U.S. ACTION PLAN FOR LAKE ERIE

Image credit: Michigan Sea Grant

2018-2023

Commitments and strategy for phosphorus reduction

This document outlines federal and state efforts to achieve the binational phosphorus load reduction targets adopted in 2016 under the Great Lakes Water Quality Agreement.

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U.S. Action Plan for Lake Erie

COMMITMENTS AND STRATEGY FOR PHOSPHORUS REDUCTION

PURPOSE

Excessive algal growth in Lake Erie poses significant threats to the ecosystem and human health – a source of drinking water for 12 million people in the U.S. and Canada. Harmful and nuisance algal growth has increased significantly in the past 10 years, in large part because of high levels of nutrients, specifically phosphorus that is delivered from major rivers during spring storms. Record-setting algal blooms and associated "dead zones" – oxygen depleted areas created when algae die and decompose – threaten drinking water quality and Lake Erie's critical $12.9 billion tourism industry and world class fishery. Immediate and strategic actions are needed to address this problem which impacts 5 U.S. States and the province of Ontario.

Through the U.S.-Canada Great Lakes Water Quality Agreement Annex 4 (Nutrients), binational phosphorus reduction targets were adopted for the western and central basins of Lake Erie to address harmful algal blooms and hypoxia. While the bulk of the phosphorus reductions will come from sources in Ohio, Michigan, and Indiana, all 5 of the U.S. states in the basin are committed to taking action to reduce nutrient loadings and minimize problems of excessive algal growth in Lake Erie. The U.S. Action Plan presents a summary of each state's efforts, coupled with federal activities, which together comprise our overarching strategy to achieve the goals in the basin. In addition, more detailed implementation plans were developed at the state-level.

The primary goal of this plan is to enable U.S. federal and state partners and our stakeholders to measure and track our collective progress in meeting the phosphorus reduction targets in Lake Erie. Our objectives are to:

- Clearly articulate federal and state commitments
- Identify potential policy/program needs
- Provide focus for allocation of resources
- Establish accountability for actions and results
- Provide a consistent framework across the Lake Erie basin for implementing programs and monitoring success

This plan was developed by the U.S. Environmental Protection Agency, Great Lakes National Program Office, in collaboration with:

Indiana Department of Environmental Management
Indiana Conservation Partnership
Michigan Department of Environmental Quality
Michigan Department of Agriculture and Rural Development
Michigan Department of Natural Resources
New York State Department of Environmental Conservation
National Oceanic and Atmospheric Administration
Ohio Department of Agriculture
Ohio Environmental Protection Agency
Ohio Lake Erie Commission
Pennsylvania Department of Environmental Protection
United States Army Corps of Engineers
United States Department of Agriculture
United States Geological Survey

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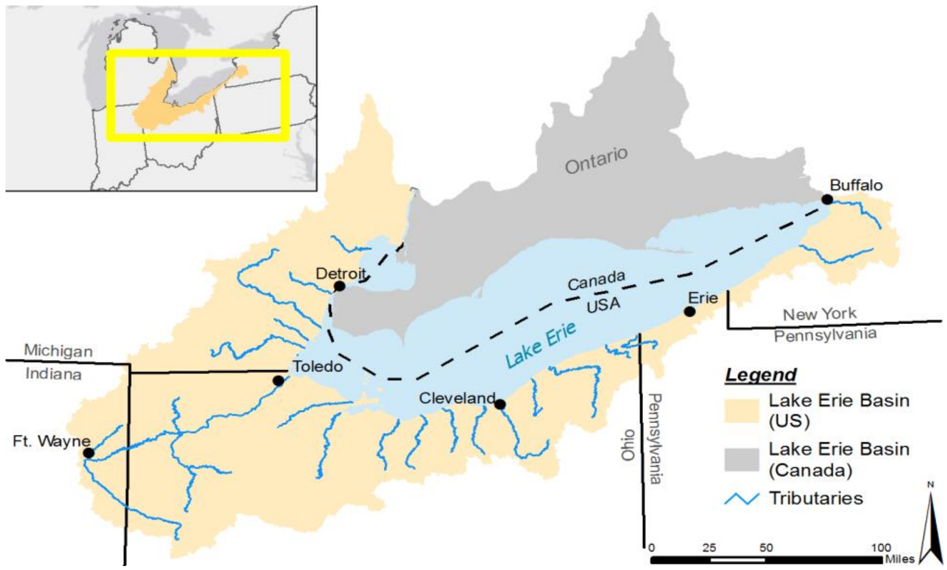
BACKGROUND

The Lake Erie Basin encompasses two countries, five U.S. states, more than ten thousand square miles of farmland, and the urban centers of Ft. Wayne, Detroit, Toledo, Cleveland, Erie, and Buffalo.

Within this large and diverse landscape resides a population of more than 10 million people that rely on the Lake for clean drinking water, swimming and fishing opportunities, and other services. Recurring episodes of massive algal blooms in western Lake Erie over the last decade threaten the drinking water supply and can significantly limit the use and enjoyment of the Lake.



Harmful and nuisance algal growth has increased significantly in the past 10 years, in large part because of high levels of nutrients, specifically phosphorus that is delivered from major rivers during spring storms. The negative impacts of harmful algal blooms (HABs) have been highly publicized and have spurred significant effort to protect the public through advisory systems, drinking water treatment technology, and forecasting tools. Although significant progress has been made in these areas (identifying and responding to HABs), continued investments in strategic and coordinated actions across the basin are needed to ultimately address this problem by reducing the input of nutrients to the Lake that fuel algal growth.

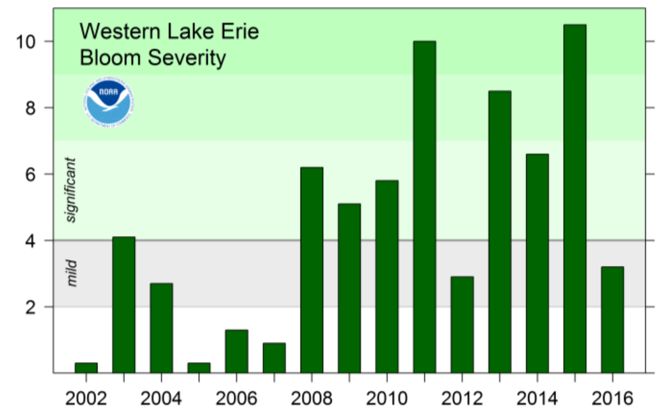
Recent years have seen federal and state governments heed this call by renewing their commitment to nutrient management.

- In 2012, the U.S. and Canadian governments signed an updated binational Great Lakes Water Quality Agreement (GLWQA). Under Annex 4 of the GLWQA, the U.S. and Canada committed to develop phosphorus loading targets and allocations for Lake Erie by 2016 and domestic action plans by 2018.
- After significant scientific review and consultation, in February 2016 the U.S. and Canada formally adopted new phosphorus targets for the western and central basins of Lake Erie. In the U.S., domestic action plans are required for four States: Ohio, Michigan, Indiana and Pennsylvania. Public consultation and engagement on the draft plans took place in 2017. The U.S. and Canadian plans were finalized in February 2018 and posted to the GLWQA Annex 4 website: https://binational.net/annexes/a4/.

This overarching joint plan presents a coordinated approach to link and scale up the efforts across the states to achieve the nutrient goals in the basin. It builds on the work to date by summarizing actions that are being taken across the basin and providing a mechanism for tracking progress to ensure accountability.

Problem and drivers

Harmful algal blooms (HABs) are a growing threat around the world, with serious consequences for the environment and human health. HABs can potentially produce toxins capable of causing illness or irritation, sometimes even death, in pets, livestock and humans. Concentrations of the algal toxins in the raw water supply can be extremely high – measurements of microcystin during the 2011 bloom were 50 times higher than the World Health Organization limit for safe body contact, and 1,200 times higher than the limit for safe drinking water. In August 2014, more than 500,000 people were without drinking water for three days when elevated levels of algal toxins forced the closure of the Toledo, Ohio, drinking water treatment plant. In addition to producing toxins, HABs pose other treatment challenges for public water systems, such as taste and odor.



Images provided by NOAA and Ohio Sea Grant. Left: Satellite image of 2011 algal bloom. Top right: Bloom Severity Index 2002-2016. Bottom right: Lake Erie algal blooms.

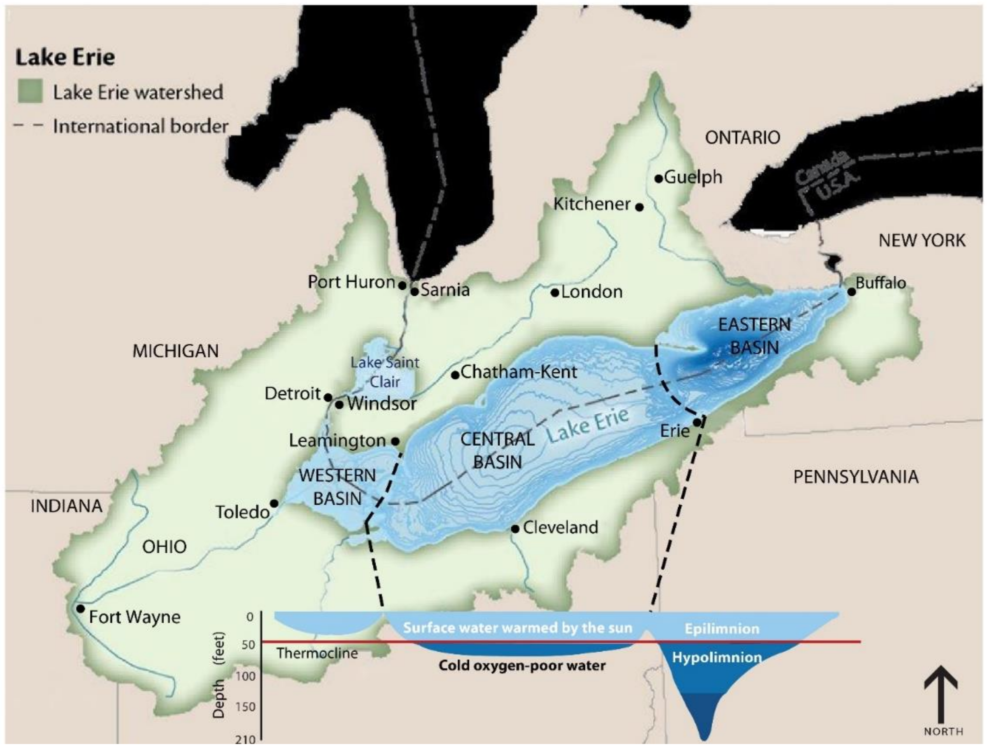
The severity of algal blooms in Lake Erie have increased over the past decade, with 2015 being the worst year on record. Viewable from space, the green water persists for weeks during summer as blooms are carried by winds and currents eastward through the Lake. The algae can foul beaches and clog water intakes, negatively impact commercial fishing and the ability of residents and visitors to enjoy the many recreational opportunities Lake Erie has to offer.

Excessive nuisance algal growth also contributes to hypoxia – low oxygen dead zones that are created when algae die and decompose. Since the early 2000s, the hypoxic (low-oxygen) area in the Central Basin of Lake Erie has increased to about 4,500 km^2, on average, with the largest hypoxic event of 8,800 km^2 occurring in 2012, subsequent to the record setting algal bloom in 2011. Hypoxic conditions can affect the growth and survival of fish species. In 2012, hypoxic conditions were responsible for tens of thousands of dead fish washing up on a 40 km stretch of Ontario's shoreline.

Cladophora and other types of nuisance benthic algae – filamentous algae that grows on the rocky substrate – is also a concern, primarily in the Lake's eastern basin. Excessive *Cladophora* growth degrades fish habitat and can be a significant nuisance when it sloughs off and washes onto shore. Beyond clogging industrial water intakes and degrading fish habitat, rotting mats of *Cladophora* on beaches encourage the growth of bacteria and are a factor in beach closures. The presence of *Cladophora* also may create an environment conducive to the development of botulism, which results in bird and fish deaths.

Lake Erie's 3 basins

Water moves through Lake Erie relatively fast. Lake Erie has the shortest residence time of the Great Lakes: on average, water is replaced in Lake Erie every 2.7 years (for comparison, Lake Ontario is 6 years; Lake Superior is 173 years). Most of the water enters the western basin of the Lake, where it quickly (in a matter of days) flows into the central basin. From there water moves through the eastern basin and eventually flows into Lake Ontario.



Map of Lake Erie watershed showing depth profile of lake basins. Source: Environment and Climate Change Canada

Along the way, nutrients and algae interact in unique ways in each of Lake Erie's three distinct basins. The Western Basin receives about 61 percent of the whole lake annual total phosphorus load, while the Central Basin and Eastern Basin receive 28 percent and 11 percent, respectively. The types and densities of algae growing in each basin is different due to the depth, water temperature, substrate, and local influence of tributaries.

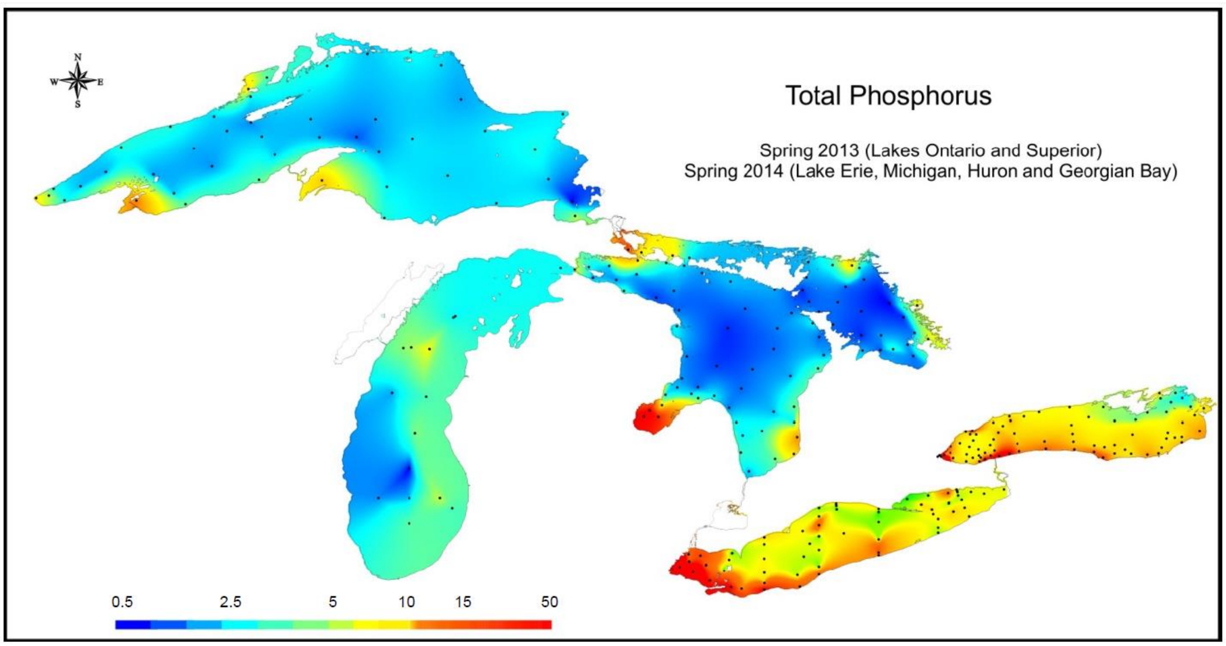
The Western Basin is very shallow with an average depth of 7.4 meters (24 feet) and a maximum depth of 19 meters (62 feet). It is warm, and it receives most of the total phosphorus load because of the size of the Detroit and Maumee Rivers. As a result, algal blooms dominated by the blue-green alga (cyanobacteria) *Microcystis aeruginosa* occur regularly in the summer months. This species can form blooms that contain toxins (e.g., microcystin) dangerous to humans and wildlife.

The Central Basin is deeper with an average depth of 18.3 meters (60 feet) and a maximum depth of 25 meters (82 feet). Algal blooms that originate in the Western basin often move into the central basin, as well. Blooms also form at the mouth of Sandusky River, which is the third highest tributary nutrient load to the Lake overall. Excess phosphorus also contributes to hypoxic conditions (low-oxygen) in the cold bottom layer of the Lake (the hypolimnion) when algae die and decompose. The biological activity uses up the oxygen during the summer, leaving little to none for the aquatic community which suffocates or moves elsewhere, creating Lake Erie's "Dead Zone."

The Eastern Basin is the deepest of the three basins with an average depth of 24 meters (80 feet) and a maximum depth of 64 meters (210 feet). While the phosphorus levels in the Eastern basin are generally much lower than the Western and Central basins, conditions are adequate to promote the excessive growth of algae, primarily *Cladophora*, on the rocky substrate. Mats of *Cladophora* can cause beach fouling, undesirable odors from decomposing *Cladophora*, clogged industrial intakes and degraded fish habitat. These conditions are experienced more frequently on the northern shore of the basin.

The Need to Control Phosphorus

This is not a new problem; in fact, algal blooms in the 1970s were a major driver of the first Great Lakes Water Quality Agreement. Lake Erie is susceptible to excessive algal growth, in part, due to its physical characteristics – as the smallest of the Great Lakes by volume, the shallowest and southernmost, Lake Erie waters are the warmest and the most biologically productive. However, Lake Erie also receives the highest loads of phosphorus of all the Great Lakes. Lake Erie is exposed to the greatest stress from urbanization, industrialization and agriculture. It is the most populated of the Great Lakes, serving a population of over 11 million. Lake Erie surpasses all the other Great Lakes in the amount of effluent received from sewage treatment plants and is also most subjected to sediment loading due to the nature of the underlying geology and land use.



Total Phosphorus Concentrations (μg/L) based on lake-wide cruises conducted by Environment and Climate Change Canada and the United States Environmental Protection Agency.

The Lake is responding to high levels of nutrients and other recent changes in the ecosystem. Data collected by Environment and Climate Change Canada and U.S. Environmental Protection Agency show that, while phosphorus concentrations in the Lake can be highly variable, the concentrations in the western and central basins consistently exceed the desired levels for a healthy ecosystem. Annual estimates of loading from tributaries and other sources indicate that the total annual amount of phosphorus entering the Lake varies significantly each year due to the corresponding variability in nonpoint runoff. Since the resurgence of blooms in the late 1990s, there has been a significant increase in the proportion of the phosphorus load to Lake Erie that is in dissolved, as opposed to particulate, form. Dissolved phosphorus[1] is more easily taken up by algae and contributes to increased algal growth.

Compounding this problem, the ecosystem has changed due to the spread of invasive zebra and quagga mussels that became established in the 1990s. Invasive mussels retain and recycle nutrients in nearshore areas through their filtering and excretion activities. In addition, the increased water quality results in greater penetration of solar energy for chlorophyll production and warming of the water column, allowing algae to grow at greater depths. These alterations to water clarity and in-lake nutrient cycling is resulting in greater nuisance algal growth in the nearshore regions, closer to where humans interact with the Lake.

Other factors contributing to the resurgence of algae include the loss of wetlands and riparian vegetation that once trapped nutrients. Increasing temperatures in recent years is creating longer growing seasons for algae, and more frequent high-intensity spring storms are delivering nutrients at a critical time when they can promote the intensity and duration of summer algal blooms. While many factors contribute to algal growth, controlling phosphorus concentrations and loads remain the best management strategy to address these problems.

Phosphorus is the growth-limiting nutrient and the primary focus of this action plan. While many other nutrients are present in water, such as nitrogen, silica, carbon, and even trace metals, these nutrients are considered to be only secondarily or seasonally limiting in Lake Erie. However, there is increasing evidence that both N and P should be considered as part of a more comprehensive nutrient management strategy to control harmful algal blooms. For instance, emerging research indicates that phosphorus reduction in the absence of nitrogen reduction would not reduce the toxicity of algal blooms[2]. In other words, while *Microcystis* blooms would be smaller in spatial extent, they could continue to be toxic and possibly toxic longer throughout the season.

Our current strategy is focused on phosphorus reduction, and assumes that management actions to reduce phosphorus will also reduce nitrogen. USEPA's external Science Advisory Board supported this approach and recommended a number of research questions to focus further investigations on the role of nitrogen in toxin production. Moving forward, we will continue to research and monitor the effects of nitrogen loads and concentrations so that management decisions and actions can be adapted as necessary.

GLWQA Commitments

The U.S. and Canada committed in the 2012 GLWQA to manage nutrients to achieve the following overarching goals, called Lake Ecosystem Objectives:

1. Minimize the extent of hypoxic zones associated with excessive phosphorus.
2. Maintain the levels of algae below the level constituting a nuisance condition.
3. Maintain algal species consistent with healthy aquatic ecosystems in the nearshore waters of the Great Lakes.
4. Maintain cyanobacteria at levels that do not produce concentrations of toxins that pose a threat to human or ecosystem health in the waters of the Great Lakes.

[1] Known as "soluble reactive phosphorus" or "dissolved reactive phosphorus". These terms tend to be used interchangeably.
[2] C.J. Gobler et al. (2016) The dual role of nitrogen supply in controlling the growth and toxicity of cyanobacterial blooms. Harmful Algae 54: 87–97. http://dx.doi.org/10.1016/j.hal.2016.01.010

5. Maintain an oligotrophic state, relative algal biomass, and algal species consistent with healthy aquatic ecosystems, in the open waters of Lakes Superior, Michigan, Huron and Ontario.
6. Maintain mesotrophic conditions in the open waters of the western and central basins of Lake Erie, and oligotrophic conditions in the eastern basin of Lake Erie.

In response to this commitment, following a robust science-based process and binational public consultation, Canada and the U.S. adopted the following phosphorus reduction targets (compared to a 2008 baseline) for Lake Erie:

- **To minimize the extent of hypoxic zones in the waters of the central basin of Lake Erie:** a 40 percent reduction in total phosphorus (TP) entering the western and central basins of Lake Erie—from the United States and from Canada—to achieve an annual load of 6,000 metric tons to the central basin. This amounts to a reduction from the United States and Canada of 3,316 metric tons and 212 metric tons respectively.

- **To maintain algal species consistent with healthy aquatic ecosystems in the nearshore waters of the western and central basins of Lake Erie:** a 40 percent reduction in spring TP and soluble reactive phosphorus (SRP) loads from the following watersheds where algae is a localized problem: in Canada, Thames River and Leamington tributaries; and in the United States, Maumee River, River Raisin, Portage River, Toussaint Creek, Sandusky River and Huron River (Ohio).

- **To maintain cyanobacteria biomass at levels that do not produce concentrations of toxins that pose a threat to human or ecosystem health in the waters of the western basin of Lake Erie:** a 40 percent reduction in spring TP and SRP loads from the Maumee River in the United States. Using 2008 as the baseline, this equates to a spring (March-July) load of 860 metric tons TP and 186 metric tons SRP.

While these reductions are expected to reduce open lake phosphorus concentrations in the Eastern Basin, and thereby have positive impacts on excessive nuisance *Cladophora* growth on the lake bottom, the science remains unclear whether reductions in phosphorus loading from sources in Lake Erie's Eastern basin are warranted. In the spirit of adaptive management, the U.S. and Canada committed to re-evaluate the viability of setting targets for the Eastern basin in 2020. In the interim, the U.S. and Canada agreed to take precautionary actions and support targeted research efforts aimed to improve our scientific understanding of how to effectively manage the *Cladophora* problem in the Eastern basin and elsewhere in the Great Lakes.

Technical resources for more information:

Recommended Phosphorus Loading Targets for Lake Erie – Factsheet: https://www.epa.gov/glwqa/recommended-binational-phosphorus-targets

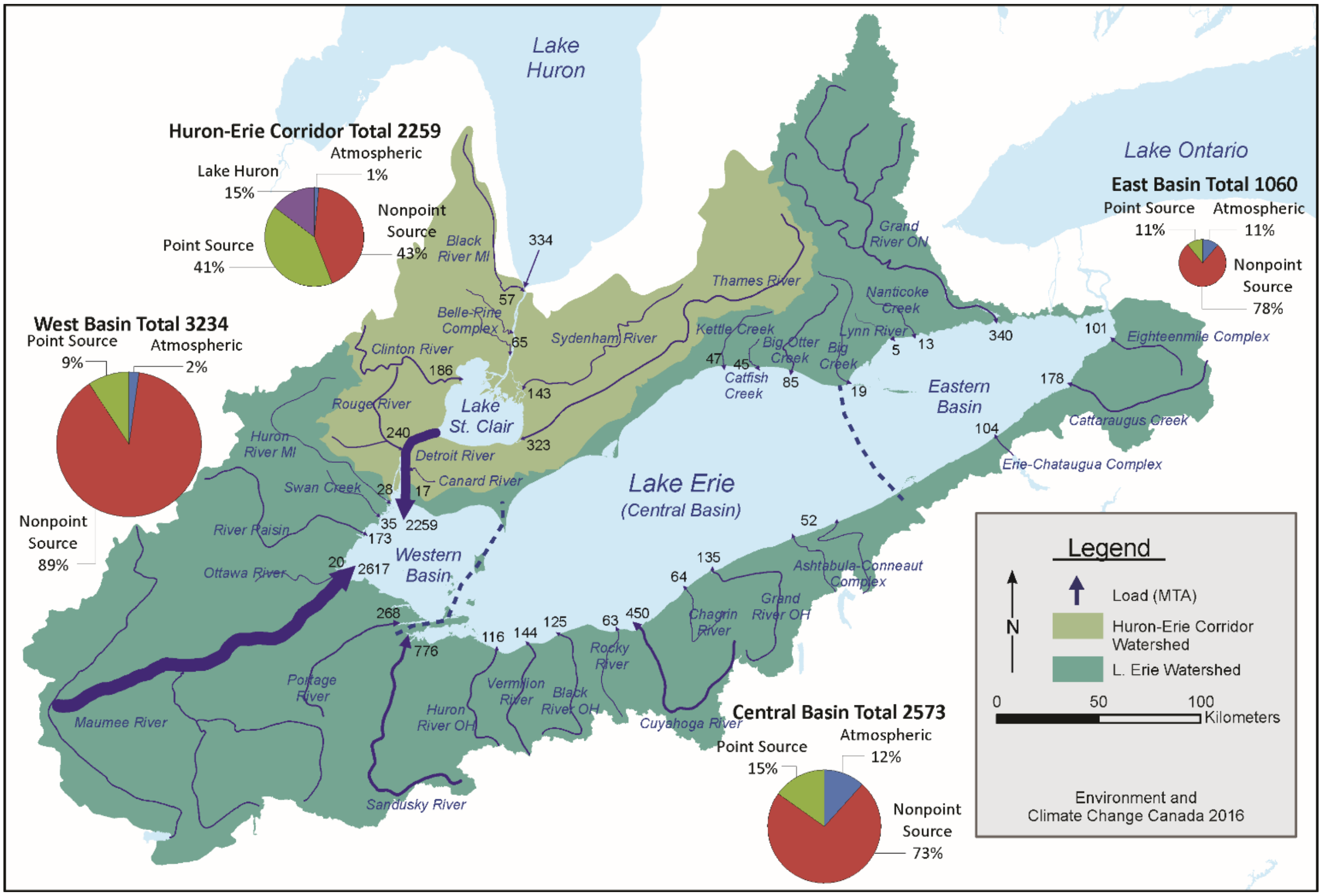
Annex 4 Objectives and Targets Task Team Final Report to the Nutrients Annex Subcommittee: https://www.epa.gov/sites/production/files/2015-06/documents/report-recommended-phosphorus-loading-targets-lake-erie-201505.pdf

Annex 4 Multi Modeling Report: https://www.epa.gov/glwqa/annex-4-final-multi-modeling-report

EPA Science Advisory Board Final report: https://yosemite.epa.gov/sab/sabproduct.nsf/LookupWebReportsLastMonthBOARD/F72D723750A13C2285258137006E65CE/$File/EPA-SAB-17-006.pdf

PHOSPHORUS REDUCTION GOALS AND PRIORITY WATERSHEDS

Major Sources of Phosphorus



Average Total Annual Phosphorus Loads 2003-2013 from Maccoux et al 2016.

As shown above, most of the total annual phosphorus load to the Lake is delivered from a few major tributaries: the Maumee, Detroit, and Sandusky Rivers in the U.S. and the Thames and Grand Rivers in Ontario.

On average, runoff from nonpoint sources are estimated to be responsible for about 72 percent of the total phosphorus load entering Lake Erie each year; in the western basin, nonpoint sources are estimated to contribute upwards of 89 percent of the annual total phosphorus load in that portion of the lake's tributaries. Nonpoint sources include a combination of present day and legacy sources. These loads can be highly variable from year to year.

The source and timing of delivery of nutrients is important to understand because loads of similar magnitude can have different impacts on the Lake. Phosphorus loads from the Maumee River, for example, are the single best predictor of the severity of the western basin bloom. This is in part because the phosphorus concentrations are so high. The Detroit River has a high nutrient load, but a much higher flow and low concentrations of nutrients. Lake Huron water comprises 95 percent of the flow of the Detroit River via the St. Clair River. As a result, the concentration of TP in the Detroit River is much smaller than the Maumee River

(0.014 mg/L versus 0.42 mg/L respectively, or 25 times smaller, during the period 2011-2013). The Detroit River TP concentration is too low to spur an algal bloom, but the load over time contributes to excess algal growth, which contributes to hypoxia.

2008 Baseline Year

The 2008 Water Year was selected as the baseline year from which to compute recommended load reduction percentages (a Water Year runs from October through September). This year was selected in part because it was the most recently available information at the time the modeling to develop the targets was being done in 2014-2015. Since then, researchers updated the phosphorus loading estimates for Lake Erie through 2013. The baseline values can be found in Maccoux et. al 2016: https://doi.org/10.1016/j.jglr.2016.08.005.

These lake-wide loading estimates are calculated by tabulating readily available monitoring data from multiple sources including municipal and industrial point source dischargers, tributaries, connecting channels, and atmospheric deposition. In some cases, we have limited data and made assumptions to derive an estimate. For example, while believed to be a small source (~6%), the estimate for atmospheric load is derived from 2-3 monitoring sites in the basin. The largest loads are delivered by major tributaries, many of which have high frequency data collection and thereby high confidence in loading estimates. There are some tributaries however, with little to no monitoring. Loading estimates for unmonitored tributaries were calculated based on unit area loads from nearby tributaries. As we improve the sampling frequency or load estimation methods, loads will likely change simply because we have better data.

Note that 94% of the 2008 annual TP load from the Maumee was nonpoint source (NPS) in origin, while 34% of the Detroit River load (includes the St. Clair River, Lake St. Clair and Detroit River sources) was from NPS, 16% from Lake Huron, and the remaining 50% from point sources (PS) (primarily Detroit's Wastewater Treatment Plant (WWTP)). More information on tributary sources can be found in each state's DAP.

Load Allocations

Using 2008 as the baseline, we determined that a reduction of 3,528 metric tons would be required to achieve the annual TP loading target of 6,000 metric tons. Each country agreed to reduce their load to the central basin of Lake Erie by 40% from 2008 levels. **Therefore, a load reduction of 3,316 metric tons, or approximately 7.3 million pounds per year, is needed from U.S. sources**.

The 2008 annual TP estimates were used to develop initial allocations of this target among the States in the basin, shown below. This is intended to convey the relative magnitude of load reductions needed. We expect to improve on these estimates as new data are collected.

Note that while we have generally high confidence in the lake-wide total loads, our confidence in the estimates for individual tributaries varies. In some cases, tributary estimates were based on very limited data. Furthermore, in some cases the multi-state watershed loads will need to be allocated using more precise methods. For example, here the Maumee River load was apportioned between Ohio, Michigan and Indiana based on percentage of land in the drainage area. This initial approximation will be refined as water quality monitoring data become available.

Preliminary TP Load Allocations by State, expressed in metric tons per year (MTA) for the 2008 water year (October 1 2017 – September 30, 2018).

Note: target loads are estimated only for priority tributaries (in green)

	Confidence in estimate	WY 2008 TP Load Estimate (MTA)	40% Reduction Amount	Target Load (MTA)
Michigan				
Huron-Erie Corridor				
Belle-Pine Complex	low	47		
Black River-MI	low	31		
Clinton River	low	193		
Rouge River	low	125		
Detroit WWTP	high	865		
Total Detroit River (U.S. Portion)		**1,261**	**504**	**756**
Western Basin				
Huron River-MI	low	39		
Raisin River	high	**262**	**105**	**157**
Swan Creek	low	55		
Maumee River*	low	267	**107**	**160**
Total Michigan Allocation		**1,883**	**753**	**1,130**
Indiana				
Western Basin				
Maumee River*	low	724	**290**	**435**
Total Indiana Allocation		**724**	**290**	**435**
Ohio				
Western Basin				
Maumee River*	high	2,821	**1,128**	**1,693**
Ottawa River	low	32		
Portage River	low	359	**144**	**215**
Direct dischargers	high	19		
Central Basin				
Sandusky River	high	1,101	**440**	**661**
Huron River-OH	low	205	**82**	**123**
Vermilion River	high	202	**81**	**121**
Black River-OH	low	54		
Rocky River	low	47		
Cuyahoga River	high	452	**181**	**271**
Chagrin River	low	28		
Grand River-OH	low	165	**66**	**99**
Direct dischargers	high	141		
Total Ohio Allocation		**5,625**	**2,250**	**3,375**

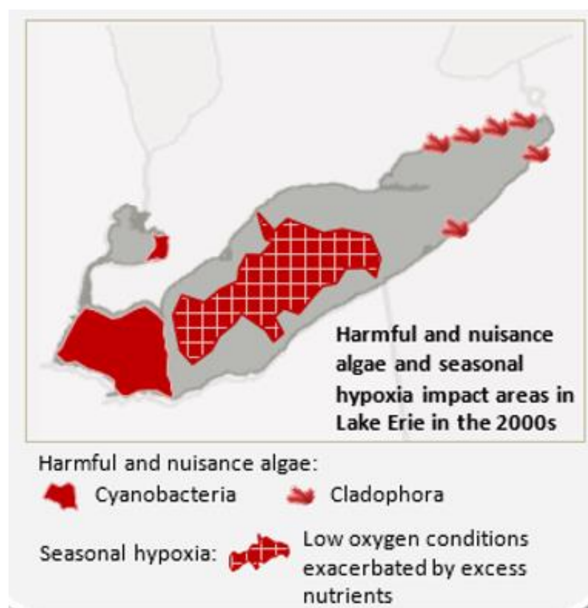
Pennsylvania				
Central Basin				
Ashtabula-Conneaut Complex	low	69		
Total PA Allocation (Central Basin)		**69**	**28**	**41**
Eastern Basin				
Erie-Chautauqua Complex	low	128		
New York				
Eastern Basin				
Cattaraugus Creek	low	111		
Eighteenmile Complex	low	57		
Direct dischargers	high	65		
Western + Central Basin		**8,301**	**3,321**	**4,981**
Lake wide Total		**8,662**	**3,321**	**5,341**

***Maumee River loads distributed among Ohio, Michigan, and Indiana based on percentage land use in the basin.**

Basin-specific Goals

Reductions in total and dissolved forms of phosphorus, especially under high flow conditions, are necessary to combat nutrient related problems in Lake Erie. The three key nutrient issues to be addressed through this plan are:

- in the western basin, blue-green algae (cyanobacteria) blooms and associated toxins,
- in the central basin, seasonal hypoxia – areas of low oxygen, and
- in the eastern basin, excessive growth of nuisance algae, primarily *Cladophora,* on the lake bottom.



The applicable goals and targets are described for each basin below.

Western Basin Goals

The goal in the western basin is to reduce the amount of cyanobacteria biomass to mild levels 90% of the time. The total cyanobacteria biomass is measured by remote sensing and in situ measurements using a severity index developed by NOAA. The target was set based on modeling which showed that reducing the spring phosphorus loads from the Maumee River would produce blooms no worse than what was observed in 2004 or 2012. In 2012 the severity index was 2.9 on a scale of 1 to 10. It is important to note that even in a "mild" bloom year, there can still be impacts in shoreline areas, which is why tributaries where blooms were observed forming at the mouths in nearshore areas were also prioritized for reduction.

The U.S. and Canada set unique targets for the nearshore priority tributaries to take into account the timing and availability of phosphorus to algae. The 40% reductions apply to both total and dissolved forms of phosphorus during the critical spring and early summer months when the phosphorus can be easily taken up by algae to spur growth. The targets for these tributaries are also unique in that they are expressed in terms of loads and concentrations. Specifically, the flow weighted mean concentration (FWMC) – which is a way to normalize the load for flow. This is important because much of the load is delivered during storm events. It means that efforts to reduce the load must take into account and try to also reduce the amount of runoff. It also provides an important backstop and relative measure of whether P reduction efforts are actually having an impact. In the event of a dry year, the load may be low due to less runoff, but the FWMC will still be high if the proportion of phosphorus in that runoff is high.

The calculation of spring load requires high frequency flow and water quality monitoring, which is now in place for all priority tributaries. However, due to a lack of 2008 baseline data, spring loading and concentration targets have so far only been developed for the Maumee and Sandusky Rivers. For example, a 40 percent reduction in spring TP and SRP loads from the Maumee River equates to a spring (March-July) load of 860 metric tons TP and 186 metric tons SRP, and FWMCs of 0.23 mg/L TP and 0.05 mg/L SRP, based on 2008 baseline data for the stream gage at Waterville, Ohio. Similar calculations are being performed for the other priority tributaries and will be updated in the State DAPs as they become available.

U.S. Targets to Address HABs

Priority Tributary	Spring (March – July) Targets	
	Load Metric tons	FWMC mg/L
Maumee River	860 TP 186 SRP	0.23 TP 0.05 SRP
Portage River	tbd	tbd
Sandusky River	230 TP 43 SRP	0.23 TP 0.05 SRP
River Raisin	50 TP SRP tbd	0.09 TP SRP tbd

Central Basin Goals

The U.S. and Canada agreed to limit the total phosphorus (TP) load to Lake Erie's central basin, which includes inputs from the St. Clair-Detroit River corridor, to 6,000 Metric Tons per year (MTA) annually. This was based on modeling of the hypoxic zone which indicated that 6,000 MTA is the maximum load that would result in a dissolved oxygen concentration of at least 2 mg/L in the bottom waters during the summer stratified period.

