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FINAL PROGRESS REPORT: POLICY TOOLS FOR REDUCING HARMFUL ALGAL BLOOMS

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Cover Photo: Image of Lake Erie via NASA's MODIS Terra and Aqua Instruments

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Nutrient Enrichment and Harmful Algal Blooms in Lake Erie: A Description of the Problem

In recent years, Lake Erie has been experiencing symptoms of eutrophication resulting from excess flows of nutrients from agricultural and urban sources. One of the consequences of this nutrient enrichment is the occurrence of large Harmful Algal Blooms (HABs) in Lake Erie – particularly in its western basin. A HAB is any large increased density of algae that is capable of producing toxins (Ohio Sea Grant, 2011). These blooms have received significant attention in recent years, with a (formerly) record-breaking bloom occurring in Lake Erie in 2011. That algal bloom extended from the western basin of Lake Erie near Toledo to the central Lake Erie Basin past the City of Cleveland. In 2014, toxins from a HAB near Toledo were detected in the city's public water system, which uses Lake Erie to supply water for several hundred thousand people in the Toledo area. This contamination resulted in a ban on the use of water from the city's public water system. Yet another record-breaking HAB spread across Lake Erie in 2015 (Associated Press, 2015). In addition to HABs, excess nutrients have also resulted in anoxic zones within the lake, and nuisance levels of Cladophora[1] (Great Lakes Commission (GLC), 2015).

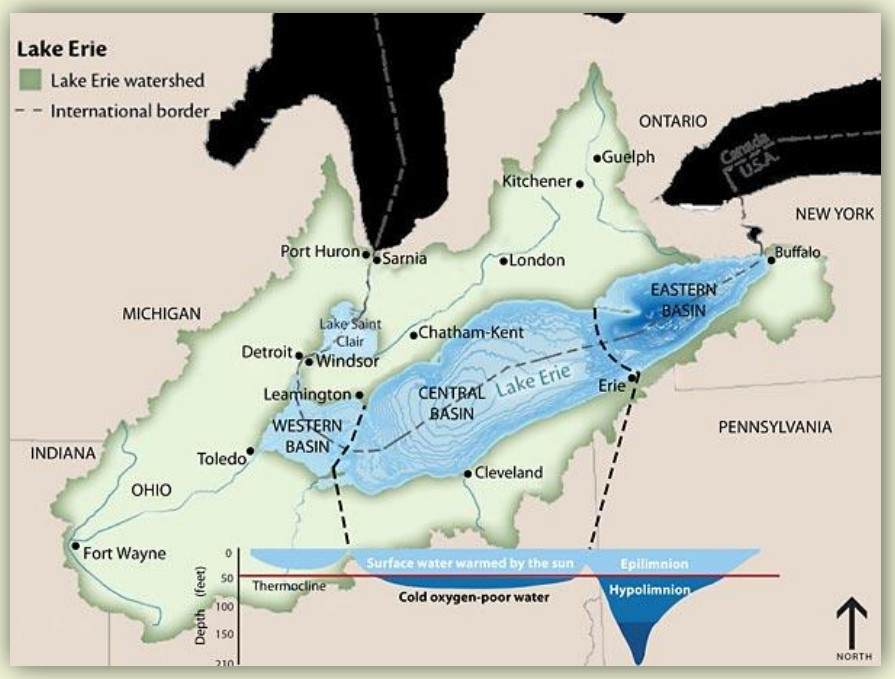
Excess nutrients and HABs result from excess loadings and elevated concentrations of two key nutrients, phosphorus and nitrogen. Both of these nutrients result from non-point sources, such as agricultural operations and urban storm-water, as well as point-sources of nutrient pollution which flow through discrete pipes or conveyances such as wastewater treatment plant outfalls, Combined Sewer Overflows (CSOs) outfalls, and other sources (OSG 2011, IJC 2014, Ohio Phosphorus Task Force 2013, and the GLC, 2015). Existing data and studies suggest that agricultural operations account for the largest share of these excess nutrients, and that phosphorus is a key nutrient of concern for Lake Erie (Phosphorus Task Force, 2013; IJC, 2014; Lucas County Board of Commissioners, 2015). It is also important to recognize that studies have suggested that dissolved phosphorus, as opposed to total phosphorus, may be of particular concern in the creation of HABs in Lake Erie (Phosphorus Task Force, 2013).

HABs can yield a range of negative impacts for human health, the environment, and the economy. These negative impacts include threats to public and ecological health, including toxic effects on human neurological systems, anoxic conditions, and other undesirable effects (Zingone and Enevoldsen, 2000). They also include economic impacts, as HABs may inhibit recreational and other uses of Lake Erie which can reduce the significant economic benefits associated with Lake Erie waters (Austin et al, 2007).

There have been policy responses to the issues of HABs occurring in Lake Erie at the state level in Ohio, and at the federal and international levels. At the state level in Ohio, these responses have included the repurposing of funding from agencies such as Ohio's Environmental Protection Agency (OEPA) and Department of Natural Resources (ODNR) to provide monies to reduce nutrient pollution through the

[1] Cladophora are true algae (unlike the cyanobacteria that create HABs) that can also create large algal blooms. These blooms can be a nuisance and also cause environmental problems. However, they do not produce toxins associated with HABs (OSU Sea Grant, 2011)

Ohio Clean Lakes Initiative and other programs (Clean Lakes Initiative, 2014). The state has also developed new legislation and regulations to reduce the use of agricultural fertilizer during winter months and to further investigate nutrient discharges from certain POTWs. In June of 2015, Ohio also signed an agreement with Michigan and the Canadian Province of Ontario to reduce phosphorus loads to Lake Erie by 40% by 2025.



- The Lake Erie Basin (USEPA, 2016)

The federal government has also been active in attempting to reduce nutrient flows to Lake Erie and the other Great Lakes through the Great Lakes Restoration Initiative (GLRI), and other programs funded and/or administered by federal agencies. It has also been involved in ongoing international processes to coordinate nutrient reduction efforts between the US and Canada via the Great Lakes Water Quality Agreement (GLWQA), an agreement that was last updated in 2012. In February of 2016, the U.S. and Canadian Governments made the 40% phosphorus reduction target an official goal of both nations (USEPA, 2016a). Over the next few years, the two countries plan to use agreed upon mechanisms in Annex 4 of the GLWQA to develop loading allocations to meet this targeted level of phosphorus reduction and to instigate Domestic Action Plans in an effort to achieve the needed reductions. These domestic action plans are expected to define steps to be taken to reduce nutrient loads consistent with the loading allocations made through the Annex 4 process.

To our knowledge, there has not yet been any significant and comprehensive effort to take stock of the nutrient reduction strategies and tools currently in place in Ohio's Lake Erie basin[2]. In addition, we have

[2] As we proceeded with this research, we did uncover a Great Lakes Commission (2012) study that reviewed nutrient reduction programs in place in Great Lakes states and provinces, but it did not deal with efforts in the Ohio Lake Erie basin specifically. In

not seen systematic efforts to compare nutrient management programs and efforts across water basin programs in the United States (US). The inventory and assessment developed through this project takes initial steps to address both of these gaps in our current knowledge base.

Research Objectives

This project seeks to inform current nutrient reduction efforts in Ohio and elsewhere. We present an inventory of policy tools being used in the Ohio portion of the Lake Erie basin to reduce nutrient flows to the lake. We also share the results of an effort to identify and review nutrient reduction efforts being carried out by other water basin management programs in the United States (US). In addition, we use our inventory and the information gained from our review of other American water basin programs to offer ideas for policymakers and public administrators to consider regarding additional policy tools they may want to use in addressing excess nutrient enrichment problems in the Lake Erie basin.

Specifically, we have pursued the following research objectives through our work:

- Create an inventory of current nutrient reduction policies being utilized in the Lake Erie water basin in northern Ohio as a result of state and/or federal programmatic efforts, along with key elements of the strategies used to implement them;
- Identify nutrient reduction policies and implementation strategies used by other place-based water quality management programs elsewhere in the country, and collect information relevant to their effectiveness;
- Determine nutrient reduction strategies that appear promising for reducing nutrient loads to Lake Erie from Ohio, based on their success or perceived success in other areas of the country and the potential for them to usefully supplement current policies and strategies being implemented in Ohio;
- Develop lessons learned and recommendations for nutrient policies and strategies to implement in northern Ohio.

