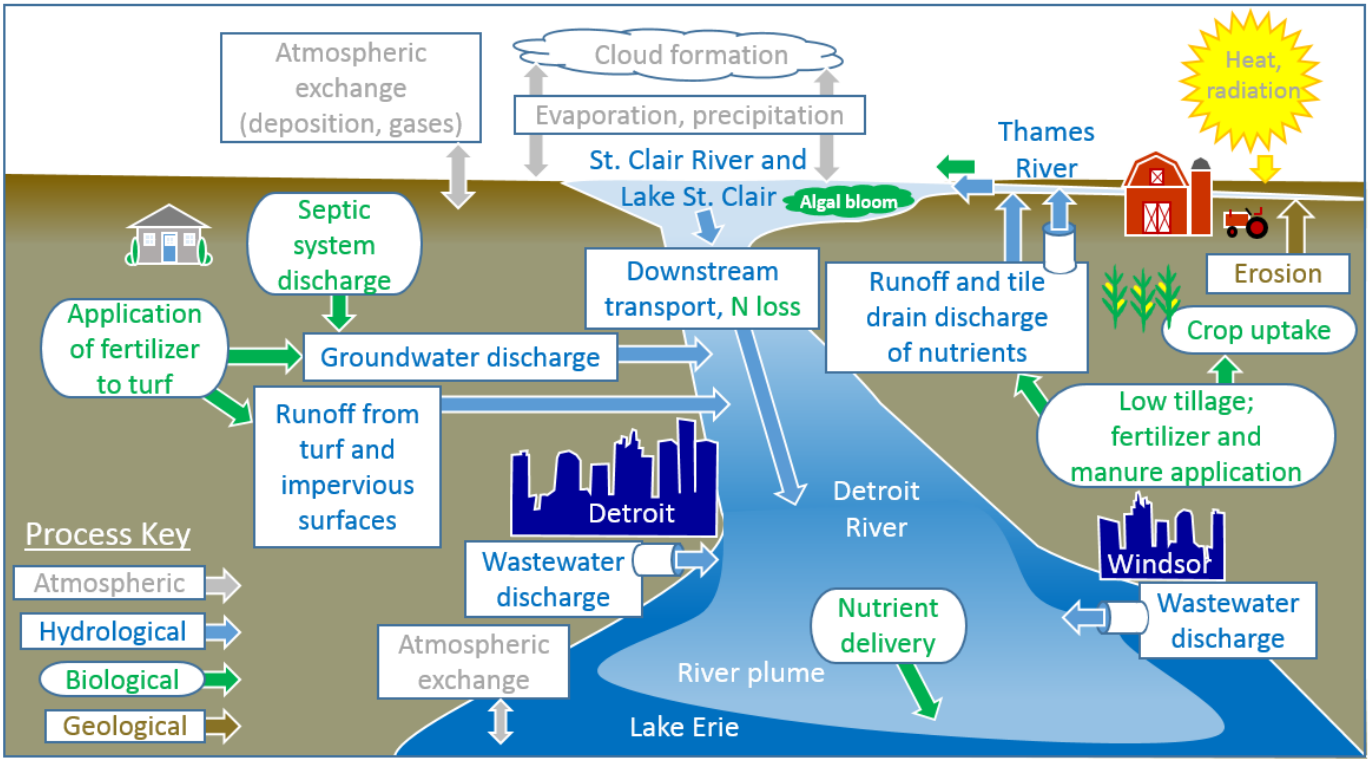
Appendix B - Figure 2. Conceptual model diagram of Western Basin of Lake Erie showing HABs-related processes.



Appendix B - Figure 3. Conceptual model diagram of River Raisin point source and nonpoint inputs. The watershed lies almost entirely within the state of Michigan.



Appendix B - Figure 4. Conceptual model diagram of Central Basin hypoxia in Lake Erie.