In the U.S., the priority tributaries for minimizing central basin hypoxia are the Detroit, Maumee, Portage, Sandusky, and Cuyahoga Rivers. Reductions of 40% from these 5 rivers, as shown below, will achieve a total reduction of 2,800 metric tons, which is 84% of the reduction needed from the U.S. towards the binational target.

Targets to Address Hypoxia

Priority Tributary	WY 2008 Annual TP Load (MTA)	40% Reduction Amount	Target TP Load (MTA)
Detroit River (U.S. share)	1,261	504	756
Maumee River	3,812	1,525	2,287
Portage River	359	144	215
Sandusky River	1,100	440	660
Cuyahoga River	452	181	271

Eastern Basin Goals

In the Eastern basin, the goal is to maintain levels of algae below that constituting a nuisance condition, and to maintain an oligotrophic state, relative algal biomass, and algal species consistent with healthy aquatic ecosystems, in the open waters. The incidence of shoreline fouling and nearshore *Cladophora* growth on the U.S. side is limited.

Offshore nutrient levels are already meeting or below the interim target concentration of 10 µg/L TP, and expected to be lowered further as loads from the western and central basins are reduced. The models indicate that if the 40% reductions are achieved, the resulting concentration in the eastern basin would be as low as 6 µg/L TP. Until such time that specific targets are identified for Eastern basin tributaries or nearshore areas, the U.S. will continue to use the open lake concentration (measured as spring mean), along with reports of nuisance algae conditions, as indicators for the achievement of Lake Ecosystem Objectives.

Location	Interim Target concentration	Timeframe	Source
Eastern Lake Erie (open waters)	10 µg/L TP	Spring (April-May)	2012 GLWQA

Priority Tributaries

The Annex 4 Objectives and Targets Task Team identified 11 priority tributaries in the U.S., as shown below.

Lake Erie Priority Tributaries in the U.S.				
Basin	**Tributary**	**Nutrient Issue and Target**		
		Cyanobacteria: 40% Spring TP & SRP Reduction	Central Basin Hypoxia: 40% Annual P Reduction	Eastern Basin *Cladophora*: *Insufficient science to establish P reduction target at this time
Western	**Detroit River**		X	
Western	River Raisin	X	X	
Western	**Maumee River**	X	X	
Western	**Portage River**	X	X	
Western	Toussaint Creek	X		
Central	**Sandusky River**	X	X	
Central	Huron River	X	X	
Central	Vermillion River		X	
Central	**Cuyahoga River**		X	
Central	Grand River		X	
Eastern	Cattaraugus Creek*			X

MAJOR PARTNERS AND ACTIONS

Key Partners

In June of 2015, nearly a year before Canada and the U.S. officially adopted the new targets for Lake Erie, the Governors of Ohio and Michigan along with the Premier of Ontario signed a collaborative agreement to work to achieve the recommended 40% reductions in phosphorus by 2025. The Collaborative also set an aspirational goal of a 20% reduction by 2020. The timeframe and preliminary implementation plans developed pursuant to this agreement speak to the level of commitment across the region to work together to solve this problem.

Producers and landowners in the Western basin are the key audience we need to influence if we are to be successful. Surveys of U.S. farmers in the Western basin indicate there is tremendous potential to improve landowner knowledge and awareness of the issues. Adoption of agricultural management practices to control phosphorus losses are reliant on voluntary actions by farmers, and require investments in time and money. A 2016 USDA study estimated that $277 M is invested annually in conservation – a considerable portion of which comes from private landowner investments.

We recognize the importance of BMP adoption that occurs outside of the direct involvement of government programs. Furthermore, we do not expect that government programs will be directly involved in all the work that is needed to achieve goals for Lake Erie. Many nongovernmental organizations such as universities, conservation districts, and private sector entities such as agricultural crop advisors have a role to play. These organizations can connect with land owners in unique ways to advance knowledge and understanding of nutrient management strategies. We need the help of these and other key partners to educate and engage local citizens like Lake Erie associations and local governments (cities, townships, counties), watershed groups, cooperative extensions, agri-business and commodity organizations, among others.

Finally, while agriculture has a large role to play in achieving the needed reductions in Lake Erie, reductions will be needed from urban, suburban, and rural non-farm areas too. Most U.S. wastewater treatment facilities in the basin are currently permitted to discharge 1.0 mg/L of Total Phosphorus. However, many are actually discharging at lower rates and others present opportunities to reduce discharges in the absence of significant investments in new treatment technologies or infrastructure. Possibly the best example of this is the Detroit facility, which through optimization methods is discharging at 0.3-0.6 mg/L. This was accomplished without significant capital investments.

Local governments have important roles and areas of responsibility. In Ohio, the City of Toledo and Lucas County are highly motivated to work on solving the problem and are making significant investments in projects to ensure they can provide clean drinking water to residents. Other examples of local government roles include CSO long term control plans and county health department home sewage treatment controls.

Successful implementation of this domestic action plan will require broad support, coordination, and collaboration among agencies, academia, local government, private industry, and citizens. All of these groups have a role to play in contributing to the restoration of Lake Erie. Through this plan, USEPA and its federal and state partners aim to provide a framework within which all the key players can work together to implement actions that are impactful and cost effective.

Overall strategy

Recognizing that there is no silver bullet to address the problem, and a combination of strategies addressing multiple sources will be needed, we know that **reducing nonpoint phosphorus losses during storm events, especially during the spring, is of utmost importance and will be critical to our success in preventing harmful and nuisance algal blooms in Lake Erie**. It is clear that our ongoing efforts to limit excess phosphorus loading to the Lake – through municipal sewage treatment, managing stormwater, and implementing best management practices on agricultural lands – must continue and be accelerated. But we also know that what worked in the past is no longer sufficient, so we must go further to find opportunities to improve our effectiveness and ability to adapt to new challenges.

In the past, our management strategies aimed to reduce the whole-lake annual total phosphorus load; we now have to refine our management strategies to consider where the phosphorus is coming from, when, and in what form. Having multiple endpoints to manage towards will enable more effective targeting to the problem, but it requires that program managers be nimble and adjust management priorities in response to new challenges. For example, adding focus to dissolved rather than particulate phosphorus is a major paradigm shift for most agricultural conservation programs which have traditionally focused on preventing soil erosion. Likewise, traditional programs to address waters impaired for nutrients through water quality monitoring, assessments, TMDLs, and implementation of point and nonpoint source controls have historically focused on controlling sediment-bound nutrients or dissolved nitrate in groundwater. Wastewater treatment plants do not have discharge or monitoring requirements for SRP. The idea that we need to control the more bioavailable forms of phosphorus has not been on the radar for long[3], and in many cases our first step will be to start collecting SRP data. It is not possible or necessary at this time to develop a detailed accounting of the treatment needs, but we are working to dramatically improve our knowledge about potential sources through more robust monitoring and assessments.

Accelerated water management as well as nutrient management is essential to addressing algal bloom issues in Lake Erie, and the key focus of our strategy. We will employ multiple tactics to target efforts at the sources in most need of control through cost effective measures. As stated earlier, a significant portion of the phosphorus reductions needed in the Lake Erie basin will rely on voluntary actions by private landowners. We are leveraging many funding resources to accelerate implementation of conservation programs, while also aiming to expand the tools available. Some of the new emerging technologies include variable rate technologies, drainage water management, saturated buffers, phosphorus removal beds or structures, two stage ditches, blind inlets, and phosphorus-optimal wetlands. Comprehensive conservation planning to address specific water quality concerns, hydrologic flow pathways, and soil nutrient status will be essential to identifying effective conservation options for site-specific conditions.

Federal, state, and local authorities have numerous regulatory and nonregulatory programs and authorities available to help meet the reduction goals laid out in this plan. In some instances, new regulations or stronger enforcement of existing regulations will need to occur. Ohio for example has adopted new regulations to restrict the application of fertilizer on frozen or snow-covered ground, and require fertilizer applicators be trained and certified in proper nutrient management. This plan focuses on prioritizing efforts to accelerate nutrient management and water management in the region through optimization of existing programs and collaboration with non-government partners (e.g. the 4R Certification Program). No new federal regulations are being proposed at this time.

[3] Baker, D.B., Confessor, R., Ewing, D.E., Johnson, L.T., Kramer, J.W., Merryfield, B.J., 2014. Phosphorus loading to Lake Erie from the Maumee, Sandusky and Cuyahoga rivers: the importance of bioavailability. J. Great Lakes Res. 40, 502–517.

The individual State action plans describe in more detail the specific phosphorus reduction measures, program and policies that are suitable for their jurisdiction. To summarize, the highest priority measures to manage tributary phosphorus loading to address algae impacts in the Lake Erie basin include the following:

- On agricultural lands:
    - Reduce nutrient applications on frozen or snow-covered ground, saturated soils, and prior to significant rain events.
    - Adopt 4Rs Nutrient Stewardship Certification program or other comprehensive nutrient management programs, with an emphasis on soil-testing, variable rate technologies, and subsurface placement, where appropriate.
    - Target conservation practices to areas most prone to phosphorus losses as part of a whole farm comprehensive planning approach.
    - Rotate crops, retain crop residues, and maintain other living ground cover between plantings to reduce soil erosion and improve soil health.
    - Encourage and accelerate investments in edge of field practices to intercept and infiltrate phosphorus runoff from farm fields (e.g. buffers, wetlands, erosion control structures).
    - Manage drainage systems to hold back or delay delivery of surface runoff and subsurface flow to receiving waterbodies while maintaining healthy agronomic function.
    - Encourage implementation of innovative phosphorous removal structures or blind inlets where appropriate.

- In urban, suburban and non-farm rural areas:
    - Reduce total phosphorus from the highest loading municipal dischargers in the western and central Lake Erie basins. Conduct optimization and upgrade studies to evaluate costs and compliance options for further reductions to point source discharges of total and dissolved phosphorus.
    - Encourage and accelerate investments in green infrastructure for urban stormwater.
    - Incorporate watershed scale considerations into local land use development planning.
    - Phase out residential phosphorus fertilizer applications.
    - Identify and correct failing home sewage treatment systems, either through repair/replacement or connection to public sewers.
    - Establish ecological buffers for rivers, streams and wetlands to intercept and infiltrate stormwater runoff, reduce flashiness, and prevent streambank erosion.

- Wherever possible in the landscape
    - Restore streams to address current stream health concerns and legacy loads.
    - Restore wetlands and riparian habitat to filter nutrients while benefiting aquatic communities.

Kelsey Creek stream restoration, Ohio. Source: Ohio EPA.

Strategy for reducing agricultural sources

The WLEB holds some of the most productive farmland in the Midwest. Using appropriate BMPs is important for all farms, but is critically important in WLEB due to the amount of intensive agriculture and magnitude (40%) of phosphorus reduction needed to prevent harmful algal blooms in Lake Erie.

In September 2017, a group of experts & researchers prepared the white paper titled, ***Summary of Findings and Strategies to Move Toward a 40% Phosphorus Reduction***[4]. In this paper, the researchers combined insights from the effectiveness of BMPs at field and watershed scales, with behavioral analyses of the likelihood of practices to be adopted.

The lead agricultural agencies and partners at the state and federal level reviewed the white paper and concurred with several of the researchers' findings and recommendations. Here we explain how we intend to apply these recommendations as part of our adaptive management strategy for agriculture.

Agricultural producers should be following the 4R's of Nutrient Stewardship (right time, right place, right rate, and right source). In addition to precision in nutrient management other BMPs like blind inlets and cover crops are necessary to manage drainage and control erosion. Advancing toward a 40% reduction will likely require a combination of changes in practices, that are appropriately placed in the landscape, adequately funded, and promoted through multiple policy mechanisms and incentives.

Through the 4R Nutrient Stewardship Certification Program, nearly 2.8 million acres have been enrolled representing more than 5,900 farmers and 45 Certified Crop Advisors and Ag. Retailers in the WLEB. In support of Ohio's DAP, The Nature Conservancy, Ohio Agribusiness Association, and the 4R Nutrient Stewardship Council will continue to reach out to WLEB retailers and CCAs to enroll in the program. Their goal is to have 80% of farmed acres in the WLEB under 4R certified management by 2020. In addition to Ohio, ten other states and the province of Ontario are looking to adopt the 4R Nutrient Stewardship Certification Program by 2020. See https://4rcertified.org/ for the latest news.

Overall, the majority of farmers in the WLEB are concerned and knowledgeable about nutrient loss and water quality impacts, but are not convinced the proposed BMPs are effective (either feasible to implement or likely to reduce nutrient loss and improve water quality) (Zhang et al. 2016; Wilson In Review). Recent survey data in the Maumee River watershed indicates ~1/3 of farmers (equivalent to about 1/3 of the acres in the basin) are engaged in best practices or are willing to do so, ~1/3 are hesitant but considering best practices, and ~1/3 are unlikely to change their practices in the short-term (specific numbers depend on the practice) (Wilson et al. 2014).

To identify feasible policy solutions that will result in improvements in water quality *and* likely be adopted by the agricultural community, we must consider both the effectiveness of BMPs at reducing phosphorus loss at field and watershed scales, as well as the likelihood that farmers will adopt the BMP. For example, while watershed modeling indicates that cover crops and subsurface placement of fertilizer or manure (along with filter strips) show great promise at achieving the 40% reduction at specified adoption levels (Scavia et al,

[4] By Kristen Fussell, Gail Hesse, Laura Johnson, Kevin King, Greg LaBarge, Jay Martin, Jeffrey Reutter, Robyn Wilson, and Christopher Winslow. http://go.osu.edu/habswhitepaper

2017), not all are equally promising from a behavioral standpoint. Furthermore, research on the performance and economics associated with BMP implementation is ongoing. Currently, the most promising practices behaviorally may be determining application rates based on soil testing, followed by subsurface placement, and then cover crops. A 2017 survey by Ohio State University[5] indicates that targeting those individuals who are currently willing to consider the practice or focusing on the larger farms may be sufficient to achieve necessary adoption levels. These tactics could result in more acreage under conservation, but may not necessarily be the highest risk acres from a biophysical standpoint. Continual evaluation of BMP effectiveness, costs, and implementation will be necessary to ensure that forecasted reductions are being achieved and resulting in the desired water quality improvements.

In the following table, we summarize the current research findings and recommendations for some of the most promising BMPs from a behavioral and effectiveness standpoint. These are highly effective BMPs that need to be implemented more broadly on the landscape. However, we recognize there is no silver bullet solution and these BMPs should be adopted as part of comprehensive plans and systems of practices to reduce P from in field, edge of field, and in stream legacy sources. More assessment of the significance of these sources is required to help guide future effective restoration efforts and overall progress toward reductions of DRP and TP instreams and the lake.

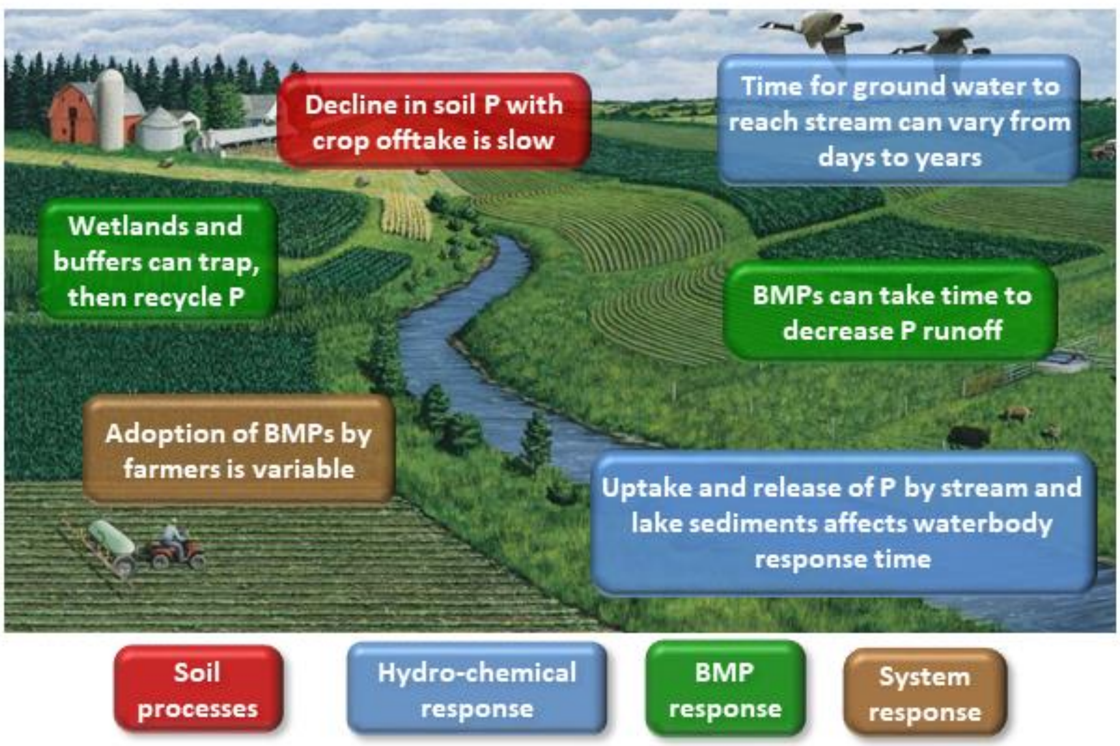


Illustration of legacy P processes modified from Sharpley et al. 2013.

[5] Prokup, A., Wilson, R., Zubko, C., Heeren, A, and Roe, B. 2017. 4R Nutrient Stewardship in the Western Lake Erie Basin. Columbus, OH: The Ohio State University, School of Environment & Natural Resources.

BMP	Description	Effectiveness at reducing phosphorus	Current status of adoption	Likelihood to adopt	Additional notes
Soil test-informed application rates	Soil testing should be done with sufficient frequency and density to accurately inform rates (e.g., once in the crop rotation, at a minimum following the 590 standards).	Generally, no application of fertilizer is needed for corn or soybeans when STP levels are above 40 ppm Bray P1 or 58 ppm Mehlich III-ICP due to a lack of economic return (note this threshold is higher for wheat and vegetable crops).	As of 2016, 60% of farmers in the WLEB were reporting an intention to determine application rates based on soil test results. Another 30% indicated a willingness to do so in the future.	Very High – ~90% of the target farming population is willing to use soil tests at sufficient frequency to inform nutrient application and likely to do so with little additional persuasion.	Adoption of soil-test-informed application rates is generally low-cost, or no-cost, to farmers and provides concrete on-farm benefits.
Subsurface placement	Inserting fertilizer when applied (e.g., banding, in-furrow with seed)	Subsurface placement can reduce DRP loss significantly at the field level (King et al. 2015; Williams et al. 2016). Watershed modeling analyses found that subsurface placement on all row crop acres across the Maumee watershed could result in reductions of DRP of 46% (annual) and 42% (spring), and reductions of TP of 29% (annual) and 27% (spring) (Gildow et al. 2016).	As of 2015, 25% of farmers in the WLEB were reporting subsurface application (banding, in furrow), while 21% reported broadcast without incorporation, and 54% broadcast with incorporation.	High – ~65% of the target farming population appears willing to use subsurface placement, and may be persuaded with better information about the relative costs and benefits (i.e. increased application cost vs. decreased application rates).	Adoption of subsurface placement is limited by the cost and accessibility of the equipment and the slower speed at which fertilizer is applied.

Conservation cropping systems	Systems of practices to build soil health. Cover crops can be utilized in a conservation cropping system to take up and recycle soil nutrients, and when implemented in combination with rotating crops and long term no till can reduce runoff by maintaining/increasing organic matter in soils.	Soils containing more soil organic matter can retain more water from each rainfall event and make more of it available to plants. (Hudson, 1994). Recent edge of field studies in NW Ohio have shown cover crops to be very effective at reducing N losses with limited benefit to P in the short term, but more research is needed.	Behavioral data indicates that ~75% of the WLEB acres are in conservation tillage or no-till, and adoption of cover crops is at ~20%.	Medium – Approximately ~58% of the target farming population appears willing to use cover crops. Because future on-farm benefits can take 5 to 10 years to realize, they are unlikely to do so without incentives to off-set the short-term cost/risks.	More research is needed to assess the long term benefits of cover crops on water quality, on which types of cover crop species are most effective at scavenging P, and on cover crop P removal strategies that could be used to support drawdown. More research is also needed on the use of soil amendments (gypsum).
Tile drainage control structures (in field)	Drainage water control structures let the farmer retain water on fields during dry periods, which facilitates more infiltration in the soil, crop uptake of nutrients and reduces runoff.	Drainage water management can reduce DRP and TP from tiles by greater than 50% (Ross et al., 2016). Eliminating direct connections between the soil surface and tile drains, such as by converting tile risers to blind inlets, can reduce P loss by 60%	Behavioral data indicates that current adoption levels are at <20%, but another 15% of farmers are willing to consider the practice.	Low – There is relatively low interest in this practice, due to the expense of installing structures, additional level of management needed and concerns about flooding.	If implemented properly, drainage management should not reduce yields and in fact could improve yields during dry seasons, and improve ease of field operations.

		(Smith and Livingston, 2013).			
P filters and drainage management (edge of field)	Innovative BMPs like saturated buffers, two stage ditches, and P removal structures can intercept and treat P in surface or subsurface runoff from fields and drainage ditches.	Research on effectiveness of these types of innovative practices is underway by USDA ARS and NRCS CEAP. Initial studies demonstrate they can be highly effective at capturing runoff and filtering dissolved P.	N/A	Low – These practices are less likely to be adopted because they are new and more data and communication on practice benefits is needed.	For greater effectiveness, focus and edge of field P filtering and drainage management practices where opportunities exist to treat DRP runoff from fields exhibiting high soil test P (>150 ppm).

Based on our review of these findings and other information, our proposed strategy for agriculture is as follows:

1. Continue to promote whole-farm comprehensive conservation planning to identify fields (or areas within fields) and management options that lower the risk of P losses.

    a. Continue financial and technical assistance to help farmers overcome short term risks and barriers to adoption of practices.

    b. Track progress towards building soil health and effective nutrient management through a systems approach.

    c. Prioritize incentive programs where conservation practices are needed most i.e., focus on fields with the greatest estimated P losses.

    d. Support extension education and outreach to provide more information to land owners on the benefits of various conservation options, especially edge of field and drainage management practices. Focus outreach to those individuals who are currently willing to consider and adopt the practice, and those who are community leaders and can help to extend the practice to others.

2. Focus resources on expanding adoption of the most effective P reduction BMPs as follows:

    a. Nutrient Management – expand adoption of the 4R's of Nutrient Stewardship (right time, right place, right rate, and right source), with emphasis on:

        i. Soil-test informed application rates – through education/outreach and adoption of variable rate technologies.

        ii. Subsurface placement – through making equipment available/affordable.

        iii. Timing of application – through development and use of innovative tools like precision ag and runoff risk advisory tools; also continue to educate producers on the importance of following fertilizer and manure application guidance and regulations.

        iv. Source – support research and development of manure transformation technologies; also ensure compliance with existing fertilizer and manure application guidance and regulations.

    b. Agricultural water management – this includes in-field, edge of field, and in-stream practices to reduce surface and subsurface runoff and filter p to prevent it from moving downstream.

        i. By promoting Soil Health and Conservation Cropping Systems initiatives

        ii. By prioritizing implementation of phosphorus filtering practices to treat runoff from fields (or areas within fields) exhibiting high soil test P (>150 ppm).

3. Enhance collaboration and communications among agricultural partners (government agencies, land grant universities, certified crop advisors, farm bureaus, commodity groups) to significantly ramp up farmer education and outreach in WLEB.

a. There are numerous ongoing collaborations between the partners that, when combined with efforts like CEAP Watersheds and edge of field monitoring and research, will aid in demonstrating efficacy of practices (e.g. Blanchard River Demonstration Farms, 4R Nutrient Stewardship Certification Program, and Indiana's Nutrient Strategy/Soil Health Strategy).

b. Voluntary adoption of recommended practices will not occur unless outreach focuses specifically on building farmer's confidence in their ability to implement a set of cost-effective solutions. Continued support for and coordination with extension and education efforts in the region (e.g. SERA-17, Field to Faucet, Transforming Drainage) will be critical for our success.

4. Continue to support research to fill key information gaps, such as:

   a. Alternative strategies and programs to aid farmers who are dealing with manure application and distribution challenges.

   b. Cost-benefit relationship for cover crops, water management, and other BMPs, e.g., cost-benefit analysis of fertilizer placement tool bar for farmers.

   c. How soil health impacts nutrient cycling, stratification and fertility; water holding capacity; P loss; and water infiltration as well as soil health interactions with tillage and fertility management.

   d. What combination of practices will effectively retain water to reduce load delivery at the watershed scale.

As part of the adaptive management framework, we will periodically compile and assess information from conservation assessments, edge of field monitoring, and watershed and behavioral models to evaluate the effectiveness of suites of management practices at reaching nutrient reduction targets, as well as assess the likely adoption levels as a result of different policy mechanisms. For example, we anticipate future farmer surveys will inform the pace of progress towards meeting the 40% reduction target for individual recommendations (e.g., cover crops, subsurface placement, soil test informed application rates, etc).

There is evidence that well-designed outreach and incentive programs could result in increased voluntary adoption of BMPs due to the high level of motivation to act among farmers in the WLEB (Prokup et al. 2017). An increase in voluntary actions means there will be less of a need for regulations. Additional modelling work underway will help us understand what can be achieved through voluntary adoption with available resources.

STATE-LED EFFORTS

In many ways, the States are at the forefront in developing phosphorus reduction strategies for Lake Erie. A number of state-led efforts have been building momentum in recent years:

- Ohio convened a Lake Erie Phosphorus Task Force in 2007 in response to the increased harmful algal blooms in the early 2000s. Their findings led to formation of an Agricultural Nutrients and Water Quality Working Group to identify and implement, at the state level, agricultural practice initiatives which would ultimately result in the reduction of harmful algal blooms developing in Ohio's inland lakes and Lake Erie. These efforts were further coordinated with the development of Ohio's statewide Nutrient Reduction Strategy in 2012. The Task Force II final report (2013) includes a detailed review of state and federal efforts, including research results from some of the initial studies recommended by the Task Force I and a phosphorus target for Lake Erie's Western Basin.
- On June 13, 2015, the governors of Ohio and Michigan, and the premier of Ontario signed the Western Basin of Lake Erie Collaborative Agreement, in which they committed to a goal of reducing phosphorus loadings to Lake Erie by 40 percent by 2025. The Collaborative is intended to advance nutrient reduction efforts under GLWQA. For example, in response to the Collaborative, Michigan and Ohio developed implementation plans ahead of the GLWQA 2018 deadline for domestic action plans.
- Later in 2015, the Great Lakes Commissioners from the eight Great Lakes states and two Canadian provinces endorsed a joint action plan developed by the Commission's Lake Erie Nutrient Targets (LENT) Working Group, which proposed a set of 10 steps to achieve the 40% reduction targets.

10 joint actions called for by the Great Lakes Commission's LENT working group:

1. Reduce nutrient applications on frozen or snow-covered ground.
2. Adopt 4R's Nutrient Stewardship Certification or similar programs.
3. Reduce total phosphorus from seven key U.S. municipal dischargers.
4. Encourage investments in green infrastructure.
5. Reduce open water disposal of dredged material.
6. Pilot innovative performance-based nutrient reduction projects.
7. Phase out residential phosphorus fertilizer applications within five years.
8. Target conservation at the watershed scale.
9. Validate or refine the reduction targets and timelines using an adaptive approach.
10. Develop an integrated monitoring, modeling, tracking and reporting network for Lake Erie.

While the bulk of the phosphorus reductions will come from sources in Ohio, Michigan, and Indiana, all 5 of the states in the basin are committed to taking action to reduce nutrient loadings and minimize problems of excessive algal growth in Lake Erie. The following summaries describe each State's portion of the Lake Erie basin and areas of priority for program implementation as described in further detail within the individual State domestic action plans.

Ohio

Ohio's Lake Erie Watershed

Ohio's Lake Erie Watershed covers 11,649 square miles (7,455,360 acres) and drains portions of 35 counties with a total population of 4.65 million people. Of this land, more than 72 percent is agricultural or open space, 20 percent is wooded, and slightly more than 2 percent remains wetland. The developed and urban environment which includes industrial, commercial, residential, quarries, transportation and institutional uses, accounts for 4 percent. The remaining 1 percent is covered by inland lakes and rivers.

There are eight counties along the coast: Lucas, Ottawa, Sandusky, Erie, Lorain, Cuyahoga, Lake, and Ashtabula. There are 332 cities or villages and 403 townships in Ohio's part of the watershed. This includes the major metropolitan areas of Toledo and Cleveland.

Major Sources of Phosphorus

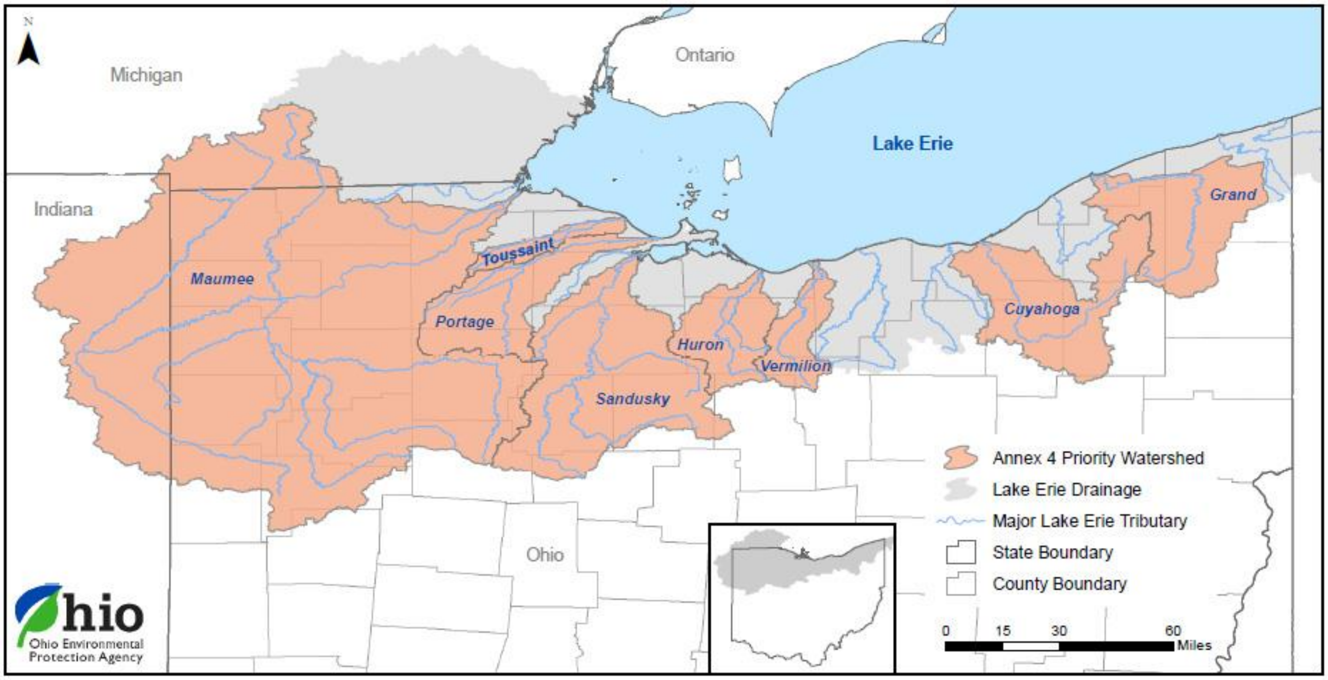
Based on the USDA 2012 Census of Agriculture there are approximately 20,700 farms within the Lake Erie basin, with over 14,000 located in the Western Lake Erie Basin (WLEB) watershed. Soybeans, corn, wheat and hay are the four dominant crops within the Lake Erie watershed. Soybeans and corn make up approximately 90 percent of the production, with over 50 and 39 percent of the acreage respectively.

There are 65 concentrated animal feeding facilities permitted within the Lake Erie watershed in Ohio. These operations are permitted through the Ohio Department of Agriculture - Division of Livestock Environmental Permitting (DLEP). Permitted livestock facilities are concentrated in Northwest Ohio, with 56 of the concentrated animal feeding operations in the WLEB. These permitted facilities must follow manure management plans and DLEP reviews manure application rates and records.

While agriculture is the dominant land use in Ohio's portion of the Lake Erie basin, and more highly concentrated in northwest Ohio, the distribution of point and nonpoint sources of phosphorus can vary significantly by watershed.

The Ohio Environmental Protection Agency conducted a nutrient mass balance study[6] to evaluate major sources of phosphorus in watersheds across the state, including the most significant four of the Annex 4 priority watersheds in Ohio (Maumee, Portage, Sandusky, and Cuyahoga). The next edition of this study, required by state law to be completed by the end of 2018, will include the Huron, another Annex 4 priority watershed.

[6] Nutrient Mass Balance Study for Ohio's Major Rivers: http://epa.ohio.gov/Portals/35/documents/Final%20Nutrient%20Mass%20Balance%20Report_12_30_16pdf.pdf



Sources of Phosphorus in the Maumee River Watershed

The Maumee River drains 6,568 sq. mi. in northwestern Ohio, southeastern Michigan and northeastern Indiana. Agricultural production dominates the watershed, which includes the fertile drained lands of the Great Black Swamp. There is a notable shift in land use as the river enters the Toledo metropolitan area downstream of Waterville. Downstream of this point, the proportion of agricultural production reduces from 79 percent to 49 percent whereas both high/low intensity development and natural lands increase in proportion.

Total P loads from the Maumee River were 2,295 metric tons per year (mta) in water year (WY) 2013 (October-September) and 2,062 mta for WY 2014.

In WY13, the nonpoint source was the largest proportion of the load in the Maumee River at 87 percent for total P. The permitted point sources (NPDES) comprised 9 percent of the total P, and home sewage treatment systems (HSTS) are the remaining 4 percent. The NPDES sources are further broken down into source categories corresponding to plant type and size. The majority of the NPDES load (47 percent) is from major WWTPs. The second largest NPDES contribution is from out of state sources at 28 percent of the NPDES total P load.

Sources of Phosphorus in the Portage River Watershed

The Portage River drains 585 sq. mi. in northwest Ohio. Agricultural production dominates the landscape, with 81 percent of the total land area being dedicated to agricultural production. Natural areas and low intensity development were similar to each other at 8.4 percent and 8.7 percent respectively.

Total P loads from the Portage River were 168 metric tons per year (mta) in WY 2013 and 219 mta for WY 2014.

In WY13, the nonpoint source was the largest proportion of the load in the Portage River at 84 percent for total P. The permitted point sources (NPDES) comprised 11 percent, and HSTS are the remaining 6 percent. The largest permitted point source load contributor is major WWTPs (34 percent). CSOs and class 2 WWTPs

(0.5 – 1.0 mgd) are also large total P load contributors contributing 22 and 27 percent of the total NPDES loads, respectively.

Sources of Phosphorus in the Sandusky River Watershed

The Sandusky River drains 1,420 sq. mi. in north central Ohio. Agricultural production dominates, with 80 percent of the total land area. Natural areas are the second leading land use at 11 percent and the remainder are developed lands. The watershed is home to 220,000 people (120 people per square mile), making it the least densely populated of Ohio's major watersheds.

Total P loads from the Sandusky River were 711 metric tons per year (mta) in WY13 and 615 mta for WY14. In WY13, the nonpoint source was the largest proportion of the load in the Sandusky River at 94 percent for total P. The NPDES sources comprised 4 percent, and HSTS are the remaining 2 percent of the total P loads. The largest NPDES load contributor is from CSOs, comprising 42 percent of the NPDES total P load. The major WWTPs contributed a similar amount of total P as the Class 2 facilities (0.5 – 1.0 mgd) for total P at 28 and 23 percent, respectively. Discharge limits for phosphorus are the reason that the major WWTPs are not the leading NPDES source.

Sources of Phosphorus in the Cuyahoga River Watershed

The Cuyahoga River drains 808 sq. mi. in northeast Ohio. Natural areas and low intensity development dominate the land use of the Cuyahoga watershed at 38 percent and 36 percent, respectively. Closer to the lake shore, there is a notable shift in land use with a reduction of natural and agricultural areas to largely low and high intensity development, 56 percent and 36 percent, respectively.

Total P loads from the Cuyahoga River were 327 metric tons per year (mta) in WY13 and 402 mta for WY14. In WY13, the nonpoint source was the largest proportion of the total P load in the Cuyahoga River at 60 percent. The NPDES sources comprised 29 percent, and HSTS are the remaining 14 percent of the total P load. The single largest NPDES load contributor is from major WWTPs for total P comprising 56 percent of the total P load. CSOs were the second leading NPDES contributor at 40 percent of the NPDES total P load.

Phosphorus Reduction Goals & Priority Watersheds

Ohio's Domestic Action Plan includes actions to reduce Harmful Algae Blooms in the Western Basin of Lake Erie and address the low oxygen levels in the Central Basin of Lake Erie.

Priority tributaries of Lake Erie in Ohio include the Maumee, Portage, and Toussaint Rivers which flow to the Western Basin, and the Sandusky, Huron, Vermilion, Cuyahoga, and Grand Rivers which flow to the Central Basin of Lake Erie.