- Harmful Algal Bloom (NOAA, 2009)

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addition, it did not specifically compare nutrient reduction efforts for Lake Erie with those in place elsewhere in the country. As such, we used it to inform our project efforts.

Methodology

Inventorying Current Policy Efforts to Reduce Nutrient Flows in the Ohio Lake Erie Basin

To develop an inventory of policy efforts focused on nutrient control in the Lake Erie basin of Ohio, we sought to identify and document use of nutrient control efforts in the State of Ohio generally, and in the Lake Erie basin in particular. To do so, we used Hood's policy tools framework (1983) as a guide and sought to identify exercises of government regulatory authorities, expenditures of funds and resources, key nodal communications such as guidance and information provided by governing organizations, and organizational resources and capacities.[3]

We searched for data and information in these areas through multiple searches on Ohio government agency websites and interviews with officials who are knowledgeable regarding nutrient reductions efforts in the state of Ohio. Our efforts took place over a period of approximately one year in duration and included searches of website material posted by the following federal and state agencies: US Environmental Protection Agency (USEPA); US Department of Interior (USDOI); US Department of Commerce – National Oceanographic and Atmospheric Administration (NOAA); US Department of Agriculture (USDA); Ohio Environmental Protection Agency (OEPA); Ohio Department of Natural Resources (ODNR); Ohio Department of Agriculture (ODOA); Ohio Development Services Agency (ODSA); Ohio Public Works Commission (OPWC), and; the Ohio Lake Erie Commission (OLEC).

We also sought out and interviewed multiple state and federal officials who are knowledgeable regarding nutrient control initiatives the Ohio Lake Erie basin. Our interviews with these officials were intended to: 1) identify nutrient reduction efforts we had missed during our web searches, and; 2) clarify our understandings of the written materials we had collected. The interviews conducted included discussions with staff, or former staff, of OEPA, ODNR, ODA, the Lake Erie Commission, ODSA, and USEPA.

- Long Island Sound Study Logo (LISS, 2016)

Investigating Other American Water Basin Programs

To draw lessons from other water basin programs about ways to address nutrient enrichment problems, we sought to identify water basin management programs around the country. We held discussions with USEPA officials and conducted independent research efforts to identify water-basin programs throughout the country. Through these efforts, we identified a total of 32 water basin programs to investigate. Twenty-eight of these water basin programs were part of the USEPA's National Estuary Program (NEP) and four additional programs were place-

[3] In 1983, Christopher Hood's "The Tools of Government" proposed that government can be viewed as a set of resources that define the policy tools that can be used to "detect" what is going on in society and to "effect" societal conditions in ways that are consistent with policy goals. He defined four major resources: 1) "authority"; 2) "treasure"; 3) "nodality", and; 4) "organization". To improve readability, we interpret these categories as "regulatory interventions", "expenditures of funds and resources", "government strategies, plans, and communications", and "organizational resources and capacities".

based programs set up independent of the NEP. We then subjected these 32 basin programs to a three-phase screening review in an effort to identify programs that were likely to yield potentially useful lessons and insights for the Lake Erie watershed. A list of these screened programs is provided in Appendix 1.

During the first phase of the project, we reviewed websites for each of the programs involved -- along with other publicly available information -- to gain a broad understanding of the work they do. More specifically, we assessed: 1) whether or not nutrients were of concern in the water basin; 2) the likely and/or predominant sources of nutrient flows; 3) stakeholders in the process and the number of jurisdictions involved, and; 4) evidence of potentially innovative and/or effective policy or management approaches to nutrient control.

In the second stage of the screening process, we sought to identify programs that seemed to have potential to reveal insights for addressing nutrient concerns in Lake Erie. At this stage, we sought to identify promising programs based on the following criteria: 1) did they address phosphorus and/or nitrogen? 2) were there notable agricultural contributions to nutrient flows in the basin? 3) was there evidence of coordinated implementation across jurisdictions? and 4) was there evidence of potentially innovative and/or effective policy or management practices being undertaken? Eight programs that addressed nutrients and scored relatively highly across the three other areas were selected for further investigation.

- Chesapeake Bay Program Logo

We then conducted more in-depth reviews of these eight programs, including discussions with program officials where appropriate, to identify one or two programs that we would investigate in greater detail. During the course of these more detailed investigations, we also asked those we were interviewing whether there were other programs or nutrient reduction efforts that they were aware of that would be likely to yield useful insights for the Lake Erie effort. Based on these further investigations, we chose three programs that were making significant efforts to measure the effectiveness of their nutrient control efforts as a whole and appeared likely to yield useful insights for the Lake Erie Basin. They were the Chesapeake Bay Program (CBP), the Long Island Sound Study (LISS) Program, and the Tampa Bay Estuary Program (TBEP).

We then proceeded to investigate these programs and the policy instruments they used in greater detail. These investigations involved additional interviews with program staff(s) and deeper research into secondary information sources. Throughout the process of investigating these water basin programs, we inventoried nutrient control policies and management strategies with particular focus on approaches that we did not see being implemented in the Ohio Lake Erie basin.

Limitations

Like most research efforts, this project is characterized by limitations that affect both the data and information compiled and the conclusions reached. First, time and resource limitations -- as well as our reliance on publicly available documents and interviews -- mean that we cannot guarantee that we have identified *all* current nutrient reduction efforts in the Ohio Lake Erie basin. However, we did spend a good bit of time collecting data and information, so we believe that we were able to identify most – if not all – significant public sector nutrient reduction efforts being undertaken in the Ohio Lake Erie basin area.[4]

- Tampa Bay Estuary Program Logo (TBEP, 2016)

Second, while other water basin management programs we investigated all focused on nutrients, they were different than the Ohio Lake Erie basin efforts in other respects. The watersheds differed in size, so policy tools which vary in effectiveness or utility based on size might not transfer well to water basins with differing size characteristics. The watershed basin programs we investigated also differed in the nature and extent of cross-jurisdictional work that is required to coordinate nutrient reduction efforts

Third, while we set out with the hope of identifying information on the measured effectiveness of policy tools used in other watersheds, we did not find this kind of information available. We did, however, find watershed programs that were making substantial efforts to measure their *overall* progress against defined nutrient loading criteria and nutrient-related ambient water quality goals, so we chose to focus attention on those efforts in order to enable relevant learning to inform the potential development of similar efforts in the Lake Erie basin.

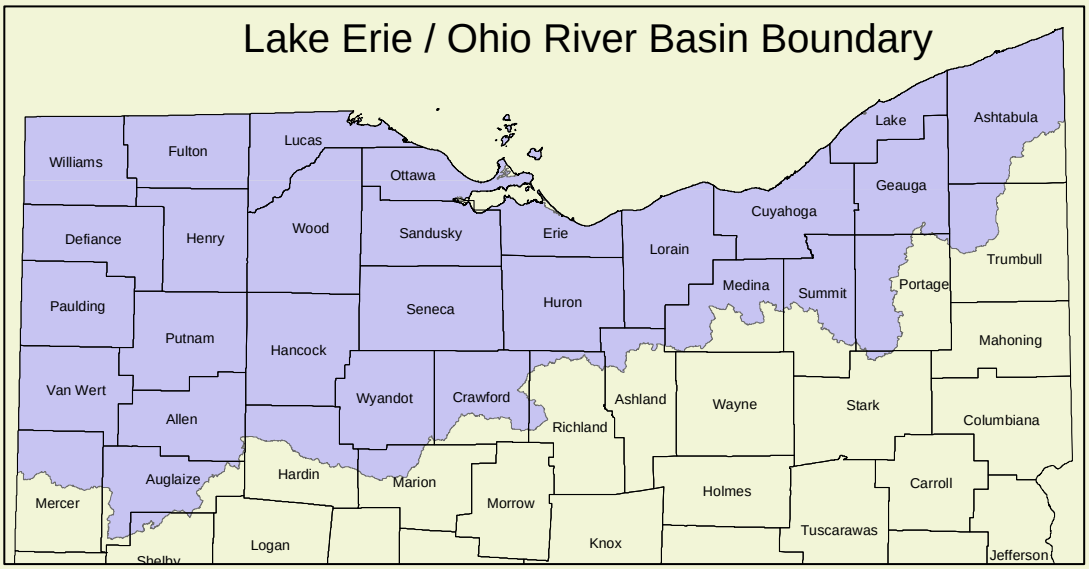
In spite of these limitations, this work has resulted in a rather complete and current compilation of information available on nutrient reduction efforts in the Ohio Lake Erie basin. It also presents an assessment of policy tools that are a part of nutrient reduction strategies which (collectively) are yielding at least some level of progress in their pursuit of water quality improvement goals in other water basins. As a result, the information presented here can enlighten policymakers and natural resource administrators on policy tools that are being used to reduce nutrient flows in other large American water basins. It can inform their discussions about addressing nutrient enrichment and HABs in Lake Erie.

