Ohio | Environmental Protection Agency
John R. Kasich, Governor
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November 15, 2011

Tinka Hyde, Director
Water Division (W-15J)
U.S. EPA Region 5
77 West Jackson Blvd.
Chicago, Illinois 60604-3507

Dear Ms. Hyde:

I am pleased to transmit herein a document entitled *Nutrient Reduction Strategy Framework for Ohio Waters – DRAFT*.

Ohio EPA Division of Surface water staff have worked in collaboration with John Kessler, Ohio Department of Natural Resources, and Kevin Elder, Ohio Department Agricultural, to compile this framework on what we know about water quality problems in Ohio caused by nutrients, what we think needs to be done in very broad terms, and how we as a State intend to develop specific implementation strategies that will reduce nutrient loadings and bring about water quality improvements.

If you have any questions, please contact Dan Dudley at (614) 644-2876 or via email at dan.dudley@epa.state.oh.us. I look forward to your review of this framework.

Sincerely,

George Elmaraghy

George Elmaraghy, P.E., Chief
Division of Surface Water

Enclosure

cc: Tim Henry, U.S. EPA Region 5
Tom Davenport, U.S. EPA Region 5
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Nutrient Reduction Strategy Framework for Ohio Waters

Prepared by

Ohio EPA, Division of Surface Water

with contributions from

Ohio Department of Agriculture, Livestock Environmental Permitting Program

Ohio Department of Natural Resources, Division of Soil and Water Resources

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D) Free from substances entering the waters as a result of human activity in concentrations that are toxic or harmful to human, animal or aquatic life and/or are rapidly lethal in the mixing zone; 86

Introduction

Nutrients Are Damaging Ohio's Water Quality

Conditions in Ohio's surface waters have reached a critical situation with regards to pollution impacts caused by nutrients. This reality is apparent if one looks at the condition of Ohio's waterways:

- harmful algal blooms (HABs) are common on Lake Erie and inland lakes;
- the issuance of public health warnings to avoid swimming;
- widespread nuisance growths of aquatic vegetation;
- increased water treatment costs for clean public water supplies
- changes in aquatic communities and declining fisheries;
- renewed concern over the increased size of anoxic areas in Lake Erie (see box); and
- fewer dollars being spent on water based recreation and tourism.

To address these problems Ohioans need to make radical changes regarding the management of agricultural and urban landscapes to minimize the loss of nutrients to our waterways. And further consideration must be given to the design, construction and operation of nutrient removal technologies at wastewater treatment facilities. The nature of these changes and the approaches taken by governmental agencies, agri-businesses, farmers, landowners, wastewater treatment service providers and researchers are must be constructively debated and quickly implemented if further damage to the environment is to be avoided. The purpose of this document is to create a useful, widely accepted framework to develop and implement nutrient reductions strategies in Ohio waters.

Recent Trends

Impacts caused by nutrient pollution have become more evident in the past several years. The summer of 2010 exhibited some of the worse water quality conditions in recent memory at inland lakes and Lake Erie beaches. Blooms of cyanobacteria were seen in, Grand Lake Saint Marys and 19 other inland lakes (see Figure 1). Extensive blooms covered western Lake Erie in 2010 and 2011.

Lake Erie Anoxia

In the past few years, concern has risen about the increasing size of the area of anoxia at the bottom of the central basin. This condition develops in late summer when oxygen in the hypolimnion of the central basin becomes depleted following bacterial decomposition of dead algae and other organic materials. Thermal stratification of the water prevents surface water oxygen from being remixed into the deeper waters. The result is an area in which most organisms are unable to survive. To some degree, anoxia occurs as a natural event, however, the unexpected increase in area suggested something more than natural conditions.

The increased area of anoxia and higher spring phosphorus concentrations in the lake led the U.S. EPA to fund a two-year study to determine why this is occurring. Numerous researchers on both the U.S. and Canadian sides of the lake are cooperating in this investigation.