On June 13, 2015, the governors of Ohio and Michigan, and the premier of Ontario signed a Collaborative Agreement to reduce total and dissolved phosphorus loadings to the Western Basin of Lake Erie by 40 percent by 2025. The Collaborative also set an aspirational goal of a 20 percent reduction by 2020. This goal applies to Ohio's western basin tributary watersheds, which include the Maumee River, Portage River and Toussaint River. Annex 4 added to these goals by specifying that the 40% reductions occur during the spring (March – July) timeframe. The same springtime loading goal also applies to the Sandusky River to control HABs occurring in the Sandusky Bay.

Due to a lack of 2008 baseline data, specific tributary loading and concentration targets have so far only been developed for the Maumee, Sandusky, and Cuyahoga Rivers. Ohio EPA will continue to develop a process to identify additional targets for all Annex 4 priority watersheds as data become available. This includes targets to be set within the very large Maumee River watershed that is shared with Indiana and Michigan. Options being considered include applying the percentage reduction targets to a year which had a similar flow to 2008, or using modeling methods to estimate the 2008 load.

A precursor to the DAP, Ohio's Collaborative Implementation Framework identified tiered priority areas within the Maumee at the HUC 12 level. These were derived in part from the application of multiple watershed models to identify potential hotspots. Prioritization of implementation efforts will continue as these models are refined and additional water quality data are collected. Ohio EPA has used this information to prioritize water quality monitoring at 'sentinel sites' within the basin: subwatersheds that were likely to have relatively higher contributions of phosphorus, and therefore would be expected to demonstrate water quality improvements in response to management actions more quickly. For maps and details please refer to Appendix B of the Ohio DAP.

Major Partners and Actions

The Ohio Lake Erie Commission (OLEC) will serve as the overall coordinating entity working in conjunction with the various state, federal agencies and other partners to achieve the Domestic Action Plan and WLEB Collaborative goals. The responsibility and accountability for ensuring implementation of programs and progress toward the agreed to goals will be with the various state agencies; Ohio Department of Agriculture (ODA) has responsibility for agricultural nonpoint; Ohio EPA has responsibility for point source and water quality monitoring; and the Ohio Department of Health (ODH) for home sewage treatment systems. Ohio Department of Natural Resources (ODNR) will be responsible for private lands wildlife habitat management and Lake Erie fisheries.

1. Agricultural Land Management
    a. ODA will monitor the progress of academic research into edge of field, Tri-state Fertility Guide, and Phosphorus Index adjustments.
    b. ODA will target the Ohio Clean Lake Initiative - Impaired Watershed Restoration Program within select sub-basins of the Maumee and Sandusky Rivers in portions of 10 counties. This "systems approach" uses a combination of management practices (soil testing, cover crops, drainage water management, fertilizer placement technology and manure storage structures and/or roofed feedlots).
    c. ODA will collaborate with USDA via Ohio's network of Soil and Water Conservation Districts on the Lake Erie CREP, cost share for installation of on-farm best management practices, and providing technical assistance.
    d. ODA will continue to educate producers on the importance of following the fertilizer and manure application restrictions and fertilizer certification requirements. Implementation and enforcement of these restrictions will be a top priority for ODA and Ohio's SWCDs.
2. Community-Based Nutrient Reduction
    a. Ohio EPA will evaluate those facilities in the Maumee River basin that currently do not have a permit limit for total phosphorus and that are discharging less than 1 MGD to determine options on a facility by facility basis for reducing phosphorus discharge.
    b. Ohio EPA will continue to focus State Revolving Loan Fund dollars and coordinate with other infrastructure funding programs to direct funding at priority CSO separation projects, wastewater treatment plant upgrades, storm water management, and, in conjunction with ODH, home sewage treatment systems.
    c. OEPA and OLEC will work to improve the Watershed Implementation Plan/TMDL Implementation Plan coverage and quality throughout the Lake Erie watershed in Ohio. Cost

share from the state for the WIP will be sought through a re-allocation of existing dollars or new funding.

d. Ohio EPA's stormwater management program working with ODA, local SWCDs and watershed groups will investigate opportunities to utilize storm water management in addressing hydrologic factors that influence nutrient loading into Lake Erie. Revisions to the Rain Water Manual[7] may include increasing upland, channel or storm water storage, floodplain reconnection, and nutrient treatment.

3. Restore and Support Ecosystem Services
   a. ODNR, in cooperation with Ohio EPA, will continue to fund and complete engineering and design work for potential in-water coastal wetland restoration projects in the western basin and Sandusky Bay that beneficially use dredged material and can help assimilate in-lake nutrients.
   b. ODNR will continue to coordinate with and assist the USFWS/NOAA Upper Midwest and Great Lakes Landscape Conservation Cooperative (LCC) coastal conservation workgroup to develop a tool to identify potentially restorable wetlands, and in cooperation with Ohio Sea Grant shall jointly fund projects to investigate and quantify nutrient processing and reduction benefits of coastal wetlands.

Major Milestones

The years 2020 and 2025 will be used as major benchmarks for tracking progress.

The tabulated list of activities with their corresponding milestones are as follows.

Agricultural:

1. Preliminary proposal of updated Tri-State Fertility Guidelines and Phosphorus Risk Index in April, 2018.
2. ODA's Clean Lake Initiative will complete construction of awarded projects in 2018.
3. The pilot Farm Stewardship Certification Program will run in the western basin of the Lake Erie watershed through spring, 2018 to collect information to be used to develop a larger program.
4. The initial round of Agricultural Fertilizer Applicator Certifications was completed as of September 30, 2017 as required by law. Education and outreach for new certifications will be ongoing.

Communities:

5. The review of significant minor facilities that discharge phosphorus is underway and will be completed within the next 5 years. The last permit on the list of identified significant minor facilities expires May 31, 2022.
6. Funding has been made available for 13 Watershed Implementation and NPS-IS Implementation Plans to be created or updated in the Maumee watershed. Plan status will be updated in spring 2018, and plans should be completed by 2019.
7. The Rain Water Manual is currently under revision with drafts expected in April 2018 and a completed update by the end of 2018.

Restoration:

8. Several Sandusky Bay coastal wetland construction projects will begin construction phase in 2018.

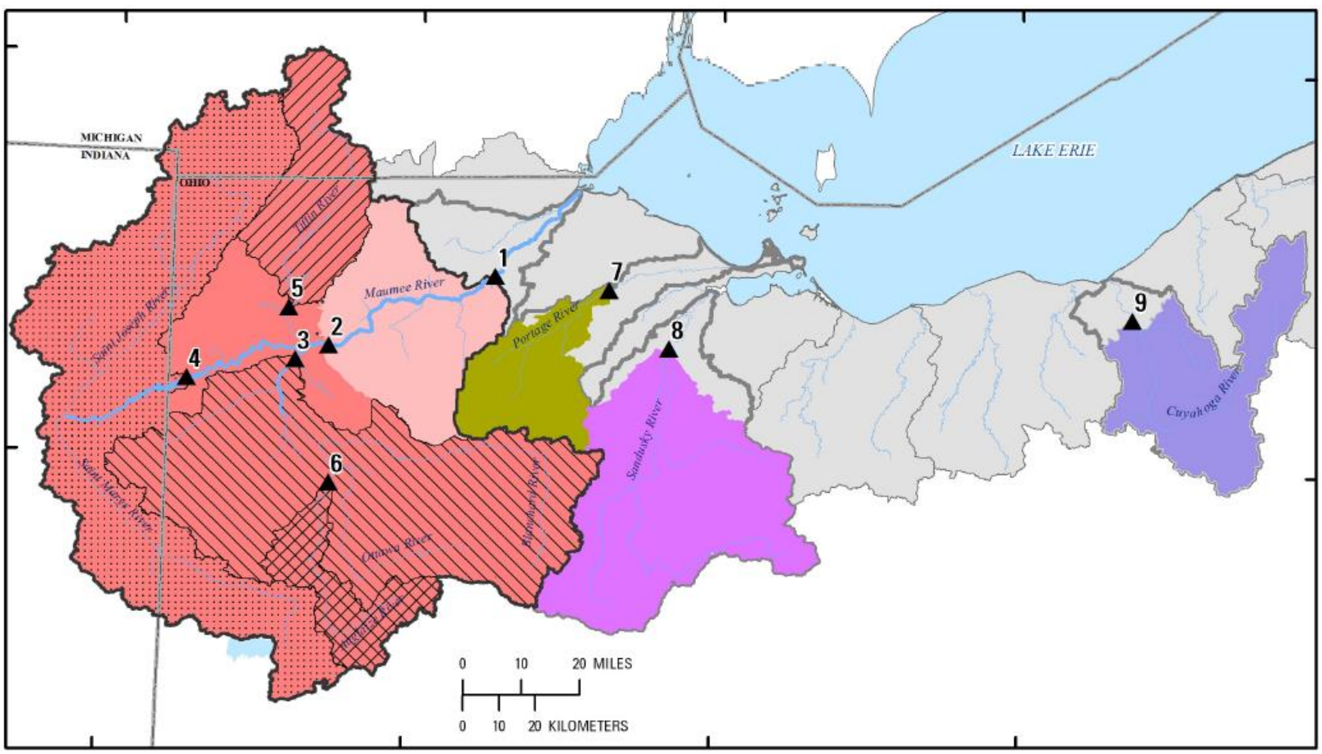
[7] http://epa.ohio.gov/Portals/35/storm/technical_assistance/RLD_11-6-14All.pdf

How Progress Will Be Measured

In addition to participating in the federal and binational efforts to track and report progress under the GLWQA Annex 4, such as ErieStat, Ohio will use the following methods for measuring its progress:

- The primary indicator of progress will be water quality monitoring and associated load calculations at the key downstream station on each of the Annex 4 priority watersheds in Ohio.
- Ohio continues to collaborate with federal and research partners to enhance the monitoring network to capture an improved data set for measuring and tracking loads at smaller and larger watersheds, particularly within the Maumee River watershed.
- These data will be used as part of an overall water quality monitoring strategy which includes monitoring data from edge of field, sub-watershed, Annex 4 priority watersheds, and Lake Erie in order to provide a total picture of nutrient sources and the nutrient delivery system.

Ohio EPA, ODNR, USGS, and Heidelberg University have established many sampling stations in the Lake Erie watershed. Some of these stations are in the same locations to take advantage of USGS streamflow gage locations. Ensuring funding for these stations for the long term is critical to measuring the success of nutrient reduction efforts. Since 2014, Ohio has prepared an annual Water Monitoring Fact Sheet to summarize the observed phosphorus loads concentrations in comparison to the target levels. The fact sheets can be accessed at the OLEC homepage: http://lakeerie.ohio.gov/



Location of sampling stations in Ohio's Water Year 2016 Monitoring Summary.

Public Engagement and Reporting

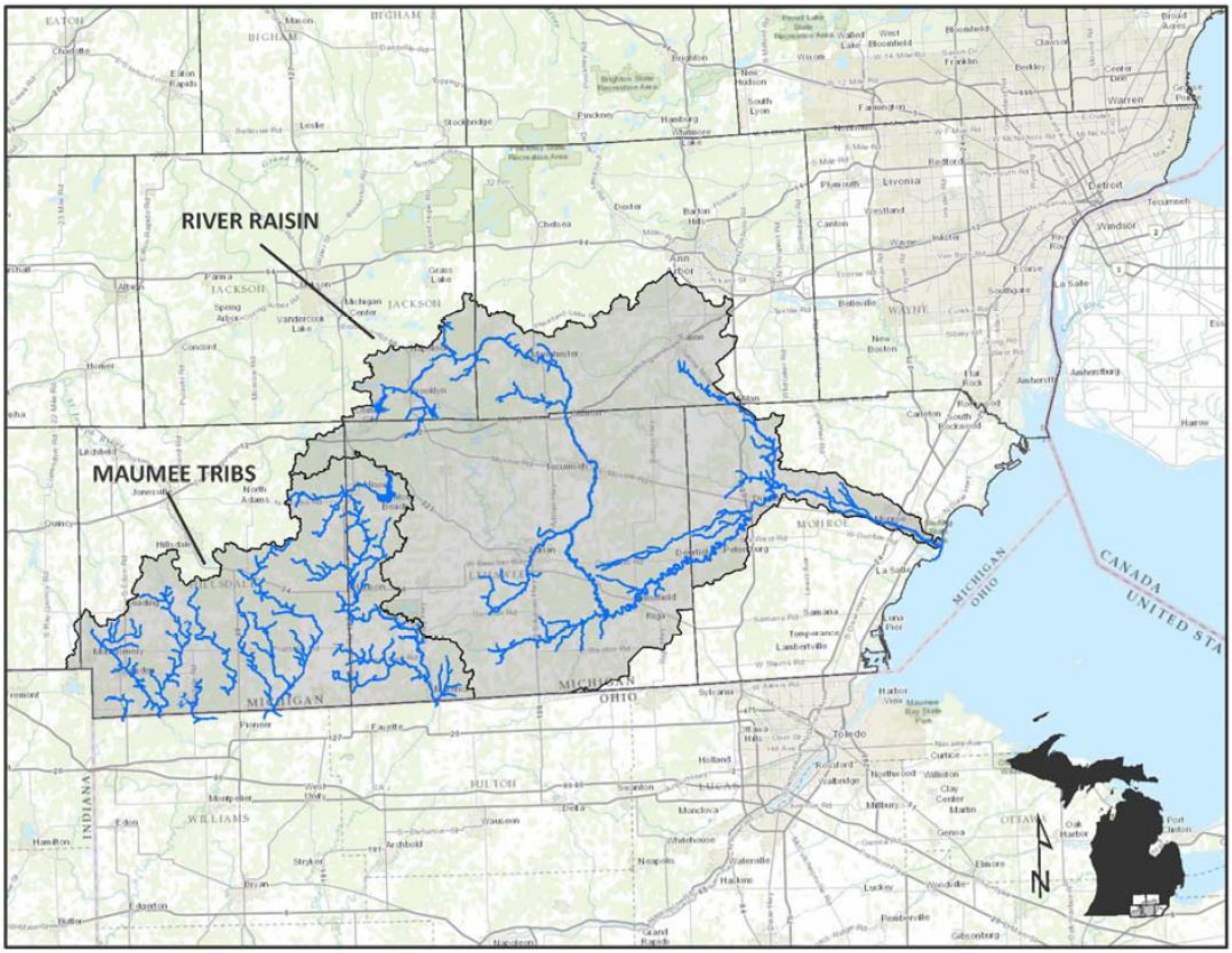
Ohio will continue to engage the public in further development and implementation of the DAP through periodic public meetings and discussions with stakeholder groups. Because we are using an adaptive management approach, Ohio's DAP may be updated in the future as new environmental and nutrient loading data become available and knowledge gaps are filled.

For more details on Ohio's DAP, visit:
http://lakeerie.ohio.gov/LakeEriePlanning/OhioDomesticActionPlan2018.aspx.

Michigan

Michigan's Portion of the Lake Erie Basin

Michigan has 5,800 square miles of area tributary to Lake Erie. It encompasses the Detroit Metropolitan area, as well as other urban areas. It also encompasses agricultural areas. For purposes of the DAP and the Collaborative Agreement that was signed by Michigan, Ohio and Ontario, Michigan is focused on three major watersheds in the Western Lake Erie Basin. These include the mouth of the Detroit River (for all sources of flow to the upstream St. Clair-Detroit River System), the River Raisin, and Michigan's portion of the Maumee River watershed.



Michigan's Priority Watersheds for P reduction to Lake Erie.

Major Sources of Phosphorus

Major sources of phosphorus (P) in the Michigan watershed to Lake Erie include municipal wastewater treatment plants (WWTPs) and stormwater point sources, non-point sources, and agricultural sources. Each of the priority watersheds has an identified dominant source that will be addressed. The mouth of the Detroit River is point source, while River Raisin and Michigan's portion of the Maumee watershed are agricultural sources.

Municipal sources

Michigan has the unique situation where one regulated entity comprises the bulk of the State's phosphorus load to Lake Erie: the Great Lakes Water Authority (GLWA). The GLWA Water Resource Recovery Facility (formerly the Detroit Water and Sewerage Department WWTP) is the largest single site wastewater treatment facility in the U.S. The Facility services 35% of the state's population contained within Detroit and 76 other communities in a service area of more than 946 square miles. Detroit's treated wastewater and stormwater runoff was estimated to make up over 60% of the U.S. load to the Detroit River in 2008. The next largest wastewater sources are in the municipal areas of Wyandotte, Ypsilanti township, and the city of Monroe: the Wayne County Downriver facility (DWTF), the Ypsilanti Community Utility Authority (YCUA WWTP), and the Monroe Metro WWTP. Together with the GLWA, these four WWTPs discharge over 90% of the total P load from point sources to Lake Erie.

Michigan implemented a statewide residential fertilizer phosphorus ban in 2012. Phosphorus fertilizer applications are restricted on residential and commercial lawns in Michigan, including athletic fields and golf courses statewide. This includes applications by both homeowners and commercial applicators. A more restrictive ban in 2006 in the city of Ann Arbor has been shown to reduce phosphorus loadings in surface waters in residential areas by about 30 percent.

Agricultural sources

Agriculture is the dominant land use in the River Raisin and Michigan's portion of the Maumee River Basin. The predominant crops are corn, soybeans and wheat.

The River Raisin Watershed drains approximately 1,072 square miles in southeastern Michigan before it reaches Lake Erie. As of 2010, the watershed was home to 178,577 people and 65% of the land was used for agriculture.

Michigan's portion of the Maumee River basin is relatively small, about 300,000 acres in size representing about 7 percent of the land area in the basin. Land use in Michigan's portion is mainly agriculture, including eight concentrated animal feeding operations (CAFO) under National Pollutant Discharge Elimination System (NPDES) permit. These 8 CAFOs use about 21,000 acres for land application, representing 7 percent of the Michigan portion.

It total, there are 14 concentrated animal feeding operations (CAFOs) in Michigan's portion of the Western Lake Erie Basin (WLEB). Nine of these CAFOs are for dairy, three are for swine, and two are for heifers. The latest general permit ensures protection of all water resources, including: storage, comprehensive nutrient management plans (NMPs), and other needed requirements. These CAFOs have been and will continue to be inspected for compliance with permit conditions. For example, the NPDES permit requires six months of available liquid manure storage by December 1st in any given year.

Other Sources

Other sources such as storm water, pet wastes, lawns, tributaries to the Lake, septic systems, and dredged sediments also can contribute P to Lake Erie.

Phosphorus Reduction Goals & Priority Watersheds

On June 13, 2015, the governors of Ohio and Michigan, and the premier of Ontario signed a Collaborative Agreement to reduce phosphorus loadings to the Western Basin of Lake Erie by 40% by 2025. Michigan's specific objectives to meet the larger ecosystem goals established under Annex 4 and its commitment under the Collaborative Agreement are as follows. Based on 2008 loads, reduce the following by 40%:

- Annual total phosphorus (TP) loads from the Detroit River.
- Spring and Annual TP loads from the River Raisin.
- Spring soluble reactive phosphorus (SRP) loads from the River Raisin.
- Spring TP and SRP, and annual TP contributions from the Maumee River. This objective will be refined for Michigan's waters of the Maumee River following results of watershed monitoring conducted by Michigan, Ohio, and Indiana.

According to Maccoux et. al. 2016, the U.S. share of the Detroit River load in 2008 was ~1,261 tons. A 40% reduction from that baseline value is 504 tons, for a target load of 757 tons. Based on available monitoring data from the GLWA, it appears that the Detroit River has already achieved a reduction of 400 metric tons TP, or 32%. This reduction is mainly due to additional controls at the discharge points at the GLWA Detroit WRRF and its associated treated combined sewer overflows (CSOs).

River Raisin P data are based upon water quality and flow data collected by Heidelberg University's Tributary Loading Program and an adjacent U.S. Geological Survey (USGS) gauging station (No. 04176500), and accounting for loads from the Monroe WWTP. Historically, the River Raisin long term data record is robust; however, some years (2008, 2010, 2012, and 2013) had significant water quality data gaps. Using the 2008 baseline annual load of 262 MT and normalizing for flows, it appears that there has been a 25% TP load reduction since 2008. No trend in SRP is discernible, and spring TP and SRP loads have not yet been analyzed.

Michigan's tributaries to the Maumee River are Bean Creek and the St. Joseph River. There is very limited data on streamflow or phosphorus monitoring data for either tributary. These data are not sufficient to calculate loads or flow weighted mean concentration targets with confidence.

Priority Objective	2008 TP Target Load*	40 Percent Reduction Amount	Target Load
Detroit River TP Load	1,261	504	756
River Raisin TP Load	262	105	157
River Raisin SRP Load**	N/A	TBD	TBD
MI Maumee River TP Load	267+	107	160
MI Maumee River SRP Load**	N/A	TBD	TBD
Total Michigan Load Allocation	1,883	753	1,130

* Based on 2008 load estimates established by Annex 4. + Load estimate based on percentage of land use in Michigan's portion of the Maumee River Watershed. ** No SRP loading estimate have been determined for the River Raisin or the Maumee River.

Major Partners & Actions

The development and implementation of Michigan's DAP is being led by the Quality of Life (QOL) departments including the Michigan Department of Agriculture and Rural Development (MDARD), Michigan Department of Environmental Quality (MDEQ), and Michigan Department of Natural Resources (MDNR). For municipal sources, the four major WWTPs contributing over 90% of the P load will be the focus for reduction (i.e. P limits changed from 1.0 mg/l to a growing season average of 0.6 mg/l). The approach on agricultural lands will use comprehensive conservation planning to identify site-specific best management practices (BMPs) for individual fields. These BMPs will result in the greatest environmental benefit, while maintaining productivity. This will ensure that technical and financial assistance can be utilized most efficiently and effectively.

Michigan's DAP is focused on achieving P reduction goals for the mouth of the Detroit River, the River Raisin Watershed, and Michigan's portion of the Maumee River Watershed. Because of focusing on these areas, it does not mean that the QOL departments will not implement P correction in other areas that drain to the WLEB. However, the total loads removed from other WLEB watersheds will be in addition to the loads removed in the priority watersheds.

The primary tool for working with agriculture in the WLEB is the Michigan Agriculture Environmental Assurance Program (MAEAP). MAEAP is an innovative, proactive program that helps farms of all sizes and all commodities voluntarily minimize agricultural pollution risks. In 2017, MAEAP initiated a new database to better track the cumulative impact of conservation practices across the watershed or county scale. In 2018-2019, this database will be enhanced with spatial mapping that will enable technicians and farmers to target acres that are most vulnerable to sediment and nutrient loss.

Michigan has been proactive and successful in reducing P loads to Lake Erie since 2008, but the work is not complete. Michigan remains committed to addressing current problems by focusing on the following major actions:

1. Maintain the reductions achieved in the GLWA WRRF discharge as a result of the tightened permit limits.
2. Achieve reductions in P discharged from the Wayne County Downriver WWTP, and continue reductions at YCUA WWTP.
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.
4. Support and invest in research to better understand the causes of HABs, including invasive mussels and SRP (urban and rural sources) and how these factors impact HAB events.
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.
6. Implement P control actions in the River Raisin Watershed to achieve the target load reductions.
7. Maintain and expand partnerships to provide valuable technical and financial assistance to farmers. Maintain an increased level of Conservation District MAEAP technical assistance levels.
8. Increase and maintain MAEAP practice implementation for long term water quality improvement.
9. Improve and increase outreach to the public and farmers to promote understanding of the WLEB and good conservation practices by initiating new targeted outreach campaigns, workshops, field demonstrations and information sharing.
10. Promote wetland restoration and land management to reduce P loading.

Major milestones

The Collaborative Agreement calls for an aspirational goal of a 20% reduction by 2020 and a goal of a 40% reduction by 2025.

Michigan's DAP Workplan outlines timelines for activities and includes several near-term milestones, such as:

- Monitoring to improve understanding of phosphorus contributions from Michigan's portion of the Maumee watershed. Michigan initiated surface water monitoring in Bean Creek and the St. Joseph river in 2016. Results were used to inform development of a more detailed monitoring strategy for 2017.
- Development of watershed management plans for Tiffin and Bean Creek watersheds (target completion is January 2019).
- Issuance of more stringent permit limits at 2 WWTPs (Wayne County & Monroe) by 2020.
- Undertake a study to evaluate SRP discharge quality as a function of level of municipal treatment.
- Increase farmer participation in MAEAP, e.g. cropland nutrient management implementation on 35,000 additional acres each year.
- Implementation of drain water management controls on 3,300 acres per year for 3 years.

How Progress Will Be Measured

In addition to participating in the federal and binational efforts to track and report progress under the GLWQA Annex 4, such as ErieStat, Michigan will use the following methods for measuring its progress:

Tracking changes to in-stream P concentrations, and load reduction measurements:

- The QOL agencies will create an online presence to track performance against the percent reduction goals.
- For the Detroit River, reductions will be calculated primarily using the GLWA and Wayne County discharge monitoring.
- For the Raisin River, reductions will be tracked using the monitoring data at the USGS gauging station and the Monroe WWTP discharge monitoring.
- Michigan will also develop a long term monitoring strategy for the Maumee River tributaries (i.e., Bean Creek and St. Joseph River) as appropriate for its contribution to overall P loads from Michigan's portions of the Maumee River Watershed.

Tracking progress of actions taken to reduce P loads from point and nonpoint sources:

Point Sources

- Reduce TP concentration limits in NPDES permits for four largest municipal wastewater facilities: the GLWA Facility, the DWTF, the YCUA WWTP, and the Monroe Metro WWTP.
- Permit limits consistently achieved at the largest WWTPs; no significant noncompliance.
- Continue to remove untreated CSOs.
- Continue to implement other programs including:
    - Municipal Separate Storm Sewer Systems programs
    - CAFO permits
    - Biosolids permits.

Nonpoint Sources

- The River Raisin Watershed and Michigan's portion of the Maumee River Watershed will have USEPA approved 319 watershed management plans.
- Annually document that at least an additional 3.5 percent or 35,000 more cropland acres in WLEB are managed under nutrient management plans.
- Maintain a minimum of 85 percent MAEAP reverification rate for farms in the WLEB
- Through MAEAP technical assistance:
    a. Reduce additional sediment entering the waters in the WLEB by 44,000 tons per year;
    b. Reduce additional P loading by 74,000 pounds per year; and
    c. Reduce additional nitrogen (N) loading by 176,000 pound per year.
- Through MDEQ Nonpoint Source program, add an additional 120 drain water management controls to reduce tile line discharges from 3,300 acres of cropland per year for three years.

Public Engagement and Reporting

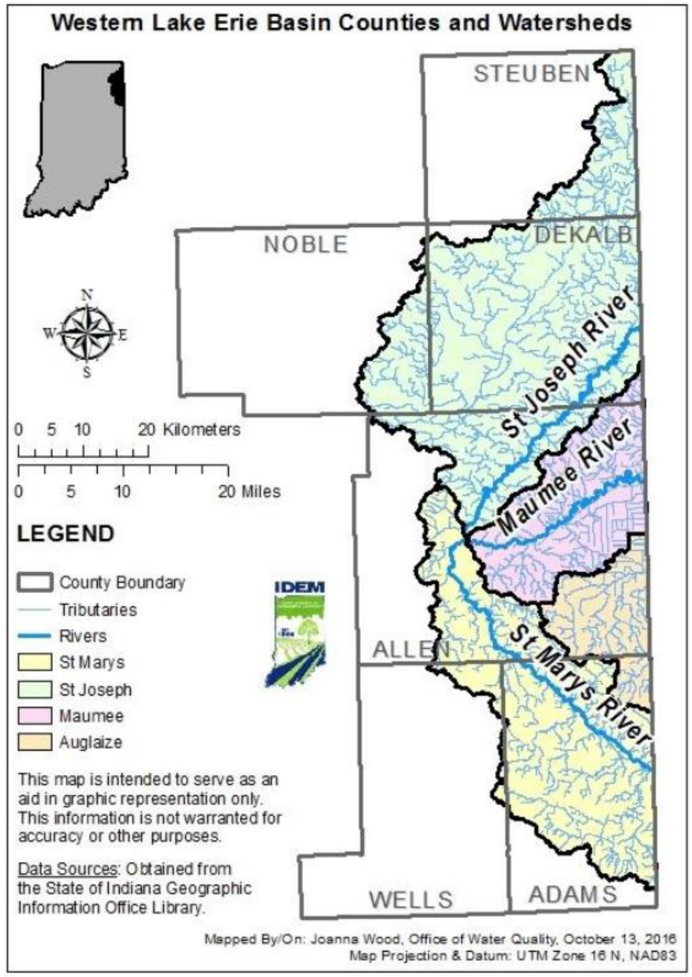
The QOL agencies are committed to improve and increase outreach to the public and farmers to promote an understanding of the WLEB ecosystem conditions and the importance of good conservation practices by initiating new targeted outreach campaigns, workshops, field demonstrations and information sharing. For example, advancement of goals set in the DAP will be regularly reported as part of Michigan Water Strategy implementation through outlets including a public Great Lakes e-mail list with nearly 10,000 current subscribers, a Michigan Water Strategy Web page (www.michigan.gov/waterstrategy), QOL agency Twitter accounts using the **#MiWaterStrategy** hashtag, and other platforms. Implementation progress will also be distributed from the QOL agencies through e-mail lists, web features, and individual program messaging with the inclusion of webinars, community meetings, infographics, and digital media approaches.

Michigan will continue to engage the public in further development and implementation of the DAP through these outreach mechanisms. Because we are using an adaptive management approach, Michigan's DAP may be updated in the future as new environmental and nutrient loading data become available and knowledge gaps are filled. For more details on Michigan's DAP, visit: www.michigan.gov/deqgreatlakes.

Indiana

Indiana's Portion of the Lake Erie Basin

Indiana drains roughly 12 percent of the western Lake Erie basin (WLEB) and is comprised of the St. Joseph, Maumee, Auglaize, and St. Marys watersheds that encompass approximately 821,300 acres in the counties of Steuben, DeKalb, Allen, Noble, Adams, and Wells. The St. Joseph River and the St. Marys River enter Indiana from Ohio and, at their confluence near Fort Wayne, form the Maumee River, which flows approximately 29 miles eastward into and through Ohio for another 108 miles to its mouth at Maumee Bay in Lake Erie near Toledo.



This portion of the WLEB is home to nearly a half million people. The largest city is Ft. Wayne with a population of approximately 260,000. More than 70 percent of the land is used for agriculture, 15 percent is developed, and the remaining 15 percent is comprised of forests, wetlands, and open water.

Major Sources of Phosphorus

Opportunities exist to reduce phosphorus (P) and other nutrient inputs from both urban and rural landscapes, including point (approximately 15-20%) and non-point sources (approximately 80-85%). Indiana's DAP seeks to address these sources by effecting the most change with the least cost; prioritizing resources to areas with the most P reduction potential; seeking to engage citizens who are not participating in conservation efforts; using social indicators; and employing adaptive management. Emphasis will be on using existing regulatory instruments and implementing voluntary best management practices.

Point sources

There are four major (one million gallons/day) municipal waste water treatment plants (WWTPs) with a TP effluent limit of 1 mg/L including Fort Wayne, Decatur, Auburn, and Butler. These WWTPs average a discharge concentration below the 1mg/L TP limit. There are three minor municipal WWTPs and an additional seven industrial/other minor dischargers.

Within the developed areas, there are seven combined sewer overflow (CSO) communities including Auburn, Berne, Butler, Decatur, Fort Wayne, New Haven, and Waterloo, each with an approved long term control plan (LTCP) or consent decree with compliance schedules. There are 13 designated municipal separate storm sewer systems (MS4s) with approved storm water management plans (SWMPs) including one in Adams County, 11 in Allen County, and one in DeKalb County.

Nonpoint sources

The leading source of phosphorus is runoff derived from land disturbing activities, septic system failures and agricultural production. Row crop agricultural land, with corn and soybean rotation predominating, is mostly drained by subsurface tiles which, during significant rainfall events, discharge to streams transporting phosphorus, nitrogen, and in some cases suspended sediment.

There are 78 active, regulated confined feeding operations (CFOs) in the WLEB with 50 in Adams County, 12 in Allen County, 12 in DeKalb County, 1 in Steuben, and 3 in Wells County. Under the Confined Feeding Operations Rule, 327 IAC 19[8], the Indiana Department of Environmental Management (IDEM) regulates facility design, construction, and maintenance; facility setbacks from streams, wells, roads, property boundaries, and residences; manure handling and storage; manure application rates and setbacks; monitoring and record keeping; storm water run-off from the production area; closure of manure storage structures; the handling of emergency spills; and waste digesters located on a CFO regulated site. Operators are required to test manure for nitrogen and phosphorus, conduct soil tests of manure application fields and apply manure at nitrogen or phosphorus limited agronomic rates depending on soil phosphorus levels. Approximately 36,000 acres within Indiana's portion of the WLEB are used for application of manure generated by animals regulated by IDEM.

The Certification for Distributors and Users of Fertilizer Materials, 355 IAC 7-1-1[9], is a rule administered by the Indiana Office of the State Chemist to ensure fertilizer materials are applied, handled, and transported effectively and safely in a manner that protects water quality. It pertains to both commercial and private fertilizer applicators. Any entity that only distributes but does not use fertilizer material must obtain a fertilizer distributor business license.

Phosphorus Reduction Goals & Priority Watersheds

The focus of Indiana's DAP is the reduction goal for the Maumee River, which drives harmful algal blooms (HABs) in the WLEB and contributes to central basin hypoxia. Indiana's goal is to meet the spring-time flow weighted mean concentration (FWMC) targets of 0.23 mg/L and 0.05 mg/L for TP and SRP respectively in the Maumee River as it flows across the border into Ohio. The watershed contributing the most phosphorus to the Maumee River appears to be the St. Marys. Using different models, analysis of water quality monitoring data from IDEM, Allen County Soil and Water Conservation District (SWCD), Tri-State Watershed Alliance (TSWA), and the City of Fort Wayne indicates the highest TP concentrations and loads here. Using the FWMC target for TP, the load duration curves show most of the sampling events exceed the target across all flow conditions signifying both point sources and nonpoint sources. Nutrient loading from unregulated livestock operations and community septic system failures are of concern. To better characterize nutrient loading in the St. Marys watershed, Indiana will fund a USGS auto-sampler monitoring site through a USEPA Great Lakes Restoration Initiative (GLRI) grant for a minimum of three years and will support additional monitoring by the local water monitoring entities.

[8] http://www.in.gov/legislative/iac/iac_title?iact=327&iaca=19
[9] http://www.in.gov/legislative/iac/T03550/A00070.PDF

Major Partners & Actions

Indiana's DAP, founded on the principle of adaptive management, is informed by the intensive planning, research and steadfast work that is already underway in the WLEB. All watersheds except the Auglaize have an approved watershed management plan (WMP) and Total Maximum Daily Load Report (TMDL). The DAP is developed by an advisory committee comprised of representatives from different stakeholder sectors[10] and led by IDEM. This advisory committee identifies three major priorities for implementation to achieve the 40% reduction goal in WLEB:

1. Restore natural hydrology and ecological functions
   i. Promote water management that emphasizes the importance of allowing water to infiltrate where it falls. In urban landscapes, create a green infrastructure paradigm by seeking incentives and opportunities for it. In rural and agricultural landscapes, restore stream sinuosity and riparian buffers, and address runoff and drainage with soil health strategies, saturated buffers, constructed wetlands, and drainage water management techniques, to name a few.

2. Urban/Rural: use existing regulatory instruments and best management practices (BMPs) to reduce nutrients. A few examples include:
   i. WWTPs and publicly owned treatment works (POTWs) will employ optimization techniques and track improvements.
   ii. CSO communities will implement their LTCPs and associated compliance schedules and track progress.
   iii. MS4 communities will implement their SWMPs and track progress.
   iv. Put infrastructure in place and extend sewers to communities with failing septic systems.
   v. Septic system installation, operation, maintenance, and repair will follow the site specific design regulations and septic system failure rates will be tracked.

3. Agriculture: use existing regulatory instruments and voluntary conservation practices.
   i. Ensure compliance with the CFO and Fertilizer Certification rules via routine inspections and timely investigate reports of nutrient mismanagement/runoff from unregulated farms.
   ii. Implement best nutrient management practices by employing the "4 Rs" namely, applying the right nutrient source at the right rate at the right time in the right place.
   iii. Emphasize soil health: Healthy soil with a higher organic content reduces erosion, requires less nutrient inputs, ameliorates the effects of flood and drought, and reduces nutrient and sediment loading to streams and rivers.

Major milestones

Indiana will use various indicators, including social indicators, to track progress from different sectors and will use 2020 as a checkpoint to determine progress toward the target P loads on the Maumee to validate or re-evaluate the priority watersheds, programs and practices. By that time, Indiana plans to have more baseline monitoring at the HUC-12 scale that will facilitate setting a timeframe for achieving the P target loads in the

[10] Members include Adam's Co. Soil and Water Conservation District (SWCD), Allen Co. SWCD, City of Fort Wayne, DeKalb Co.unty SWCD, Indiana Farm Bureau, Indiana Pork Producers, Indiana University Purdue University Fort Wayne, Indiana State Department of Agriculture, Indiana Department of Natural Resources, Natural Resource Conservation Service of USDA, Sierra Club, St. Joseph Watershed Alliance, Steuben Co. SWCD , The Nature Conservancy, Tri-State Watershed Alliance, United States Geological Survey. As time allows: Agribusiness Council of Indiana, Agricultural Research Service, USDA, Allen Co. MS4, City of Auburn, Hoosier Environmental Council, Purdue University, and The Andersons, Inc.

sub-watersheds in order to meet the FWMC on the Maumee. A few key projects over the next few years include the following:

- The City of Fort Wayne LTCP and Tunnel Works Project: construction began in 2017 with all parts of the Tunnel Works system to be completed and operational by 2025, which will reduce CSOs to the St. Marys and Maumee Rivers by 90%, from about 71 times per year to just four. https://www.cityoffortwayne.org/utilities/tunnel-works.html.
- Adams County Regional Sewer District (RSD): extension of sewer to the unincorporated community of Pleasant Mills commenced in 2017.
- DeKalb County Updated Onsite Sewage System and Installation Ordinance: implementation of this ordinance that passed in 2017.
- Allen County SWCD Upper Maumee P-Risk Pilot project: 4-year CWA Section 319(h) grant to reduce P loss from 10,000+ cropland acres, reduce 4,800 tons of sediment, 16,300 lbs. nitrogen, and 8,300 pounds of phosphorus; commencing in 2018.
- 4R Nutrient Stewardship Certification Program: Indiana has 1 certified retailer. The Nutrient Stewardship Council will work toward the goal of having 80% of farmed acres under certified management by 2025.
- St. Marys River Watershed Initiative: 4-year CWA Section 319(h) grant to implement a paired watershed monitoring project and soil health monitoring through 2021.
- Rethinking Drainage for the 21st Century: Purdue University and the Nature Conservancy will conduct workshops with county surveyors and drainage professionals; goal is to establish an innovative drainage pilot project.