[4] However, we should point out that, due to limitations on the availability of geographically available information, we were limited to statewide information on some nutrient reduction programs in the Lake Erie basin. This was particularly true for agricultural programs, which appear to be subject to limits on data availability due to statutory provisions in the federal "Farm Bill" law.

Principal Findings

Nutrient Reduction Policies in the Ohio Lake Erie Basin

Our investigations of nutrient reduction policy efforts in the Ohio Lake Erie basin identified multiple policies targeting nutrient load reductions to Lake Erie. We summarize key findings below.



- Counties within the Lake Erie Basin (OEPA, 2007).

Regulatory Interventions to Reduce Nutrient Flows from Point Sources

We identified multiple instances in which federal and state regulatory authorities are used to achieve nutrient loading reductions in Ohio. Federal authorities exist under the Clean Water Act (CWA) which require point source dischargers of pollutants to waters of the US to obtain regulatory discharge permits. However, these federal requirements are administered by state agencies in Ohio (and elsewhere as well). To understand regulatory controls for nutrients in Ohio, we investigated National Pollutant Discharge Elimination System (NPDES) point source permits issued pursuant to the federal CWA, as well as state requirements which apply to releases of nutrients to Ohio waters.

We investigated three kinds of NPDES regulated point source discharges: 1) traditional NPDES permits for facilities discharging wastewaters from sewage treatment facilities and industrial/commercial processes; 2) permits for addressing storm-water discharges from separated and combined sewer systems, and; 3) potential releases from Concentrated Animal Feeding Operations (CAFOs), which are treated as point sources under the CWA.[5]

[5] For all three of these types of point source permits, we investigated current permits in Ohio and the Lake Erie basin, using information available through state agency sources and – in most cases – these sources are available through the websites of the agencies involved. Where needed, we sought clarifications regarding the written information provided from agency staff persons who are knowledgeable regarding the information being investigated.

Our review of NPDES wastewater discharge permits found that:

- OEPA has issued a total of 1,148 NPDES permits for wastewater discharges in the Lake Erie basin.
- Of these permits, 102 are considered major permits which USEPA and OEPA define as those governing discharges of one million gallons of a day (MGD) of wastewater flow or which contain pollutants of particular concern to the water bodies to which they flow (USEPA, 2016b). The remaining 1,046 are considered minor permits.
- Out of the 102 OEPA major permits in the Lake Erie Watershed, 83 permits (81%) have effluent limits on at least one nutrient (Nitrogen and/or Phosphorus). A total of 79 of these permits have effluent limits on total phosphorus.
- There are 19 (19%) major permits that do not appear to have any nutrient limits at all.
- The majority of major permits also have monitoring requirements for nutrients, only 14 out of 102 (14%) had no monitoring requirements at all.
- Minor permits appear to be less likely to have nutrient limits and monitoring requirements than major facilities.

These and other findings are summarized in Table 1 below:

Table 1: Overview of NPDES permits in the Ohio Lake Erie Basin[6]

	Major Permits	Minor Permits	Total
#'s of Permits	102	1046	1148
Nutrient Limits (Either P or N)	83	601	684
No Limits	19[7]	445	464
Nutrient monitoring (either P or N)	87	756	843
No monitoring	15	290	305

In interpreting the figures in Table 1, however, one should be aware that not all permits necessarily need effluent limits – or perhaps even effluent monitoring requirements -- for nutrients. This is because some wastewaters discharged by NPDES permittees do not come from organic sources that are likely to include nutrients such as phosphorus and nitrogen.

One type of NPDES permittee that is likely to discharge wastewaters containing nutrients is Publicly Owned Treatment Works (POTWs). POTWs collect wastewaters from residences, businesses, and storm

[6] We compiled data on effluent limits and monitoring requirements relating to phosphorus and nitrogen by identifying and reviewing hundreds of NPDES permits issued by OEPA in the Lake Erie basin. We retrieved and reviewed the permits from the OEPA website, http://www.epa.ohio.gov/dsw/permits/npdes_info.aspx, between Summer 2015 and Spring 2016. For nitrogen, we looked for effluent limits and monitoring requirements on ammonia and nitrates, both of which contain nitrogen. For phosphorus, we looked for and found effluent limits and monitoring requirements on total phosphorus in a number of the permits we reviewed. Additional information on methods used and NPDES related findings is available upon request.

[7] Among these 19 major permits without nutrient limits, 11 permits are for various industrial facilities, 7 are for Power Plant facilities and 1 permit is for an Oil Refinery.

water sources, and their discharges often contain organic materials. For this reason, we took a closer look at permit limits and monitoring requirements contained in NPDES permits issued to POTWs. We found:

- All major Publically Owned Treatment Works (POTWs) had some form of nutrient limits (with 55/56 having at least phosphorus limits), while only one POTW had only nitrogen limits.
- There are 141 minor POTWs that have no nutrient limits whatsoever.

Because phosphorus is of particular concern in the creation of HABs in Lake Erie, we also looked specifically at the phosphorus limits we found in major POTW permits. In particular, we assessed the monthly average total phosphorus concentration limits written into the permits of all of the major POTWs in the basin. We found that:

- Among major POTWs in the Lake Erie basin, all concentration limits are at or below 1.0 mg/L[8], as was suggested by the International Joint Commission (IJC) for major POTWs discharging to the Great Lakes about 35 years ago.
- Ten of the fifty-six permits issued to major POTWs in the Lake Erie basin have more stringent limits than 1.0 mg/L average monthly concentration, with the lowest average monthly concentration limit being .60 mg/L.

A summary of these and other findings is provided in Table 2 below.

Table 2: Overview of NPDES Permits for POTWs in the Ohio Lake Erie Basin

	Major Permits	Minor Permits	Total
#'s of Permits	56	187	243
Nutrient Limits (Either P or N)	56	141	197
No Limits	0	46	46
Nutrient monitoring (either P or N)	56	183	239
No monitoring	0	4	4

We identified controls on Combined Sewer Overflows (CSOs), which can discharge nutrients from combined sewers after major storms or rainfall events. Among NPDES permits issued by OEPA, we found that:

- There are currently 77 communities in Ohio that have approximately 1,144 permitted CSOs among them (OEPA, 2015a).[9]

[8] In 1980, the IJC's Phosphorus Management Workgroup recommended that Wastewater Treatment Plants (WWTP's) in the Great Lakes should be designed and operated so that the total phosphorus concentrations in their effluents would not exceed a maximum of 1.0 (mg/L) (IJC,1980). However, it appears as though the GLWQA itself suggested a more ambitious 0.5 mg/L goal for major POTWs in the Lake Erie water basin (GLWQA, 2012), to the extent deemed necessary by the regulatory officials involved.

- Of the 77 communities in Ohio, 45 (58%) are within the Lake Erie watershed, and may therefore discharge nutrients to the Lake Erie basin when they overflow during or after major storm events.
- Of the 45 NPDES permits for the POTWs in those Lake Erie basin communities, we found that none of the permits had CSO nutrient discharge limits but they typically had CSO monitoring and reporting requirements of some kind.

Relatedly, our review of 56 major NPDES permits for POTWs in the Lake Erie Basin revealed that all of them had monitoring requirements for Sanitary Sewer Overflows (SSO's), which can release untreated sewerage and nutrients from separated sewerage systems after major rain events.