Increased phosphorus concentrations in the lake are a suspected cause of the expanded anoxic area. Invasive species such as zebra mussels, quagga mussels, and gobies may also be altering Lake Erie's ecosystem in as yet unknown ways to contribute to the anoxia. Other suspected causes are low lake levels, changing weather patterns, and alterations in the internal processes in the lake. (State of the Lake Report, 2004. Ohio Lake Erie Commission)

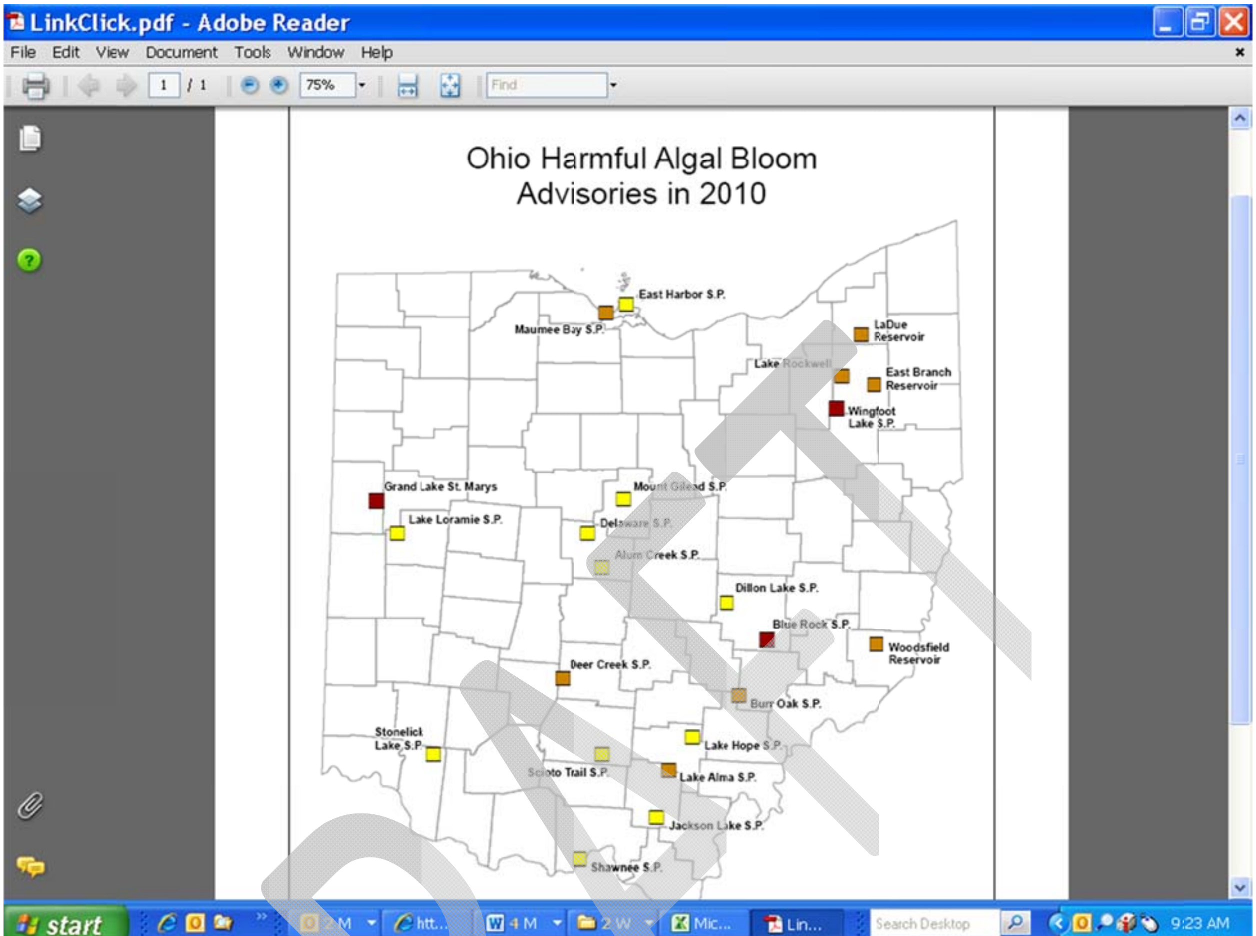


Figure 1. Ohio lakes where public health advisories were posted in 2010 on account of potentially harmful algal blooms.