How Progress Will Be Measured

In addition to participating in the federal and binational efforts to track and report progress under the GLWQA Annex 4, such as ErieStat, Indiana will use the following methods for measuring its progress:

- Ambient water quality monitoring data will be reported annually for the fixed station grab sample sites operated at the state, local and municipal levels, as well as for the Antwerp, OH and Fort Wayne, IN USGS operated auto-sampler sites.
- The spring tillage and cover crop transect is done every other year, and the fall tillage and cover crop transect is done every year. Data from these transects are used to track the extent of residue and cover crops in use in each county and reported annually. These data are important for capturing the voluntary adoption of these practices that occurs both with and without assistance or cost-share.
- The nutrient load reductions calculated using the Region 5 BMP Load Reduction Model for all Indiana Conservation Partnership (ICP) assisted conservation practices will be reported annually.
- POTW discharge monitoring reports are submitted monthly and will be graphed annually.
- Cost-share program project milestones and updates will be reported annually.

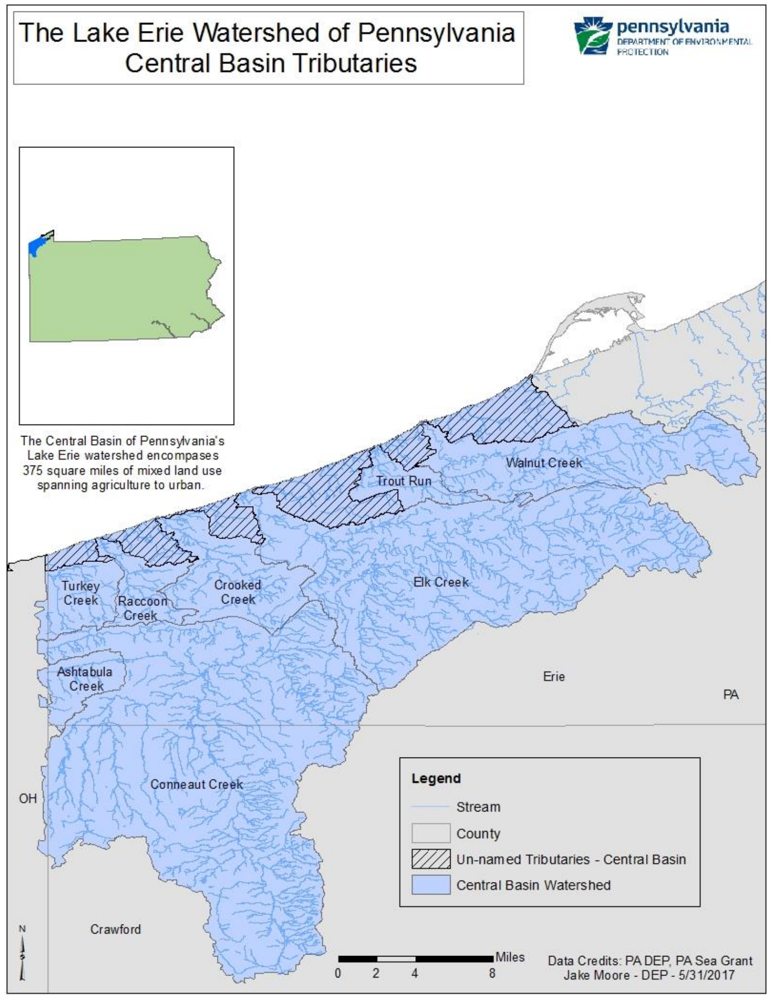
Public Engagement and Reporting

Indiana will continue to engage the public in further development and implementation of the DAP through periodic public meetings and discussions with stakeholder groups. Because we are using an adaptive management approach, Indiana's DAP may be updated in the future as new environmental and nutrient loading data become available and knowledge gaps are filled. For more details on Indiana's DAP, visit: http://www.in.gov/isda/3432.htm.

Pennsylvania

Pennsylvania's Portion of the Lake Erie Basin

The Pennsylvania Lake Erie Central Basin watershed covers approximately 375 square miles (mi^2) within Erie and Crawford Counties. The Central Basin is defined as all watershed area draining to Lake Erie from the base of Presque Isle (Longitude 42.109938, Latitude -80.159606) west to the Pennsylvania-Ohio border, containing eight significant named tributaries ranging in size from 6.94 mi^2 to 153.10 mi^2 and six small watershed areas that discharge directly to the Lake.



Approximately 32 percent of the land is used for agriculture, 14 percent is developed, and the remaining 54 percent is comprised of forests, wetlands and open water.

Major Sources of Phosphorus

Previous screenings of Pennsylvania Central Basin tributaries identified no significant point source or non-point source phosphorus discharges. It is estimated that Pennsylvania's annual total phosphorus loading to the Central Basin during the years 2008-2013 averaged approximately 40.7 metric tons per annum (MTA) from all sources. This represents approximately 0.5% of the total annual U.S. and Canadian phosphorus loading to the Central Basin.

Municipal sources

Within the developed areas, there are seven NPDES-permitted Publicly-Owned Treatment Works (POTWs) that discharge to Central Basin tributaries. Five POTWs are Minor Sewage Facilities discharging less than 1 million gallons per day (MGD) and two are Major Sewage Facilities discharging greater than 1 MGD and less than 5MGD. Major Sewage Facilities in Pennsylvania discharging to Lake Erie tributaries have NPDES permit conditions limiting maximum effluent concentration of total phosphorus to 1.0 milligram per liter.

Pennsylvania has a growing number of non-publicly owned Small Flow Treatment Facilities (SFTFs) in the Central Basin watershed that treat wastewater for an individual facility including single-family residences, individual residential/community developments, or businesses that do not have access to publicly-owned wastewater infrastructure. There are 166 SFTFs located in the Central Basin with additional facilities being permitted annually.

Pennsylvania also has five designated municipal separate storm sewer systems (MS4s) within the Central Basin, three of which maintain MS4 NPDES General Permits (PAG-13), one that maintains an MS4 Individual Permit, and one municipality that is waived from requirements due to meeting criteria in 40 CFR 122.32 (d) and (e).

Agricultural sources

Approximately 119.3 square miles of the Pennsylvania Central Basin watershed, around 31.8%, is defined as agricultural land use, consisting largely of viticulture, fruit crops, row crops, and commercial ornamental tree and shrub operations. There are two Concentrated Animal Feeding Operations (CAFOs) in Pennsylvania Central Basin watershed, one in Erie County that is a Concentrated Animal Operation (CAO) with greater than 300 animal equivalent units, and one in Crawford County that is an agricultural operation with greater than 1000 animal equivalent units.

Phosphorus Reduction Goals & Priority Watersheds

Current estimates of Total Phosphorus loading to the Lake is not of sufficient resolution to determine a load from the Pennsylvania drainage to the Central Basin. The data indicate that little, if any reductions would be needed from this area to achieve a 40% reduction from the 2008 baseline. Due to a lack of significant nutrient sources, focus in the DAP was placed on creating a better understanding of Pennsylvania phosphorus loading characteristics through acquiring data, developing a gap analysis, then completing a tributary land use assessment and GIS-based nutrient modeling. Additional focus will be placed in watersheds that are experiencing localized nutrient and urban stormwater impairments and have watershed management plans.

Major Partners & Actions

Pennsylvania's DAP looks to enhance Central Basin phosphorus reductions through partnering with county agencies and non-governmental organizations to implement programs addressing various sources of phosphorus. The following cooperative programs are examples of management efforts:

Program Name: Pennsylvania Vested in Environmental Sustainability (PA VinES)
Program Partner: Erie County Conservation District (ECCD)

PA VinES is a cooperative, coordinated agricultural initiative between Pennsylvania Department of Environmental Protection (PADEP), ECCD, Penn State Cooperative Extension, Cornell University, USDA Natural Resources Conservation Service, and Pennsylvania Farm Bureau. The mission is to foster and promote concepts of environmental consciousness and sustainability through education, outreach, and self-assessment to reduce conflicts between viticulture and water quality in the Lake Erie basin. The program focuses on a guided self-assessment workbook that identifies opportunities to enhance environmental sustainability and profitability, then provides an ECCD-sponsored cost-share program for installation of agricultural best management practices to reduce non-point source pollution runoff.

Program Name: Erie County Small Flow Treatment Facility (SFTF) Program
Program Partner: Erie County Department of Health (ECDH)

Certain soil types in the Pennsylvania Lake Erie Central Basin can be challenging for the proper function of traditional, in-ground, on-lot private sewage treatment in the absence of public sewage collection infrastructure. There are currently 166 permitted Non-Publicly Owned Wastewater Treatment Systems and Small Flow Treatment Facilities (SFTF) in Pennsylvania's Central Basin tributaries. In previous years, ECDH discovered that a significant percentage of these systems were in noncompliance for violations such as lack of disinfection, inadequate operation and maintenance, and failure to submit reports. These systems contribute to nutrient, bacterial, and other forms of pollution of Lake Erie tributaries. ECDH is dedicating staff to the SFTF Program to provide a better understanding of the impact on streams by:

- Conducting geospatial mapping of SFTF locations.
- Identifying treatment system owners who are failing to submit required self-monitoring reports.
- Contacting system owners to provide education and outreach.
- Monitoring and sampling of SFTF outfalls.
- Developing and implementing a more robust compliance program to evaluate, quantify, and abate pollution to Lake Erie tributaries.

Program Name: Urban Stormwater Management and Green Infrastructure Initiatives
Program Partners: Erie County Department of Planning (ECDP), Non-Governmental Organizations (NGOs)

The Pennsylvania Lake Erie Central Basin watersheds are geographically outside of the urban core of the City of Erie metropolitan area, although one of Erie County's fastest growing commercial corridors is in the Central Basin tributary of Walnut Creek. Additionally, the Erie County Comprehensive Plan and associated Erie County Demographic Study anticipate continued residential and commercial growth in the Central Basin tributaries extending west from the City of Erie. Urban stormwater management and green infrastructure programs will be integral to assuring that water quality issues caused by past development are rectified and that new problems are avoided through contemporary stormwater management and green infrastructure.

Opportunities exist for the coordination of MS4 permit obligations for communities in the Lake Erie Basin and the streamlining of how municipalities manage stormwater both within their own jurisdictions and across watershed boundaries. Partnerships to encourage municipal stormwater management coordination include Erie County government resources such as the ECDP and NGOs. Likely areas of coordination include Minimum Control Measures such as Public Education and Outreach, Public Involvement and Participation, and Illicit Discharge Detection and Elimination.

Major milestones

Pennsylvania will use indicators to track reductions from the various sectors and will evaluate in 2022 the progress made toward meeting the programmatic and practice commitments in the DAP.

How Progress Will Be Measured

In addition to participating in the federal and binational efforts to track and report progress under the GLWQA Annex 4, such as ErieStat, Pennsylvania plans to use the following methods for measuring its progress:

- Pennsylvania Department of Environmental Protection (PADEP) will compile and evaluate conservation practices installed through state grants and will report annually.

- PADEP will quantify and report known phosphorus contribution and reduction data for the purposes of tracking and accounting for total lakewide phosphorus reductions.
- PADEP will implement an Adaptive Management approach to allow for adjustments and improvements to programs and practices.

Public Engagement and Reporting

Pennsylvania will continue to engage the public in further development and implementation of the DAP through periodic public meetings and discussions with stakeholder groups. Because we are using an adaptive management approach, Pennsylvania's DAP may be updated in the future as new environmental and nutrient loading data become available and knowledge gaps are filled. For more details, please visit the PADEP Great Lakes Program webpage:
http://www.dep.pa.gov/Business/Water/Compacts%20and%20Commissions/Great%20Lakes%20Program/Pages/default.aspx

New York

New York's Portion of the Lake Erie Basin

New York's Lake Erie watershed is comprised of 12 HUC-10 sub-watersheds that encompass approximately 1.5 million acres in the counties of Erie, Chautauqua, Cattaraugus and very small portions of Allegany and Wyoming. In total, there are 2,441 miles of small lakes, rivers and streams draining to Lake Erie. The Buffalo River and Cattaraugus Creek are the largest tributaries and sub-watersheds, flowing westward into the eastern basin of Lake Erie. The Buffalo River enters Lake Erie at the head of the Niagara River so nearly all of its water leads directly downstream towards Lake Ontario having minimal or no impact on Lake Erie. The Cattaraugus Creek enters Lake Erie approximately 30 miles south of the Niagara River and most of its outflow mixes within the nearshore flowing north into the Niagara River.

Within the watershed, there are three cities: Buffalo, Lackawanna and Dunkirk, and several villages such as Westfield, Fredonia, Silver Creek, Gowanda, Arcade, Hamburg and Springville. Buffalo is the largest with a population of over 350,000, although geographically within the Lake Erie watershed, its municipal wastewater is discharged directly into the Niagara River after treatment, with exception of a couple overflow outlets into the Buffalo River.

The Lake Erie watershed varies from heavily developed areas in the northeast along the Lake to suburban areas in the central portion and rural/agricultural in the southwest. Urban sprawl, both residential and commercial, is a significant issue in the upper portion of the watershed. Fragmented forests are the primary land cover in the southeastern portion of the basin. The predominant land cover classifications are agricultural lands (46%) and deciduous and mixed forest (42% combined) lands, according to the USEPA's multi-resolution land classification (MRLC) map information. Agricultural lands are classified as row crops or pasture/hay lands based on MRLC interpreted data. The MLRC national data distinguishes between natural grassland and old fields, hay, pasture, and row crops. There are no lands classified as natural grasslands in the basin. In NY, pasture/hay lands and row crops are often referred to as grasslands by the management agencies. In the southwestern portion of the watershed, especially along the Lake escarpment, conversion of croplands to grape vineyards is occurring.

Major Sources of Phosphorus

While New York State Department of Conservation (DEC) does not believe that there are any major sources of P within the Lake Erie watershed that are resulting in widespread impairments or other detrimental impacts to the Lake, there are a variety of municipal and agricultural sources that are known, or have the potential, to contribute to P loadings within the watershed.

Municipal sources

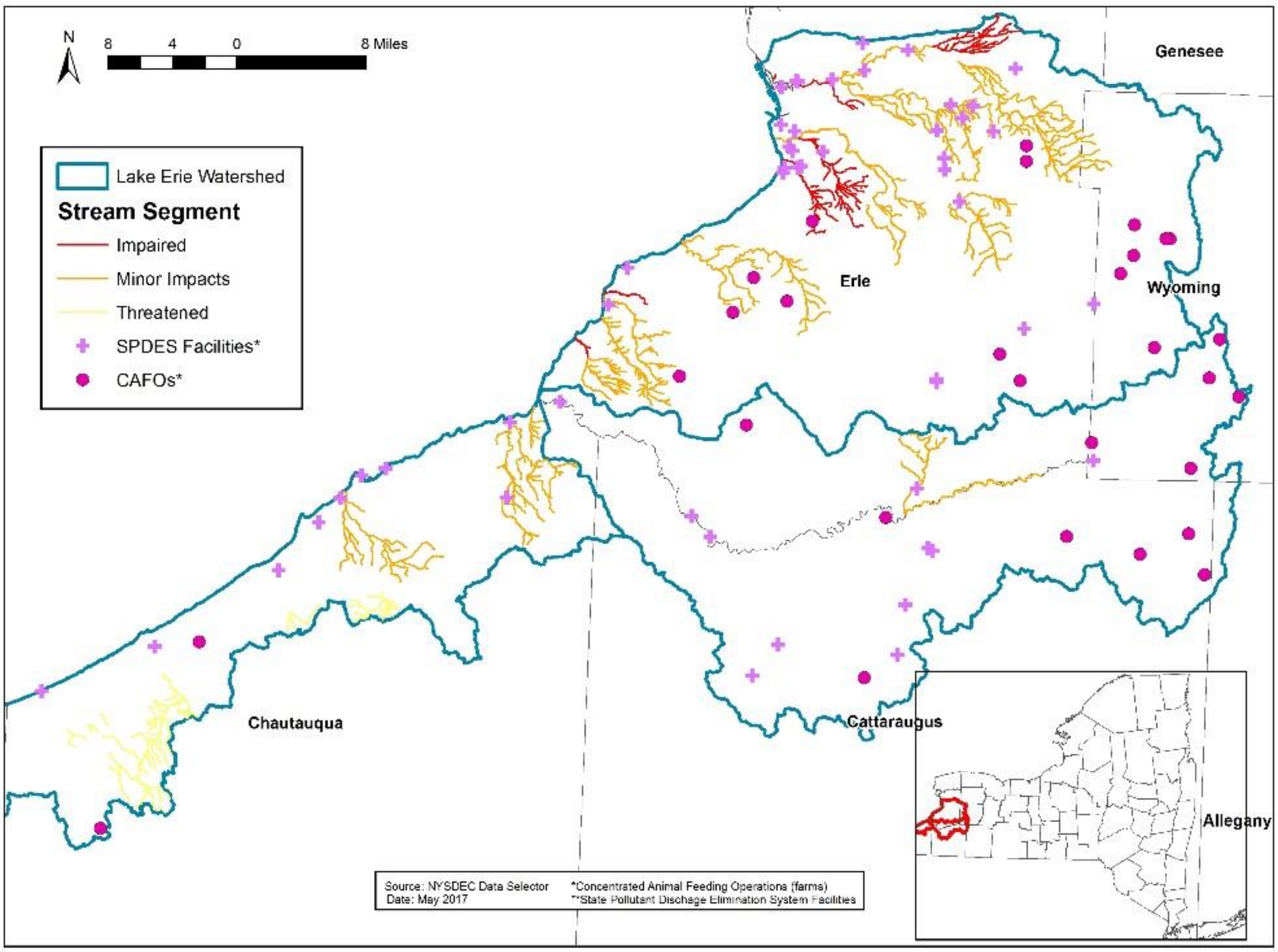
There are 10 Major Municipal and 18 State Significant Municipal wastewater treatment facilities in New York's Lake Erie watershed, the largest being Buffalo Sewer Authority; and 29 private/industrial facilities.

Within the developed areas, there is 1 combined sewer overflow (CSO) community (Dunkirk) with an approved long term control plan (LTCP). There is one designated municipal separate storm sewer systems (MS4s) (Buffalo) with an approved storm water management plans (SWMPs).

Agricultural sources

Runoff from row crop agricultural land (primarily grape vineyards, corn and soybeans) is another potentially significant source. Because much of this land is drained by subsurface tiles it can behave as developed land (impervious surfaces) during significant rainfall events with rapid discharge to streams.

There are 29 active CAFOs in New York's portion of the Eastern Basin of Lake Erie, of which six are large CAFOs (more than 700 dairy cows or their equivalent), and 23 are medium CAFOs (More than 200, but less than 700, dairy cows or their equivalent).



Phosphorus Management Goals & Priority Watersheds

The focus of New York's Nine Element Lake Erie Watershed Plan is to maintain the "Interim Substance Objective for Total Phosphorous Concentration in Open Waters of Eastern Basin of Lake Erie" of 10μg/L, consistent with the Great Lakes Water Quality Agreement as amended in 2012. New York's Lake Erie nearshore waters are classified as "Class A-Special" based on their best use as a source of water supply for drinking, culinary or food-processing purposes, primary or secondary recreation and fishing. These waters are not designated as "impaired or threatened" due to nutrients in the Clean Water Act Section 303(d) Priority Water Bodies List (PWL). However, they are designated as "impaired" due to pathogens and bacteria contributing to beach closures, and toxic chemicals (PCBs and Mercury) attributed to fish consumption restrictions. Within the watershed, 13 stream segments are designated as impaired or suspected due to nutrient contamination. The Cattaraugus Creek sub-watershed is of primary focus due to its water loading to the Lake and approximately 50 miles of nutrient and suspended sediment stressed or threatened stream segments. In the upper section and tributaries, DEC's prior "Rotating Intensive Basin Survey" (RIBS) sampling results indicated slightly impacted conditions. In such samples the community is slightly altered from natural conditions. Some sensitive species are not present and the overall abundance of macroinvertebrates is somewhat lower. However, the effects on the fauna appear to be relatively insignificant and water quality is considered to be good. The nutrient biotic index and impact source determination indicate low enrichment in the stream and fauna that is most similar to (natural) communities influenced by impoundment effects and nonpoint sources. Aquatic life support is considered to be fully supported in the stream, and there are no other apparent water quality impacts to designated uses.

Major Partners & Actions

The Lake Erie Watershed Protection Alliance (LEWPA), a voluntary collaboration among Erie, Chautauqua and Cattaraugus counties and 80 municipalities, is developing a Nine-Element Watershed Management Plan for the entire eastern Lake Erie watershed in partnership with the New York DEC.

Other partners in Lake Erie watershed protection include:

- Seneca Nation of Indians (SNI) – SNI are the largest tribal member (in terms of reservation acreage and population) within the historic Iroquois Confederacy of Nations. They govern a major reservation along the lower section of Cattaraugus Creek and have an innovative environmental management program to protect and conserve natural resources incorporating Traditional Ecological Knowledge (TEK) into local management practices.
- Buffalo-Niagara Riverkeeper (BNR) – a local non-profit chapter of national Riverkeeper organization that works closely with LEWPA, local governments, state agencies and others to promote water quality and public awareness of water uses and issues. BNR is developing a Niagara River watershed plan component called "Healthy Niagara" that will be integrated with the Lake Erie 9-Element Plan in the future.
- Academic Institutions – including New York Sea Grant, State University of New York (SUNY) at Buffalo, SUNY College at Buffalo, SUNY College at Fredonia, Canisius University, Hobart College, Medaille College, and local community colleges that all have environmental science curricula enabling researchers and students to work on different aspects of watershed management.
- Local chapters of regional/state/national organizations focusing on natural resource protection and conservation, including Southtowns Walleye, Trout Unlimited, Isaak Walton League, Fly Fishers Federation, New York Audubon, Buffalo Audubon, Western NY Land Conservancy, Niagara Musky Association, The Nature Conservancy, Alliance for the Great Lakes, Ducks Unlimited, Sierra Club, Citizens Campaign for the Environment and others.

Under New York's "Ocean and Great Lakes Ecosystem Conservation Act of 2006" and its implementing Great Lakes Action Agenda, New York DEC has organized a Lake Erie-Niagara River Watershed Work Group, consisting of 60 stakeholder organizations and 140 individuals. The work group has elected to begin developing an integrated implementation plan to promote watershed health and ecological and community resiliency within the Cattaraugus Creek watershed. Current planning activities are focused on developing collaborative and innovative solutions to address nonpoint source pollution, flooding and erosion issues and protection and restoration of natural infrastructure such as floodplains, riparian buffers and headwater forests.

The Cattaraugus Creek sub-watershed was studied as a whole at the 8-digit HUC scale. It encompasses about 358,000 acres, or 550 square miles, in the southeast portion of the Lake Erie watershed. It has moderately high (56%) natural cover, including forests, wetlands, and open water. The remainder of the sub-watershed is primarily agricultural lands with scattered rural residential sites and small villages. The main matrix forests include both climax (hemlock-northern hardwood forest; beech-maple mesic forest; maple-basswood forest) and successional (mix of northern and southern hardwoods) forest types. There are a large number of intermittent and perennial streams flowing into the main stem of the Cattaraugus Creek. This main stem is about 50 miles long, segmented at Springville by a defunct hydroelectric dam. There are high quality riverine biological communities in the small headwater streams with intact forests, and more affected larger streams from upstream agricultural runoff in the lower part of the watershed.

In 2017, New York DEC and USGS initiated a tributary monitoring program in order to better characterize nutrient, pathogen and bacteria concentrations and loading from streams within the overall Lake Erie watershed. The objective of this project is to collect baseline nutrient water quality data that can be used to 1) build a watershed model that will help focus future water quality improvement efforts in the basin, and 2) aid in future regional target-setting efforts for nutrient reduction. Sites were selected by the New York DEC by including segments from the impaired waters list, input from LEWPA, and to cover a range of watershed size and land use types. Sample collection will be conducted by the USGS and will include event sampling and flow data to be used in calculation of pollutant loads. This project is funded by GLRI and NYS.

Major Milestones

New York, with U.S. partners and Canada committed to re-evaluate the viability of setting science-based numeric targets for the Eastern basin in 2020. In the interim, New York will support four major efforts:

Lake Erie tributary monitoring
1-2 years of water quality sampling beginning summer of 2017. This will provide baseline data for development of a watershed model as part of the 9 Element plan for NY's Lake Erie Watershed.

Development of the 9 element plan
The data collected through the Lake Erie tributary monitoring project will be used to support the 9 element plan, which is expected to be developed by 2020.

Nuisance and harmful algal bloom research
New York State is committed to participating in Annex 4's *Cladophora* initiatives/research. New York will continue ongoing research efforts on algal blooms both within Lake Erie and other New York waters.

Reduced residential fertilizer use
New York State implemented a ban on phosphorous-containing residential fertilizers in 2016 and will continue an active enforcement/surveillance program to monitor compliance of residential fertilizer sales.

How Progress Will Be Measured

New York is participating in the federal and binational efforts to track and report progress under the GLWQA Annex 4, such as ErieStat. Additional milestones and performance metrics will be identified in the Nine-Element Watershed Management Plan for the eastern Lake Erie watershed.

Public Engagement and Reporting

New York State DEC and the Lake Erie Watershed Protection Alliance will engage the public in the development and implementation of the Lake Erie watershed based plan through the 9-element planning process. For more information, please visit: https://www.dec.ny.gov/chemical/103264.html.

FEDERALLY-LED EFFORTS

The federal government has made substantial progress in understanding and managing Great Lakes HABs and hypoxia events through coordinated research and management programs. HAB and hypoxia prevention in Lake Erie requires a strong federal coordination role, in addition to state and local leadership, due to the fact that the waters are shared among two countries and 5 States. Federal governments are coordinating efforts to meet GLWQA objectives with domestic statutes and authorities so that opportunities to prevent HABs and hypoxia are maximized.

For example, in response to the 2014 amendments to the Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA), federal agencies are collaborating to develop a research plan and action strategy to address the causes and effects of HABs and hypoxia in the Great Lakes. This work is coordinated by an Interagency Working Group of 13 federal agencies co-chaired by NOAA and USEPA.

Furthermore, under the Great Lakes Restoration Initiative (GLRI), federal governments have allocated significant expenditures since 2010 for a wide array of projects aimed at reducing nutrient loading into the Great Lakes. As an example, in response to the 2014 drinking water ban in Toledo, Ohio, federal and state agencies quickly received nearly $12 million in GLRI funds for projects intended to reduce and monitor HABs in western Lake Erie. More than $67 million of GLRI funds were invested in the Lake Erie basin from 2010 through 2016 to reduce nutrient pollution and to support related science and monitoring work. The GLRI is implemented by an Interagency Task Force of 11 federal departments or agencies.

While many federal agency programs support phosphorus reduction, monitoring, and research efforts in the Great Lakes, the lead agencies involved in the Lake Erie Action Plan are USEPA, USDA, USACE, USGS, and NOAA. The following sections summarize each Agency's relevant programs and authorities, and highlight current efforts to address the problems in Lake Erie.

Center to our approach is the effort we are making to improve coordination, communication and collaboration among government and non-government partners. Federal, state and local leaders have to work in partnership to be successful in affecting change over such a large region and adapting management for continual progress. Success will require active participation and continued diligence among multiple levels of government and stakeholders in the region.

USEPA

The USEPA is working with state and federal partners to combat nutrient pollution to Lake Erie in several ways. Through oversight of regulatory and nonregulatory programs, USEPA provides significant technical and financial support to States for nutrient management and HABs prevention work. As the lead agency coordinating the implementation of the GLWQA and the GLRI, USEPA has an important role in assisting Great Lakes States and partners working collaboratively to minimize and prevent HABs. USEPA is also leading a national research program and studies the effects of HABs in order to provide the latest scientific information on health effects, analytical methods, and recommendations for public water systems on treatment technologies available to manage risks from harmful algal blooms and cyanotoxins. USEPA brings significant resources to bear to address the challenges posed by excess nutrients and algae necessary to meet the Agency's core mission to protect human health and the environment.

Current and Ongoing Programs and Authorities

CLEAN WATER ACT PROGRAMS

The Federal Water Pollution Control Act of 1948 was the first major U.S. law to address water pollution. As amended in 1972, the law became commonly known as the Clean Water Act (CWA). The 1972 amendments established the basic structure for regulating pollutant discharges into the waters of the United States, and gave USEPA the authority to implement pollution control programs such as setting wastewater standards for industry. While significant progress has been made in cleaning up waters of the U.S., nutrient pollution remains one of America's most widespread and costly environmental and public health challenges.

Under the CWA, USEPA reviews and approves state water quality standards for nutrients, and works with states to identify waterbodies impaired by nutrients and then develop pollution diets - Total Maximum Daily Loads (TMDLs) - to restore them. TMDLs are then implemented through State regulatory and nonregulatory programs, with USEPA oversight and technical assistance. For example, USEPA Regional offices work closely with the states to implement the National Pollutant Discharge Elimination System (NPDES) which regulates point source discharges to waterbodies. Nutrient pollution from runoff and diffuse sources is managed through State nonpoint source management programs, with federal funding for projects under Section 319 of the CWA. CWA Section 319 funding for nonpoint source control projects in the Lake Erie Basin to date totals over $22 million, complementing an additional $19 million in matching funds from state and local partners. Projects, most of which are in the WLEB, have focused on reducing nutrient losses from cropland, restoring stream banks, establishing riparian buffers and upgrading septic systems. Estimated annual pollutant load reductions from these projects total 127,454 pounds of phosphorus, 302,638 pounds of nitrogen and 88,741 tons of sediment.

A critical backbone for the water programs are measurements of water quality conditions and stressors through routine monitoring and assessment. Under Section 106 of the CWA, USEPA provides funding to states to support their ambient water quality monitoring programs and their participation the National Aquatic Resource Surveys (NARS) – a collaborative program between USEPA, states, and tribes designed to assess the quality of the nation's coastal waters, lakes and reservoirs, rivers and streams, and wetlands using a statistical survey design. USEPA leverages national and state-level programs to monitor and report on trends in nutrients and water quality conditions in Lake Erie waters specifically, as described in more detail below.

GREAT LAKES PROGRAMS

Created in 1987, USEPA's Great Lakes National Program Office (GLNPO) serves as the liaison with Canada and is specifically charged with coordinating actions of the Agency (including actions by headquarters and regional offices thereof) with the actions of other federal agencies and state and local authorities to meet GLWQA objectives and commitments. GLNPO is authorized under the Clean Water Act to monitor the water quality of Great Lakes, and develop and implement action plans and strategies to improve Great Lakes water quality.

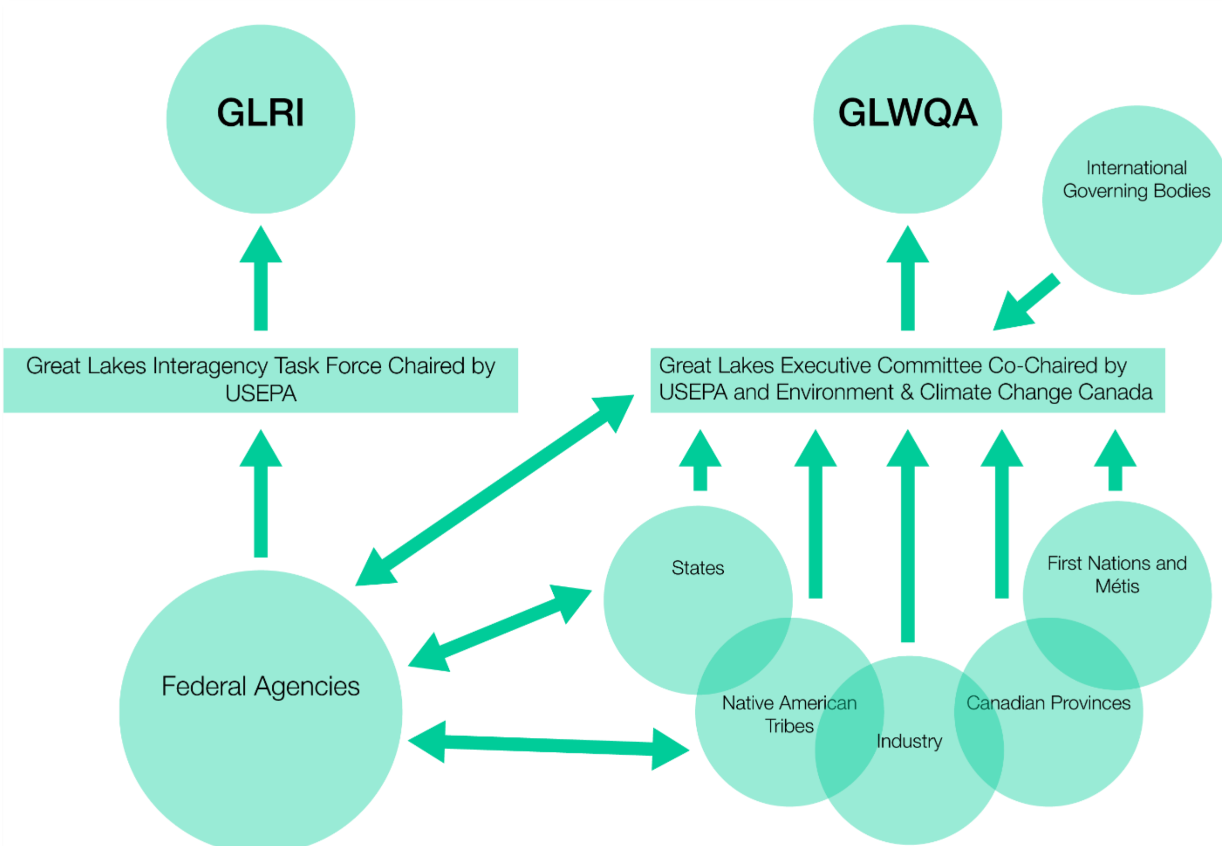
The GLRI was launched in 2010 with the goal to restore and maintain the environmental integrity of the Great Lakes ecosystem, in accordance with the GLWQA and the CWA. USEPA's GLNPO coordinates implementation of the GLRI, by leading an Interagency Task Force of 11 federal departments or agencies. The federal partners fund work directly or through others such as states, tribes, cities, universities, and non-governmental organizations. In December 2016, as part of the Water Infrastructure Improvements for the Nation Act (WIIN Act), Congress placed USEPA's GLRI authorities in Section 118(c)(7) of the CWA. The WIIN Act authorized $300 million per fiscal year from 2017 through 2021 to carry out activities in support of the GLRI and the GLWQA.

A significant portion of GLRI investments are targeted to restoration and supporting science in high-priority watersheds and receiving waters that have high potential or known risk for experiencing HABs and/or hypoxia events, including the Fox River-Green Bay, Saginaw River-Saginaw Bay, and Maumee River-western Lake Erie. GLRI has five focus areas – As it pertains to HABs and hypoxia, funding and results from GLRI Focus Area 3: "Reducing Nutrient Runoff that Contributes to Harmful/Nuisance Algal Blooms", Focus Area 4: "Habitats and Species", and Focus Area 5: "Science-based Adaptive Management", all support work to achieve GLWQA Annex 4 commitments. Attainment of GLWQA Annex 4 commitments will in turn contribute to achievement of GLRI Action Plan goals.

Coordination is an essential aspect to implement the binational commitments under the GLWQA through the GLRI and CWA programs.

As called for in the 2012 amendments to the GLWQA, USEPA and Environment and Climate Change Canada (ECCC) established a Great Lakes Executive Committee (GLEC) to help coordinate and implement the programs and other measures undertaken to achieve the purpose of the GLWQA. To meet the commitments under GLWQA Annex 4, USEPA co-chairs the Nutrients Annex Subcommittee with ECCC, which has representation from more than 20 federal, state, and regional organizations.

Similarly, to meet the commitments under GLWQA Annex 2, USEPA and ECCC lead the development of binational action plans for each Great Lake, known as Lakewide Action and Management Plans (LAMPs). Through partnership with many stakeholders, these plans are intended to facilitate information sharing, set priorities, and assist in coordinating binational environmental protection and restoration activities. The next Lake Erie LAMP will be issued in 2018. Actions to address nutrients identified in the Annex 4 DAPs will be incorporated into the LAMP.



Coordination under GLRI and GLWQA. Though the GLRI and GLWQA function independently, there are crossovers between the members and stakeholders. The GLRI is not a part of the GLWQA governance structure, but it is a tool that provides information used to implement the GLWQA.