We also reviewed required management programs relating to the control of storm water flows among large and small municipalities.[10] These programs are targeted toward large communities with 100,000 or more persons (Phase I storm water requirements) and smaller communities (Phase II storm water requirements) as well. Our review of the Ohio NPDES storm water program found that OEPA has[11]:

- Issued at least two Individual Phase I Municipal storm water permits within the Lake Erie Basin (Toledo and Akron).
- Covered 133 government entities in counties that are at least partially in the Lake Erie Basin under its small MS4 Phase II Storm Water General Permit.
- Covered 6,942 permittees in the counties that are at least partially inside of the Lake Erie Basin under its Construction Storm Water General Permit.
- Covered 1,265 permittees in those same counties under its Industrial Storm Water General Permit.

We also investigated the use of NPDES Concentrated Animal Feeding Operation (CAFO) permits to control polluted waters flowing from larger animal feeding operations in Ohio.[12] We found that:

- Currently, OEPA's NPDES CAFO program has permitted 35 operations in Ohio. However, only 15 appear to be within the 35 counties that are at least partially within the Lake Erie Watershed.
- There are currently 113 Ohio Department of Agriculture (ODA) permitted animal feeding facilities within Ohio counties that are at least partially within the Lake Erie Watershed. The

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[9] We identified a listing of communities in Ohio with CSOs from the OEPA website (http://www.epa.ohio.gov/dsw/cso/csoindex.aspx#116135672-how-many-csos-are-in-ohio). There were a total of 77 communities in the inventory that did not have an implementation status of "complete". Using ODNR's High Quality Watershed map we were able to identify the communities within the Lake Erie Watershed. We then reviewed the NPDES permit for each community in the watershed to see if the permits included CSO controls. Those that had CSO controls in their permits are included in the tallies presented.

[10] We reviewed the list of permittees under each type of storm water general permit (Phase II, Construction, Industrial, and Marina) and performed a simple count of the number of permittees covered under each general permit for the counties that are at least partially in the Lake Erie Watershed.

[11] County by county information is available upon request.

[12] We utilized the lists of permitted CAFO and CAFF facilities provided by OEPA and ODA on their respective websites and performed a simple count of the number of permitted facilities in the counties that are at least partially within the Lake Erie Basin.

ODA permitting program, the Combined Animal Feeding Facility (CAFF) program, applies to both large CAFO's and other animal feeding operations that do not meet NPDES CAFO requirements.

Overall, we found an abundance of regulatory interventions to reduce and/or control nutrient flows in the Lake Erie water basin. However, we found no central place or information source that would enable integrated management of these requirements, and we also found instances where current NPDES permits could potentially be strengthened to exercise greater control over nutrients than currently exists. In addition, for regulatory controls relating to wet weather related sources, it appeared that information on the actual implementation of compliance activities was not as readily available as it could be.

Expenditures of funds and resources to Reduce Nutrient Flows

During the course of our work, we identified multiple ways in which federal and state agencies expend funds and make investments to reduce nutrient flows. Below we summarize these efforts and the findings that stem from them. Two summaries are provided. One summary focuses on investments to reduce nutrient flows from point sources, where wastewaters are discharged through pipes and/or conveyances. A second summary focuses on non-point sources, where nutrients are released through diffuse flows of waters over land after rain events.

Investments in Point Source Wastewater Treatment

- WPCLF Logo (OEPA, 2014)

We investigated funding and expenditures that are made available to help control nutrients from wastewater treatment plants in Ohio and the Ohio Lake Erie Basin.[13] Ohio utilizes financial assistance programs that benefit from both state and federal funding to help local governments address point source issues. The Ohio Water Development Authority (OWDA) and the OEPA jointly manage and implement the Water Pollution Control Loan Fund (WPCLF), which provides below market rate loans to public entities for sewerage systems, Wastewater Treatment Plants (WWTPs), and related planning and construction projects. The OWDA also manages additional loan programs, such as the Fresh Water Fund, the Community Assistance Fund, and the Un-sewered Area Assistance Account. Between 2010 and 2015, these funding sources provided $2.769 billion to finance wastewater planning and construction projects in Ohio (OWDA Annual Reports 2011-2014; OEPA 2015 Annual Report). In 2015, OEPA offered a Nutrient Reduction Discount, where the agency provided an additional $1 million in loans available at a 0% interest rate for projects that include "equipment and facilities at POTWs to reduce levels of phosphorus and other nutrient pollutants" (OEPA, 2014).

[13] We reviewed the OWDA's annual reports from 2011-2014, which provide an overview of the planning and construction loans for each year. We utilized the 2015 OEPA Annual Report to identify the total funding provided by the WPCLF (which may result in an underestimate of funding because it does not include the other OWDA loan programs highlighted above).

Investments in Nutrient Reduction from Non-Point Sources

There are numerous programs being implemented that are either directly or indirectly related to controlling nutrient flows from non-point sources (NPS's) to Lake Erie. The programs applicable to the Lake Erie Watershed are presented below. They have been separated into Federal and State funded programs. It should be noted some that some programs are federally funded but are implemented at the state level by state agencies.

Federal agencies implementing non-point source-related programs include:

- US Environmental Protection Agency (USEPA)
  - Clean Water Act Section 319 Grant Program
  - Urban Waters Grant Program
- US Department of Agriculture (USDA)
  - Multiple Farm Bill Programs[14]
- US Department of Interior (USDI)
  - Land and Water Conservation Fund Grant Program
  - US Fish and Wildlife Wetland Grant Programs
- US Department of Commerce
  - National Oceanic and Atmospheric Agency (NOAA) Coastal Management Grants
- Multi-Agency Grant Programs
  - Great Lakes Restoration Initiative
  - Sustain Our Great Lakes

- LWCF Logo

- Property protected by NOAA-ODNR Coastal Management Program

We investigated federal expenditures in these programs that support efforts to reduce nutrients in Ohio and the Lake Erie basin between 2010 and 2015, and found substantial expenditures across these programs.[15] The non-USDA programs listed above represent about $162 million in investments to reduce nutrient flows by the federal government from 2010-2015 in the Lake Erie Basin. Over 330 individual projects were supported that directly or indirectly impact nutrient flow reductions within the Lake Erie Basin. In 2014, these programs invested in 67 projects totaling about $33 million in expenditures. In 2014 alone, USDA Farm Bill programs

[14] Farm Bill Programs include: Agricultural Conservation Easement Program, Conservation Technical Assistance, Conservation Stewardship Program, Conservation Innovation Grants, Environmental Quality Incentives Program, Conservation Reserve Program, Conservation Reserve Enhancement Program, Forest Legacy Program.

[15] We relied on publically available reports on expenditures and projects funded by these federal programs between 2010 and 2015. We summarized information related to the numbers of projects funded, the funding amount, and any available details on the projects, such as their purpose and implementation agency. We also differentiated among projects based on whether they: 1) were explicitly focused on nutrient reduction; 2) appeared likely to reduce nutrient flows indirectly through other conservation measures, and; 3) focused on education and research relevant to nutrient flows in the Ohio Lake Erie basin.

made investments exceeding $90 million statewide.[16] This USDA funding in 2014 implemented Best Management Practices on over 700,000 acres of land in Ohio.

As we conducted research underlying this project, we found it difficult to locate geographically specific information on the use of federal funds to implement nutrient controls by farmers and the agricultural community. Without this kind of information it is difficult to determine the extent to which agricultural practices to reduce nutrient loads are being implemented or to gauge their effectiveness. It appears that the difficulties we experienced in this area are not unusual. Rather, they appear to be at least partially traceable to Section 1619 of the 2008 federal Farm Bill (which is codified in 7 U.S.C. 8791) (Chite, 2014), which prohibits the release of any information on agricultural operations that is tied to participation in federal farm programs. Ultimately, addressing nutrient enrichment problems in the Lake Erie basin and elsewhere depends on developing, maintaining, and using a solid base of information on nutrient loadings and efforts made to reduce them.

- Property protected in part by ODNR's Nature Works Program

We also investigated state funding for non-point source nutrient control efforts in the Lake Erie basin[17]. We found that the State of Ohio also funds a number of programs that directly target non-point sources of nutrient flows to the state's waters, as well as programs that indirectly help reduce nutrient flows from non-point sources. The state agencies tasked with implementing state-funded non-point source pollution reductions have included:

- Ohio Department of Agriculture (ODA)
  - Agricultural Pollution Abatement Program
- Ohio Department of Natural Resources (ODNR)
  - Nature Works Grant Program
- Ohio Environmental Protection Agency (OEPA)
  - Surface Water Improvement Fund Grant Program
- Ohio Development Services Agency (ODSA)
  - Green Storm-water Infrastructure Loan Program
- Ohio Public Works Commission (OPWC)
  - Clean Ohio Green Space Protection Fund
- Ohio Lake Erie Commission (OLEC)
  - Lake Erie Protection Fund

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[16] We found that information on expenditures by some USDA programs more difficult to identify and collect than other nonpoint source expenditures. For this reason, we report only 2014 statewide figures here.