Appendix B - Figure 5. Conceptual model diagram of Detroit River point source and nonpoint inputs from the U.S. and Canada.

APPENDIX E - ACRONYMS AND INITIALISMS

319	Section 319 of the Clean Water Act covers nonpoint sources of water pollution
4Rs	Right Source, Right Rate, Right Time, Right Place (fertilizer application guidance)
AMP	Adaptive Management Plan
Annex 4	Nutrients Annex of 2012 Great Lakes Water Quality Agreement
BMP	Best Management Practice
CAFO	Concentrated Animal Feeding Operation
CCA	Certified Crop Advisor
CD	Conservation District
CMI	Clean Michigan Initiative
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
CSO	Combined Sewer Overflow (or Outfall)
CSS	Combined Sewer System
DAP	Domestic Action Plan
DMR	Discharge Monitoring Report
DNR	Michigan Department of Natural Resources
DUWA	Downriver Utility Wastewater Authority
DWM	Drainage Water Management
ECCC	Environment and Climate Change Canada
EGLE	Michigan Department of Environment, Great Lakes, and Energy
EQIP	Environmental Quality Incentives Program
FWMC	Flow-Weighted Mean Concentration
GAAMPs	Generally Accepted Agricultural and Management Practices
GIS	Geographic Information System
GLC	Great Lakes Commission
GLEC	Great Lakes Executive Committee
GLERL	Great Lakes Environmental Research Laboratory (NOAA)
GLNPO	Great Lakes National Program Office (USEPA)
GLRI	Great Lakes Restoration Initiative
GLWA	Great Lakes Water Authority
GLWMS	Great Lakes Watershed Management System
GLWQA	Great Lakes Water Quality Agreement
HAB	Harmful Algal Bloom
HUC	Hydrologic Unit Code
LTCP	Long Term Control Plan
LUG	Local Unit of Government
MAEAP	Michigan Agriculture Environmental Assurance Program
MDARD	Michigan Department of Agriculture and Rural Development
MS4	Municipal Separate Storm Sewer System
MSU	Michigan State University

MSUE	Michigan State University Extension
NGO	Non-Governmental Organization
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NRCS	Natural Resources Conservation Service (USDA)
P	Phosphorus
RMP	Residuals Management Program
RTB	Retention Treatment Basin
SEMCOG	Southeast Michigan Council of Governments
SPARROW	Spatially Referenced Regressions on Watershed Attributes
SRP	Soluble Reactive Phosphorus
SSO	Sanitary Sewer Overflow
TP	Total Phosphorus
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WLEB	Western Lake Erie Basin
WMP	Watershed Management Plan
WRD	Water Resources Division, EGLE
WWTF	Wastewater Treatment Facility
WWTP	Wastewater Treatment Plant
YCUA	Ypsilanti Community Utilities Authority

APPENDIX F - REFERENCES

Annex 4 Objectives and Targets Task Team, 2015. Recommended Phosphorus Loading Targets for Lake Erie. Annex 4 Objectives and Targets Task Team Final Report to the Nutrients Annex Subcommittee (of the 2012 Great Lakes Water Quality Agreement), May 11, 2015. www.epa.gov/glwqa/report-recommended-phosphorus-loading-targets-lake-erie.

Baker, D.B., Johnson, L.T., Confesor Jr, R.B., Crumrine, J.P., Guo, T., and Manning, N.F., 2019. Needed: Early-term adjustments for Lake Erie phosphorus target loads to address western basin cyanobacterial blooms. Journal of Great Lakes Research, 45(2):203-211.

Beletsky, D., Saylor, J.H. and Schwab, D.J., 1999. Mean circulation in the Great Lakes. Journal of Great Lakes Research, 25(1):78-93.

Blonde, A. and Cleland, B., 2019. Bean Creek Watershed Management Plan.

Bocaniov, S.A. and Scavia, D., 2018. Nutrient loss rates in relation to transport time scales in a large shallow lake (Lake St. Clair, USA–Canada): Insights from a three-dimensional model. Water Resources Research, 54(6):3825-3840.