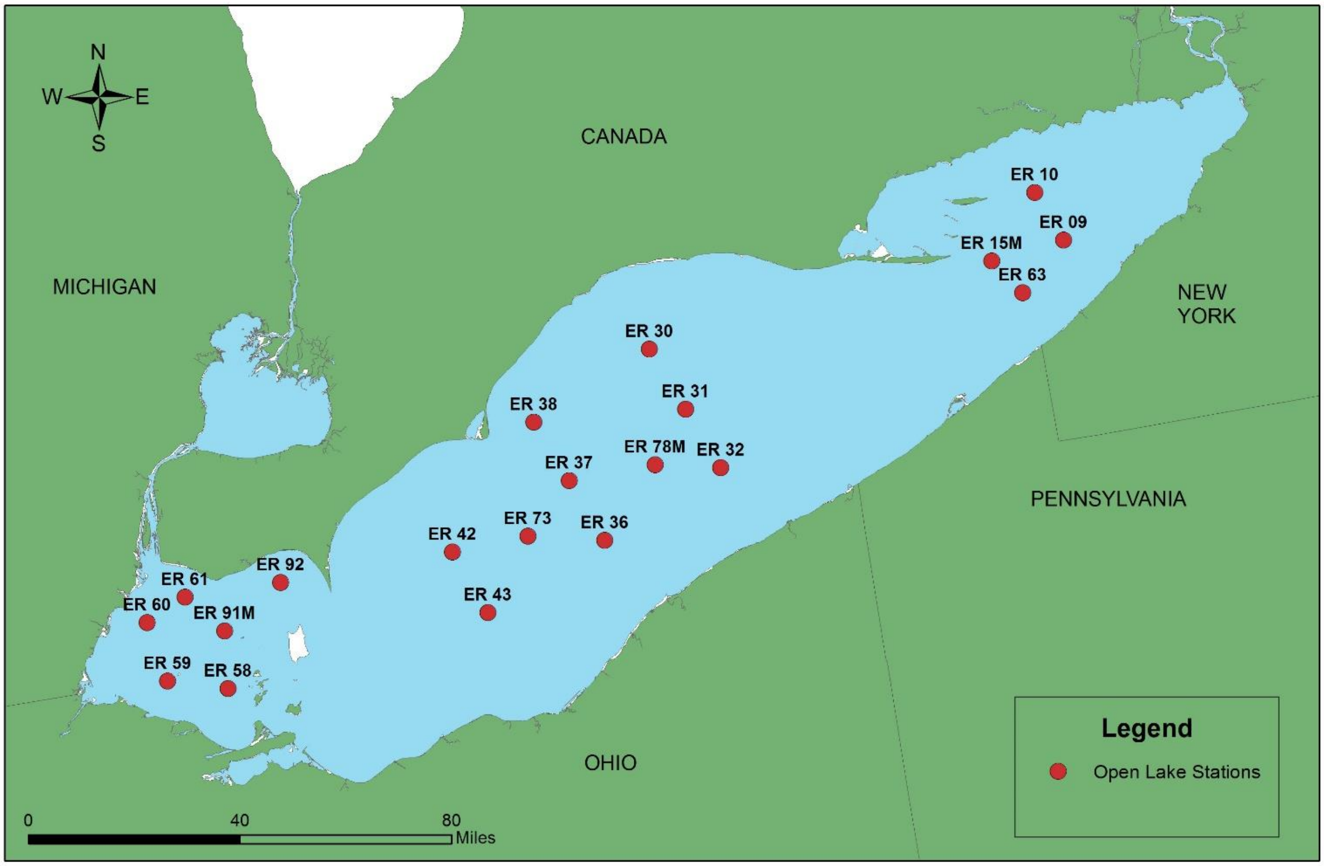
Long term monitoring programs

USEPA works with many partners to monitor and report on environmental status and trends. State of the Great Lakes reports are produced jointly by USEPA and ECCC to provide independent, science-based reporting on the health of the Great Lakes basin ecosystem. These assessments are informed by GLNPO's long term surveillance programs and by periodic intensive studies under the Cooperative Science and Monitoring Initiative (CSMI). The CSMI is conducted on each Great Lake annually on a rotational basis. Lake Erie was the CSMI Great Lake for 2014. Planning is already underway for the next CSMI in 2019 in coordination with other federal partners, states and universities.

The *Lake Guardian* is the largest Great Lakes research and monitoring vessel owned by U.S. EPA.

USEPA has conducted water quality surveys in Lake Erie, twice a year in spring and summer since 1983. Measurements of water chemistry, including nutrients, are collected from 20 fixed stations in the open waters of Lake Erie. In addition, USEPA measures the oxygen and temperature profiles at 10 sites in the

Central Basin of Lake Erie throughout the stratified season each year. The annual dissolved oxygen (DO) monitoring program helps to determine if the areal extent or duration of the oxygen-depleted area in the bottom waters of the Central Basin of Lake Erie is improving or further deteriorating. These long term data are a critical resource for federal and state water quality agencies to assess the effectiveness of phosphorous load reduction programs.



GLNPO Water Quality Survey Sampling Stations. All 20 sites in Lake Erie are sampled for nutrients each spring and summer. In addition, the 10 sites in the central basin are studied more intensely for hypoxia annually.

SAFE DRINKING WATER ACT

The Safe Drinking Water Act (SDWA) is the federal law that protects public drinking water supplies throughout the nation. Under the SDWA, USEPA sets standards for drinking water quality and with its partners implements various technical and financial programs to ensure drinking water safety. Congress passed the SDWA in 1974. It was most recently amended in 2015 with the passage of the Drinking Water Protection Act, which requires USEPA to develop and report to Congress a strategic plan outlining the risks to human health from drinking water provided by public water systems contaminated with algal toxins and to recommend feasible treatment options, including procedures and source water protection practices, to mitigate any adverse public health effects of algal toxins.

Algal toxins are not currently regulated under the SDWA. In 2015, USEPA developed, and submitted to Congress, the Algal Toxin Risk Assessment and Management Strategic Plan outlining how the Agency will continue to assess and manage algal toxins in drinking water.

USEPA has included cyanobacteria and multiple cyanotoxins in the published list of unregulated contaminants to be monitored by public water systems as required by the SDWA. Ten (10) cyanotoxins were included in the fourth Unregulated Contaminant Monitoring Rule (UCMR 4), proposed on December 11, 2015 to be monitored between 2018 and 2020 using USEPA approved analytical methods. This monitoring provides a basis for future regulatory determinations and, as warranted, actions to protect public health. In 2015, USEPA developed Health Advisories (HA) for two cyanobacterial toxins, and supporting guidance for states and utilities. USEPA is developing a Draft Human Health Recreational Ambient Water Quality Criteria and/or Swimming Advisories for *Microcystins* and *Cylindrospermopsin* to protect the public from incidental ingestion of these two cyanotoxins during primary contact recreation.

NATIONAL RESEARCH AND DEVELOPMENT

USEPA supports a national research program that studies the pathways and effects of nutrients on ecosystems and focuses in finding innovative and optimal solutions to reduce nutrient pollution. USEPA is conducting a national study on nutrient removal – i.e., how to control nutrients, develop and implement water treatment technologies -- at municipal wastewater plants. USEPA also helped manage the Nutrient Sensor Challenge which allowed teams from all over the world to participate in developing affordable dissolved nitrate and/or phosphate sensors.

USEPA is leading a multi-agency project among the National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), and U.S. Geological Survey (USGS), to develop an early warning indicator system using historical and current satellite data to detect algal blooms in U.S. freshwater systems. The Cyanobacteria Assessment Network (CyAN) project supports federal, state, and local partners in their monitoring efforts to assess water quality to protect aquatic and human health.

New and/or Innovative Efforts in Lake Erie

USEPA is leveraging its programs and authorities to accelerate nutrient reductions and the supporting science needed to inform and target new implementation efforts. Many new and innovative projects are being funded under GLRI that will have direct impact on achievement of phosphorus reduction goals in Lake Erie. USEPA is also working to enhance state and national programs to monitor and report on trends in nutrients and water quality conditions in Lake Erie nearshore waters and in tributary watersheds.

Accelerating nonpoint source nutrient reduction

In an effort to accelerate implementation of nonpoint source projects at the local level, USEPA has offered competitive funding opportunities for implementation of watershed management plans under the GLRI nearly every year since 2010. These projects add significantly to the funding opportunities typically available for this type of work under base federal and state nonpoint programs. For example, federal funding under CWA 319 totaled $22M for nonpoint projects in Lake Erie from 2002-2015 and reported phosphorus reductions of 127,454 lbs. From 2010-2015, USEPA funded $26 M in GLRI grants for agricultural nutrient reduction and $10 M for urban stormwater projects in Lake Erie. These projects are expected to provide an additional 200,000 lbs phosphorus reduction.

Pay for performance

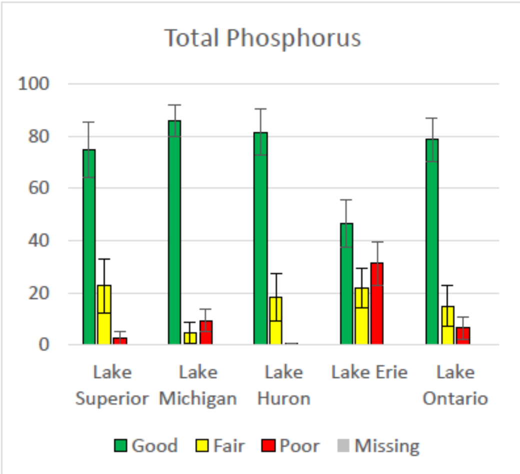
USEPA is supporting a number of pilot programs in GLRI priority watersheds aimed at testing non-traditional funding options to accelerate the implementation of conservation practices in agricultural areas. For example, in 2017, USEPA provided a GLRI grant to support a pilot Phosphorus Risk Reduction project in the River Raisin watershed. The project aims to equip farmers with tools to help identify fields most at risk for phosphorus and sediment loss, compare conservation practice benefits, and plan manure/fertilizer application to reduce runoff. Farmers, conservation technicians, and private industry partners will work together to implement the pilot through a unique grassroots engagement process. Project partners will build upon existing capacity in the watershed to accelerate the adoption of needed conservation practices in the River Raisin Watershed to help meet the 40% phosphorus reduction targets in the Western Lake Erie basin.

Improved watershed monitoring and assessments in WLEB

USEPA is partnering with WLEB States to improve watershed monitoring and assessments, including development of nutrient TMDLs, in several Lake Erie watersheds. In the Maumee river basin in particular, USEPA is working with Indiana, Michigan and Ohio, to establish a water quality monitoring network to track phosphorus loads and concentrations against the Annex 4 targets. This effort will require new and continued investments in high frequency monitoring to accurately capture loads and dissolved phosphorus contributions. USEPA is also supporting these states in establishing targets and baselines for subwatersheds to the Maumee. Currently, a contractor to USEPA is developing a protocol for assessing whether the TMDLs for upstream watersheds (specifically the St. Joseph and Tiffin rivers) are sufficient to meet the Annex 4 goals downstream. This analysis is unique for the TMDL program and will be critically important to determining how future state TMDLs are developed to assist in meeting the goals of Annex 4.

Enhanced nearshore monitoring

USEPA is coordinating CWA and GLRI programs and funding to support enhanced monitoring of Lake Erie nearshore areas. In 2010, the Great Lakes was fully incorporated into USEPA's National Coastal Condition Assessment (NCCA) for the first time. The NCCA - one of four National Aquatic Resource Surveys - is designed to yield unbiased estimates of the condition of the nearshore waters and to assess changes over time. The 2010 Great Lakes assessment found that over 30% of Lake Erie's nearshore waters were in poor condition for excess phosphorus. The 2015 survey was enhanced with 34 additional Lake Erie sites to allow for more refined assessments of the western, central and eastern basins. Furthermore, USEPA provided CWA and GLRI funds to support Ohio's development of a new nearshore monitoring program, built on the NCCA – the Lake Erie Shoreline Monitoring and Assessment Program. The program assesses water quality and habitat annually and in 2016 transects were added to map the central basin anoxic zone.



Caption: Nearshore waters condition assessment for phosphorus from National Coastal Condition Assessment 2010 Great Lakes Technical Memorandum

In-lake monitoring and modeling

In support of the 2014 Cooperative Science and Monitoring Initiative (CSMI), the Ohio Lake Erie Commission secured a grant from USEPA to assemble a team of researchers with expertise in lake sediment sampling and experimentation, watershed monitoring and modeling, and lake ecosystem simulation modeling. The study, completed in 2016, demonstrated through in-lake sediment sampling and modeling, that internal phosphorus loading from sediments is a relatively minor contributor to the development of HABs. The results confirmed the central importance of the Maumee River as a source of phosphorus during the critical spring period leading to development of HABs.

Cladophora research

USEPA is working with USGS, NOAA and academic partners to develop a *Cladophora* Research Program. The program will consist of concerted monitoring efforts at sentinel sites, coupled with enhancements to *Cladophora* growth models to better understand *Cladophora* growth and allow for future development of phosphorus targets in Lake Erie's eastern basin and the other Great Lakes. We intend to enhance and build on Canada's monitoring of the northern shore of Lake Erie by conducting exploratory monitoring on the U.S. side in 2018; this will be followed by a more intensive effort in 2019 under CSMI. The goal is to update *Cladophora* growth models so that by 2020, we can determine whether a phosphorus target can be developed for the eastern basin of Erie to minimize the impacts of nuisance *benthic algae*.

USDA

The U.S. Department of Agriculture (USDA) promotes innovation in agriculture and preservation of our Nation's natural resources through conservation, restored forests, improved watersheds, and healthy private working lands. Multiple agencies within USDA implement programs to address conservation needs and improve effectiveness of agricultural management measures through innovative research and education. USDA Natural Resources Conservation Service (NRCS) provides voluntary, incentive-based conservation technical and financial assistance to landowners through local field offices in nearly every county of the nation. NRCS also conducts leading edge research to assess the effects of conservation practices and programs through the Conservation Effects Assessment Program (CEAP). The USDA also supports intramural and extramural research, extension and education efforts through the Agricultural Research Service (ARS, intramural research) and the National Institute of Food and Agriculture (NIFA, extramural research, education and extension) to develop and improve best management practices for agricultural production, ensuring a safe and abundant food and fiber supply while preserving natural resources.

Current and Ongoing Programs and Authorities

NRCS FARM BILL CONSERVATION PROGRAMS

USDA's Natural Resources Conservation Service (NRCS) assists landowners in developing conservation plans and enrolling private working lands into conservation programs, working with more than 500,000 farmers and ranchers nationwide to implement conservation practices that prevent soil erosion, protect wildlife habitat, and promote clean air and water. NRCS provides technical and financial assistance to producers in the Lake Erie watershed through voluntary Conservation Technical Assistance Program (CTA), the Environmental Quality Incentive Program (EQIP), Conservation Stewardship Program (CSP), the Agricultural Conservation Easement Program (ACEP), and the new Regional Conservation Partnership Program (RCPP).

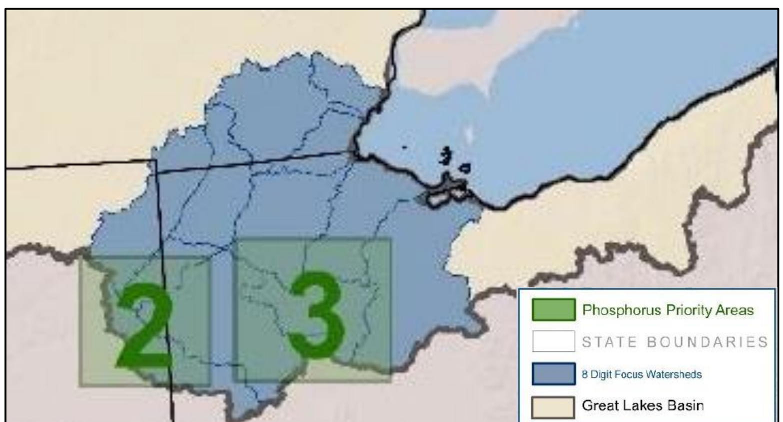
- CTA is the 'Boots on the Ground' professional NRCS Conservation Planners that are available to any group or individual interested in conserving our natural resources and sustaining agricultural production in this country.
- EQIP assists people in reducing soil erosion, enhancing water supplies, improving water quality, increasing wildlife habitat, and reducing damages caused by floods and other natural disasters. EQIP incorporates National, State and Local priorities into ranking of applications.
- CSP is the largest conservation program in the United States with 70 million acres of productive agricultural and forest land enrolled and is completely focused on working lands. CSP helps farmers build on their existing conservation efforts while strengthening their operation's financial bottom line.
- ACEP protects the long-term viability of the nation's food supply by preventing conversion of productive working lands to non-agricultural uses. NRCS provides financial assistance to eligible partners for purchasing Agricultural Land Easements under ACEP that protect the agricultural use and conservation values of eligible land.
- A new program in the 2014 Farm Bill is the Regional Conservation Partnership Program (RCPP). Under this program, nearly $40 million has been awarded to four projects in the Great Lakes region, including a significant project in the WLEB: the Tri-State Western Lake Erie Basin Phosphorus Reduction Initiative. This RCPP project rallies together more than 40 partners to spur voluntary conservation practices that will reduce phosphorus runoff in the WLEB. NRCS dedicated $17.5 million matched by $36 million from partners.

The Western Lake Erie Basin of the Great Lakes (WLEB) was made a special priority area by USDA in 2012. NRCS prioritizes the delivery of conservation assistance on private agricultural lands using several methods. Each NRCS State Conservationist is advised by a State Technical Committee made up of stakeholders from federal and state natural resource agencies, American Indian Tribes, agricultural and environmental organizations, and agricultural producers. They provide information, analysis, and recommendations on the implementation of the natural resources conservation authorities of the agency. In addition, local partners at the county level provide input for prioritizing resource concerns under EQIP. These two mechanisms are critical to the NRCS model of locally lead conservation.

GLRI PRIORITY WATERSHEDS

The Maumee River basin is one of four GLRI Priority Watersheds for nutrient reduction to address harmful algal blooms. NRCS, in partnership with USEPA, implements the GLRI to provide additional targeted assistance to address GLRI Action Plan objectives through EQIP and CTA program authorities. GLRI EQIP applications are funded on a competitive basis considering factors that reduce soil loss, improve water quality, reduce nutrients in surface water, and focus limited funds to the most vulnerable soils around Lake Erie. EQIP application screening and ranking criteria are informed by science and assessments, to help identify the applications yielding the greatest benefits. NRCS also collaborates with USGS, USEPA, and USDA ARS to conduct edge of field monitoring in GLRI priority watersheds.

GLRI priority watersheds are determined with state and local input, and informed with analysis of geospatial data, agricultural extent and conservation opportunities, water quality model results (e.g. SPARROW and CEAP Cropland Assessment results), other watershed condition information (e.g. CWA 303d listings) and consideration for monitoring or assessment in the watershed. This process resulted in the selection of two Phosphorus Priority Areas within the larger WLEB GLRI Priority Watershed being jointly recognized by USDA-NRCS, USEPA-Great Lakes National Program Office, USGS, and NOAA – National Weather Service: the Blanchard River in Ohio, and the St. Marys and Upper Maumee subwatersheds in Indiana. In both of these areas, NRCS collaborates with multiple partners to prioritize funding for phosphorus reduction and edge of field monitoring activities.



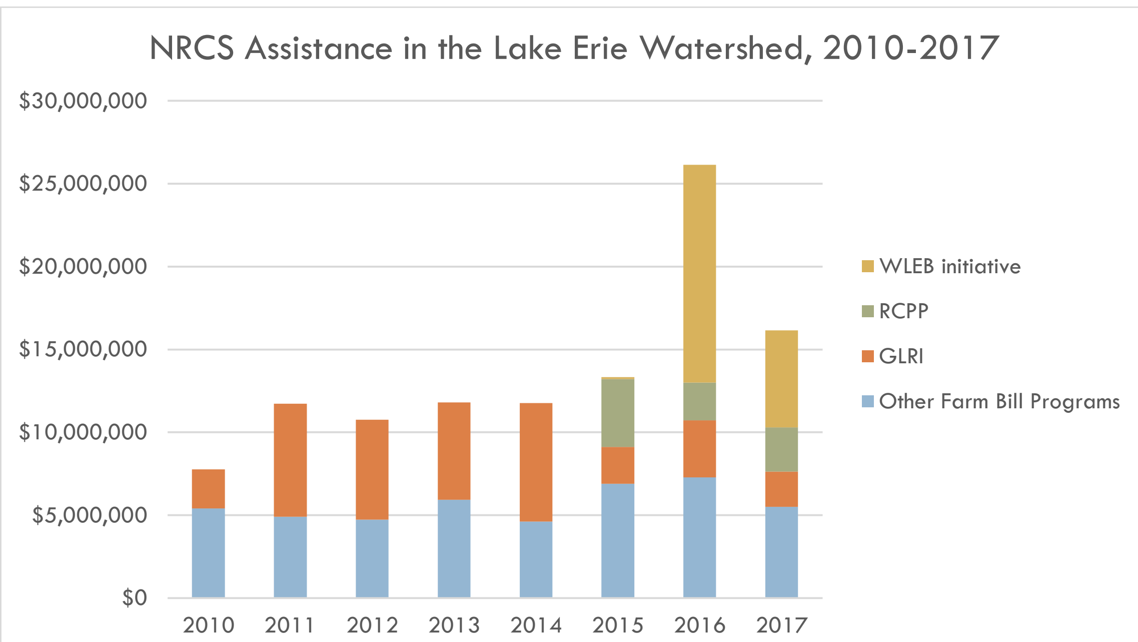
Location of GLRI Priority Phosphorus Reduction Areas (shaded green) within the WLEB watershed. There are 5 priority areas in the Great Lakes basin, these areas marked 2 and 3 refer to the St. Marys/Upper Maumee, and Blanchard River, respectively. More detailed maps of these areas are available at: https://www.epa.gov/sites/production/files/2016-12/documents/2016-glri-rfa-supplementary-material-20161216-7pp.pdf

WESTERN LAKE ERIE BASIN INITIATIVE

In March 2016, USDA began implementing the WLEB Initiative: a new strategy which aims to double the level of conservation applied in the WLEB through additional targeted assistance. USDA will invest an additional $41 million, for a combined three-year investment of $77 million so that, by the end of 2018, NRCS estimates that it will be able to assist farmers in applying conservation systems on about 870,000 acres of cultivated cropland across the WLEB.

NRCS had been active in the Lake Erie watershed prior to the 2016 WLEB Initiative. Since 2009, NRCS has invested over $73 million in technical and financial assistance to farmers in the WLEB through Farm Bill Programs. The conservation improvements they have made through more than 2,000 conservation contracts now cover more than 580,000 acres. Farmers and landowners in the region have stepped up, and with their help the conservation practices these funds supported reduced edge of field annual nutrient and sediment losses by an estimated 7 million pounds of nitrogen, 1.2 million pounds of phosphorous, and 488,000 tons of sediment between 2009 and 2014.

Taken together, the combination of Farm Bill (WLEB Initiative, RCPP, and other Farm Bill programs) and GLRI funding is expected to significantly increase the rate of adoption of conservation practices in the WLEB. To illustrate, the chart below summarizes the amount of financial assistance to farmers and livestock producers in the Lake Erie basin from 2010-2017.



Source: USDA NRCS. A total of $109 million was obligated to farmer contracts from 2010-2017 to reduce soil loss and improve water quality. Assuming a flat cost-share rate of 75% in most instances, farmers would have matched these funds with additional $36 million, for a total investment of $145 million over the 8-year period.

CONSERVATION EFFECTS ASSESSMENTS

The Conservation Effects Assessment Project, or CEAP, is a multi-agency effort to quantify the environmental effects of conservation practices and programs and develop the science base for managing the agricultural landscape for environmental quality. CEAP findings are used to guide USDA conservation policy and program development and delivery and help stakeholders, including policy-makers, conservationists, farmers and ranchers, make more informed conservation decisions. CEAP assessments in the Western Lake Erie Basin are carried out at basin, small watershed, and edge of field scales and address various ecosystem services related to agroecological systems, including but not limited to water, air, and soil quality, yields, and biodiversity on cropland and for wildlife resource concerns.

A number of recent CEAP publications are highly relevant to nutrient management efforts in Lake Erie. The results and science from these studies have been used to inform both federal and state programs and strategies in the basin under this Domestic Action Plan. For example, a national synthesis of the CEAP findings and lessons learned were published in 2012 and used to inform NRCS program design and delivery including GLRI's Priority Watershed approach, methods for estimating P reductions annually and updates to conservation practice standards. Results from future and on-going CEAP assessments will be used to support documentation of progress and metrics for this Domestic Action Plan.

To access CEAP reports and storymaps, visit: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/ceap.

- **The CEAP-1 National Assessment (2003-06)** was the first time CEAP-Cropland provided a regional assessment of the "current" conservation efforts in the Great Lakes region, including estimating rates and types of conservation adoption; their impacts on soils, yields, and water quality; and ongoing conservation needs. CEAP-1 generated a report on the Great Lakes Region released in 2011. **CEAP-2** will provide an updated version (2015-2016) of this assessment.

- "**Effects of Conservation Practice Adoption on Cultivated Cropland Acres in Western Lake Erie Basin, 2003-06 and 2012"**, released in 2016, found that conservation efforts increased between the two survey periods. Assessment of phosphorus management practices showed phosphorus application rates declined, use of improved phosphorus application methods increased, and phosphorus application timing remained unchanged. At the same time, use of complementary structural practices to reduce sediment losses and surface flow losses increased. Model assessment suggests the conservation practices adopted between 2003-06 and 2012 reduced phosphorus losses from cultivated cropland in the Western Lake Erie Basin by 11.4 million pounds per year.

- **"Conservation Practice Adoption on Cultivated Cropland Acres: Effects on Instream Nutrient and Sediment Dynamics in Western Lake Erie Basin, 2003-06 and 2012"** (2017). This analysis considers the impact of conservation adoption on instream and delivery dynamics of nutrient and sediment and draws attention to the need to consider legacy loads and associated time-lags when setting conservation goals and determining metrics of success. Once fully functional, conservation practices adopted between 2003-06 and 2012 will further reduce edge of field phosphorus losses from cropland by 17 percent, reduce phosphorus deposition in the Western Lake Erie hydrological system by 30 percent, and reduce phosphorus delivery to Lake Erie by 3 percent, relative to 2003-06 values. Note: this survey period ended in 2012, and as noted in the 2016 Cropland Assessment, conservation efforts increased after that time.

- **Western Lake Erie Basin Conservation Effects Assessment Project – Wildlife [11] (2016).** USDA NRCS and ARS in partnership with The Nature Conservancy and The Ohio State University developed a process for assessing and predicting stream fish community condition response to agricultural conservation practices. Results showed that many streams in the WLEB have high levels of sediment and nutrients that potentially limit fish community health in more than 10,000 km of streams and rivers, representing more than 50% of the watershed, and that suites of practices are needed to achieve measurable improvements to fish communities. Results also showed that, while improvements in stream health could be made by maintaining current conservation practice treatment levels and further treating farm acres in high-need of treatment (~8% of the watershed), a much larger portion of the watershed (~48%) needs to be treated to achieve widespread benefits for stream fishes. The findings are being used to help identify areas within the WLEB where additional agricultural conservation treatment will result in the most benefit to stream fish communities.

- **Watershed-scale Assessments of the Effects of Conservation Practices.** The CEAP Watersheds component quantifies cumulative changes in water quality and changes in processes due to conservation practices implemented within a watershed through both monitoring and modeling in small watersheds and within (subwatersheds and fields). Three CEAP studies in the WLEB recently ended in the Auglaize, the Tiffin and Rock Creek in the Sandusky. One study remains active in the St. Joseph River watershed in Indiana, and another was recently added for the Blanchard River Ohio starting in 2018. Results from these studies are published in peer reviewed journals and include findings on the need for systems of conservation practices, tradeoffs among practices, tile drainage and dissolved phosphorous contributions, and new innovative practices.

ARS EDGE OF FIELD RESEARCH

The USDA Agricultural Research Service Soil Drainage Research Unit located in Columbus, Ohio, has established a water quality monitoring network dedicated to quantifying the impacts of agricultural practices on edge of field water quality. The current network is comprised of 40 monitored fields on 20 separate farms across the intensively drained region of Ohio. A majority of the sites are located in the Western Lake Erie Basin. The first edge of field monitoring sites were installed in 2003, with additional sites instrumented over the past twelve years. Since its inception, the edge of field monitoring network has facilitated multidisciplinary research efforts aimed at developing solutions for the complex water quality problems found in tile-drained landscapes. The edge of field monitoring network has been an integral component of several regional and national initiatives including NRCS CEAP, the GLRI, the new Western Lake Erie Basin Initiative and multiple Conservation Innovation Grants with university partners and non-governmental organizations. Recently, the edge of field monitoring network has

Photo of edge of field runoff from Williams et al. 2016

[11] http://lakeerieceap.com

also become part of the Eastern Corn Belt Long-Term Agroecosystem Research Network, The Ohio State University Field to Faucet Initiative, and the 4R Research Project.

NIFA RESEARCH, EDUCATION AND EXTENSION

USDA National Institute of Food and Agriculture (NIFA) invests in and provides national leadership to advance agricultural research, education, an extension to solve societal challenges by providing competitive and capacity funding grants. Through support to both land grant universities and local offices of the Cooperative Extension System, NIFA is supports delivery of science-based information to a range of audiences to improve practices and support communities. Extension, in partnership with NIFA, translates research into action by bringing cutting-edge discoveries from research laboratories to those who can put knowledge into practice. Land-Grant University System faculty and staff experts extend extension's reach even further by providing science-based content for eXtension.org. This site offers an online resource where users have continual access to research information on a wide range of topics, fosters collaboration between Extension professionals, and even supports education that provides Continuing Education Units to certified agricultural professionals.

An important resource for research and extension on issues related to agricultural nutrient management and water quality is the Southern Extension and Research Activity (SERA) – 17 (https://sera17.org/about), an information exchange group administered through the Southern Region Land Grant Universities. SERA-17 functions on a voluntary basis with over 300 members from around the world, and is the "go-to" organization for expert, up-to-date science-based information on agricultural nutrient management (particularly P). Reauthorized in 2013, the Hatch Multistate Committee **SERA-17: Innovative Solutions to Minimize Phosphorus Losses from Agriculture** is identifying P sensitive watersheds and water bodies and expanding and improving upon the Phosphorus Index site assessment tool, an integral part of a nutrient management plan. Work on this tool includes developing best management practices to reduce agricultural P losses, animal manure application strategies to reduce nutrient run off, and new soil testing methods that can more accurately identify sites where P loss will be of significant environmental concern.

National Integrated Water Quality program (NIWQP)

The NIWQP was supported by the Section 406 Agricultural Research, Extension, and Education Reform Act of 1998 until 2014, when the program last received appropriations to support grants for applied research, extension and education projects for universities. NIWQP supported a Great Lakes Regional Water Quality Coordination Program at one time for integrated land grant university research, education and extension programming in the region. This program worked on issues such as drainage management, nutrient and manure management, social indicators, behavior change and training to support adoption and maintenance for conservation, e.g. the manure applicators training network. It also promoted collaboration and collaborative projects between land grant programs and sea grant programs within and across institutions.

Some of the integrated watershed projects supported by the NIWQP are still ongoing. Topics include conservation effects assessment in the WLEB (as part of CEAP), two-stage ditches and water quality; drainage spacing and drainage water management practices for water quality; and human dimension of agricultural producer nutrient management practices and conservation behavior. The Ohio State University also received funding through the NIWQP to improve surface water quality by improving the education and outreach efforts to current and future streamside landowners in the risk-based context of degraded watersheds in the Great Lakes region. Some of this prior effort evolved into the North Central Water Program, which currently offers webinars and educational programming on agriculture, water quality, and watershed planning.

Agriculture and Food Research Initiative (AFRI)

AFRI was established by Congress in the 2008 Farm Bill and re-authorized in the 2014 Farm Bill. NIFA's AFRI funding portfolio includes both single- and multi-function research, education, and extension grants that address key problems of national, regional, and multi-state importance. AFRI-funded projects sustain all components of agriculture, including farm efficiency and profitability, ranching, renewable energy, forestry (both urban and agroforestry), aquaculture, rural communities and entrepreneurship, human nutrition, food safety, biotechnology, and conventional breeding. Within the AFRI, there are several areas that support research to improve water quality, natural resource management, and the environmental impact of agricultural production.

The Water for Agriculture Challenge Area supports the development of management practices, technologies, and tools for farmers, ranchers, forest owners and managers, public decision makers, public and private managers, and citizens to improve water resource quantity and quality. The AFRI Foundational Program has an existing priority on Sustainable Agroecosystems: Functions, Processes and Management. This program supports research projects that will lead to substantial improvements in water, nutrient, carbon, and/or land use efficiencies or footprints, or improvements to impaired natural resources and ecosystem services.

Small Business Innovation Research (SBIR)

The USDA SBIR program operates under the authority of the SBIR/STTR Reauthorization Act of 2016. The program has ten program areas; such as Air, Water, and Soil and Aquaculture; that provides competitive grants to qualified small businesses to support high quality research related to important scientific problems and opportunities in agriculture that could lead to significant public benefits. A 2014 Phase I project was awarded to Metamateria Technologies in Ohio to look at the feasibility developing a controlled drainage technology using novel nano-engineered porous ceramic media that can control nutrients and trace pharmaceuticals in the agricultural drainage discharge, with a specific emphasis of reducing P loading into Lake Erie.

New and/or innovative efforts in Lake Erie

NRCS is collaborating with other agencies, universities and organizations on numerous innovative projects. These projects demonstrate how USDA is applying over 80 years of experience, science-based assessment, and on-the-ground success, to meet the challenges in Lake Erie.

Western Lake Erie Basin Initiative Strategy

The WLEB Initiative is one of the key results of a series of partner workshops NRCS held in fall 2015 to develop recommendations for accelerating conservation in the Basin. The initiative further sharpens the focus of NRCS investments and helps increase the impact of ongoing work by conservation groups and state and local governments. This partnership will work with data from the CEAP Reports and other sources along with the recommendations of farmers and other conservation partners to match the right conservation solution to the unique qualities of each field to maximize the impact of each dollar invested.

The goal of the WLEB Initiative is to accelerate conservation opportunities for agricultural producers in several ways.

- The WLEB Initiative invests an additional $41 million, for a combined three-year investment of $77 million, effectively doubling the amount of funding available for technical and financial assistance to implement conservation practices.
- As a result of these conservation investments, edge of field losses will be reduced by more than 640,000 pounds of total phosphorus (annually), 175,000 pounds that is in the form of soluble phosphorus[12]. These edge of field phosphorus reductions will contribute to reducing the phosphorus load reaching tributaries that empty into Lake Erie.
- NRCS gives priority consideration for financial assistance to highly vulnerable soils, particularly in areas draining directly to Lake Erie tributaries.
- The four elements of the Initiative strategy are: avoid excess nutrient application, control nutrient and sediment movement, trap nutrient and sediment losses and manage hydrological pathways to reduce nutrient and sediment losses.

Erie P Market: A Multi-Jurisdictional Water Quality Trading Framework for Western Lake Erie

The Erie P Market project was launched in early 2016 through a two-year Conservation Innovation Grant from NRCS to develop and test a multijurisdictional framework for water quality trading in the WLEB. Indiana, Michigan, and Ohio participate, with Ontario observing to share experiences. Modeled after the Ohio River Basin water quality trading project (Indiana, Ohio, and Kentucky), Erie P Market seeks to explore the potential for water quality trading to as another tool to achieve a WLEB phosphorus reduction targets.

Demonstration Farms

Demonstration Farms are sites where universities, government agencies, the local farmer and the general public can gather to review active water quality research and agricultural best management practices as well as innovative practices. One such site is the Blanchard River Demonstration Farms Network (BRDFN) - a joint partnership between NRCS and the Ohio Farm Bureau Federation launched in 2016. BRDFN is designed to showcase and demonstrate leading edge conservation practices on agricultural land to improve water quality. This project will test new and standard conservation systems for reducing phosphorus and share lessons learned with farmers, agribusiness, conservation agencies and the public. For more information, see: https://ofbf.org/tag/blanchard-river-demonstration-farms-network.

New CEAP Watersheds projects in WLEB

A new small watershed assessment study under CEAP was initiated in 2018 in the Blanchard River Watershed. The assessment, funded by USDA NRCS, in partnership with USDA ARS and Heidelberg University, will be carried out over 3 to 5 years initially but is desired to be a long-term project. USGS is also a partner and will be supporting stream gages within the study watersheds. The study will relate water quality and soil changes within paired watersheds to conservation practices on the ground to assess watershed water quality effectiveness. In the future, local partners on the project will be able to extend insights on the effectiveness of practices in conjunction with the existing outreach and demonstration efforts such as the Blanchard River Demonstration Farms and Blanchard River Watershed Partnership.