[17] We relied on publically available reports on expenditures and projects funded by state agencies between 2010 and 2015. We collected and summarized information on funding allocated, numbers of projects, and descriptive information on the funded projects (as available). This data collection approach is similar to the one that we used for assessing federal NPS expenditures.

The state funded non-point source programs represent about $135 million investment over the 2010-2015 time period (not including funds provided through the ODA Agricultural Pollution Abatement Program). Funds were utilized to support 244 projects that directly or indirectly targeted nutrient load reductions in Ohio's Lake Erie Basin.

Overall, the information presented above demonstrates that federal and state agencies have invested many millions of dollars in efforts to reduce nutrient flows in the Lake Erie basin. While these significant investments appear appropriate given the impacts of the HAB problem, it seems unlikely that significant investments – in and of themselves – represent an adequate remedy for the continuing HAB problems that confront the Lake Erie basin and the people and economy that depend upon it.

Strategy, Planning, and Communications Efforts Focused on Lake Erie

Through our web searches and discussions with Lake Erie water management professionals, we also identified multiple efforts by the State of Ohio, US federal agencies, and the international organizations with whom they work to define problems associated with nutrient flows to Lake Erie and communicate ways in which they can be addressed. Significant efforts and documents we encountered include the following:

- Lake Erie Binational Nutrient Management Strategy (2011)
- Directors' Agricultural Nutrients and Water Quality Working Group Final Report and Recommendations (2012)
- Great Lakes Water Quality Agreement (Annex 4) (2012)
- Lake Erie Commission (2013): Lake Erie Protection and Restoration Plan
- Ohio Lake Erie Phosphorus Task Force II Final Report (2013)
- OEPA (with ODA and ODNR): Ohio Nutrient Reduction Strategy (2013)
- International Joint Commission's Lake Erie Ecosystem Priority (LEEP) Report (2014)
- Great Lakes Commission: A Joint Action Plan for Lake Erie (2015)
- US and Canada Agreement on Nutrient Reduction Targets (2016)

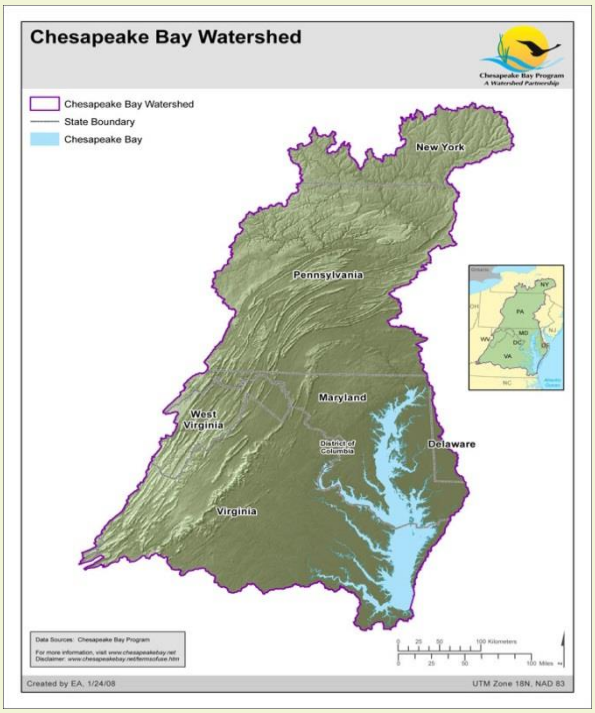
In most of these cases, these efforts were focused on characterizing the nutrient problem and signaling broad directions through which it could be addressed. However, in these cases, the focus was generally not on targeted communications with specific groups or individuals whose work or behaviors directly yielded nutrient flows to Lake Erie. While many of these documents were created in a collaborative fashion, involving multiple agencies and organizations, they often focused on broadly framing the issue and the strategies to address the problems. We were unable to identify a document that serves as a "one stop shop" that clearly delineates the roles and responsibilities of specific jurisdictions and agencies that can serve as a management framework. However, there may be an opportunity to create such a tool through the GLWQA Annex 4 process currently underway for Lake Erie.

Organization: Engaging Resources and Capacities to Reduce Nutrient Flows

We found ample evidence of government agency efforts to achieve nutrient reductions in the Lake Erie basin. We identified four federal agencies and six state agencies that have pursued this goal over the past five or six years, and these agencies funded and implemented numerous regulatory, financial assistance,

and information dissemination programs. What we did not find, however, was any single organization or organizational effort that manages ongoing implementation of interventions to achieve the goal of nutrient reduction in the Lake Erie basin. The Lake Erie Commission plays a valuable coordination role, but it is a small organization that was built to advise on the development of policy, not to steer and guide policy implementation. This point is exemplified by the fact that it took our team substantial time to compile the basic information on policy efforts currently in place to reduce nutrient flows in the Lake Erie basin. This experience appears symptomatic of substantial policy fragmentation, and a need to better enable coordination of nutrient reduction efforts in Ohio. This picture of fragmentation in Ohio is exacerbated when one recognizes that Ohio is just one of a number of political jurisdictions that have an interest in the quality of water in Lake Erie and in the control of nutrients that have been giving rise to HABs.

Nutrient Reduction Policies in Other American Water Basins: Chesapeake Bay, Long Island Sound, and Tampa Bay



- Chesapeake Bay Watershed (CBP, 2012)

Chesapeake Bay: Background and Accomplishments

The Chesapeake Bay watershed lies in the mid-Atlantic region of the US, and spans more than 64,000 square miles. It encompasses parts of six states—Delaware, Maryland, New York, Pennsylvania, Virginia and West Virginia—and the entire District of Columbia. For decades now, the Chesapeake Bay has endured stresses relating to the release of nitrogen, phosphorus, and sediments to the bay. In 1983, Maryland, Virginia, and Pennsylvania – along with the District of Columbia, the Chesapeake Bay Commission, and the USEPA – established the Chesapeake Bay Partnership (Chesapeake Bay Agreement, 2014). Following years of voluntary efforts to address nutrient enrichment in the Bay, USEPA released its Chesapeake Bay TMDL, the largest TMDL developed to date in the US in December of 2010.

The Chesapeake Bay Program and the states with which it works have begun implementing the Chesapeake Bay TMDL, as well as an accountability framework that was established to enable its success (described briefly below). Through this process, they have systematically reviewed information provided by the states on steps taken to reduce nutrient loads to the bay. The results of this tracking process are publicly available on the Chesapeake Bay Program website.

According to information drawn from this publicly available tracking system in early 2016, there have been nutrient load reductions of 13% for nitrogen and 10.5% of phosphorus between 2009 and 2015. These reductions brought total estimated loadings of nitrogen to 242 million pounds and phosphorus to 17 million pounds. The nitrogen and phosphorus loading goals for 2015 are 207,571,430 pounds and 14,457,190 pounds, respectively, so there is still much work needed to meet the CBP's long term nutrient reduction goals (Chesapeake Bay Stat, 2016). Even so, these estimated loading reductions, along with

some indicators of ambient water quality improvement in the bay (Langland et al, 2012; CBP, 2015) suggest that measureable progress in water quality improvement is being made.