These blooms prompted advisories to limit recreation in and on the water. Other types of aquatic vegetation reached nuisance levels by fouling boat motors and washing up on beaches. As a result local communities saw dramatic declines in tourism and its associated economic activity causing economic hardship for small business owners. Drinking water supplies experienced taste and odor problems and increased water treatment costs. The presence of toxins produced by cyanobacteria was detected in raw water supplies and trace amounts were occasionally detected in treated water. Fortunately there were no interruptions in drinking water supplies in 2010, but given the toxin levels recorded the future risk of service interruptions is real.

In the face of this evidence most water resource professionals agree that nutrient enriched waters have reached a critical stage and that immediate actions must be taken to reduce the amount of nutrients reaching our waterways. The search for solutions to water pollution problems can begin by looking at existing federal and state authorities. However, as this report will describe that search has failed to identify a complete set of solutions that are adequately funded and fully capable of delivering solutions. If we want to protect our water Ohioans will need to solve these problems with the tools we have using innovation and our own initiative.

National Nutrient Pollution Priorities

Concerns over nutrient enrichment or cultural euthophication are not new. Widespread pollution from sewage and runoff led to gradual but marked declines in the water quality and fisheries of the Great Lakes, Lake Champlain, Lake Tahoe, Lake Washington near Seattle and many other bodies of water.

With the passage of the Clean Water Act in 1972 and the eventually funding of a construction grants program to build sewage treatment plants a significant decline in phosphorus loading was achieved. Elimination of phosphorus in detergents and the adoption of no-till agricultural also contributed to reductions in total pollutant loadings in the Great Lakes and elsewhere. The pollutant loading reductions were matched by measureable improvements in water quality. Following these initial successes with nutrients the programmatic attention of many water resource agencies shifted to the control of toxic chemicals, combined sewer overflows and the effects of changing land use on storm water runoff. Meanwhile aquatic ecosystems continued to receive high levels of nutrients. The collapse of large scale ecosystems that serve as nutrient sinks such as the Chesapeake Bay and Long Island Sound and the hypoxic zones in Lake Erie and the Gulf of Mexico provide amble evidence that the nation faces an urgent water pollution problem. Added to the ecological problems are the costs and human health concerns associated with excessive nitrogen loading to surface and ground waters. Water supplies with nitrate levels above 10 mg/l are unsafe and recent data suggest a doubling of drinking water system violations impacting the quality of water for nearly 2 million people.

Over the past decade there has been a growing call for renewed attention to nutrient pollution. Some of the more significant national program directives and reports are listed below.

Selected Document and Reports on National Nutrient Pollution

EPA Memorandum on Policy / Program Direction

- Working in Partnership with States to Address Phosphorus and Nitrogen Pollution through Use of a Framework for State Nutrient Reductions. N. Stoner, EPA AA, 03/16/11
- Nutrient Pollution and Numeric Water Quality Standards. Benjamin Grumbles, EPA AA, 05/25/07
- Development and Adoption of Nutrient Criteria into Water Quality Standards. G. Grubbs, EPA, OST, 11/14/01

Program Assessments and Technical Reports

- An Urgent Call to Action: Report of the State-EPA Nutrient Innovations Task Group (August 2009)
- EPA Needs to Accelerate Adoption of Numeric Nutrient Water Quality Standards Report No. 09-P-0223 EPA Office of Inspector General (08/26/09)
- EPA Science Advisory Board: *Reactive Nitrogen in the United States: An Analysis of Inputs, Flows, Consequences, and Management Options* (USEPA 2009a)
- EPA Science Advisory Board: *Hypoxia in the Northern Gulf of Mexico* (USEPA 2007c)
- Nation Research Council: *Mississippi River Water Quality and the Clean Water Act: Progress, Challenges, and Opportunities* (NRC 2008a)
- NOAA: *Effects of Nutrient Enrichment in the Nation's Estuaries: A Decade of Change* (Bricker et al. 2007