In addition, NRCS and ARS recently established a new CEAP Watersheds project to evaluate the progressive and cumulative effects of stacking conservation practices as part of a system. A new and innovative project

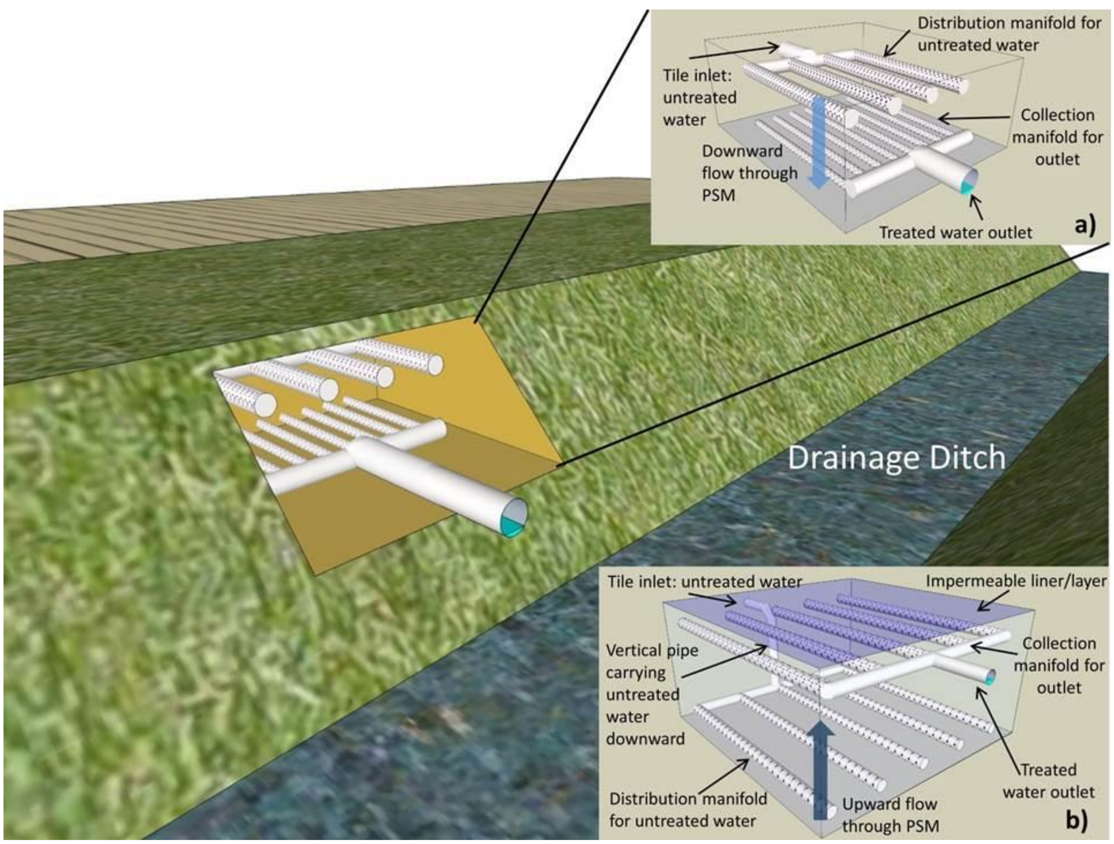
[12] https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/newsroom/releases/?cid=nrcseprd892606

initiated in 2016 in the Western Lake Erie Basin will measure reductions from implementing a series of conservation practices in a treatment train. As practices are implemented, phosphorus reductions will be assessed in the field, at the edge of field and instream.

Designing and Evaluating More Effective Conservation Practices for Phosphorous Removal

USDA ARS has been working in partnership with NRCS under CEAP Watershed Assessments to identify the need for new or modified conservation practice standards, and evaluate those for performance over time. Continued long-term assessment of newly developed practice standards is important to determine the practice life span per design standards as well as any future operational or maintenance needs to maintain effectiveness over time. In support of adaptive management, new practices are designed specifically to target other flow paths or sources of nutrients, based on new knowledge. These innovative practices include the Phosphorous Removal Structure and the Blind Inlet, among others.

Recently, a new phosphorous removal structure was installed under the design of USDA ARS in a farm field in Ohio to treat tile drainage. The Phosphorous Removal Structure (shown below) is designed to collect untreated tile drainage water, which contains dissolved phosphorous, filter the untreated drainage water through steel slag (or other phosphorous removal medium), and allow the filtered and now treated water to flow out of a collection pipe and into a drainage ditch. This practice is designed to focus treatment on the dissolved or soluble forms of phosphorous, which are known to be important for minimizing algal blooms in Lake Erie.



Removing Phosphorous from Tile Drainage Water: The structure can be designed have water flow from the top-downward (a) or the bottom-upward (b). Design b is useful for sites that are limited based on hydraulic head due to a shallow drainage ditch, flat landscape, or a current tile outlet drain located near the bottom of a drainage ditch. Diagram by Stan Livingston, USDA-ARS. Penn, C.J., Bowen, J.M. 2017. Design and construction of phosphorus removal structures for improving water quality. https://www.ars.usda.gov/research/publications/publication/?seqNo115=344469

Science-based management of agricultural drainage channels in the WLEB

Two-stage ditches and other alternative channel designs in agricultural drainage can be more sustainable than traditional channelization practices and reduce nutrient and sediment loss. Ohio State University is conducting social science research, including semi-structured interviews with county drainage officials and surveys of landowners in the WLEB, to identify important barriers to adoption of alternative channel designs. Understanding these barriers will help tailor outreach and education efforts, and target extension to areas where adoption of this innovative practice will have the greatest effect on improving water quality.

Transforming Drainage

This USDA NIFA-funded and Purdue University-led project brings a team of researchers and extension specialists in the Midwest together to address the need to provide more secure water for crops throughout the growing season while maintaining adequate drainage during wet periods and limiting nutrient losses through practices that store water in the landscape. This project delivers extension-based programming across the Great Lakes region, with several field sites in the Lake Erie basin.

One practice being tested, saturated buffers, stores water within the soil of field buffers by diverting tile water into shallow laterals that raise the water table within the buffer and slows outflow. The research on saturated buffers suggests that they are effective at removing nitrate from tile drain water before it is discharged into surface waters. Another practice, controlled drainage, has been shown to be effective in reducing the outflow of water and nitrate-nitrogen from drainage systems. The project is also looking at a closed loop system of drainage water recycling, in which drainage water is recirculated onto the same field, or water drained from one field can be used to irrigate another field.

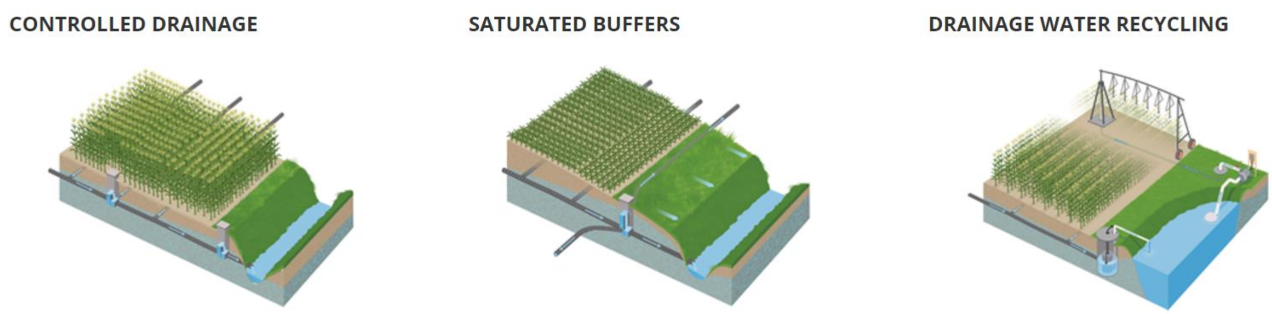


Image from http://transformingdrainage.org

Agricultural Conservation Planning Framework (ACPF) pilot project in WLEB

Developed by USDA ARS, National Laboratory for Agriculture and the Environment in Ames IA, Environmental Defense Fund and The Nature Conservancy, in partnership with USDA NRCS CIG and CEAP, and with contributions from Environmental Defense Fund and The Nature Conservancy, the ACPF tool comprises a framework and geospatial approach for incorporating precision conservation concepts and a systems approach to conservation into the agricultural watershed planning process. NRCS and ARS are planning to use ACPF with universities and conservation partners in the region as a pilot project in 6 selected watersheds in the WLEB. The ACPF framework is receptive to landowner and community preferences, is compatible with voluntary implementation policies, and could be used to inform more effective small watershed (HUC 12) conservation strategies. The framework identifies many options to locate multiple practices and scenarios that can be evaluated as part of the comprehensive conservation planning and program delivery processes at watershed and farm level scales. It focuses on effective citing of edge of field practices for greatest effect within a small watershed. Traditional as well as innovative practices and trapping practices, such as wetlands, are included. This pilot will also help the ACPF development team adjust and expand the ACPF for WLEB landscapes and practices used there.

Linking Soil Health Assessment to Edge of Field Water Quality in the Great Lakes Basin

NRCS is working with researchers at the University of Wisconsin – Green Bay, Purdue University, and the USGS Water Science Centers to conduct soil quality assessments in concert with the GLRI edge of field monitoring programs. The focus of this project is to establish standardized, in-field soil health monitoring protocols for edge of field sites, create a robust baseline dataset of soil health at edge of field sites, and connect field-scale soil health parameters with the water quality leaving these fields. For more information: http://news.uwgb.edu/log-news/news/02/01/cesu-grant-for-great-lakes-water-quality-study/.

USACE

The U.S. Army Corps of Engineers (USACE) has leveraged several authorities that have provided Interagency Partners and related stakeholders with broad technical support and site specific activities related to addressing the increase of Harmful Algal Blooms (HABs) in the Western Lake Erie Basin (WLEB) of the Great Lakes. It has become clear that achieving the reduction of phosphorus (P) loads from the Maumee River watershed to reduce the HABs will require collaborative and adaptive approaches. A combination of actions will be needed including: improved fertilizer management; and measures to minimize losses of P from the field, edge of field, riparian zones, and instream. It is these latter two areas of action (riparian and instream P reductions) that the USACE is currently working on.

Current and Ongoing Programs and Authorities

Two of the most noteworthy USACE authorities applied to addressing concerns related to HABs include the Great Lakes Tributary Modeling Program (GLTM) and the Ecosystem Management and Restoration Research Program (EMRRP). Data and models that were originally developed under the USACE GLTM have been further refined and then applied in several subsequent projects led by other federal and state agencies and research programs to help understand the causes, establish targets, and evaluate potential solutions to meet the targets necessary to address the HAB problem in the WLEB. These watershed, river, and lake models were crucial to the establishment of the 40% Phosphorus (P) load reduction target for the WLEB and to gaining consensus among agencies and researchers on the challenges of and potential approaches to meeting the targets.

In addition to the work conducted under the GLTM and EMRRP that is specifically geared toward HABs issues, USACE is also conducting projects and has established interagency partnerships under other authorities such as the Great Lakes Fisheries and Ecosystem Restoration (GLFER) and Section 441 of the Water Resources Development Act. The projects and partnerships conducted under these authorities are potentially synergistic opportunities to address P reduction while meeting the missions of the authorities. For example, wetlands or stream restoration projects for flood mitigation, or habitat restoration projects could also potentially provide water quality improvements through nutrient reductions. In addition, the WLEB Partnership facilitates the multi-agency and stakeholder collaboration that will be necessary to achieve the P load reductions in the Maumee basin.

USACE-related work performed in the Maumee River basin under each of these authorities (GLTMP, EMRRP, GLFER, and Section 441) are described below.

GREAT LAKES TRIBUTARY MODELING PROGRAM (GLTM)

The GLTM program was established through Section 516(e) of the Water Resources Development Act of 1996. This authority enables USACE to develop tools to assist state and local agencies with the planning and implementation of measures for soil conservation, sedimentation and nonpoint source pollution prevention. Models with underlying data can be developed at all tributaries to the Great Lakes that discharge to federal navigation channels or Areas of Concern (AOCs). The ultimate goal of this program is to reduce watershed loadings of sediments and pollutants from tributaries in order to enhance Great Lakes water quality, delist Great Lakes AOCs, and reduce the need for navigation dredging.

Modeling work in Western Lake Erie Basin (WLEB) that predated the Great Lakes Restoration Initiative (GLRI) was coordinated with the U.S. Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) and USDA Agricultural Research Station (ARS) and provided enormous benefits related to accelerating a better understanding best management practices that would later be directly used to help evaluate scenarios informing Lake Erie agricultural nutrient management. The GLTM program provides USACE with the authority to develop models but these models are then handed off to stakeholders that can help facilitate the implementation of prioritized management actions across the watershed. There were two types of models developed under the GLTM for the Maumee basin: river/lake models and watershed models. The river/lake model has become the Western Lake Erie Ecosystem Model (WLEEM), operated by Limnotech in support of many WLEB projects.

ECOSYSTEM MANAGEMENT AND RESTORATION RESEARCH PROGRAM (EMRRP)

The EMRRP is USACE's responsive, tactical research and development response to the demand for new and expanding technologies to address the need for ecosystem assessment, restoration, and management activities at the project level. The EMRRP provides rapid, cost-effective technology to meet USACE's most pressing research and development needs in functional assessment, restoration, and stewardship of high priority ecosystems. The EMRRP is targeted toward ecosystems of particular concern to USACE, namely: streams, riparian corridors, wetlands, and special aquatic sites. Technologies developed under the EMRRP build upon a sound understanding of ecosystem functions, which lead to sustainable stewardship of USACE resources.

Under EMRRP, USACE has initiated an effort to evaluate the potential utility of wetlands in reducing phosphorus loading to the WLEB. Wetlands, both natural and designed, have long been understood to provide water quality improvement benefits, including nutrient reduction. The main challenge to large-scale implementation of wetlands used to reduce phosphorus in agricultural runoff is in identifying the factors that optimize phosphorus removal. The current USACE scope of work includes several initial studies that will advance the body of knowledge regarding wetland optimization for phosphorus removal and will lay the foundation for subsequent full-scale testing in priority Great Lakes watersheds. Although the present work focuses mainly on the Maumee River watershed and WLEB, the findings and outcomes will be readily transferrable to other priority Great Lakes watersheds. In fact, the current work includes monitoring and data analysis support for pilot wetlands being built by the Outagamie County Land Conservation Department in the Fox River watershed of Green Bay.

GREAT LAKES FISHERIES AND ECOSYSTEM RESTORATION (GLFER)

GLFER, authorized under Section 506 of the Water Resources Development Act of 2000, is a full service program to plan, design, and construct projects that restore ecosystems across the large landscape of the Great Lakes watershed. The GLFER program is implemented in partnership with the Great Lakes Fishery Commission, who coordinates the review of project proposals by representatives from state, tribal, and federal agencies. Individual projects require a non-federal partner(s) to provide 35% of project costs (including all lands, easements, rights-of-way, relocations) and to operate and maintain the completed projects. State, tribal, and local agencies, as well as non-profit and private interests are eligible to sponsor GLFER projects.

WLEB PARTNERSHIP

The WLEB Study was established through Section 441 of the Water Resources Development Act of 1999. This authority includes the ability to evaluate comprehensive investigations of measures to improve fish and wildlife habitat, navigation, flood risk management, recreation, and water quality in the WLEB, including the Maumee, Ottawa and Portage River watersheds. One of the key results of the work under this authority was the formation of the WLEB Partnership in 2006. USACE and USDA-NRCS Co-chair the leadership of this interagency team that includes a wide array of both federal and non-federal representation.

New and/or Innovative Efforts in Lake Erie

USACE is leveraging its authority under the EMRRP to evaluate potential approaches and collaborative opportunities to reduce P loads in riparian zones and instream. USACE Engineer Research and Development Center (ERDC), the Buffalo, Chicago, and Detroit Districts are working with stakeholders to evaluate targeted wetlands restoration and creation as a potentially long-term and effective means for P removal. USACE is also working with USEPA to enhance and expand current WLEB ecosystem model capabilities so that decision makers can evaluate loading scenarios and eutrophication response indicators in the Lake.

P Optimal Wetlands

USACE is working in collaboration with other Great Lakes stakeholders interested in the subject of wetlands for phosphorus reduction, including The Nature Conservancy, Ducks Unlimited, academic institutions and other federal agencies, to conduct research and engineering evaluation to inform decision-making about the potential for treatment wetlands to be a significant part of controlling phosphorus from agricultural runoff in the Great Lakes. One of the challenges to large-scale implementation of wetlands (besides loss of private agricultural land) is identifying the factors that optimize phosphorus removal. A comprehensive literature review and analysis led by researchers at the USACE ERDC found that soil phosphorus sorption capacity (SPSC) is a significant factor in wetland phosphorus removal function and may help explain why phosphorus retention in wetlands can vary significantly. This work reinforces the importance of understanding the role of legacy phosphorus.

We are collecting SPSC data at several constructed sites to validate assumptions and standardize these assumptions for future prioritization of work. This presents an important step forward in effectively siting and designing wetlands for phosphorus control. Upon completion of the current research effort, which will be paired with spatial analysis and modeling to identify optimum sites for wetlands, the next steps will include supplemental monitoring of wetland projects constructed by others, such as the Maumee Bay State Park wetlands led by the University of Toledo. USACE and partners anticipate construction of new full-scale wetland sites to test and demonstrate the potential of P optimal wetlands starting in 2019.

Lake Ecosystem Modeling

The Western Lake Erie Ecosystem Model (WLEEM) is an integrated hydrodynamic/sediment transport/water quality model of the Maumee River and Western Basin of Lake Erie was first developed in 2010 WLEEM is a time-dependent, 3-D model that computes temporal and spatial profiles of water, sediment, nutrients, and plankton and benthos dynamics as a function of loadings from the watershed and Detroit River and hydro-meteorological forcing functions. As recommended by USEPA's Science Advisory Board, future work will expand this model to include all of Lake Erie and will incorporate updated *Cladophora* growth models. This expanded model will also link to existing basin tributary monitoring network and watershed loading models. The goal of this new effort is to create a tool for decision makers that looks at a linked suite of impacts and effects of new lake-wide loading scenarios and eutrophication response indicators.

USGS

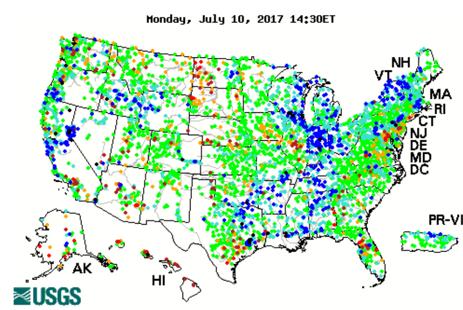
USGS provides a key science support role in nutrient load estimation, assessment of water quality trends, and HABs and hypoxia forecasting.

USGS operates several streamflow gages which provide the critical underpinnings of tributary nutrient load estimates. Daily and hourly streamflow data in many cases are provided in real time. As part of the Great Lakes monitoring program, USGS scientists collected samples and used state-of-the-art sensors to gather water-quality data for 30 major Great Lakes tributaries during 2011 through 2013. Sophisticated models were then used to analyze these data and estimate nutrient and sediment loads.

USGS staff across the region conduct monitoring and research to help managers track and understand the development of HABs and hypoxia in the Great Lakes. USGS topical experts also participate and provide expertise at various levels of the GLRI, the GLWQA, and the HABHRCA interagency working group. In support of Annex 4 of the GLWQA, USGS has provided scientific expertise specifically related to the monitoring and fate and transport of nutrients. USGS topical experts from the across the country have joined this process to provide additional support and guidance based on their experience from working in areas such as the Chesapeake Bay and the Mississippi River Basin.

Current and Ongoing Programs and Authorities

GROUNDWATER AND STREAMFLOW INFORMATION PROGRAM (GWSIP)



The Groundwater and Streamflow Information Program (GWSIP) is one of four Water Programs funded by Congress to identify, measure, and assess the Nation's water resources.
The GWSIP is the principal USGS Program for streamflow and groundwater-level data in real-time and over the long-term, at the regional/national scales – providing critical information for the understanding of the Nation's water resources.

Within the Lake Erie Basin, the GWSIP either fully or partially funds the operation of numerous streamflow and groundwater-level monitoring stations. High-frequency streamflow data generated by the program are necessary for computing nutrient and sediment loads. Streamflow monitoring sites on most of the tributaries to Lake Erie that are being monitored for nutrient loads are at least partially funded by the GWSIP.

NATIONAL WATER QUALITY PROGRAM (NWQP)

The National Water Quality Program provides an understanding of water-quality conditions; whether conditions are getting better or worse over time; and how natural features and human activities affect those conditions. Long-term NWQP activities have provided an overall assessment of water quality conditions in the rivers and streams of the Lake Erie basin, including an assessment of water-quality trends from 1972-2012 at selected streamflow monitoring stations.

COOPERATIVE MATCHING FUNDS (CMF)

The Cooperative Matching Funds Program is a USGS program that is designed to bring local, State, and Tribal water science needs and decision-making together with national capabilities related to USGS nationally consistent methods and quality assurance; innovative monitoring technology, models, and analysis tools; and robust data management and delivery systems. The significant ties to local, State, and Tribal issues allows the Cooperative Matching Funds Program to respond to emerging water issues, raising those issues to regional and national visibility. In addition to the GWSIP, many streamflow monitoring sites in the Lake Erie basin are operated using a combination of CMF and partner (local, State, federal, etc.) funds. Water Science Centers in New York, Ohio, and Indiana all have local agreements with those States to perform water quantity and water quality monitoring to help support activities related to Lake Erie nutrient reduction strategies under Annex 4 of the GLWQA.

USGS'S WATER SCIENCE CENTERS

USGS has Water Science Centers located in each Great Lakes state that regularly work closely with local and State water resource entities. These entities often enter into Cooperative Agreements with the Centers to allow the USGS to perform monitoring and science support activities to assist in achieving the overall nutrient reduction goals. Staff located at these Centers within the Lake Erie basin (MI, OH, IN, PA, and NY) provide expertise on local and regional water quantity and water quality issues and regularly participate on team and committees related to large regional issues such as the GLWQA and HABHRCA.

GLRI GREAT LAKES TRIBUTARY MONITORING

Under the GLRI, USGS is monitoring nutrient inputs to all of the Great Lakes from 26 of the tributaries with the largest nutrient contributions to the Lakes. This information is being used to track changes in nutrient inputs over time and reveal potential impacts of the various conservation efforts and best management practices (BMPs) across the basin. Ten of the twenty-six monitoring sites are on rivers flowing into Lake Erie.

GLRI EDGE OF FIELD MONITORING

Under the GLRI, USGS is working jointly with USDA-NRCS and USEPA to identify the direct impacts of agriculture BMPs by monitoring at "edge of field" locations where BMPs have been incorporated. Information from this effort allows NRCS and other managers to track the direct impacts of BMPs and potentially identify specific BMPs that are most successful at reducing sediment and nutrient loss from fields. Edge of field monitoring locations in the Lake Erie basin are located in the Black Creek watershed in Indiana and the Eagle Creek watershed in Ohio.

New and/or Innovative Efforts in Lake Erie

Real-time Nutrient Loads Using Water Quality Surrogates

In addition to the traditional monitoring of nutrient loads, USGS is in the process of developing surrogate models for estimating "real-time" concentrations of nutrients at the same 26 tributaries mentioned previously, with 10 located on tributaries to Lake Erie. These surrogate models will allow USGS to estimate nutrient concentrations based on previously defined relationships to basic water quality parameters such as turbidity, specific conductance, and dissolved oxygen. The USGS real-time data network (https://waterdata.usgs.gov/nwis/rt) along with these surrogate models will allow USGS to estimate nutrient concentrations and, when combined with streamflow data, nutrient loads and subsequently present the information in real-time on the USGS website.

In-situ Dissolved Phosphorus Monitoring

Determining the amount of dissolved phosphorus in the water is becoming increasingly important as many researchers have identified links between the dissolved form and HABs production. Currently, the dissolved phosphorus concentrations are determined by collecting water samples and analyzing those samples in a lab. This process can often take several days depending on sampling logistics and transportation/shipping times. USGS is in the process of installing in-situ phosphate analyzers at several of the Lake Erie tributary monitoring sites. Once installed and connected to the USGS real-time data network (https://waterdata.usgs.gov/nwis/rt), these analyzers will record dissolved phosphorus concentrations in the stream on an hourly basis and the results will be available on the USGS website in real-time. This information will be very useful to HABs forecasters and local managers to support in decision making.

Investigation of Nutrient Cycling in Rivermouths

The goal of this work is to evaluate the magnitude of rivermouth effects on the delivery of nutrients to the nearshore zone. Algal blooms and nearshore productivity are strongly influenced by the nutrient loads, the timing of nutrient delivery and nutrient form upon delivery. Estimating the rivermouth effect on nutrients requires a complicated connection of water mixing models with assessments of biotic communities in the rivermouths and in the water column itself. Results of this effort may lead to a better understanding of potential restoration of rivermouth habitats could offer a mechanism to minimize impacts of excessive nutrient loads from upstream watersheds. Study sites for this effort are located across the Great Lakes basin, including the Maumee River in Ohio.

NowCast for Drinking Water and Recreational Sites

The USGS has led the research and implementation of "Nowcast" models for determining in real-time the quality of Great Lakes recreational waters, specifically near beaches and water intakes. These models were initially developed to estimate E. coli concentrations; however, additional work has shown that using regression models to estimate toxin concentrations from cyanoHABs is also feasible. USGS scientists are continuing to work closely with local and State partners along the Lake Erie shoreline in Ohio, Pennsylvania, and New York (https://ny.water.usgs.gov/maps/nowcast/); to collect data to develop, test, and expand the use of models and "Nowcasts" to provide estimates of toxin concentrations at Great Lakes drinking-water and recreational sites.

NOAA

NOAA's dedicated scientists use cutting-edge research and high-tech instrumentation to provide citizens, planners, managers and other decision makers with reliable information they need when they need it. NOAA's Great Lakes Environmental Research Laboratory, in concert with academic, agency, and private sector partners, has been actively monitoring Lake Erie and issuing forecasts on cyanobacteria location and concentration since 2008. In addition to leading a number of HABs and Hypoxia research efforts in the Great Lakes, NOAA works in partnership with Great Lakes states and USEPA to address nonpoint source pollution through coastal zone management programs, and supports vital education and outreach through the Sea Grant Program. These ongoing programs are spurring innovative approaches to meet the challenges in Lake Erie. For example, NOAA's National Weather Service forecast models are being used to develop decision support tools to help farmers make informed decisions on the best time to apply fertilizer to their fields.

Current and Ongoing Programs and Authorities

COASTAL ZONE MANAGEMENT (CZM) PROGRAM

The program is a voluntary partnership between the federal government and U.S. coastal and Great Lakes states and territories authorized by the Coastal Zone Management Act (CZMA) of 1972 to address national coastal issues. A wide range of issues are addressed through the program, including coastal development, water quality, public access, habitat protection, energy facility siting, ocean governance and planning, coastal hazards, and climate change. One of the primary components is the Coastal Nonpoint Pollution Control Program, which was established in 1990 by Section 6217 of the Coastal Zone Act Reauthorization Amendments, and is jointly administered by NOAA and USEPA. The goal of CZARA is to ensure that participating states have the necessary tools to prevent and control polluted runoff. All coastal and Great Lakes states and territories that participate in the National Coastal Zone Management Program are required to develop coastal nonpoint pollution control programs which include management measures to use in controlling runoff from six main sources: agriculture, forestry, urban areas, marinas, hydromodification (shoreline and stream channel modification), wetlands, and riparian and vegetated treatment systems.

HARMFUL ALGAL BLOOM AND HYPOXIA RESEARCH AND CONTROL ACT

Originally established in 1998, the Harmful Algal Bloom and Hypoxia Research and Control Act amendments of 2004 and 2014 reaffirmed and expanded the mandate for NOAA to advance the scientific understanding and ability to detect, monitor, assess, and predict HAB and hypoxia events. This legislation established the Interagency Working Group on HABHRCA (IWG-HABHRCA). It tasked the group with coordinating and convening federal agencies to discuss HAB and hypoxia events in the United States, and to develop action plans, reports, and assessments of these situations. NOAA co-chairs the IWG-HABHRCA with USEPA and 11 other federal agencies participate.

NOAA is authorized by the HABHRCA to conduct research in its labs and centers and to fund research by extramural partners. The National Centers for Coastal Ocean Science (NCCOS) oversees a number of HABs research programs including:

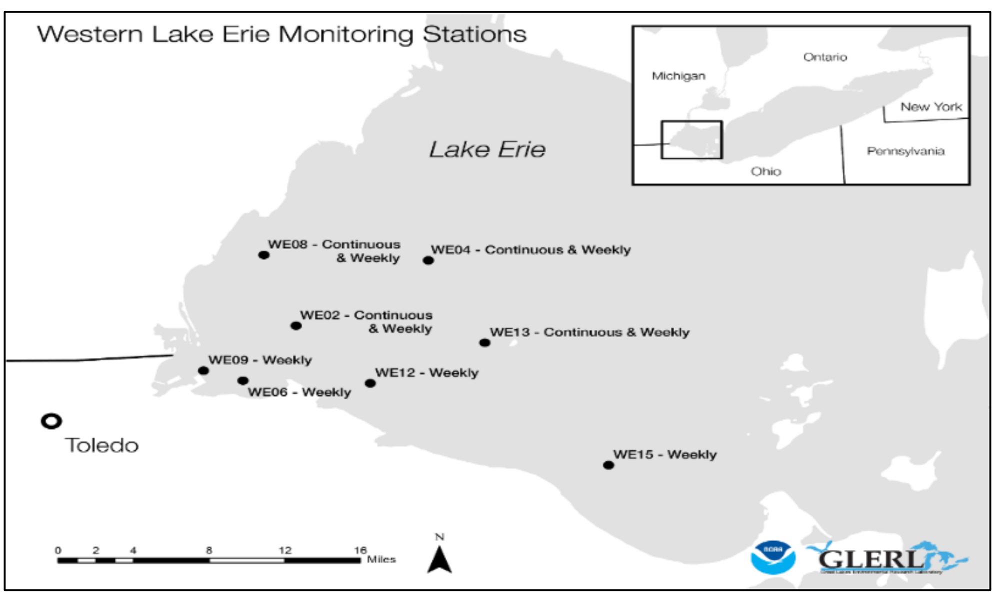
- Harmful Algal Bloom Forecasting
- Harmful Algal Bloom Rapid Response
- Prevention, Control, and Mitigation of Harmful Algal Blooms
- Physiology, Molecular Ecology
- Harmful Algal Bloom Sensors

SEA GRANT COLLEGE PROGRAM

For 50 years, Sea Grant has been putting science to work for America's coastal communities. NOAA Sea Grant is a federal-private partnership supporting innovative research, outreach and education in 33 universities including each of the Great Lakes States. Current efforts in Lake Erie include funding opportunities to investigate approaches for nutrient load reduction, study algal toxin production and related human health impacts, research algal bloom dynamics, develop improved information for toxin reduction at water treatment plants.

NOAA'S GREAT LAKES ENVIRONMENTAL RESEARCH LABORATORY

NOAA-GLERL and its partners conduct innovative research on the Great Lakes and coastal ecosystems to increase the understanding of environmental conditions in the Great Lakes Basin which, in turn, provides information for resource use and management decisions needed to address current and emerging issues. Key research programs include: Ecosystem Dynamics, Integrated Physical and Ecological Modeling and Forecasting, and Observing Systems and Advanced Technology. Many of these programs provide critical data to drive Lake Erie ecosystem models. For example, the Great Lakes Coastal Forecasting System is a set of hydrodynamic computer models that predict lake circulation and other physical processes (e.g. circulation, thermal structure, waves, ice dynamics) of the lakes and connecting channels. NOAA-GLERL conducts weekly on-lake monitoring of the Lake Erie algal bloom from June – October. NOAA-GLERL also produces a yearly report on HAB areal extent derived from NASA MODIS imagery and weekly hyperspectral overflights. Hyperspectral flyovers detect and map HABs near water intakes and under clouds where satellite coverage is ineffective. These hyperspectral data are being used to differentiate HABs from other phytoplankton for more accurate toxin prediction. Additionally, buoys and sensors collect observations of water quality characteristics in real time.



NOAA GLERL stations sampled weekly for HAB toxins and real-time buoy observations.

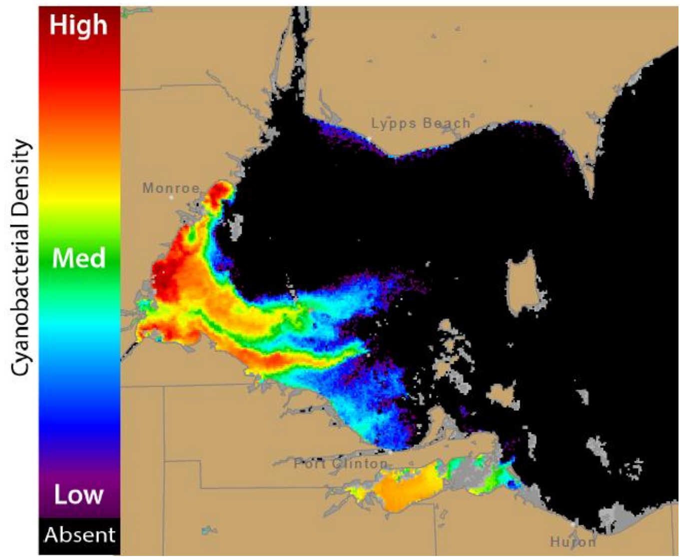
New and/or innovative efforts in Lake Erie

With support of the Great Lakes Restoration Initiative, NOAA has made vast improvements in detecting, monitoring, and forecasting HABs in recent years. HABs bulletins provide analysis of the location of blooms, as well as 3-day forecasts of transport, mixing, scum formation, and bloom decline. NOAA is also developing forecasts to warn Lake Erie drinking-water managers when hypoxic water approaches intake pipes, and to help farmers decide when to apply fertilizer to their fields.

HAB Forecasting in Lake Erie

The Lake Erie HAB Tracker produces daily 5-day forecasts of bloom concentration and trajectory, using daily satellite imagery, real-time monitoring data, and modeling. The Tracker measures where the bloom will travel, providing important information to municipal drinking water managers who are concerned about HABs reaching water intake pipes.

NOAA and partners produce early season HAB forecasts starting in mid-May. The seasonal forecast estimates bloom severity based on Maumee River discharge and bioavailable phosphorus using data from Heidelberg University National Center for Water Quality Research. During the HAB season (from July through October) each year, HABs Bulletins are published twice weekly. A post season assessment is published in November.



Cyanobacterial Density as measured by satellite. Source: modified from August 31, 2017 Bulletin.

"A Lab in a Can": First-Ever Deployment of Freshwater Environmental Sample Processor

In 2016, NOAA GLERL deployed the world's first freshwater Environmental Sample Processor (ESP) near the Toledo, Ohio, water intake in Lake Erie. Via this "lab in a can", NOAA expects near real-time detection of HABs and their toxins throughout the bloom season. The ESP provides local and municipal managers early warnings of blooms and toxicity.

Monitoring HABs and Hypoxia in Lake Erie

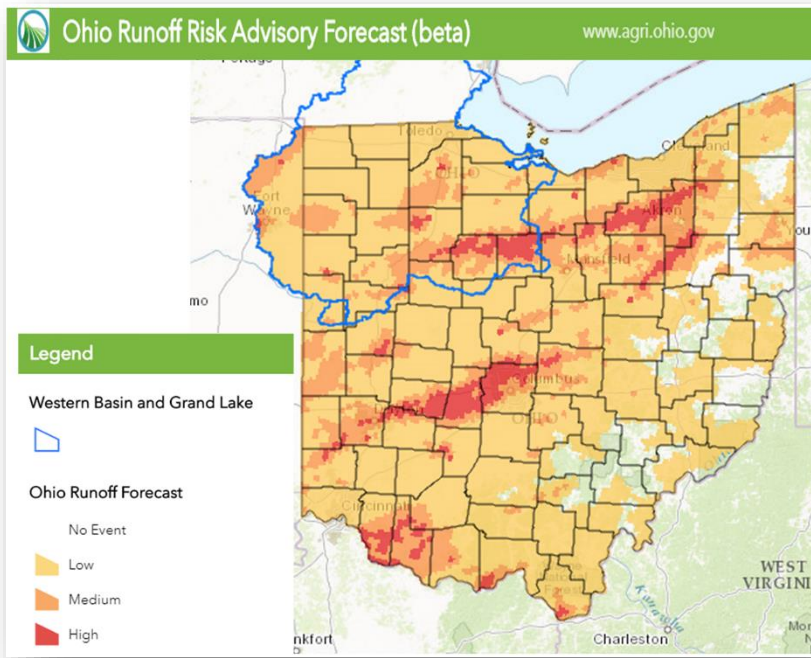
Field monitoring, buoys, sensors and satellite data assist in the development of tools that predict the magnitude and movement of algal blooms to help NOAA to quantify the influence of nutrients and HAB growth and toxicity and provide critical information to regional stakeholders. NOAA, in collaboration with University of Michigan Cooperative Institute for Great Lakes Research (CIGLR), provides in-lake monitoring at eight sites weekly and deploys continuous near-real time water quality monitoring buoys at four of those sites from June - October in Lake Erie. Additionally, observations of water quality characteristics including water temperature, phosphorus, nitrogen, chlorophyll and phycocyanin are reported on the GLERL Real-time Buoys website and the Great Lakes Observing System (GLOS) HAB Data Portal. To support the hypoxia forecasts, sensors deployed around the central basin provide near-continuous temperature and dissolved oxygen measurements at various depths. NOAA is also collaborating with Environment and Climate Change Canada to monitor Lake St. Clair, and conduct weekly airborne observations using a hyperspectral imaging system flying over U.S. and Canadian waters under the NOAA/ECCC Bilateral Agreement. More information is available at https://www.glerl.noaa.gov//res/HABs_and_Hypoxia/.

Hypoxia Early Warning System

In 2016 GLERL and the Cooperative Institute for Great Lakes Research received a five year grant from NOAA's Center for Sponsored Coastal Ocean Research to develop a model to predict the movement of hypoxic (low oxygen) water in Lake Erie's central basin. This model will provide an early warning to drinking water intake managers when an encounter with hypoxic water is likely. Hypoxic water requires expensive treatment to remove metals and other contaminants prior to distribution in the public supply system.

Runoff Risk Advisory Forecasts for Farmers

Runoff Risk Decision Support is a real-time forecasting tool that gives farmers guidance about when to apply fertilizers to their fields. Fertilizer application generally occurs during the winter and spring, the riskiest times of year for runoff from rain and snowmelt. In fact, a significant percentage of annual nutrient losses can occur from only a few large runoff events per year. The information provided by Runoff Risk helps farmers ensure that fertilizer and manure stay on the fields, instead of washing off into waterways. Relying on NOAA's National Weather Service (NWS) modeling, on-farm research data, and multi-partner collaboration, this tool offers a science-based approach to nutrient application timing.



Runoff Risk Decision Support was first developed in 2008 in the state of Wisconsin, in response to a previous winter and spring season punctuated with contaminated runoff events. In following years, Great Lakes Restoration Initiative (GLRI) funding enabled expansion to other Great Lakes States and improvements to the modeling approach. There are currently state working groups consisting of academia, state, and federal agencies coordinating on the development of second generation runoff risk tools. Beta-release tools are currently available in MI, OH, MN, and WI as of spring 2018. Collaboration for building similar tools in the remaining Great Lake States (IL, IN, NY) is expected to ramp up in 2018, as well.