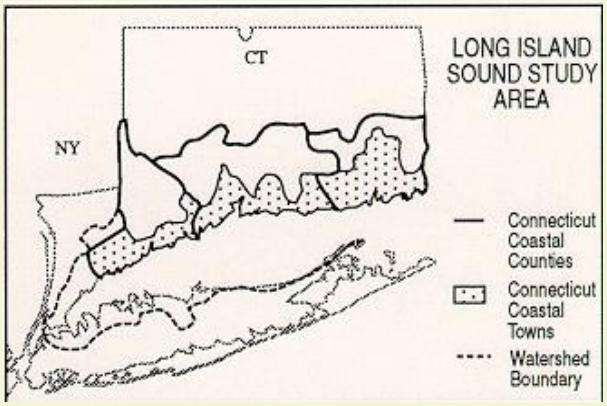
Policy Tools in the Chesapeake Bay

Through our efforts to review policies and programmatic efforts to address nutrients in the Chesapeake Bay Region we identified the following policy approaches and tools being developed and/or used in the Chesapeake Bay area that we did not encounter for the Ohio Lake Erie basin:

- A management framework consisting of 1) a scientific basis for integrated watershed and pollutant transport models across the entire Chesapeake Bay; 2) a tracking and accountability framework, and; 3) an organizational effort to implement nutrient controls that is commensurate with the scope of the bay's water quality problems.
- Water Quality Criteria and Standards for the Chesapeake Bay (USEPA and Delaware, Maryland, Virginia, and the District of Columbia)
- A TMDL framework for guiding nutrient reduction efforts
- Nutrient Management Requirements for Smaller Animal Feeding Operations (AFOs)
- Water Quality Trading Programs
- Agriculture Certainty Programs
- Innovative funding (Virginia's budget surplus Water Quality Improvement Fund)

Long Island Sound Study Program: Background and Accomplishments

The Long Island Sound drainage basin is about a quarter the size of the Chesapeake Bay's drainage basin, as it covers about 16,000 square miles of land from New York and Connecticut up into portions of New England (CCMP, 2015). One substantial water quality challenge facing the Sound is low levels of dissolved oxygen (DO), which yield anoxic zones that threaten fish and other aquatic species. This problem has been recognized for years now, and it is traceable to nitrogen loads released to the Sound from WWTP's in the surrounding urban areas, upstream agricultural sources, air deposition, and the ocean itself.



- Long Island Sound Study Area (LISS, 2016)

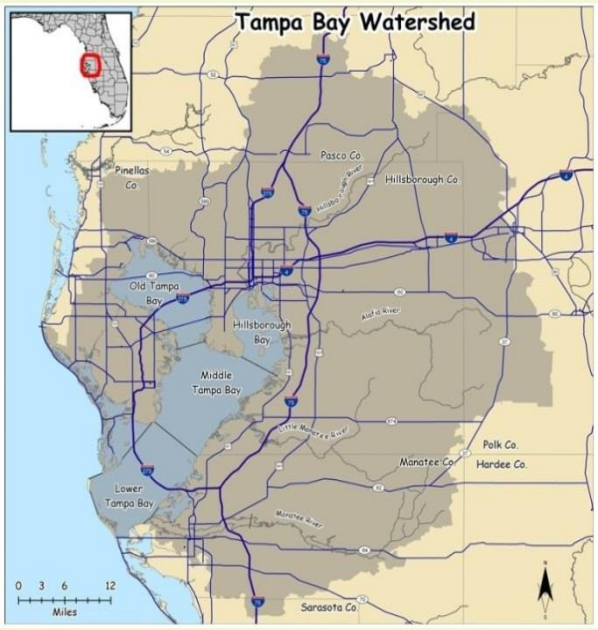
Through efforts at the state and federal levels, and the increased attention to the health of the Sound that was associated with them, USEPA and the states of New York and Connecticut established the Long Island Sound Study (LISS), "a Management Conference involving federal, state, interstate, and local agencies, universities, environmental groups, industry, and the public" (LISS, 2015). In 2001, the USEPA approved a multi-jurisdictional TMDL calling for a 58.5% reduction in nitrogen loads (LIS TMDL, 2000), a large proportion of which were to be achieved through upgrades to WWTP's.
In 2014, wastewater treatment facilities in the Sound's water basin were reported to have achieved "94% of the nitrogen reduction goal established in the USEPA approved DO TMDL, which means that 108,000 fewer pounds of nitrogen were discharged into the Sound every day" (LISS, 2015). In addition, the overall

trends appear to suggest that the size and durations of hypoxic areas size in the Sound appear to be diminishing.[18]

Policy Tools in the Long Island Sound

As was the case for other water basin programs reviewed during the course of this work, policy tools used in the Long Island Sound included regulatory interventions such as NPDES permits, funding support programs, and activities providing communications to broad audiences about the conditions of the Sound and the steps necessary to address them. Policy approaches and tools we encountered in the Long Island Sound that we did not identify in Ohio included:

- Connecticut's Effluent Trading Program which allows dischargers to trade their Waste Load Allocations across NPDES permits.
- New York's "Bubble" Permit Policy for New York City, through which the state has enabled the city to pool permitted nitrogen discharges together under two WLA "bubble" allocations. This enables the city to achieve its allocated reductions in whatever plants are most likely to yield the needed reductions in the most cost-effective fashion.
- A scientific network with ties to the Long Island Sound Study Program, which appears to serve as a cross-jurisdictional coordinating office.



-The Tampa Bay Watershed (TBEP, n.d.)

Tampa Bay Background and Accomplishments

While the Tampa Bay is much smaller than both the Chesapeake Bay and the Long Island Sound, it is the largest open water estuary in the State of Florida. Tampa Bay extends in a "Y" shape from the Gulf of Mexico, and covers about 400 square miles within a watershed of about 2600 square miles (Greening, 2014). Nitrogen is the nutrient of concern in the Bay, as it is reported to contribute to eutrophication and it affects both water quality in the Bay and the aquatic life that inhabits it.

In 1991, the Tampa Bay Estuary Program (TBEP) was established with support from USEPA. As with LISS, the TBEP benefited from funding provided through the NEP. The TBEP and its partners also adopted a Comprehensive Conservation and Management Plan (CCMP) that included measureable goals for the achievement of Tampa Bay's designated uses (Greening et al, 2014).

As a result of coordinated efforts between the public and private sectors in the Tampa Bay region, nutrient loadings are estimated to have been reduced by more than 50% since the 1970s (Greening, 2008).

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[18] While the trends suggested here are encouraging, it is important to recognize that they remain subject to both significant variability on a year to year basis and to long term change. In 2012, for example, the size of hypoxic area in the Sound increased dramatically due to climatic, temperature, and precipitation related factors.

However, because of population growth in the Tampa Bay Region, the overall level of nitrogen loading reduction is estimated to reflect an 80% reduction in per capita total nitrogen contributions to the Tampa Bay between the mid-1970's and 2010 (Greening, 2008). Importantly, these loading reductions have been accompanied enhanced compliance with "chloryphyll a" water quality targets for the Tampa Bay estuary in recent years (Greening et al, 2014).

Policy Tools in the Tampa Bay

As was the case with the other water basin programs we investigated, we found evidence of the use of regulatory permits, grant funding, and communications to broad audiences regarding to nutrient issues in Tampa Bay. We also identified policy approaches and tools in the Tampa Bay region that we did not identify in our Ohio Lake Erie Basin inventory. Some of these policy approaches and tools are outlined below:

- A public-private partnership, the Tampa Bay Nitrogen Management Consortium (TBNMC), comprised of public and private sector stakeholders who are concerned about water quality and economic vitality in the Tampa Bay area.
- A tracking and accountability system to measure ongoing progress in the implementation of nutrient reduction efforts
- State fertilizer law regulating turf grass fertilizer products and their application.
- Policies targeting Air Emissions of nitrogen
- Lawn Fertilizer Social Marketing Campaign
- An "Integrated Watershed-Groundwater-Circulation-Ecology Model" to provide a scientific foundation for nutrient reduction efforts.

Significance

The significance of this project lies in its compilation of information on nutrient reduction efforts in the Ohio Lake Erie basin and its review of othere basin-wide nutrient reduction efforts, as well as in the lessons and ideas it offers to inform policy discussions about ways to reduce nutrient flows to Lake Erie. We have found that federal government agencies and the State of Ohio are making *substantial* efforts to reduce nutrient flows in the Ohio Lake Erie basin. They are requiring many hundreds of federal and/or state permittees to assess and/or develop nutrient treatment and management capacities. They are spending many millions of dollars on nutrient reduction efforts. They are also collecting and disseminating information on nutrient enrichment, HABs, and ways in which these problems can be addressed. And finally, both federal and state governing entities are organizing multiple efforts to address and/or manage flows of nutrients to the Lake Erie water basin. In spite of these efforts, however, Ohio and its jurisdictional neighbors in the Great Lakes region continue to face challenges and threats associated with nutrient enrichment and HABs in Lake Erie.