It is clear from these and other documents that the debate is not over "is there a problem" but rather "what should be done to solve the problem." For over a decade the USEPA has made nutrient pollution and the adoption of State WQS for nitrogen and phosphorus one of the top water program priorities. Efforts to control nutrient runoff have met with mixed results at best, and very few States have adopted WQS for nutrients. At the national level there seems to be no consensus on what should be done next. If Ohioans want to protect their valuable water resources then we must act to develop a cohesive strategy based upon our knowledge base and the skill sets and strengths of our water quality and resource agencies.

Ohio's Plan of Action

Ohio has initiated a number of actions in response to the unprecedented symptoms of nutrient enrichment that were seen in 2010. A monitoring and response plan has been prepared to assess water quality and to warn the public when conditions are un-safe. At hard-hit GLSMs specific steps are underway to reduce in-lake phosphorus concentrations through the addition of alum and other experimental techniques. Overall loadings from the predominately agricultural watershed are being closely monitored. New regulations enable the Chief of the Division of Soil and Water at Ohio DNR to declare "distress watershed status" thereby requiring all producers to improve manure management practices over time. GLSM is now Ohio's first "distressed watershed" and significant resources are dedicated to educating and assisting producers with compliance. While all these steps are important and significant they represent stop gap measures to address the most immediate symptoms of nutrient enrichment. A more comprehensive look at nutrients in Ohio is necessary if we are to effectively curb the many sources of nutrients and ensure that Ohio's drinking water and surface waters are protected.

This report is a preliminary assessment of nutrient enrichment problems in Ohio, what is currently being done, and what else needs to be done to restore and maintain good water quality. Nutrient problems have not arisen overnight, and they won't disappear quickly. A key observation made by Ohio EPA personnel is that past and current approaches in the management both point source and NPS nutrient control programs have to change. To succeed we need to spur the development and implementation of innovative long term nutrient reduction programs. This report serves as a starting point in defining the State's strategy for achieving nutrient reductions.

As the State's water quality agency Ohio EPA has the lead role in strategy development. However, we cannot fully develop and accomplish what is needed without the involvement and assistance of other State and federal agencies and departments, the regulated community, agricultural producers, and a wide range of industry and public interest groups. Ideally the collective and individual input from all these parties will help shape the final set of nutrient reduction strategies. See the final section of this report for additional discussion. Every organization and interest group that has a stake in how nutrient reductions are achieved needs to constructively participate and agree to move forward with a common sense plan that protects drinking water supplies and surface waters. If recent water quality trends continue the costs of inaction will soon outweigh the costs of controlling nutrient inputs.

Assessment of Water Quality

This section briefly describes Ohio's water resource and the methods used to assess water quality in Ohio and the water quality conditions of Lake Erie, Ohio's inland lakes and Ohio's rivers and stream are reported. Estimated loading rates of nitrogen and phosphorus from various source categories are provided.

Ohio's Water Resources

Compared to other parts of the world and the United States Ohio is blessed with ample water resources. The State has more than 29,000 miles of perennial rivers and streams with 24 stream and river reaches designated as State Wild, Scenic, or Recreational Rivers (amount to over 800 miles). Ohio also has a 451 mile border on the Ohio River, 447 publicly owned lakes, ponds, and reservoirs greater than 5 acres (118,963 total acres), and 290 miles of Lake Erie mainland and islands shoreline. Originally, Ohio had about 5 million acres of wetlands; today the wetland resource is estimated at about 500,000 acres.

Clean water is a valuable asset and one that will likely become more valuable in the coming years. At the same time the stresses placed on the nation's water resource are growing due to population growth, increased demand for food crops, urban land development and climate change. This section summarizes how water quality is assessed in Ohio, provides a summary of the general condition of the State's waters and estimates nutrient contributions for several source categories.