Bosch, N.S., J.D. Allan, D.M. Dolan, H. Han, and R.P. Richards, 2011. Application of the Soil and Water Assessment Tool for six watersheds of Lake Erie: model parameterization and calibration. Journal of Great Lakes Research, 37(2):263-271.

Burniston, D., Dove, A., Backus, S. and Thompson, A., 2018. Nutrient concentrations and loadings in the St. Clair River–Detroit River Great Lakes Interconnecting Channel. Journal of Great Lakes Research, 44(3):398-411.

Choquette, A.F., Hirsch, R.M., Murphy, J.C., Johnson, L.T. and Confesor Jr, R.B. 2019. Tracking changes in nutrient delivery to western Lake Erie: Approaches to compensate for variability and trends in streamflow. Journal of Great Lakes Research, 45(1):21-39.

Culbertson, A.M., Martin, J.F., Aloysius, N. and Ludsin, S.A., 2016. Anticipated impacts of climate change on 21st century Maumee River discharge and nutrient loads. Journal of Great Lakes Research, 42(6):1332-1342.

Daniels, M.B., Sharpley, A., Harmel, R.D. and Anderson, K., 2018. The utilization of edge-of-field monitoring of agricultural runoff in addressing nonpoint source pollution. Journal of Soil and Water Conservation, 73(1):1-8.

EGLE and LimnoTech, 2020. Nutrient chemistry of Michigan's Maumee River Tributaries Bean Creek and St. Joseph River Watersheds, Hillsdale and Lenawee Counties. www.michigan.gov/documents/egle/egle-wrd-maumee-nutrient-chemistry-report-2016-2018_695536_7.pdf

Great Lakes Water Quality Agreement, Nutrients Annex Subcommittee, June 2019. Lake Erie Binational Phosphorus Reduction Strategy, 29 p. https://binational.net/wp-content/uploads/2019/06/19-148_Lake_Erie_Strategy_E_accessible.pdf

Guo, T., Johnson, L.T., LaBarge, G.A., Penn, C.J., Stumpf, R.P., Baker, D.B. and Shao, G., 2021. Less agricultural phosphorus applied in 2019 led to less dissolved phosphorus transported to Lake Erie. Environmental Science & Technology, 55(1):283-291.

Institute for Wetland and Waterfowl Research, 2020. Determining the nutrient retention capacity of newly restored wetlands in Southwestern Ontario.

International Association for Public Participation, 2018. https://cdn.ymaws.com/www.iap2.org/resource/resmgr/pillars/Spectrum_8.5x11_Print.pdf

International Joint Commission, 2018. Fertilizer Application Patterns and Trends and Their Implications for Water Quality in the Western Lake Erie Basin, primary author/editors: J.D. Allan, M.W. Murray, and M. Child. 86 p. http://ijc.org/files/tinymce/uploaded/Publications/IJC_FertReport.pdf

Jankowiak, J., Hattenrath-Lehmann, T., Kramer, B.J., Ladds, M. and Gobler, C.J., 2019. Deciphering the effects of nitrogen, phosphorus, and temperature on cyanobacterial bloom intensification, diversity, and toxicity in western Lake Erie. Limnology and Oceanography, 64(3):1347-1370.

Kalcic, M., Crumpton, W., Liu, X., D'Ambrosio, J., Ward, A., and Witter, J. 2018. Assessment of beyond-the-field nutrient management practices for agricultural crop systems with subsurface drainage. Journal of Soil and Water Conservation, 73(1):62-74.

Kalcic, M.M., Muenich, R.L., Basile, S., Steiner, A.L., Kirchhoff, C. and Scavia, D., 2019. Climate change and nutrient loading in the western Lake Erie basin: warming can counteract a wetter future. Environmental Science & Technology, 53(13): 7543-7550.