FEDERAL ACTIONS AND MILESTONES

Federal authorities, programs and funding can provide a framework and resources to support achievement of the phosphorus reduction goals in Lake Erie. A main thrust of this plan is to track the investments and phosphorus reductions so that over time we can identify the most impactful and cost effective approaches.

USEPA & federal partners will continue to support states with financial and technical assistance as they work with their local agricultural community, watershed protection groups, water utilities, landowners, and municipalities to develop nutrient reduction strategies tailored to their unique set of challenges and opportunities. For example, we are working with the agricultural interests in Ohio, Michigan and Indiana on an implementation strategy to accelerate adoption of the most effective management practices.

Our efforts are focused on three major types of actions: 1) accelerate nutrient reductions, 2) enhance monitoring and research efforts to better understand the effectiveness of actions taken to reduce nutrient loadings, and 3) identify ways to improve implementation of federal programs and policies. Our strategy at this time is focused on leveraging existing federal authorities and programs. We believe the federal programs, once coupled with State programs, such as Ohio's recent legislation restricting winter application of fertilizer and manure, will have significant impact on reducing phosphorus loads to Lake Erie.

The following table outlines the actions being taken in the near-term based on current federal funding commitments. This list is expected to grow and change over time, in response to resources allocated by Congress and Agency leadership priorities. Agencies will continue to identify projects that align with existing program authorities, and seek innovative ways to accelerate efforts to restore Lake Erie as appropriations allow. For example, USEPA has traditionally provided GLRI funding for watershed management activities to reduce nutrients and runoff, through an annual grants competition, ~$5M per year Great Lakes wide. In response to the 2014 drinking water ban in Toledo, Ohio, federal and state agencies quickly received nearly $12 million in GLRI funds for projects intended to reduce and monitor HABs in western Lake Erie. In FY17, USEPA and federal partners were able to commit an additional $12M to high priority Lake Erie implementation, monitoring, and research projects. If current funding levels continue, we would expect to prioritize additional funding for implementation of P reduction projects as identified in the domestic action plans, once finalized.

Federal Actions and Milestones: 2018-2023

Activity	Objectives	Cost	Responsible Parties	Timeframe	Major Milestones
Programs/Projects					
Source Reductions					
WLEB Initiative	Coordinated strategy using funding from multiple Farm Bill programs and GLRI to double the number of acres under conservation in WLEB.	$77 M	USDA NRCS	FY 2016 – 2018	Programs have combined goals of 870,000 acres of conservation systems to reduce edge of field losses by 640,000 lbs TP (290 metric tons) and 175,000 lbs SRP.
RCPP Tri-State Western Lake Erie Basin Phosphorus Reduction Initiative	A diverse team of partners using a targeted approach to identify high-priority sub-watersheds for phosphorus reduction and implement conservation practices on the 855,000 acres that have been identified as the most critical areas to treat.	Over $17M from NRCS and over $28M from Conservation Partners	USDA NRCS; Michigan Department of Agriculture & Rural Development	FY 2015 - 2019	RCPP will accomplish 180 acres of wetland restorations; 500 conservation plans; 60,000 acres of nutrient management; and 1000 environmental risk assessments.
GLRI Ag Nonpoint Source Projects	Implementation of watershed management and domestic action plans to reduce nutrient loading from	$5.6 M currently obligated of	USEPA grants to State and local partners	FY 2015-2019	Anticipate over 100,000 pounds phosphorus

	agricultural lands. Projects will target best management practices to critical source areas.	anticipated $13 M cost			reduction in Lake Erie watersheds
Great Lakes Sediment and Nutrient Reduction Program	Great Lakes Commission provides grants to local governments and nonprofit organizations to control nutrient & sediment losses in order to reduce the nutrient loading into the Great Lakes.	Approximately$1.8 M in the Great Lakes Basin for the current contract period. Over $14M from 2010 - 2016 utilizing Great Lakes Restoration Initiative (GLRI) funding.	USDA NRCS & GLC	2017 – 2021	14,000 pounds of phosphorus annually across the Great Lakes Basin.
Conservation Partners Program	National Fish & Wildlife Foundation (NFWF) is managing two USDA grants awarded through this program to Ohio State University Extension and Ohio Soybean Council to develop resources to help improve nutrient management and farmer outreach in the Western Basin of Lake Erie.	Approximately $1M	USDA NRCS & NFWF	2014 - 2018	Deliverables include Nutrient Management Plans and the development of a Best Management Practice manual.
Runoff and drainage management					
Conservation Technical Assistance and	Implement whole-farm conservation plans to improve water quality, reduce nutrients loss, and	Determined annually and dependent on funding appropriations under the Agricultural Act of	USDA NRCS and local conservation partners	Determined annually and dependent on funding levels.	Acres treated and associated phosphorus reductions reported annually under GLRI

Financial Assistance	slow runoff from agricultural operations. Promote adoption of drainage water management, phosphorus filters, and other innovative techniques to reduce and treat runoff from agricultural land. Optimize siting of wetland restorations, creations and enhancements to treat agricultural runoff.	2014, (also known as the Farm Bill), and the GLRI.			Action Plan II and Action Plan III.
Transforming Drainage project	Expand extension education materials and programming on enhancing the management of drainage water to address water security and nutrient use. Understanding of potential benefits of these practices on yield, water budget, and water quality.	~$5 M	USDA NIFA, Purdue University Research and Extension, other universities	2015-2020	Deliver extension-based programming across the Great Lakes region, with several field sites in the Lake Erie basin. Provide innovative drainage water treatment or recycling options for producers based on the costs and benefits of implementing the drainage water storage practices at field sites.
Agricultural Conservation Planning	Apply assessment tools, framework and geospatial analysis, to small watershed	TBD annually	USDA ARS and NRCS, universities, conservation partners	2018-2019	Produce effective watershed scale conservation options for

Framework (ACPF) pilot in WLEB	assessment and comprehensive precision comprehensive conservation planning. Supports agricultural watershed planning process.				land owners in up to 6 small watersheds in OH and IN, including the new CEAP Watershed in the Blanchard River. Explore using output as part of locally-led conservation planning process.
Runoff Risk Decision Support Tools for Nutrient Application Timing	In partnership with Great Lake States, develop real-time decision support tools based on National Weather Service modeling and forecasts that provide producers guidance on the risk that runoff could occur, so that nutrient application preceding runoff events can be avoided.	$1.6 M in GLRI funding to date	NOAA/NWS/NCRFC, state agencies and academic researchers	Ongoing, since FY15	On-going work includes modeling improvements and expanding collaboration. Planned work includes analysis to estimate the ability of Runoff Risk to reduce nutrient losses by analyzing edge of field data and investigating the factors affecting likelihood of adoption by producers.
GLRI Urban Nonpoint Source Projects	Implementation of green infrastructure practices to reduce stormwater runoff from urban areas	$2.6 M currently obligated; total investment tbd	USEPA, State and local municipal partners	FY 2015-2019	Over 250 million gallons of untreated urban runoff captured or treated by GLRI-funded projects (broader than Lake Erie)
Ottawa River Wetland	This Great Lakes Fisheries & Ecosystem Restoration (GLFER) project will convert	$3.2 M	USACE, the City of Toledo, and the	2016-2021	The restored wetlands will be designed to maintain a hydrologic

Restoration Toledo, OH	16 acres of urban/industrial land into high quality flood plain wetlands and associated riparian habitat.		Toledo/ Lucas County Port Authority		connection with the river and result in the capture and treatment of roughly 24 million gallons of overland flow each year
P Optimal Wetlands – Demo site	Construct and actively monitor one or more permanent demonstration wetlands that are sited and designed for maximum P uptake to evaluate as a priority action that may occur systemically throughout the basin	TBD (estimated cost ~$2 M)	USACE, USGS	2019 and beyond	Construction of one or more demonstration sites in Western Lake Erie basin in 2019
Hydrologic Health Initiative	Demonstrate potential for nutrient reduction from conversion of marginal cropland to riparian habitat	TBD	USEPA, OEPA, partners TBD	2019	Identify partners to secure riparian easement for pilot project
Monitoring, Assessment and applied research					
BMP Effectiveness					
ARS Edge of Field Water Quality Research	Determine the effectiveness of various conservation practices by monitoring changes in nutrient losses from fields over time (an extension of CEAP Watersheds)	TBD annually	USDA ARS and NRCS, numerous external partners	2011- present, on-going	Peer reviewed papers published regularly; conservation practice standards evaluated in conjunction with field scale assessment.
Conservation Effects Assessment Project (CEAP) – National Cropland Assessment	CEAP Cropland was established to develop a methodology for estimating the environmental benefits and effects of conservation practices on cultivated cropland at regional scales. The assessment has been on	TBD annually	USDA NRCS, USDA ARS, Texas A&M University	2003-present, on-going	Next report assessing 2016 conservation condition is expected to be released in 2019. Prior reports released by USDA NRCS in 2011 (Great Lakes), 2016 and 2017 (WLEB).

	a 5-year cycle in the WLEB, but future timing is TBD.				
Conservation Effects Assessment Project (CEAP) – Watersheds – Stacked Practices Study	A new and innovative project initiated in 2016 in the WLEB aimed at measuring reductions from implementing a series of conservation practices in a treatment train. Practices will be implemented as a system and reductions assessed in the field, at the edge of field and instream.	$50,000 annually	USDA NRCS and USDA ARS	2016- present, on-going	Initial results in 2019. Data on the sequential and cumulative effects of "stacked" conservation practices in 3 small watersheds in northwestern Ohio.
Edge of Field BMP Monitoring in GLRI Priority Watersheds	Determine the effectiveness of various GLRI-funded BMPs by monitoring changes in nutrient loads leaving fields over time and tracking changes in soil health characteristics of the impacted fields	$1.9M annually through 2019	USGS, NRCS, and USEPA	2016-2019	Initial results by Fall 2018
Blanchard River Demonstration Farms Network, Ohio	A GLRI-supported project designed to showcase and demonstrate leading edge conservation practices to improve Great Lakes water quality.	$1M	USDA NRCS & Ohio Farm Bureau Federation, USDA ARS (monitoring)	2016 -2020	Edge of Field monitoring, economic analysis, and outreach to farmers and landowners.
P-Optimal Wetlands – Soil research	Research to understand the role of legacy phosphorus in areas being considered for wetland creation.	$200,000	USACE	2017-2019	Development of standard soil phosphorus sorption capacity (SPSC) data collection needed to identify potential constructed wetlands
Tributary/watershed					
Conservation Effects Assessment Project (CEAP) –	Long-term watershed-scale assessment of conservation practice effects on water	TBD annually	USDA NRCS, USDA ARS, university partners, USGS	2004-present, on-going	Peer reviewed papers published regularly; new conservation practice

Watershed Assessment Studies	quality, water management and soils in selected watersheds in the WLEB.				standards being developed and evaluated in conjunction with field and watershed scale assessment.
Great Lakes Tributary Monitoring Program	Track changes and identify long-term trends in nutrient and sediment loads to the Great Lakes.	$1.1M annually through 2019	USGS	2016-2019	Early results (2011-2013 annual loading estimates) were published in early 2018. The next round of results thru 2016 are expected by 2019.
Enhanced State Watershed Monitoring	Track changes in nutrient and sediment loads at specific locations in Lake Erie watersheds with high frequency monitoring (including dissolved phosphorus spring loads)	Varies annually; FY17 cost was $0.7 M	USGS, NYSDEC, OEPA, IDEM, MDEQ	2016-2019	Annual reporting
Investigation of Nutrient Cycling in Rivermouths	Evaluate the magnitude of rivermouth effects on the delivery of nutrients to the nearshore zone	$0.6 M	USGS	2016-18	Final report expected in spring 2019
P-Optimal Wetlands – Watershed modeling	Using existing models and partnerships prioritize, evaluate, & monitor permanent wetland restoration projects designed to maximize phosphorus removal	$385,000	USACE	2016-2018	Identification of one or more optimal sites in WLEB to construct and conduct long term efficacy monitoring
Load allocations	Develop a methodology for allocating in-lake targets for subwatersheds to the Maumee River.	~$100K	USEPA, OEPA, MDEQ, IDEM	2017-2018	Methodology and initial findings for St. Joseph and Tiffin Rivers expected in 2018.
Pilot integrated water management strategies	Spatial analysis and landscape modeling conducted in 2014-2017 identified opportunities to	tbd	USEPA, partners TBD	2018-2020	Disseminate tools and information to assist local watershed planners in Ohio and Michigan. Seek

	implement drainage management in selected Lake Erie & Saginaw Bay watersheds.				partners to develop pilot projects to demonstrate the potential nutrient reduction impacts of implementing a system of drainage management practices.
Tools for estimating nutrient reductions	Update the pollutant removal rates and improve functionality in two tools used by nonpoint source program managers: The Spreadsheet Tool for Estimating Pollutant Loads (STEPL) and "the Region 5 Model" (R5 Model)	Varies annually; $80K invested in 2015-2017	USEPA	Ongoing, since 2016	Updates to STEPL and the R5 Model were released in 2017. A web-based version is anticipated by 2019.
In Lake					
Cladophora research	GLRI will support a concerted monitoring and modeling effort at several sentinel sites to better understand nuisance *Cladophora* growth and allow for future development of phosphorus targets in Lake Erie's eastern basin and the other Great Lakes.	Total cost estimated to be $1.5 M	USEPA, USGS, NOAA and academic partners	2018-2020	Data collected over 2018 and 2019 field seasons will be used to update and enhance *Cladophora* growth models
Remote sensing of benthic algae	Analysis of satellite data to survey the extent of submerged aquatic vegetation (including *Cladophora*) in the lower Great Lakes	$300K	NOAA and partners TBD	2019	Maps and summary statistics of benthic algae
Nearshore assessment	An enhancement to the NCCA, 34 sites were added to the 2015 survey of Lake Erie coastal condition	~$100K	USEPA and partners	2019	Assessments of nearshore condition for western, central and eastern basins

Offshore monitoring	USEPA's Great Lakes National Program Office long term monitoring programs		USEPA and partners	Ongoing	Spring and summer surveys of water quality and annual hypoxia monitoring
HAB Forecasting	Now operational, NOAA's HABs Bulletin provides short and long term projections of *Microcystis* blooms in western Lake Erie. These forecasts help water managers identify which blooms are potentially harmful, where they are, how big they are, and where they're likely headed.	~$300 K per year	NOAA CO-OPS, NOAA-GLERL and CIGLR; Heidelberg University and other partners	Ongoing	Early season forecast based on tributary loads. Twice weekly publication of the HAB Bulletin. Daily bloom movement observations using the HAB Tracker.
Hypoxia Forecasting	Develop a low oxygen warning system for drinking water managers in central Lake Erie basin.	$1.5 M	NOAA-GLERL and CIGLR	2017-2022	Development of a model for fine-scale hypoxia forecasting to drinking water intakes.
Environmental Sample Processor	Provide water intake managers early warning of HAB toxicity.	~$600 K per year	NOAA-GLERL and CIGLR	Ongoing	Daily HAB toxicity detection during 2017 season
HABs and Hypoxia Monitoring	Weekly and real-time monitoring of relevant water quality parameters to support HABs and hypoxia forecasts. In addition to analysis of water samples, monitoring techniques also include airborne observations, satellite imagery, buoys and sensors.	~$700 K per year	NOAA-GLERL and CIGLR, and Michigan Tech Research Institute	Ongoing	Yearly satellite remote sensing estimates of average HAB extent. In 2017, weekly data sharing including toxicity; weekly cyanobacteria mapping of areas near shore, over water intakes, and under clouds not visible to satellites.

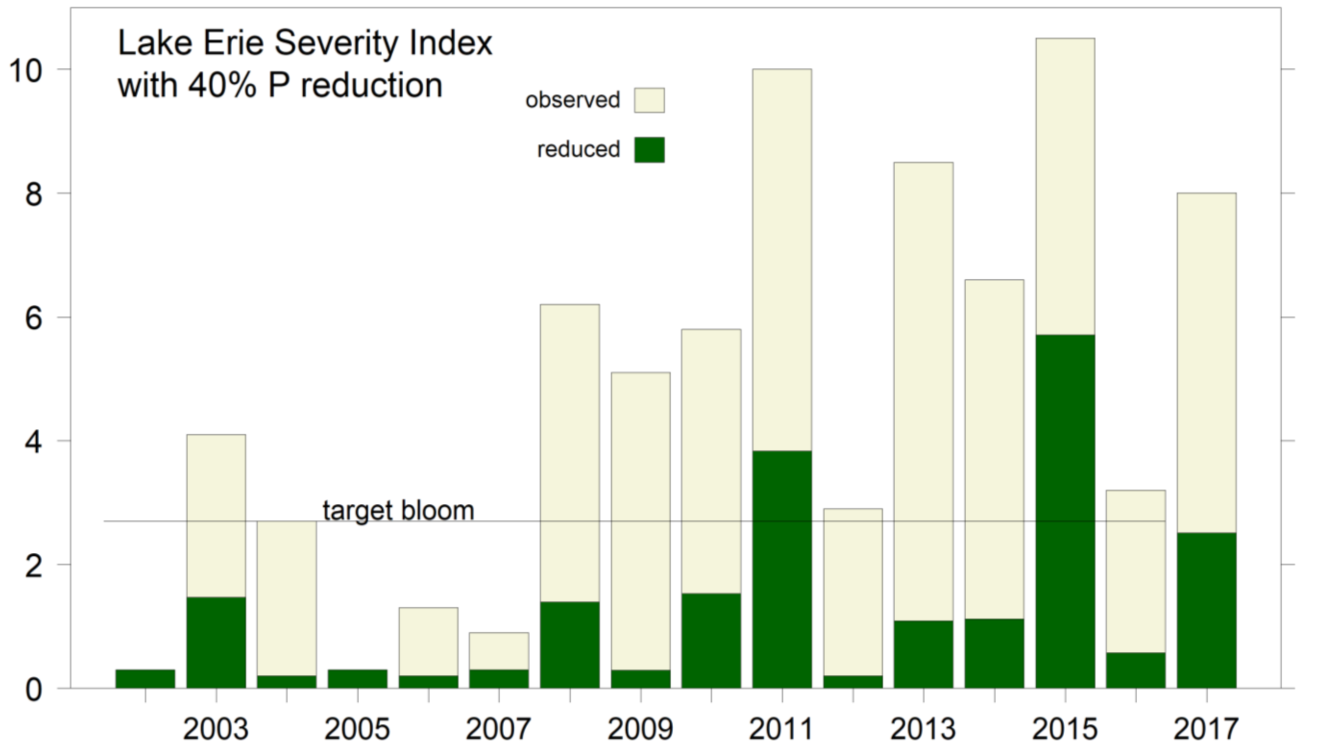
"Nowcast" for drinking-water and recreational sites	Develop models for determining, in real-time, the quality of Great Lakes waters near beaches and water intakes.	$0.7 M	USGS/various State and local partners	2017-19	Implementation of new sites and enhancements to existing sites by 2019
Lake Ecosystem Modeling	Expand and enhance current model and link to watershed model for evaluation of nutrient loading scenarios and eutrophication response.	TBD	USACE, USEPA	2018-2020	Development of a whole lake integrated watershed-lake ecosystem model
Program assessment/improvement activities					
Science Advisory Board	USEPA sought Science Advisory Board external peer review of the phosphorus reduction targets and supporting science. The review was conducted in two phases during 2015 – 2017.	-	USEPA and GLWQA Annex 4 Subcommittee	Started in 2015 and is ongoing activity	Implementation of SAB recommendations as part of an adaptive management approach
Tracking system	Efforts underway to improve methods for computing loads and report to the public through the GLC's ErieStat Pilot & Blue Accounting Initiative	-	USEPA and GLWQA Annex 4 Subcommittee	2018 and beyond	Annual tracking and reporting of phosphorus loads
Socio-economic analysis of agriculture incentive programs	A GLRI grant was awarded to the Great Lakes Commission to lead this project in FY17. The goal of the project is to understand whether GLRI investments in ag priority watersheds to date are being successful in changing farmer attitudes and willingness to adopt conservation practices.	$750k	TBD	FY18-19	Analysis and rankings of ag incentive projects funded under GLRI and recommendations to improve program implementation

GLRI Adaptive Management	A pilot study is examining GLRI work in the WLEB to inform science based adaptive management and implementation of GLRI		USEPA, USGS, NOAA, NRCS, USFWS, USACE	FY16-18	Report from Pilot study in early FY18 will include recommendations to the GLRI Regional Working Group to consider in development of GLRI Action Plan III
GLRI Action Plan III	The next GLRI Action Plan (2020-2024) will improve the integration of GLRI and U.S. domestic responsibilities under the GLWQA.		Interagency task force of 11 federal agencies, in consultation with the States and tribes. Coordination led by USEPA GLNPO.	FY18-FY19	Major Milestones: November 2018 – Public Comment September 2019 - Final
Agricultural nutrient reduction strategy	A diverse group of partners in Ohio, Michigan, and Indiana developed the agricultural nutrient reduction strategy component of the U.S. Action Plan for Lake Erie.		State and federal agriculture, water quality, and conservation representatives; commodity groups; agribusiness associations; and farm bureaus.	FY18-23	Semi-annual meetings and coordination to develop and implement strategy.
Western Lake Erie Basin Partnership (WLEB) Partnership	The WLEB Partnership is a federal and non-federal interagency tri-state effort chaired by USDA-NRCS OH and USACE Buffalo District. The partnership is dedicated to improve land and water resource management in the basin and promote a healthy, productive watershed		NRCS, USACE, USEPA, USFWS, USGS; IN, MI, OH; IN, MI & OH State Technical Committees; ODNR Division of Soil & Water Conservation; NACD; Maumee River Basin Partnership of Local Governments	Started in 2006 and is an ongoing regional partnership activity	Semi-annual meetings and outreach to identify, prioritize and enhance projects
Great Lakes HABHRCA	Federal action strategy for HABs and Hypoxia research in the Great Lakes		Interagency working group chaired by NOAA and USEPA	FY18 and beyond	Biannual progress reports

EXPECTED OUTCOMES

The first priority of all partners in implementing these actions in Lake Erie is to minimize HABs and hypoxia by significantly limiting nutrient loading that fuels excessive algal growth. The plan relies on continued significant investments in time and resources, collaboration and coordination of many activities at multiple scales, and continued diligence among all partners as they work to identify, implement, and evaluate the effectiveness of actions through an adaptive management framework.

How and when the Lake will respond



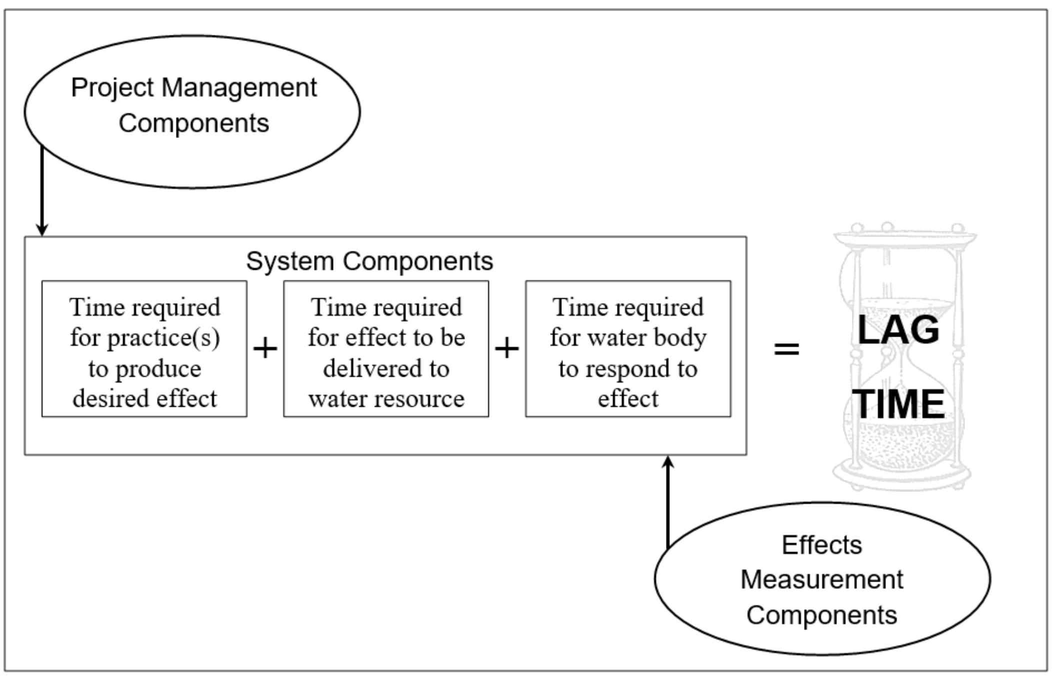
Lake Erie Algal Bloom Severity, 2002-2017. The green bars show how the bloom severity would have been reduced if there was a 40% reduction in phosphorus loading. Source: NOAA.

As summarized in the Annex 4 Objectives and Targets Task Team 2015 report, achieving the phosphorus reduction targets should achieve the following ecological outcomes for Lake Erie:

- Phosphorus loads from the Maumee River are the single best predictor of the severity of the western basin bloom. A 40% reduction in spring loads (Total and Dissolved Phosphorus) from the Maumee should significantly reduce the risk of harmful algal blooms in the Western basin by limiting cyanobacteria biomass to “mild” levels in most years. The spatial extent and density of algal biomass in the open waters would be drastically reduced. Significant blooms would still occur occasionally in extremely wet years.
- 40% reductions in spring phosphorus loads in nearshore priority tributaries would further limit the development of smaller cyanobacterial blooms along the shore.

- Together, the reductions from the Maumee and nearshore tributaries should dramatically reduce the extent and intensity of cyanobacteria growth, which we believe will also hinder toxin production, even though the extent or intensity of the bloom doesn't always correlate to the toxicity. Generally speaking, higher toxin levels are found in dense scums and mats. It is expected that reducing cyanobacteria biomass will have drastic improvements to the Lake's ecologic health and minimize shoreline fouling and potential human health impacts posed by HABs.
- Reducing the annual TP load to the Central basin to 6,000 MT should raise the average summer hypolimnetic dissolved oxygen concentration to 2.0 mg/liter or higher. This is the threshold for hypoxia and should result in improvements to the Central Basin bottom habitat and reductions in internal loading of phosphorus from Central Basin bottom sediments during periods of anoxia.
- The reductions needed to address algal blooms and hypoxia should lower the open lake phosphorus concentrations, helping to address *Cladophora* issues in the Eastern basin, while supplying enough nutrients to support the fisheries. Eutrophic levels would be lowered to mesotrophic conditions in the open waters of the western and central basins of Lake Erie, and oligotrophic conditions would be maintained in the eastern basin of Lake Erie.

It is difficult to predict when we will see these expected environmental outcomes in the Lake. The short residence time (2.7 years) and the fact that algal blooms in Lake Erie dissipated in response to phosphorus reductions in the 1980s, indicates that the Lake could again respond quickly to phosphorus reductions. Low phosphorus loads in the drought conditions of 2012 and 2016 were associated with a small bloom, providing a natural experiment to support this, however the reduced loads were primarily due to below average rainfall. The challenge will be to reduce loads during average and wet years. Due to the lag time within the system and interannual variability we will need to demonstrate progress over many years before we can claim success.



Schematic showing the major elements of lag time in water quality response to best management practice programs for nonpoint source control. Planning process and measurement components are not part of a system lag in physical response, but often contribute to a perceived lag between action and result (Meals, et. al. 2010)[13].

[13] Meals, D.W., S.A. Dressing, and T.E. Davenport. "Lag Time in Water Quality Response to Best Management Practices: A Review." Journal of Environmental Quality 39(2010/1): 85-96. DOI: 10.2134/jeq2009.0108.

While we are optimistic that improvements will be seen by 2020 and 2025, there are many factors that could delay the Lake's recovery. For one, the actual implementation of measures to achieve reductions of this magnitude will take significant time and effort to achieve. Add to that, there is a tremendous amount of phosphorus already in the system, bound to sediments in the soils and the streambeds, and on the lake bottom, that will need time to work its way through the system. Little is understood about this legacy load, particularly up in the tributary watersheds (Sharpley et al., 2013)[14].

Finally, and perhaps most important, variability of the weather and climate poses another major challenge. Recent research indicates that both precipitation and river discharge have both increased in the last decade, thereby increasing loads delivered to the Lake (Stow, 2015)[15]. So, while there is potential for the Lake to respond to management actions, the likelihood and ability to sustain lower blooms is unclear under current precipitation and discharge trends which are not possible to control (Jarvie et al., 2017)[16].

The predictions we make today may not hold true in 10 years if the frequency of large rainfall events continues to increase. It is for this reason that **our strategy is focused not only on traditional means of reducing loads through source reductions but advancing collaboration in the region to accelerate water management and develop more effective and innovative approaches for controlling the timing and delivery of phosphorus to the Lake**. This will require an adaptive management approach in which management strategies are updated in the future as new environmental data become available and knowledge gaps are filled.

What it will take to get there

Reducing phosphorus loads to the Western and Central basins by 40% will not be easy. The predominant sources and pathways in need of control will vary in the region, depending on the land management, soil type and other factors. In some areas, success will be seen sooner than others, but it won't be until the largest sources make a dent in their contribution that we will see lasting impacts in the Lake. The biggest challenge, and highest priority for reduction in the U.S, is the Maumee river.

The Maumee has the largest watershed of any Great Lakes river, with 6,571 square miles in Michigan, Indiana, and Ohio, 72% percent of which are used to grow crops. While NRCS farmer surveys indicate farmers are using conservation and stewardship practices to a significant degree —99 percent of cropland acres in WLEB have at least one conservation practice in use[17] – efforts to date have not been adequate to prevent HABs. Wider farmer adoption of the most effective practices will be necessary to meet and sustain the 40% reduction goals.

A significant portion of the phosphorus that is contributing to the harmful algal blooms in Lake Erie originates from surface and subsurface losses of commercial and organic fertilizer applied to cropland. According to USDA researchers, soluble phosphorus loss is the greatest treatment need in the Western Basin, and the

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[14] Sharpley, A., H.P. Jarvie, A. Buda, L. May, B. Spears, and P. Kleinman. "Phosphorus Legacy: Overcoming the Effects of Past Management Practices to Mitigate Future Water Quality Impairment." Journal of Environmental Quality 42(2013): 1308-1326. DOI:10.2134/jeq2013.03.0098.

[15] Stow, C.A., Y. Cha, L.T. Johnson, R. Confesor, and R.P. Richards. 2015. Long-term and seasonal trend decomposition of Maumee River nutrient inputs to western Lake Erie. Environmental Science & Technology, 49: 3392-3400.

[16] Obenour, D.R., A.D. Gronewold, C.A. Stow, and D. Scavia. "Using a Bayesian Hierarchical Model to Improve Lake Erie Cyanobacteria Bloom Forecasts." Water Resources Research 50(2014/10): 7847-7860. 10.1002/2014WR015616.

[17] U.S. Department of Agriculture, Natural Resources Conservation Service (USDA NRCS). 2016. Effects of Conservation Practice Adoption on Cultivated Cropland Acres in Western Lake Erie Basin, 2003-06 and 2012. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcseprd889806.pdf

majority of soluble phosphorus losses occur through subsurface tile drains (King et al, 2014 and Smith et al. 2014, USDA NRCS 2016). Conservation practices applied as a system, rather than individually, are needed to more effectively reduce surface and subsurface phosphorus losses (Francesconi et al. 2014)[18].

Although achieving the 40% reduction goals will be challenging, recent studies indicate it could be possible. In the Maumee River basin, for example, an application of multiple watershed models demonstrated that the forty percent reduction goal could be achieved through widespread adoption of conservation practices targeted to the areas where they are needed most[19]. In another study, USDA researchers simulated adoption of improved nutrient management, erosion control and cover crops on 95% of cropped acres to achieve a total phosphorus reduction of 43% at the edges of fields[5]. However, the instream delivered reductions are often much less than edge of field reductions because there are many interacting instream dynamics that impact load deliveries between the edge of field and Lake Erie. For example, a recent USDA CEAP study suggests that once conservation practices in place in 2012 are fully functional, annual edge of field phosphorus losses may decline from 2003-06 levels by 17 percent, but this will only decrease annual total phosphorus deliveries to Lake Erie by 3 percent[20]. It is also important to note that a 95% adoption rate of this full suite of practices in this scenario, would be challenging and take time and technical and financial resources to achieve and sustain under current conservation incentive programs.

Implementing a suite of conservation practices on nearly every acre in the watershed through voluntary programs may not seem realistic or feasible, but NRCS data suggests farmers are already moving in the right direction. In 2012, the average number of practices per acre was 2.4, with an average conservation investment per acre per year of $57. These data suggest farmers in the region are incorporating the idea of complementary practices and comprehensive management into how they manage their fields.

USDA assessments indicate that incremental progress is possible and needed throughout the Maumee river basin. If annual loadings are considered on a per acre basis, the average amount of phosphorus discharged by the Maumee River is a little more than 1 pound per acre per year (lbs/a/y)[21]. Ohio farmers are applying, on average, 19 lbs/a/y. Model simulations show that with the conservation practices in use in the Western Lake Erie basin in 2012, cultivated cropland acres lose about 1.9 pounds of phosphorus per acre per year, about half a pound less per acre than they were losing with conservation practices in place in 2003-06. For many farmers already doing a good job, agronomic losses of this magnitude are considered minimal, and any further reductions would require more precise nutrient management, such as broad use of variable rate technology. In other cases, what was considered adequate in the past will no longer be good enough.

> *Most of the phosphorus that feeds the blooms each summer is delivered through a handful of storm events. The timing and delivery of phosphorus runoff is critically important to manage. At a minimum, every producer should be following the 4Rs of nutrient stewardship. In addition, efforts to better manage nutrients must be coupled with efforts to better manage runoff.*

[18] Francesconi, W., C. O. Williams, D. R. Smith, J. R. Williams, and J. Jeong. “Phosphorus Modeling in Tile Drained Agricultural Systems Using APEX.” Journal of Fertilizers and Pesticides 7 (166/2016). DOI: 10.4172/2471-2728.1000166.

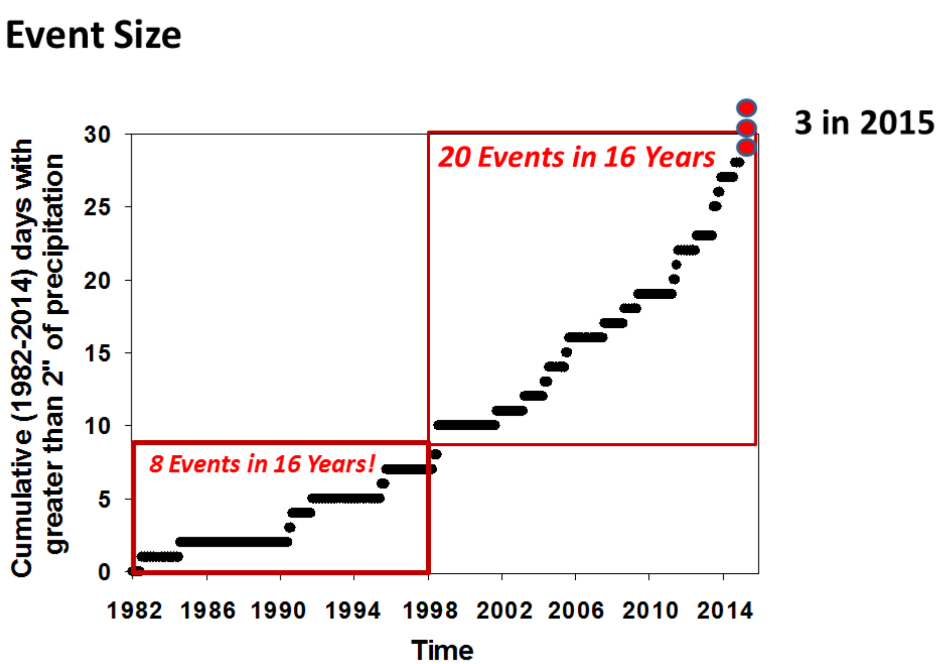
[19] Scavia D., M. Kalcic, R. Logsdon Muenich, N. Aloysius, J. Arnold, C. Boles, R. Confesor, J. DePinto, M. Gildow, J. Martin, J. Read, T. Redder, D. Robertson, S. Sowa, Y.C. Wang, M. White, and H. Yen. 2016. Informing Lake Erie Agriculture Nutrient Management via Scenario Evaluation. http://graham.umich.edu/water/project/erie-western-basin

[20] U.S. Department of Agriculture, Natural Resources Conservation Service (USDA NRCS). 2017. Effects of Conservation Practices on Water Erosion and Loss of Sediment at the Edge of the Field: A National Assessment Based on the 2003-06 CEAP Survey and APEX Modeling Databases. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcseprd1365654.pdf

[21] Based on average annual export during 2000-2015, measured at Waterville, averaged over the entire drainage area.

While recent studies indicate WLEB farmers are doing a good job overall, HABs are not responding to long term average annual loading trends. As much as 90% of the total phosphorus load to a river can be delivered during storm events. This is especially challenging during the spring runoff period, when soils are saturated and typically bare of vegetation. Water flowing over bare soils can cause soil erosion and losses of manure or fertilizer that was applied, even from the previous fall.

Improved water management is becoming increasingly important under current and future weather conditions. Recent research has shown that precipitation and discharge has increased in the past decade (Stow et al. 2015), which accounts for ~35% of the increase in loading since 2002 (Jarvie et al. 2017). Recorded rainfall data near Bowling Green, Ohio shows that in the past 10 to 15 years, the frequency of large rainfall events doubled (Kevin King, unpublished data). Success will clearly require new and innovative approaches, including new science and technology that is on the horizon.