Condition of Lake Erie

Most data on the condition of Lake Erie is collected through research performed by USEPA, NOAA, IJC, the Canadian government and university researchers. Information and recommendations regarding nutrients in Lake Erie has been summarized in a report entitled *"Status of Nutrients in the Lake Erie Basin, Lake Erie Nutrient Science Task Group for the Lake Erie Lakewide Management Plan"* (USEPA 2009). Excerpts of key findings are presented on the next page.

In consultation with Heidelberg University, Ohio EPA convened the Ohio Lake Erie Phosphorus Task Force in 2007 to review and evaluate the increasing dissolved reactive phosphorus (DRP) loading trends and the connection to the deteriorating conditions in Lake Erie. The Task Force was charged to identify and evaluate potential point and nonpoint sources and related activities that might be contributing to the increasing trends in DRP. The Task Force included a wide range of participants and presentations by invited experts in a variety of disciplines. This report presents the findings of the Task Force along with recommendations for future management actions for Ohio.

Excepts taken from *Status of Nutrients in the Lake Erie Basin (2009)*
Prepared by the Lake Erie Nutrient Science Task Group
for the Lake Erie Lakewide Management Plan

- Algal problems in some parts of Lake Erie are caused by excessive phosphorus concentrations. Previous nutrient controls, while effective at limiting eutrophication, are now insufficient given the mix of species, including exotics, and, possibly, warming effects in the lake. More control of phosphorus is needed to decrease problem algae but this control can be best directed towards the most problematic areas such as rivers with high nutrient concentrations.
- Addressing the algal problems of the west basin would cause a decrease in whole lake phosphorus load and concentration, which may benefit the *Cladophora* problem.
- The main mitigation targets remain agricultural and urban runoff and municipal sewage.
- Some rivers have so much phosphorus that they require intense remediation to ameliorate local algal blooms.
- The status of the lake needs to be constantly updated and assessed with a vigorous science program (monitoring and research). The future availability of long term data is critical to assessing the lake's progress and whether or not more management is needed. One way to enhance these activities is to include routine assessments made possible with remote sensing. The science priorities should be in the context of assessing progress and facilitating achievement of LaMP goals. An example of useful long term data would be the abundance of Dreissenid mussel veligers (planktonic immature stage) and their settlement, and the abundance of adults. Some work has been done but not annually on a whole lake basis.
- Interventions including incentives, education, awareness, policies, market mechanisms as well as scientifically derived techniques need to be developed and implemented to deal with the excessive phosphorus in larger rivers with the highest nutrient concentrations.
- There should be an examination of performance and potential for improvement with various levels of technology of phosphorus treatment at key sewage plants discharging to Lake Erie and tributaries.
- All nutrient sources, including urban runoff both direct and as combined sewer overflows or WWTP bypassing, should be assessed in terms of overall nutrient reduction strategy in a whole lake framework that would help prioritize actions.
- Phosphorus in agricultural fertilizers should be adjusted to fit individual needs.

Ongoing and Future Lake Erie Monitoring by Ohio EPA

Ohio EPA was awarded a Great Lakes Restoration Initiative (GLRI) grant in 2010 to develop a comprehensive Lake Erie nearshore monitoring program. This project will design and implement a monitoring program for the Ohio Lake Erie nearshore zone (including bays, harbors and estuaries) that can be maintained on an annual basis. Annex 11 of the Great Lakes Water Quality Agreement recommends a comprehensive surveillance and monitoring program for the Great Lakes to evaluate water quality trends, assess the effectiveness of remedial programs, measure compliance with jurisdictional regulatory programs, identify emerging problems, and support the development of remedial action plans and lakewide management plans. Such a program has existed with wide-ranging variability since it was first proposed more than 20 years ago.