Kreiling, R., 2012. Wetland Management Reduces Sediment and Nutrient Loading to the Upper Mississippi River. Journal of Environmental Quality.

Lee, D.J., G.M. Johns, and V.R. Leeworthy, 2012. Selecting Human Dimensions Economic Indicators for South Florida Coastal Marine Ecosystems. https://www.aoml.noaa.gov/ocd/ocdweb/docs/MARES/MARES_WhitePaper9_SelectingHDSindicators_20130519.pdf

Liberati, M.R., S.P. Sowa, C.A. May, and Doran, P.J., 2020. Making measures count: Structured indicator selection to improve program success. Environmental and Sustainability Indicators (8). https://doi.org/10.1016/j.indic.2020.100077

LimnoTech, 2017. Assessment of Fertilizer and Manure Application in the Western Lake Erie Basin. Completed for the International Joint Commission Science Advisory Board's Science Priority Committee. 120 p. + appendices. https://legacyfiles.ijc.org/publications/LimnoTech_IJC_Fertilizer.pdf

Long, C.M., Muenich, R.L., Kalcic, M.M., Scavia, D. 2018. Use of manure nutrients from concentrated animal feeding operations. Journal of Great Lakes Research, 44(2):245-252.

Lovelace, S., P. Fletcher, M. Dillard, W. Nuttle, S. Patterson, P. Ortner, D. Loomis and M Shivlani, 2013. Selecting Human Dimensions Indicators for South Florida Coastal Marine Ecosystems – Noneconomic Indicators.

https://www.aoml.noaa.gov/ocd/ocdweb/docs/MARES/MARES_WhitePaper5_SelectingHDSindicators_NonEconomic_20130519.pdf

Maccoux, M.J., A. Dove, S.M. Backus, and D.M. Dolan, 2016. Total and soluble reactive phosphorus loadings to Lake Erie: A detailed accounting by year, basin, country, and tributary. Journal of Great Lakes Research 42(6):1151-1165.

Maguire, T.J., Wellen, C., Stammler, K.L. and Mundle, S.O., 2018. Increased nutrient concentrations in Lake Erie tributaries influenced by greenhouse agriculture. Science of the Total Environment, 633:433-440.

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., Confesor R., Dagnew A., Guo T., Long C.M., Muenich RL, Scavia D, Redder T, Robertson DM, Wang Y-C, 2021. Evaluating management options to reduce Lake Erie algal blooms using an ensemble of watershed models. Journal of Environmental Management, 280:111710.

Michigan Department of Environment, Great Lakes, and Energy (EGLE) and LimnoTech. 2020. Nutrient Chemistry of Michigan's Maumee River Tributaries - Bean Creek and St. Joseph River Watersheds, Hillsdale and Lenawee Counties, 2016-2018. EGLE Water Resources Division Report # MI/EGLE/WRD-20/015. www.michigan.gov/egle/0,9429,7-135-3313_3681_3686_3728-452037--,00.html.

Michigan Department of Environmental Quality, Water Resources Division, 2016. Michigan's Implementation Plan, Western Lake Erie Basin Collaborative, January 14, 2016. www.michigan.gov/documents/deq/wrd-western-lake-erie_503547_7.pdf

Muenich, R.L., Kalcic, M.M., Winsten, J., Fisher, K., Day, M., O'Neil, G., Wang, Y.C. and Scavia, D., 2017. Pay-for-performance conservation using SWAT highlights need for field-level agricultural conservation. Transactions of the ASABE, 60(6):1925-1937.

Muenich, R.L., Kalcic, M. and Scavia, D., 2016. Evaluating the impact of legacy P and agricultural conservation practices on nutrient loads from the Maumee River Watershed. Environmental Science & Technology, 50(15):8146-8154.