Based on the information presented above, and other information compiled and analyzed during the course of this project, we offer at least two lessons for Ohio policymakers and natural resource practitioners. First, while the State of Ohio and federal government agencies are carrying out many activities to reduce nutrient flows, they appear to be fragmented. They do not appear to be implemented in a way that adheres to a single coordinated and focused nutrient reduction strategy targeted to the Ohio Lake Erie basin. Second, at least several other water basin programs around the US appear to be focusing their nutrient reduction efforts in strategic and coordinated fashion, and these efforts appear to be

characterized by not only clearly articulated goals but also by tracking and accountability structures that measure progress toward achieving the goals that have been established. While the international character of the Lake Erie basin creates additional challenges not faced by other water basin programs, it seems appropriate to accept these challenges and address them as a part of an effort to achieve a focused and strategic implementation of Lake Erie nutrient reduction efforts.

Our inventory of current Ohio Lake Erie basin nutrient reduction policies and assessment of other American water basin programs has yielded multiple ideas regarding specific policies and practices that can be considered for the Ohio Lake Erie basin. Below, we present a number of these ideas in three broad categories: 1) Institutionalization of nutrient reduction efforts across organizations and jurisdictions; 2) Strengthening point source nutrient reduction efforts, and; 3) Strengthening nonpoint source nutrient reduction efforts.

It is important to recognize that we offer these policy ideas – at least at this point in time -- as a menu of possible options, rather than as recommendations for immediate implementation. This is because each of the suggestions below deserves more thought and evaluation than we could provide as a part of this assessment. For example, some of the ideas below could result in reduced nutrient flows, but at costs that far exceed their benefits in terms of nutrient flow reduction. In other cases, it may be that ideas presented below are already being initiated and/or implemented in some way. However, the use of a number of these policy approaches and tools by water basin programs that appear to be moving forward in productive fashion – along with the seriousness of the Lake Erie HAB problem -- makes these ideas worthy of active consideration.

<u>Institutionalizing Nutrient Reduction Efforts Across Organizations and Jurisdictions</u>

The State of Ohio should actively consider:

- Establishing and adequately funding one central organization and tasking it with responsibility for coordinating, tracking, and *assuring implementation* of nutrient reduction efforts across the Ohio Lake Erie basin.
    - As a part of this effort, this organization should develop a coordinated system for tracking implementation actions and assuring accountability for nutrient reduction efforts in the Ohio Lake Erie basin.
    - Over time, this effort should be coordinated with, and expanded to include, other jurisdictions in the Lake Erie basin.

- Working actively with other jurisdictions in the Lake Erie basin to establish an integrated basin-wide monitoring and modeling effort that enables an integrated basin-wide understanding of ways in which specific nutrient reduction efforts may yield improvement of water quality in Lake Erie. Our discussions suggest that valuable and significant water quality monitoring and modeling efforts are being undertaken, but it appears that there may be a need to enhance the integration and coordination of these effort across funding organizations and governing jurisdictions. The efforts made to model and monitor nutrient flows in the Chesapeake Bay area provide a potential model for consideration in this regard.

- Developing a consortium of entities with a stake (economic and otherwise) in the future of Lake Erie, and forming a broad private-public sector partnership or consortium devoted to reducing

nutrient flows in the Lake Erie Basin. The nutrient management consortium managed in the Tampa Bay area provides a potential model for consideration in this regard.

- Developing and expanding pollution *abatement* strategies for nutrient flows, based on the GLWQA Annex 4 process and the water quality goals that underlying them.[19] However, over time, Ohio may also want to consider: 1) creating formal water quality standards for nutrients in Lake Erie (hopefully, ones that are consistent with the GLWQA agreement goals), and; 2) declaring impairment(s) of the Lake consistent with those standards after they are promulgated.

Strengthening Point Source Nutrient Controls

The State of Ohio should actively consider:

- Developing and implementing more comprehensive nutrient management requirements for animal feeding operations (and potentially other agricultural sectors), perhaps similar to those being implemented in Maryland.

- Reviewing existing NPDES nutrient-related permit requirements – as well as available data on nutrient concentrations in wastewater releases -- for dischargers in the Lake Erie basin. It appears as though Ohio is already moving in this direction to at least some extent. Requirements included in recent legislation (SB 1) mandate that major POTWs monitor total *and* dissolved reactive phosphorus pursuant to a new, renewed, or modified NPDES permit. In addition, all major POTWs that are not subject to a phosphorus limit will need to complete and submit to OEPA a study that evaluates the technical and financial capability of the existing treatment facility to reduce the final discharge of phosphorus to 1 mg/L. While these requirements appear to be useful steps, consideration should also be given to expanding nutrient reduction requirements to smaller POTWs and/or other NPDES permittees which are known to discharge phosphorus and nitrogen. In addition, for larger POTWs, consideration should be given to strengthening current nutrient controls, perhaps in ways that move toward and/or are consistent with the GLWQA's suggested .5 mg/l average monthly concentration limit for total phosphorus.

  Relatedly, the State of Ohio should review the manner in which it is currently funding and seeking to regulate both storm water flows for separated sewerage systems and animal feeding operations. While we found clear evidence of federal and state regulatory interventions in both of these areas, we did not encounter publicly available evidence demonstrating full implementation and compliance with these regulatory requirements. For this reason, it seems appropriate to evaluate current practices and funding levels for these programs to assure they can and are accomplishing their intended purposes.

- Investigating and considering water quality effluent trading and/or bubble permit programs for nutrient control in the Lake Erie basin. Here, lessons can be learned from the existing programs in Virginia, Connecticut, New York, and Ohio's Miami River basin.

[19] It is appropriate to acknowledge that this process already appears to be underway, to at least some extent.

Strengthening Nonpoint Source Control Efforts

The State of Ohio should actively consider:

- Engaging with the agricultural community in the state to enable greater generation and use of geographically based information on the implementation of BMPs and other nutrient reduction based agricultural management approaches. Exploring possible collaborative efforts with the agricultural community to allow for access to this information seems appropriate because privacy protection language included in the US Farm Bill appears to have made it difficult to gain access to the information needed to fully evaluate the effectiveness of existing agricultural cost share and financial assistance programs.

- Developing a budget surplus set aside policy that is targeted to support ongoing nutrient reduction efforts in the Lake Erie basin (and perhaps the Ohio River basin as well), perhaps similar to what has been done in Virginia.

- Developing and supporting voluntary initiatives to increase awareness and use of fertilizers on lawns and in other environments.

- Establishing state lawn fertilizer requirements, as we understand has been done in Florida.

- Developing a livestock exclusion and buffer zone support program to minimize nutrient flows to nearby water bodies, perhaps similar to the one that has been implemented in Virginia.

- Developing a Resource Management Plan and Agricultural Uncertainty program, perhaps modeled in part on the work that Virginia and Maryland have done in this area.

Over the next year or two, as political commitments within and across jurisdictions are solidified and allocations of nutrient reduction responsibility across jurisdictions and economic sectors are identified through the GLWQA agreement process, it will become important to identify ways to reduce nutrient flows to the Lake Erie basin in ways that will combat excessive nutrient enrichment and the HABs that are increasingly associated with it. Our hope is that the public management lessons and policy tools identified above can productively inform discussions about how best to accomplish the substantial reductions in nutrient flows that are necessary to accomplish these water quality goals.

References

Associated Press. "Record-breaking Lake Erie algae bloom was size of New York City". Accessed November 11, 2015. http://www.cbsnews.com/news/record-breaking-lake-erie-algae-bloom-was-size-of-new-york-city/. Last modified 2015.

Austin, J., Anderson, S., Courant, P., Litan, R. "Healthy Waters, Strong Economy: The Benefits of Restoring the Great Lakes Ecosystem." The Brookings Institution. 2007.

Chesapeake Bay Program (CBP). "Experts Consider Chesapeake Bay an Ecosystem in Recovery." Chesapeake Bay News. February 03, 2015. Accessed 2016. http://www.chesapeakebay.net/blog/post/experts_consider_chesapeake_bay_an_ecosystem_in_recovery .

Chesapeake Bay Program. "Water Quality: TMDL Tracking." Chesapeake Bay Program. February 2016. Accessed 2016. https://stat.chesapeakebay.net/?q=node/130.