The nearshore area is the most utilized, visible, impacted and dynamic area of the lake, yet it has not been comprehensively assessed for Lake Erie since a 1978 and 1979 nearshore intensive survey. Since that time conditions in the lake have changed considerably. Implementation of Clean Water Act programs significantly decreased the loads of toxic chemicals, nutrients, and sediment and resulted in a much improved Lake Erie ecosystem by the early 1980s. The invasion of dreissenids (zebra and quagga mussels) beginning in the late 1980s initiated dramatic changes in the internal dynamics of the lake affecting the food chain as well as water quality. In the mid 1990s, cyanobacteria (blue-green algae) blooms returned to the lake and have been increasing in temporal and spatial intensity ever since. These cyanobacterial blooms differ from those of the 1960s and 1970s as they are now composed largely of *Microcystis aeruginosa,* a toxin-producing species included under the Harmful Algal Blooms (HABs) umbrella. If present in high enough concentrations, these toxins can impact the health of humans and animals. Shoreline and shallow water growths of the filamentous algal species of *Lyngbya* and *Cladophora* are present at elevated nuisance levels in certain areas. It has also been documented that the tributary loads of dissolved reactive phosphorus and the concentrations of phosphorus in the lake have been increasing since the mid 1990s. Eutrophic conditions have returned.

The 1978-1979 intensive survey of Lake Erie divided the nearshore areas of the lake into 20 segments, or reaches, for data analysis purposes. Eight of these reaches lie along the Ohio portion of the Lake Erie shoreline, three within the Western Basin and five within the Central Basin. The GLRI grant strategy for sampling the nearshore areas of Lake Erie utilizes these segments for the placement of stations along the Ohio shoreline.

A network of eleven ambient nearshore monitoring stations, located at or near the original 1978-1979 sampling locations, has been established. One station is located in each reach area with the exception of one reach in the Western Basin and two in the Central Basin where two stations will be used. Additionally, a station has been established in Sandusky Bay. As one of several integral components of the GLRI grant plan of study, each ambient station will be sampled five times during each of the 2011 and 2013 survey seasons. One sample will be collected prior to the lake stratifying which normally occurs in mid June. Three samples will be collected approximately once per month during the time that the lake is stratified. A final sample will be collected after the lake is no longer stratified which usually occurs in mid September. Sample parameter coverage will include a full suite of physical, chemical water quality, and biological measurements.

The goals of the 2011-2013 Lake Erie nearshore monitoring program are as follows:

- To further develop methods and expertise which will allow for routine monitoring of the nearshore areas of Lake Erie by Ohio EPA,
- To provide current data regarding the limnological and biological characteristics of the nearshore areas that can be used to evaluate water quality trends,
- To provide additional information regarding the distribution and abundance of species of concern (e.g. *Microcystis*, a potentially toxic algae, and *Bythotrephes*, the spiny water flea) which will be useful in lake-wide data development,
- To provide baseline data and methodologies which will enable Ohio EPA to develop a comprehensive monitoring network of the nearshore areas of Lake Erie capable of detecting and characterizing changes in water quality over time,
- To define the vertical and aerial extent of the anoxic zone as well as track changes in the anoxic zone over time,
- To provide water quality data for Sandusky Bay, and
- To support Ohio EPA nearshore and estuary biocriteria development.

Condition of Inland Lakes

Ohio has just 110 natural inland lakes, located mostly in Northeast Ohio and the largest is Aurora Pond in Portage County at 345 acres. The major recreational lakes in Ohio are old reservoirs built for canal systems of the 1800s and newer flood control reservoirs built between 1930 and 1970. All of these waters are naturally predisposed eutrophic lake ecosystems because of patterns of glaciation, drainage and soil formations. Un-glaciated areas of in southeast Ohio are comparatively nutrient poor and may be borderline mesotrophic. The following chart describes the widely accepted trophic classification system for lake ecosystems (from Wetzel, 1983).