National Oceanic and Atmospheric Administration, 2019. Experimental Lake Erie Harmful Algal Bloom Bulletin, 31 October 2019, Seasonal Assessment. National Oceanic and Atmospheric Administration - Great Lakes Environmental Research Laboratory.
(The link provided was broken and has been removed.)

Osterholz, W.R., Hanrahan, B.R. and King, K.W., 2020. Legacy phosphorus concentration–discharge relationships in surface runoff and tile drainage from Ohio crop fields. Journal of Environmental Quality, 49(3):675-687.

Pearsall, D., P. C. de Grammont, C. Cavalieri, C. Chu, P. Doran, L. Elbing, D. Ewert, K. Hall, M. Herbert, M. Khoury, D. Kraus, S. Mysorekar, J. Paskus and A. Sasson, 2012. Returning to a Healthy Lake: Lake Erie Biodiversity Conservation Strategy. Technical Report. A joint publication of The Nature Conservancy, Nature Conservancy of Canada, and Michigan Natural Features Inventory. 340 pp. with Appendices.

Perello, M.M., Kane, D.D., Golnick, P., Hughes, M.C., Thomas, M.A. and Conroy, J.D., 2017. Effects of local weather variation on water-column stratification and hypoxia in the western, Sandusky, and central basins of Lake Erie. Water, 9(4), p.279, www.mdpi.com/2073-4441/9/4/279/htm#.

Robertson, D.M., and Saad, D.A., 2019, Spatially referenced models of streamflow and nitrogen, phosphorus, and suspended-sediment loads in streams of the Midwestern United States: U.S. Geological Survey Scientific Investigations Report 2019–5114, 74 p. including 5 appendices, https://doi.org/10.3133/sir20195114.

Rowe, M.D., Anderson, E.J., Beletsky, D., Stow, C.A., Moegling, S.D., Chaffin, J.D., May, J.C., Collingsworth, P.D., Jabbari, A. and Ackerman, J.D., 2019. Coastal upwelling influences hypoxia spatial patterns and nearshore dynamics in Lake Erie. Journal of Geophysical Research: Oceans, 124(8):6154-6175.

Rucinski, D.K., DePinto, J.V., Beletsky, D. and Scavia, D., 2016. Modeling hypoxia in the central basin of Lake Erie under potential phosphorus load reduction scenarios. Journal of Great Lakes Research, 42(6):1206-1211.

Scavia, D., S. Bocaniov, A. Dagnew, Y. Hu, B. Kerkez, C. Long, R. Muenich, J. Read, L. Vaccaro and Y. Wang. 2019a. Watershed Assessment of Detroit River Phosphorus Loads to Lake Erie. Final project report produced by the University of Michigan Water Center. 40 p. http://graham.umich.edu/project/assessing-detroit-river-nutrient-loads-lake-erie

Scavia, D., Bocaniov, S.A., Dagnew, A., Long, C. and Wang, Y.C., 2019b. St. Clair-Detroit River system: Phosphorus mass balance and implications for Lake Erie load reduction, monitoring, and climate change. Journal of Great Lakes Research, 45(1):40-49.

Scavia, D., M. Kalcic, R.L. Meunich, N. Aloysius, C. Boles, R. Confesor, J. DePinto, M. Gildow, J. Martin, J. Read, T. Redder, S. Sowa, Y.-C. Wang, and H. Yen. 2016. Informing Lake Erie agriculture nutrient management via scenario evaluation. Ann Arbor, MI: University of Michigan.

Smith, L.M., J.L. Case, H.M. Smith, L.C. Harwell, and J.K. Summers, 2013. Relating ecosystem services to domains of human wellbeing: Foundation for a U.S. Index. Ecological Indicators (28) 79-90.

State of Michigan, 2018. State of Michigan - Domestic Action Plan for Lake Erie. February 28, 2018. Prepared by State of Michigan Quality of Life departments including the Michigan Department of Agriculture and Rural Development, Michigan Department of Environmental Quality, and Michigan Department of Natural Resources. Michigan.gov/EGLE/0,9429,7-135-3313_3677_95226-507535--,00.html.