Source: Dr. Kevin King, USDA ARS.

How much reduction is expected to occur?

In an effort to understand whether current resources and proposed actions will be sufficient to meet the phosphorus reduction goals, USEPA conducted a preliminary analysis using existing, readily available information on total phosphorus (lbs/yr) reductions achieved by a few of the key federal and state programs and projects at work in the basin. Based on that information, we would anticipate a total source reduction of ~3.2 M lbs TP from 2008 levels by 2019. This estimate is based on a combination of projected estimates and reported accomplishments for NRCS-assisted conservation practices, CWA 319 and GLRI funded projects, and WWTPs. Because there are many interacting instream dynamics that impact load deliveries between sources upstream and Lake Erie, we assumed that reductions from upstream sources need to be 1.5 times greater than the desired reduction delivered to the Lake[22]. This would yield a projected reduction to the Lake of ~2.4 million lbs, which is 34% of the reduction needed from the U.S. (7.3 million lbs).

[22] Although we have applied a ratio here to try to help understand what might be possible with continued edge of field loss reductions due to conservation practice adoption, we have no accurate way of translating edge of field reductions to reductions in the Lake due to unknown factors around legacy load dynamics.

Simple calculations like this can be useful for guiding program implementation, but certainly are not robust enough for an accurate assessment of progress. There are many potential sources of error:

- Reductions are not calculated the same way (differences in methodology).
- Reductions are not additive (the sum of benefits for multiple practices is not equal to the sum of their individual benefits).
- We haven't accounted for any new sources that could potentially offset these reductions (e.g. changes in land use or land management; new livestock operations).
- We are assuming the reduction is maintained (management continues to occur, permit conditions are met, and structural practices are maintained).
- We applied a ratio to translate source reductions to reductions in the lake. In fact, there is no accurate way to predict this.

Furthermore, projecting load reductions in the lake from implementation of NPS BMPs upstream is even more complicated because:

- Actual BMP performance can be site specific.
- Not all acres are contributing equally. Treating acres with the highest losses will return the biggest gains initially, but like a diet, over time the reductions get harder to achieve.
- Annual load delivery is highly dependent on storm events.
- Legacy sources are dynamic and variable. As nutrients are transported downstream, they can transform from solid phase (attached to sediments) to soluble forms.
- The size of the legacy P pool in the basin is currently unknown and unaccounted for.

This is why in the future, we will rely on more comprehensive assessments (such as CEAP) and examine multiple indicators to assess progress (these are described further in the How Progress Will Be Measured Section).

Legacy phosphorus – the good news and the bad news

We know that only a fraction of the fertilizers applied to the landscape makes its way into Lake Erie. Most of the P in the fertilizers applied to fields is taken up by crops, some remains in the soil, and a small fraction is lost to nearby streams, and ultimately to Lake Erie. Along the way, nutrients can transform from solid phase (attached to sediment) to soluble forms, and that is impacted by stream dynamics and chemistry.

Legacy P in the fields

The bad news: in-field legacy nutrients which are present due to past management continue to be remobilized and contribute to current loads.

The good news: it hasn't become legacy in the stream yet, and with proper management the in-field legacy P can be drawn down by crops. Utilizing a conservation cropping system, farmers can account for fields or areas within fields with high soil test P and incorporate them into their nutrient management. One immediate benefit of this is that with variable rate fertilizer application technology, accurate soil P testing may lower the overall amount of fertilizer P needed – an immediate cost saving. Additional system components can be put in place to trap and treat P runoff before it leaves the field and enters a waterbody.

The science has shown that the right conservation cropping practices in the right places does reduce edge of field losses, and when implemented on the most vulnerable acres can significantly reduce downstream loading.

Legacy P in the streams

The bad news: Some of the P that was deposited in waterways in past years contributes to current loads. At the moment, we don't know exactly how much and we can't accurately predict the rate at which it will be remobilized into the system because it is highly weather dependent and variable (e.g. big storms can transport sediment that was deposited decades before). However, ongoing watershed and field-based research will provide better answers in the near future.

The good news: as corrective actions are taken to reduce P losses at edge of field, less P will end up as in stream legacy P. Also efforts to stabilize streambanks and to reduce magnitude and velocity of stream flows will reduce transport of legacy P in streams to the lake.

Legacy P in the lake

The bad news: There is some evidence that algal seeding in the lake's sediments may influence the threshold for response to nutrients delivered to the lake, such that algae respond more quickly and more intensely to any delivered nutrient loads (Obenour et al., 2014). In-lake nutrient cycling can delay measurable remediation of the eutrophic conditions, even after external nutrient loading has been reduced (Matisoff et al. 2016;[23] Paerl et al. 2016a[24], Sharpley et al. 2013[25]).

The good news: Presently, the internal phosphorus loading from sediments is a relatively small contributor to the whole lake load[26]. However, the relative significance of the internal P load could change over time, because as external loads to the lake are decreased, relatively more P will be remobilized from the bottom sediments.

In summary, the impact of legacy P (either in the fields, between the fields and rivers, in the rivers, or in the lake) is a dynamic and complex process that could significantly delay when the benefits of upstream source reductions will become apparent. This will continue to be a challenge and is one of the reasons why our management strategy is not focused solely on source reduction but on P transport, timing and delivery of P runoff. We know the only way to reduce legacy loads is to: 1) Decrease the amount replenishing the hydrologic system at the upper end by reducing edge of field losses and, 2) Remediate its impact through stream restoration or other mechanisms to bind the in-stream legacy P so it doesn't remobilize. A holistic management approach is necessary to appropriately address all components of the system.

[23] Matisoff, G., E.M. Kaltenberg, R.L. Steely, S.K. Hummel, J. Seo, K.J. Gibbons, T.B. Bridgeman, Y. Seo, M. Behbahani, W.F. James, L.T. Johnson, P. Doan, M. Dittrich, M.A. Evans, and J.D. Chaffin. 2016. Internal loading of phosphorus in western Lake Erie. Journal of Great Lakes Research 42:775-788.

[24] Paerl, H.W., W.S. Gardner, K.E. Havens, A.R. Joyner, M.J. McCarthy, S.E. Newell, B. Qin, and J.T. Scott. 2016a. Mitigating cyanobacterial harmful algal blooms in aquatic ecosystems impacted by climate change and anthropogenic nutrients. 2016. Harmful Algae 54:213-222.

[25] Sharpley, A.N., H.P. Jarvie, A. Buda, L. May, B. Spears, and P. Kleinman. 2013. Phosphorus legacy: Overcoming the effects of past management practices to mitigate future water quality impairment. Journal of Environmental Quality 42:1308-1326.

[26] http://lakeerie.ohio.gov/Portals/0/GLRI/CSMI%20Executive%20Summary.pdf

Are we on track to reduce P loads to WLEB 40% by 2025?

We cannot at this time predict with accuracy exactly when and how the P reduction goals for Lake Erie will be met. Specifically related to NPS BMP implementation and associated P reductions, we remain optimistic that the actions proposed in this plan are on the right track to meet the 40% reduction goals in the WLEB for the following reasons:

1. Our initial estimate of projected source reductions is conservative in that it does not include all federal, State and locally-funded programs; not does it include voluntary practice adoption by farmers (outside of incentive programs).
2. Some recent actions like Ohio's ban on manure or fertilizer application on frozen or snow covered ground, will likely result in significant reductions that have not been quantified.
3. The phosphorus reductions associated with training and education efforts are also difficult to quantify, such as Ohio Department of Agriculture's fertilizer certification program, which trained over 8,000 farmers in western basin counties on proper nutrient management in the past 2 years.
4. We currently only track and report on the adoption that is assisted through conservation programs but in fact we know the actual adoption on the landscape is much higher. For example, Indiana's 2015 and 2016 tillage transects verified over a million acres in cover crops statewide. This means the actual adoption of cover crops on the landscape was 4-5 times greater than the amount of acres touched by assistance programs. We also know from the USDA CEAP Cropland studies that private voluntary farmer efforts are providing substantial and increasing efforts in the WLEB.
5. Current adoption of practices to prevent soil erosion is good, but there is room for improvement in nutrient management, drainage management, and comprehensive cropping systems.
6. There is evidence that well-designed outreach and incentive programs could result in increased voluntary adoption of BMPs due to the high level of motivation to act among farmers in the WLEB (Prokup et al. 2017).
7. Many more farmers are willing to adopt and studies indicate if they do, enough acres would be treated to meet the 40%[27].
8. The proposed strategies engage multiple sector groups and partners to identify the most effective strategies for reducing P from both point and nonpoint sources.
9. The strategy for reducing agricultural sources recognizes the need to tailor solutions to individual farms, continue to build systems & implement comprehensive solutions.
10. While legacy P could significantly delay when the benefits of upstream source reductions will be apparent, we have opportunities to lessen its impact and are researching innovative technologies.

[27] Wilson (in review) found that moving motivated farmers from "willing to adopt" to "actually adopting" would result in ~770,000 acres of additional cover crops and ~1.025 million acres of additional subsurface placement. Assuming current adoption rates are maintained this would raise the adoption levels to 38% (total) adopting cover crops and 64% of farmers (total) adopting subsurface placement. The estimated multi-year average (2005-2014) total phosphorus (TP) load resulting from these total adoption levels, in addition to other practices already in place on the landscape (filter strips 30%) would meet the Maumee River March-July TP loading target of 860 metric tons (MT). It is important to note that meeting the 860 MT loading target on average does not ensure that the target will be met for each individual year, as relatively high loading years like 2011 and 2015 still exceeded the target according to this modeled scenario. Citation: Wilson, R.S., D. Schlea, C. Boles, and T. Redder. In review. "Using models of farmer behavior to inform eutrophication policy in the Great Lakes." Water Research.

Importantly, we expect a number of outcomes will occur that will advance our collective efforts to reduce nutrient loading to Lake Erie. By implementing the commitments identified in this plan, we will:

- significantly increase the rate of adoption of key management practices on agricultural lands such as nutrient management, drainage water management, and soil health initiatives.
- test and demonstrate effectiveness of new technologies, such as saturated buffers, blind inlets, phosphorus removal structures and P-optimal wetlands.
- significantly improve our tracking and measurements of phosphorus loadings to the Lake. This includes additional long term stream water quality monitoring stations and improvements to watershed and in-lake models.
- improve coordination and tracking of actions and investments, so that cost effective measures can be identified.
- strengthen local watershed restoration activities to help meet downstream objectives in the Lake.
- increase stakeholder awareness & collaboration through dissemination and engagement of this plan.

HOW PROGRESS WILL BE MEASURED

We are continuing to develop binational and domestic approaches for tracking progress under Annex 4.

Our efforts to date have largely been focused on developing a binational approach for tracking loads on annual basis, which we committed to begin reporting in 2018. The load estimation exercise is a critical backbone of a broader effort to track and report progress under Annex 4. In addition to phosphorus, federal and state partners must periodically assess and report on our progress implementing the DAPs. **Our intent is not to focus on where we are falling short, but on how we can work together and support each other to improve our collective success.**

Three key pieces of information have to be integrated in order to assess our progress:

- Reductions in loading by source (directly measured for point sources; estimated from models for nonpoint sources)
- Changes in nutrient concentrations and loads as estimated by flow-adjusted trends. This will require long-term (at least 10 years) data to account for precipitation variability, which impacts streamflow.
- Attainment of LEOs as measured by eutrophication response indicators

Federal and state agencies have developed an initial suite of indicators and metrics for measuring progress. This information will serve multiple purposes:

- Convey information on progress toward achieving:
  - P reduction goals
  - Lake Ecosystem Objectives
- Evaluate and understand:
  - Effectiveness of the actions to achieve the P reduction goals
  - Effectiveness of the targets to achieve the LEOs
- Conduct Adaptive Management:
  - Compare current state to projected outcomes
  - Explain factors affecting water quality trends
  - Enhance models using improved understanding of trends and ecosystem responses
  - Adjust DAPs as necessary to achieve desired water quality outcomes

The ultimate measure of progress will be a clean and healthy Lake Erie, no longer plagued by excess nutrients and algae. Restoring water quality in the Lake and its tributary watersheds is the main objective but will take time. Efforts to monitor progress will require continued, ongoing monitoring as part of a science-based adaptive management approach.

Agencies will look to a number of monitoring programs to track progress in the near and long-term. The following tables summarize the indicators to be used in the U.S. These indicators are categorized into three groups: Group 1 Indicators measure progress "on the ground"; Group 2 Indicators measure progress in streams and watersheds; and Group 3 Indicators measure outcomes in the Lake. For each, we identified potential metrics, the lead Agency who will measure and at what frequency.

Group 1 Indicators

1	Measuring Progress On the Ground					
Near-term						
	Measure	Scale	Program	Lead	Frequency	Potential Metrics
1.1	Conservation practice adoption	WLEB, State	Farm bill (multiple), GLRI	NRCS	Annual	# acres treated, $$ contracted, # contracts, # of practices, estimated phosphorus reductions at edge of field
1.2	Nutrient reduction projects	WLEB, State	GLRI, CWA 319, State programs	USEPA, States	Annual	# acres, project costs, # of practices, estimated phosphorus reductions at edge of field
Long-term						
1.3	Effects of agricultural conservation practice adoption on cultivated croplands	WLEB	CEAP	NRCS	5-10 years	Changes in farmer adoption rates, $$ invested in conservation, acres in need of treatment, average phosphorus reductions per acre attributed to conservation
1.4	Agricultural conservation practice effectiveness	Fields within WLEB sub-watersheds	Edge of field monitoring (USGS, NRCS), CEAP and EOF research (ARS, NRCS)	USGS, ARS and NRCS	On-going	Measured reductions in phosphorus losses at edge of field

Group 2 Indicators

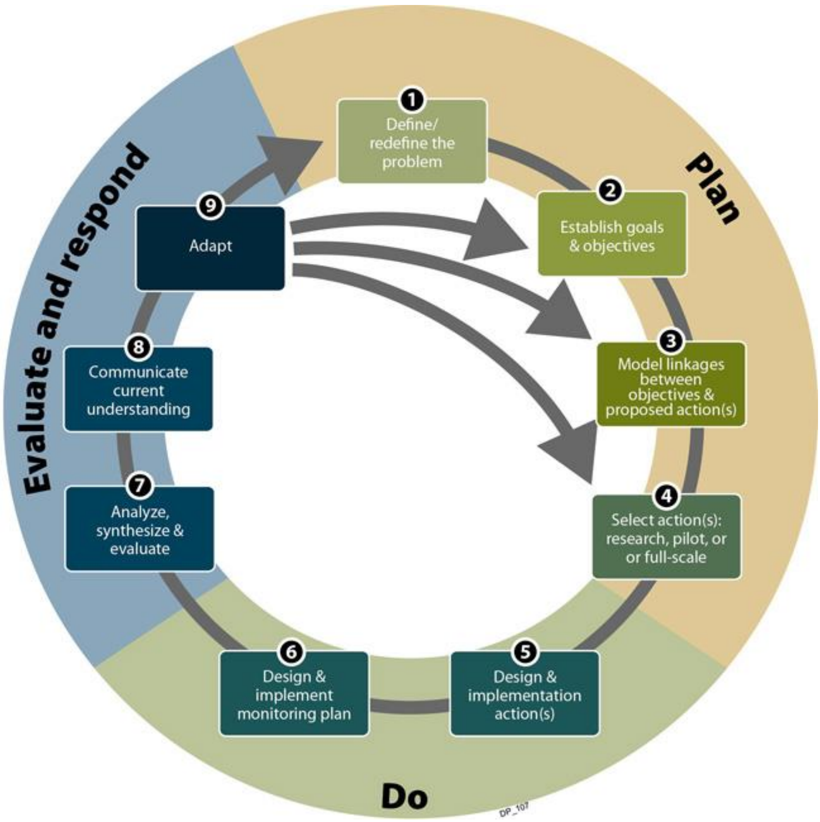
2	Measuring Progress in Tributary Watersheds					
Near-term						
	Measure	Scale	Program	Lead	Frequency	Potential Metrics
2.1	Tributary phosphorus loadings	WLEB priority tributaries	Multiple	States, Heidelberg, USGS	Seasonal/ Annual	Spring and annual FWMC, loads, and discharge
2.2	Nutrient loadings	Varies – small watershed basin wide	Multiple	States, Heidelberg, USGS USEPA, USGS	Seasonal/ Annual	Spring and annual FWMC, loads, and discharge Lake wide annual estimates for monitored and unmonitored tributaries
Long-term						
2.3	Tributary water quality	Varies	GL Tributary monitoring program	USGS	Varies by need	Long term water quality trends, changes in hydrology, subwatershed loads
2.4	Watershed effects of agricultural conservation practices	Selected HUC12s	CEAP	ARS, NRCS, university	Seasonal/ Annual	Long term field and watershed water quality trends from conservation, modeled instream load reductions attributed to conservation
2.5	Watershed stressors	County	NLCD Ag Census	USGS USDA	5 years	Land use, population changes Cropland and livestock production

Group 3 Indicators

3	Measuring Progress in the Lake					
Near-term						
	Measure	Scale	Program	Lead	Frequency	Potential Metrics
3.1	HAB severity	WLEB	Forecast/bulletins	NOAA, Heidelberg	Annual	Algal bloom severity, cyanobacteria biomass
3.2	Hypoxia	Central basin	multiple	USEPA, OEPA, Universities	Annual	Extent of low oxygen zone
Long-term						
3.3	Open-lake water quality & central basin hypoxia	Lake	Lake Guardian	USEPA	Annual surveys	Offshore phosphorus concentrations, dissolved oxygen depletion rates, and other water quality metrics
3.4	Nearshore water quality	Near-shore	NCCA	USEPA	5 years	Proportion of nearshore in good/fair/poor condition for nutrients
3.5	Nutrients and algae	Lake	SOGL	USEPA	3 years	Proportion of offshore in good/fair/poor condition for nutrients

ADAPTIVE MANAGEMENT

Adaptive management (AM) is a long term, structured and iterative process for continually improving management results by learning from the outcomes of previous policies and practices.



The Adaptive Management Cycle. Source: Delta Stewardship Council. 2013a. "The Delta Plan." Sacramento, California: Delta Stewardship Council.

In the context of the DAPs, AM refers to the process of updating implementation strategies in response to changing environmental and economic conditions. This approach is necessary because natural systems are inherently variable and the impacts of management actions are difficult to predict accurately. Uncertainty is made even greater with a changing climate and ecosystem changes caused by invasive species.

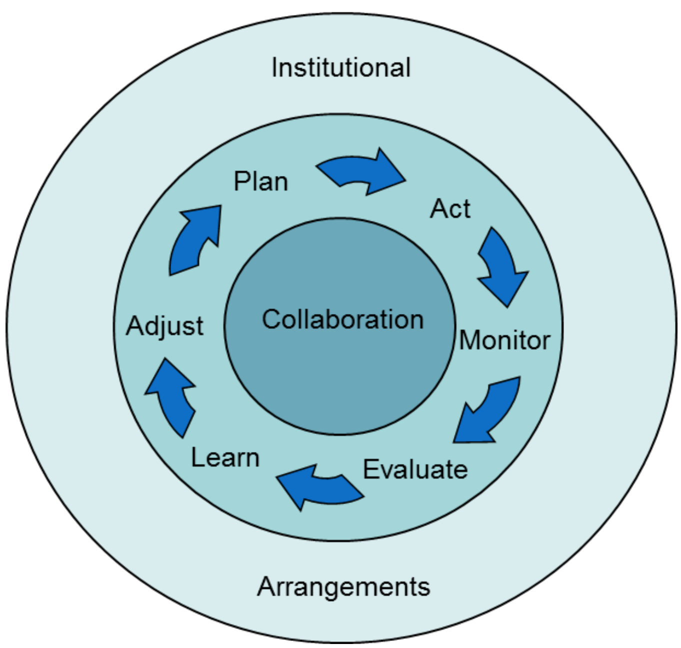
It is imperative that we implement a long term AM strategy so that we can evaluate our progress and adjust actions over time. We committed in the GLWQA to assess, and where necessary, develop, and implement regulatory and non-regulatory programs to reduce phosphorus loading from multiple sources. A wealth of information must be collected over several years before we will be able to determine whether the mitigation activities presented in this plan will be effective in reducing phosphorus loads to the Lake. There are three potential outcomes: the actions have been immediately effective in meeting targets, the actions are effective but with a delay in meeting targets due to legacy effects, or the actions are ineffective at current adoption levels. Each of these scenarios would trigger a different management response.

As we move forward in implementing our AM framework, we will examine the following questions to address implementation challenges and opportunities, incorporate new data and scientific knowledge and refine decision support tools and management strategies toward achievement of water quality outcomes:

- What progress has been made implementing the DAPs?
- What are the changes in water quality?
- What are we learning about factors affecting water quality changes to better implement practices?
- What refinements are needed in monitoring and modeling approaches to better assess trends?
- Do we need to update our models in response to better understanding other ecosystem drivers (e.g. implications of climate variability, legacy phosphorus, invasive mussels, etc.)?
- Do we need to change our programs or policies to minimize obstacles or accelerate progress towards achieving the LEOs?

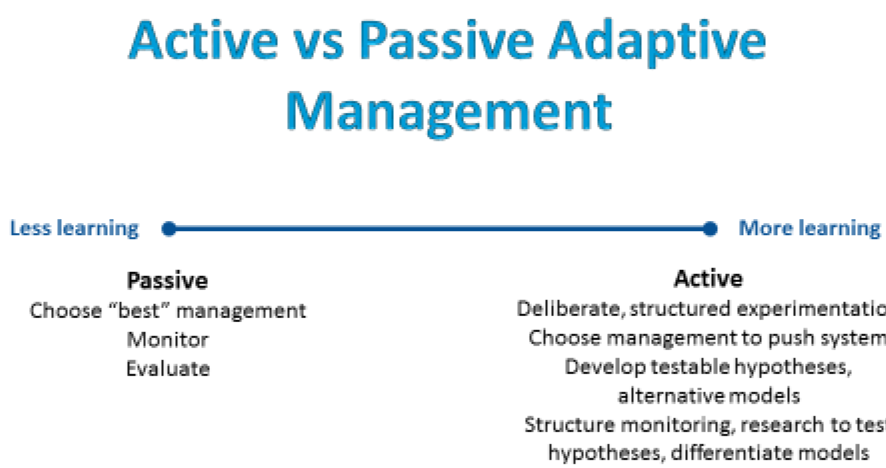
How we will implement AM

One of the biggest changes in the 2012 GLWQA was the increased importance both countries placed on engaging the broadest range of governments, organizations, and the public in work to restore and protect Great Lakes water quality. Canada and United States committed to report on progress every three years to document domestic and binational actions to achieve nutrient objectives. The International Joint Commission is tasked with reviewing and seeking public input on our progress. It is through the GLWQA's enhanced governance structure that all stakeholders can collaborate to identify program and policy changes that will accelerate our progress in restoring Lake Erie.



Caption: The GLWQA governance structure provides the institutional framework needed to effectively implement AM in Lake Erie. Source: http://www.ijc.org/files/publications/FinalReport_AdaptiveManagementPlan_20130530.pdf

USEPA's Science Advisory Board (SAB) specifically recommended establishing a formal committee to develop and implement the AM framework in Lake Erie. For the time being, the Annex 4 Subcommittee serves this role and is already modifying its membership and workgroups to conduct AM in more structured way over the next 3-5 years. As we implement and refine our approach, our goal is to build on the passive forms of AM that occur now to more fully realize the learning opportunities available under a more deliberate and active AM framework.



Caption: Active vs Passive Adaptive Management. Source: Craig Stow, NOAA GLERL

Taken together, the federal and state action plans have all the components necessary to successfully implement AM:

- *Defined problem(s)*
- *Authorization to address problem(s)*
- *An institutional framework to support collaboration*
- *Defined objectives*
- *A work plan and reporting cycle*
- *Performance measures*

Timeframes and key milestones for AM

AM is applied at different timeframes for different purposes. On an annual basis, we will track and report status of loads, update and calibrate models, and prioritize implementation resources. Every 3-5 years we will conduct analyses to evaluate progress and determine whether there is a need to change course.

Jurisdictions in the U.S. and Canada have committed to revise the DAPs at least every 5 years, starting in 2023. With that said, over the first 5 years of implementing this DAP, we expect there will be opportunities to identify management approaches and actions that are or are not working; consider scientific, fiscal and policy developments; and adjust our management strategies and implementation plans as appropriate.

We have aligned our domestic AM framework in the U.S. with the timelines and schedules already established under the GLWQA. For example, we are required to report progress towards implementing phosphorus reduction strategies every 3 years under the Progress Report of the Parties (PRP). Concurrent with the PRP, the Parties conduct a great lakes-wide assessment of ecosystem condition and trends (the State of the Great Lakes, or SOGL). The 5 year operating cycles for CSMI and LAMPs also offer opportunities for incorporating A4 activities into broader lakewide monitoring, research and assessment efforts under Annexes 2 and 10. In the U.S., we will also schedule decision points around the availability of other domestic assessments and strategic plans updated every 5 years, such as the GLRI Action Plan, USDA Farm Bill, National Coastal Condition Assessment (NCCA) and the USDA WLEB Cropland Assessment (CEAP). The key milestones for AM are summarized below.

Schedule for Adaptive Management of the U.S. DAP

AM Activity	When conducted	Where reported	Other key milestones
Finalize DAPs	February 2018	Binational.net and domestic websites	
Update loads through 2016	Spring 2018	June GLEC	- ErieStat release
Finalize binational P reduction strategy and AM framework	Winter 2018-2019	Lake Erie LAMP	
Conduct baseline water quality analysis for priority tributaries where have long term monitoring since 2008	Summer 2019	PRP/June GLEC + SOGL	- 10 years since 2008 baseline for targets - Lake Erie CSMI field year; concerted *Cladophora* monitoring effort; develop whole lake ecosystem model; results of 2015 nearshore assessment (NCCA) available; pilot new SOGL indicator for nutrient loads - Development of next 5-year Action Plan for GLRI; potentially new USDA Farm Bill; new WLEB CEAP Cropland Assessment
U.S. & Canada revisit ability to set Eastern basin target	2020	December GLEC	- U.S. federal and state partners start implementing GLRI Action Plan 3 (2020-2024) - New York & local partners start implementing watershed-based plan for eastern Lake Erie
USEPA & WLEB States assess progress towards 2020 milestones	2021-2022	2022 PRP + SOGL	- Lake Erie CSMI data analysis & reporting
U.S. & Canada revise/update DAPs	2023	Binational.net and domestic websites	- Update Lake Erie LAMP
USEPA & WLEB States assess progress towards 2025 milestones	2025	2025 PRP + SOGL	- 10 years since WLEB Collaborative agreement signed

The importance of monitoring design

While we are eager to demonstrate progress in reducing phosphorus loads to the Lake, it is critical that we first take the time to design and collect data that will be suitable to inform management decisions. Estimation of pollutant load through monitoring is a complex task that requires accurate measurement of both pollutant concentration and water flow and careful calculation, often based on a statistical approach. Both flow and concentration vary considerably over time, especially for nonpoint source pollutants. Accurate load estimation becomes an exercise in both how many samples to take and when to take them to account for this variability. It is imperative that the monitoring program be designed for good load estimation at the start.

The tracking and reporting of seasonal and annual loads is a critical backbone of our ability to assess progress under Annex 4. Hence, our initial efforts have been focused on two immediate priorities:

1. Develop a coordinated monitoring strategy and network for collecting compatible tributary data to evaluate progress towards the new phosphorus targets; and
2. Developing a system to routinely and reliably track and report loads.

In the past, loads to the lake were estimated periodically by the late Dr. Dave Dolan. Most recently, loads were updated through 2013 by his former graduate student, Matthew Maccoux, working with ECCC researchers (Maccoux et al. 2016). These approaches for calculating whole lake loadings relied on whatever monitoring data were available even if they were not collected at sufficient frequency to accurately estimate loads. In general, in order to accurately calculate tributary loads, you most often must have high frequency sampling. The choice of when to collect concentration samples is also critical. Even with a lot of samples, some of the variability in loads over time can often be due to climatic patterns, so it may take time to see a change in watershed response – at least 5-10 years or more.

We will have to use caution interpreting progress in any given year. Many of the changes we see in tributary loading from one year to the next are simply due to the weather, and it will take many years before we can tell whether a reduction has actually occurred. Furthermore, if a decrease in phosphorus loads is observed, it can be difficult to attribute that change as a response to management action. Changes can be detected sooner in small watersheds, if significant implementation occurs in a short period of time and data collection is sufficiently robust to capture it.

According to a 2015 study[28] led by the Northeast-Midwest Institute, long-term, targeted water quality monitoring in conjunction with significant increases in adoption would be necessary to detect statistically significant reductions in nutrient loads to Lake Erie resulting from the implementation of agricultural BMPs. At a minimum, 10 years of data is needed to detect a 40% reduction in loads. However, more time is needed to detect a smaller reduction. It would take 40 years to detect a 10% reduction in load. Findings from this report and the CEAP Watersheds Synthesis Study have been used to better coordinate the location of small watershed monitoring sites and conservation incentive areas in high priority watersheds.

[28] Betanzo, E.A., Choquette, A.F., Reckhow, K.H., Hayes, L., Hagen, E.R., Argue, D.M., and Cangelosi, A.A., 2015, Water data to answer urgent water policy questions: Monitoring design, available data and filling data gaps for determining the effectiveness of agricultural management practices for reducing tributary nutrient loads to Lake Erie, Northeast-Midwest Institute Report, 169 p., http://www.nemw.org/.

Current Status and Next Steps

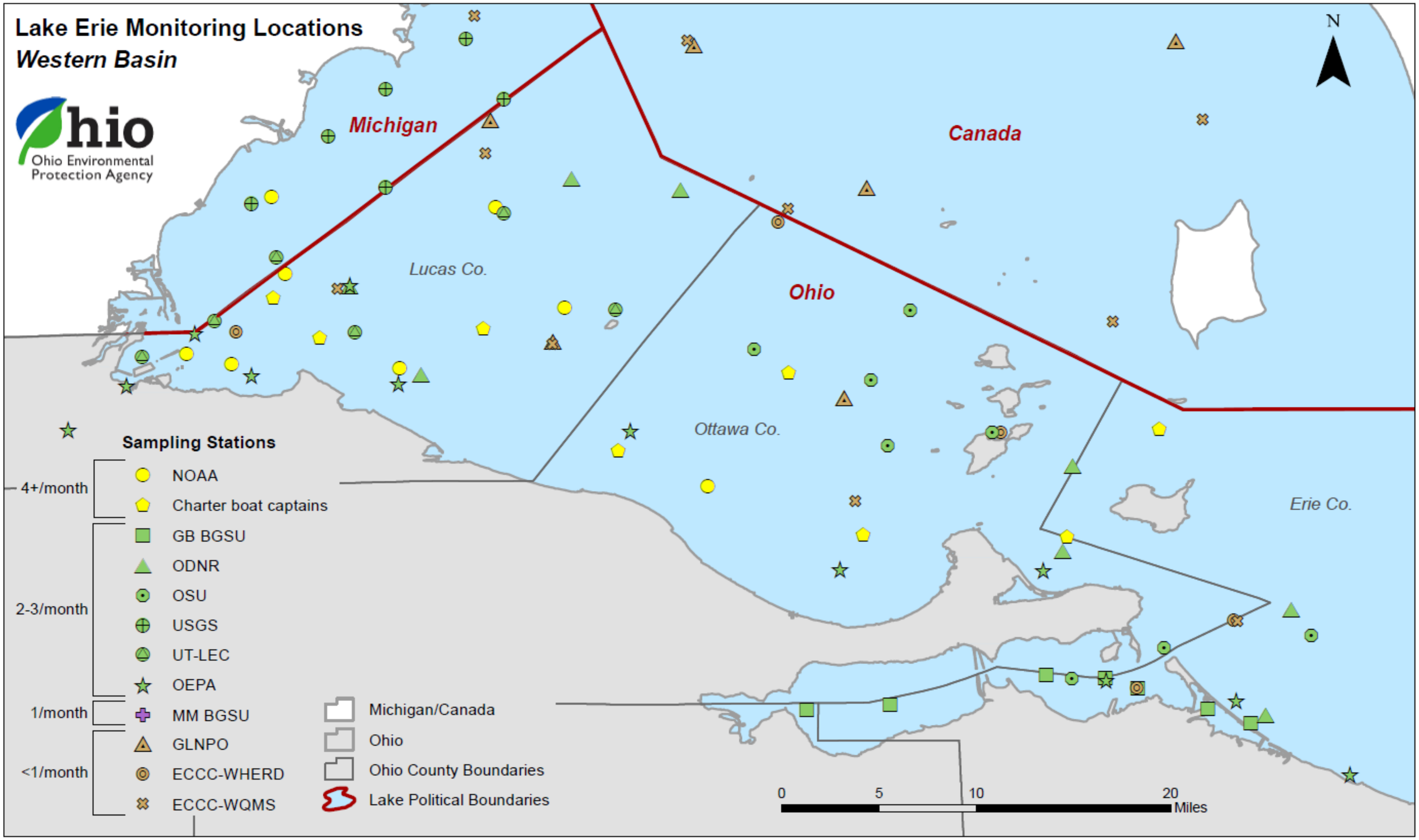
Over the past two years, the Annex 4 Subcommittee and task teams have made significant progress in developing a systematic and improved process for updating loads that is based on the historic Dolan method. This involves modernizing the Dolan approach (e.g. ECCC developed a tool to automate aspects of the calculations), and developing an institutional framework in which the Parties will be able to do this routinely to meet GLWQA reporting commitments. USEPA, ECCC and federal and state/provincial partners have a plan in place to update the whole lake loading calculations through water year 2016; we anticipate reporting those results in June 2018.

Binational workgroups established under Annex 4 have provided valuable technical assessments and recommendations that will improve efforts for collecting compatible tributary and in-lake data. These groups have so far developed inventories of tributary monitoring sites in the Lake Erie watershed and in-lake HABs monitoring sites in the WLEB. The groups have also provided guidance on sampling frequency and load estimation approaches that will help ensure adequate monitoring to reliably calculate loads and flow weighted mean concentrations (FWMCs). The design of our monitoring strategy in Lake Erie draws from a well-established body of knowledge on monitoring design for nonpoint source pollutants, such as the technical guidance documents and resources developed by USEPA's National Nonpoint Source Monitoring program: https://www.epa.gov/nps/nonpoint-source-monitoring. Through these efforts, monitoring agencies were able to ensure that all priority tributaries in the U.S. have or will soon have monitoring at sufficient frequency to calculate loads and FWMCs.

Similarly, a new sampling method for Lake Erie HABs has been developed and will be used by most parties starting in 2018. The new method consists of a scum sampling protocol that will improve consistency among the many entities sampling HABs in the WLEB (see attached map). A third workgroup will be formed in 2018 to evaluate the modeling needs. Together, the monitoring and modeling approaches recommended by these workgroups will continue to inform our domestic and binational adaptive management approaches.

Annex 4 workgroup summary of monitoring near the mouths of U.S. priority tributaries

Tributary	Monitoring for loads/FWMCs?	Monitoring all parameters?	Notes
River Raisin	YES	YES	
Maumee River	YES	YES	Continuous SRP beginning spring 2018
Portage River	YES	YES	
Sandusky River	YES	YES	
Huron River	SOON	YES	Monthly sampling with surrogates and soluble P sensor began in fall 2017; this will enable annual reporting of loads starting in 2020
Vermilion River	YES	YES	Continuous SRP beginning spring 2019
Cuyahoga River	YES	YES	
Grand River (Ohio)	SOON	YES	Monthly sampling with surrogates and soluble P sensor began in fall 2017; this will enable annual reporting of loads starting in 2020
Cattaraugus Creek	YES	YES	Continuous SRP beginning spring 2018



Map developed by Ohio EPA based on inventory by the Annex 4 workgroup.

PUBLIC ENGAGEMENT AND REPORTING

This plan will not be successful without the engagement and support of the many active partners in the Great Lakes region. We engaged stakeholders in the development of the domestic action plans in 2017, through in-person engagement sessions with targeted stakeholder groups. We will continue to engage Great Lakes stakeholders as we implement these plans and track progress towards achieving the phosphorus reduction goals.

The U.S. and Canada are required to report on the progress of implementing the GLWQA every three years. In 2016, the first Progress Report of the Parties (PRP) was issued under the revised GLWQA. A formal report was developed and the information was presented at the Great Lakes public forum. The International Joint Commission is responsible for evaluating the governments' progress and providing stakeholder feedback to agencies implementing the GLWQA. Great Lakes stakeholders will continue to have this opportunity to provide public input to the progress being made under Annex 4, and specifically the implementation of actions to achieve phosphorus reduction goals, at the Great Lakes Public Forum.

In addition to the triennial PRP and annual LAMP reports, the Annex 4 Subcommittee intends to host webinars to keep the public apprised of our progress implementing the Lake Erie domestic action plans. The Annex 4 Subcommittee will track and report phosphorus loads on an annual basis, in coordination with the Lake Erie HABs forecast and Lakewide Annual Report. The Subcommittee is also collaborating with the Great Lakes Commission (GLC) to develop a binational information platform for tracking progress.

A pilot project of the GLC's Blue Accounting Initiative, ErieStat uses metrics and relevant data to measure progress toward the jurisdictions' shared goals for nutrient reduction in Lake Erie. Importantly this tool will enable us to track progress of water quality metrics, while also tracking the impacts of strategies and investments intended to reduce phosphorus loading. Information on the website will be updated at least annually. Visit *www.eriestat.org* or *www.blueaccounting.org/issue/eriestat* for more information.

Blue Accounting ErieStat
Tracking Progress Toward a Healthier Lake Erie

The U.S. Action Plan can be accessed here: https://www.epa.gov/glwqa/glwqa-annexes

The full suite of U.S., state and Canada-Ontario domestic action plans can be accessed here: https://binational.net/annexes/a4/.