Chesapeake Bay Watershed Agreement. "Chesapeake Bay Watershed Agreement." Chesapeake Bay. 2014. Accessed 2016. http://www.chesapeakebay.net/documents/ChesapeakeBayWatershedAgreemenetFINAL.pdf .

Chite, Ralph. "The 2014 Farm Bill (P.L. 113-79): Summary and Side-by-Side." Farmland Information Center. 2014.

Great Lakes Commission (GLC) Nutrient Management: A Summary of State and Provincial Programs in the Great Lakes – St. Lawrence River Region. 2012.

Great Lakes Commission (GLC). "An Interim Joint Action Plan for Lake Erie." Great Lakes Commission. June 2015. Accessed 2016. http://glc.org/files/projects/lent/FINAL-LENT-interim-Joint-Action-Plan-June-2015.pdf .

Great Lakes Water Quality Agreement (GLWQA). 2012. Retrieved from http://www.ijc.org/en_/Great_Lakes_Water_Quality.

Greening, Holly. "Tampa Bay Nitrogen Management Consortium: RA and TMDL Update". Tampa Bay Estuary Program. November 2008.

Greening, Holly. "What's Working in Tampa Bay: Nitrogen Management Consortium". Tampa Bay Estuary Program. February 2014.

Greening, H., Janicki, A., Sherwood, E.T., R. Pribble, Johansson, J. *Ecosystem Responses to Long-Term Nutrient Management in an Urban Estuary: Tampa Bay, Florida.* Estuarine, Coastal and Shelf Science. 151 (2014) A1-A16.

Hood, Christopher. *The Tools of Government*. London, Macmillan, 1983.

International Joint Commission (IJC). "Phosphorus Management for the Great Lakes: Final Report of the Phosphorus Management Strategies Task Force." International Joint Commission. July 08, 1980. http://www.ijc.org/files/publications/D16.pdf

International Joint Commission (IJC). *A Balanced Diet for Lake Erie: Reducing Phosphorus Loadings and Harmful Algal Blooms*. 2014.

Langland, Michael, Blomquist, Joel, Moyer, Douglas, and Hyer, Kenneth. "Nutrient and suspended-sediment trends, loads, and yields and development of an indicator of stream water quality at non tidal sites in the Chesapeake Bay watershed", 1985–2010: U.S. Geological Survey Scientific Investigations Report 2012-5093, 26 p. (2012). (Also available online at http://pubs.usgs.gov/sir/2012/5093/

Long Island Sound Study (LISS). "2015 Comprehensive Conservation and Management Plan." Long Island Sound Study. September 16, 2015. Accessed 2016. http://longislandsoundstudy.net/2015/09/2015-comprehensive-conservation-and-management-plan/

Long Island Sound (LIS) TMDL. A Total Maximum Daily Load Analysis to Achieve Water Quality Standards for Dissolved Oxygen in Long Island Sound. Prepared by the New York State Department of Environmental Conservation and the Conneticut Department of Environmental Protection. 2000.

Lucas County Board of Commissioners. Moving Forward: Legal Solutions to Lake Erie's Harmful Algal Blooms. Report prepared for the Lucas County Board of Commissioners by Jack Tuholske and Ken Kilbert. 2015.

Ohio Clean Lakes Initiative. "Ohio Strengthens Efforts to Further Protect Lake Erie." Governor of Ohio, John R. Kasich. August 14, 2014. Accessed 2015. http://www.governor.ohio.gov/Portals/0/08.14.14%20Protecting%20Lake%20Erie%20Fact%20Sheet.pdf

Ohio Environmental Protection Agency. *State of Ohio Water Pollution Control Loan Fund: Final 2015 Program Management Plan.* 2014.

Ohio Environmental Protection Agency (OEPA)."Combined Sewer Overflow Control Program." 2015.Accessed April 04, 2016. http://www.epa.ohio.gov/dsw/cso/csoindex.aspx#116135672-how-many-csos-are-in-ohio

Ohio Phosphorous Task Force (Task Force). *Ohio Lake Erie Phosphorus Task Force II: Final Report*. (2013).

Ohio Sea Grant. "Harmful Algal Blooms in Ohio Waters: Ohio Sea Grant Fact Sheets". Ohio State University, 2011

Ohio Water Development Authority. "2010-2014 Annual Reports".

United States Environmental Protection Agency (USEPA) Press Release. "Governments of Canada and the United States Announce Phosphorus Reduction Targets of 40 Percent to Improve Lake Erie Water Quality and Reduce Public Health Risk." United States Environmental Protection Agency (EPA). February 22, 2016a. Accessed 2016. http://yosemite.epa.gov/opa/admpress.nsf/0/D6FB4CB50080797585257F610067D8BD

United States Environmental Protection Agency (U.S. EPA). "Supplemental Module: NPDES Permit Program." EPA. March 4, 2016b. Accessed 2016. https://www.epa.gov/wqs-tech/supplemental-module-npdes-permit-program .

Zingone, Adriana, and Henrik Oksfeldt Enevoldsen. "The diversity of harmful algal blooms: a challenge or science and management." *Ocean & Coastal Management* 43, no. 8 (2000): 725-748.

Appendix 1: List of Basin Programs in other States

NEP Programs

1. Albemarle-Pamlico National Estuary Program
2. Barataria-Terrebonne National Estuary Program
3. Barnegat Bay Partnership
4. Buzzards Bay National Estuary Program
5. Casco Bay Estuary Partnership
6. Charlotte Harbor National Estuary Program
7. Coastal Bend Bays and Estuaries Program
8. Delaware Center for the Inland Bays
9. Galveston Bay Estuary Program
10. Indian River Lagoon National Estuary Program
11. Long Island Sound Study
12. Lower Columbia Estuary Partnership
13. Maryland Coastal Bays Program
14. Massachusetts Bays Program
15. Mobile Bay National Estuary Program
16. Morro Bay National Estuary Program
17. Narragansett Bay Estuary Program
18. New York-New Jersey Harbor Estuary Program
19. Partnership for the Delaware Estuary
20. Peconic Estuary Program
21. Piscataqua Region Estuaries Partnership
22. Puget Sound Partnership
23. San Francisco Estuary Partnership
24. San Juan Bay Estuary Partnership
25. Santa Monica Bay Restoration Commission
26. Sarasota Bay Estuary Program
27. Tampa Bay Estuary Program
28. Tillamook Estuaries Partnership

Programs Outside NEP

29. Boston Harbor
30. Chesapeake Bay
31. Great Lakes Program
32. Gulf of Mexico

Appendix 2: List of Federal and State Programs Targeting Nutrients

State Non-Point Source Programs:

1. Ohio Department of Natural Resources (ODNR) – Nature Works
2. Ohio Environmental Protection Agency (OEPA)- Surface Water Improvement Fund
3. OEPA – Water Resource Restoration Sponsorship Program
4. Ohio Development Services Agency – Green Storm water Infrastructure loans
5. Ohio Public Works Commission – Clean Ohio Greenspace
6. Lake Erie Commission – Lake Erie Protection Fund

State Point Source Programs (these programs do receive federal funding as well)

1. OEPA and Ohio Water Development Authority (OWDA) - Water Pollution Control Loan Fund
2. OWDA - Fresh Water Fund
3. OWDA - Un-sewered area assistance account
4. OWDA - Community Assistance Fund

Federal NPS Programs

1. Environmental Protection Agency (EPA) – Clean Water Act Section 319 Grant Program
2. EPA – Urban Waters Small Grant Program
3. Department of Interior (DOI) – Land and Water Conservation Fund
4. DOI – US Fish and Wildlife Services (USFWS)- North American Wetlands Conservation Act
5. DOI - USFWS National Coastal Wetlands Conservation Grant Program
6. DOC-NOAA – Coastal Zone Program
7. Multi-agency – Great Lakes Restoration Initiative
8. Multi-agency – Sustain Our Great Lakes program
9. US Department of Agriculture (USDA) – Agriculture Conservation Easement Program
10. USDA – Conservation Technical Assistance
11. USDA – Conservation Stewardship Program
12. USDA – Conservation Innovation Grants
13. USDA – Environmental Quality Incentives Program
14. USDA – Conservation Reserve Program
15. USDA – Conservation Reserve Enhancement Program
16. USDA – Forest Legacy Program