State of Ohio, 28 January 2020 draft, Promoting Clean and Safe Water in Lake Erie: Ohio's Domestic Action Plan 2020 to Address Nutrients, 197 p.
(The link provided was broken and has been removed.)

Stone, J., K. Pangle, S. Pothoven, S. Brandt, T.O. Höök, T. Johengen, and S. Ludsin, *in press*. Hypoxia's impact on pelagic fish populations in Lake Erie: A tale of two planktivores. Canadian Journal of Fisheries and Aquatic Sciences.

Stow, C.A., Q. Liu, and E.J. Anderson, 2019. Nutrient loading and nonstationarity: The importance of differentiating the independent effects of tributary flow and nutrient concentration. WIREs Water 7(1) (DOI:10.1002/wat2.1396).

Stubbs, M., 2019. Agricultural Conservation: A Guide to Programs. Congressional Research Service, R40763, 27 p.

TetraTech, 2018. Methodology for Connecting Annex 4 Water Quality Targets with TMDLs in the Maumee River Basin – Final Draft. Task Order No. EP-B175-00001, August 9, 2018, 127 p. www.epa.gov/sites/production/files/2018-10/documents/annex4_methodology_with_appendices_20180809-508.pdf

U.S. Environmental Protection Agency, 2018. U.S. Action Plan for Lake Erie: 2018-2023 Commitments and Strategy for Phosphorus Reduction. United States Environmental Protection Agency, Great Lakes National Program Office, February 2018. www.epa.gov/glwqa/us-action-plan-lake-erie.

Verhamme, E.M., Redder, T.M., Schlea, D.A., Grush, J., Bratton, J.F. and DePinto, J.V., 2016. Development of the Western Lake Erie Ecosystem Model (WLEEM): Application to connect phosphorus loads to cyanobacteria biomass. Journal of Great Lakes Research, 42(6):1193-1205.

Williams, M.R. and King, K.W., 2020. Changing rainfall patterns over the Western Lake Erie Basin (1975–2017): Effects on tributary discharge and phosphorus load. Water Resources Research, 56(3), p. e2019WR025985.

Williams, B. K., R. C. Szaro, and C. D. Shapiro, 2009. Adaptive Management: The U.S. Department of the Interior Technical Guide. Adaptive Management Working Group, U.S., 72 p. www.doi.gov/sites/doi.gov/files/migrated/ppa/upload/TechGuide.pdf. Department of the Interior, Washington, DC.

Williamson, T.N., Dobrowolski, E.G., Gellis, A.C., Sabitov, T., and Sanisaca, L.G., 2020. Monthly suspended-sediment apportionment for a western Lake Erie agricultural tributary. Journal of Great Lakes Research, 46(5):1307-1320.

Wilson, R.S., D.A. Schlea, C.M.W. Boles and T.M. Redder, 2018. Using models of farmer behavior to inform eutrophication policy in the Great Lakes. Water Research, 139:38-46.

Wilson, R.S., M.A. Beetstra, J.M. Reutter, G. Hesse, K.M DeVanna Fussell, L.T. Johnson, K.W. King, G.A. LaBarge, J.F. Martin and C. Winslow, 2019. Commentary: Achieving Phosphorus Reduction Targets for Lake Erie. Journal of Great Lakes Research, 45 (4-11).

Yoskowitz, D., L. Williams, V. Ramenzoni, D. DelAngel and K. Coffey, 2019. Socio-Behavioral-Economic Observing System Indicators for Coastal Community Sustainability. 46 pages. Harte Research Institute for Gulf of Mexico Studies. Texas A&M University-Corpus Christi. www.harte.org/sites/default/files/projects/Socio-Behavioral-Economic%20Observing%20System%20Indicators%20for%20Coastal%20Community%20Sustainability%20report.pdf