PHOSPHORUS AND CHLOROPHYLL CONCENTRATIONS AND SECCHI DISK DEPTHS CHARACTERISTIC OF THE TROPHIC CLASSIFICATION OF LAKES			
MEASURED PARAMETER	Oligotrophic	Mesotrophic	Eutrophic
Total Phosphorus (mg/m3) Average	8	26.7	84.4
Range	3.0 - 17.7	10.9 - 95.6	16 – 386
Chlorophyll *a* (mg/m3) Average	1.7	4.7	14.3
Range	0.3 - 4.5	3 – 11	3 – 78
Secchi Disk Depth (m) Average	9.9	4.2	2.45
Range	5.4 - 28.3	1.5 – 8.1	0.8 – 7.0

The latest comprehensive State-wide assessment of Ohio lakes was done in 1996. Eutrophic and hypereutrophic lakes out number less enriched systems 3 to 1.

Surface water trophic state classification for 199 lakes in Ohio as reported in 1996 (citation).

Nutrient Enrichment	Trophic State	Number of Lakes Assessed	Percentage of Assessed Lakes
LOW	Oligotrophic	10	5
	Mesotrophic	37	19
	Eutrophic	120	60
EXTREEM	Hypereutrophic	33	17

<u>Ongoing and Future Inland Lake Monitoring</u>

Ohio EPA initiated a renewed monitoring effort for inland lakes in 2008. Current lake assessments address three of the four beneficial uses that apply to inland lakes: recreation, public drinking water supply, and human health (via fish tissue). Ohio EPA is currently in the process of updating the water quality standards rules for lakes. Once these rule updates are complete, Ohio EPA expects to include an assessment of the aquatic life use for lakes as a factor in listing watershed or large river assessment units in future Integrated Water Quality Monitoring and Assessment Reports.

Ohio EPA currently has resources to monitor approximately 5-10 lakes per year. Priority is being placed on lakes used for public drinking water or used heavily for recreation and suspected of being impaired for either of those uses. Secondary priorities not being addressed, because of limited resources, include developing a more robust sampling program, expanding to a wider variety of lakes, exploring the use of remote sensing in the screening of water quality in lakes, and attempting to track water quality changes in lakes that might be attributed to Section 319 funding and other watershed water quality improvement efforts. The objectives for monitoring inland lakes are:

- Track status and trends of lake quality,
- Determine attainment status of beneficial uses,
- Identify causes and sources of impaired uses, and
- Recommend actions for improving water quality in impaired lakes.

Ohio EPA has implemented a sampling strategy that focuses on evaluating the water quality conditions present in the epilimnion of lakes. Routine sampling consists of an even distribution of a total of ten sampling events divided over a two-year period and collected each year from May through September. Key water quality parameters sampled include total phosphorus, total nitrogen, chlorophyll a, secchi depth, ammonia, dissolved oxygen, pH, total dissolved solids, and various metals such as lead, mercury, and copper. Details of the sampling protocol are outlined in the following document available on Ohio EPA's web page at: http://www.epa.ohio.gov/portals/35/inland_lakes/Lake%20Sampling%20ProceduresFinal42910.pdf.

Determination of the aquatic life use attainment status for an inland lake is partially determined based on the nutrient concentrations within the lake compared to the applicable nutrient criteria. Ohio EPA has developed criteria for four nutrient parameters: total nitrogen, total phosphorus, secchi depth, and chlorophyll a. In some cases, these criteria vary by ecoregion and by lake type, as seen in Table 1.

Table 1. Draft Lake Habitat Aquatic Life Use Criteria.
Note: All criteria are outside mixing zone averages unless specified differently.

Parameter Lake type	Form[1]	Units[2]	Statewide criteria	Ecoregional criteria				
				ECBP	EOLP	HELP	IP	WAP
Chlorophyll a [3]								
Dugout lakes	T	µg/l	6.0	--	--	--	--	--
Impoundments	T	µg/l	--	14.0	14.0	14.0	14.0	6.2
Natural lakes	T	µg/l	14.0	--	--	--	--	--
Upground reservoirs	T	µg/l	6.0	--	--	--	--	--
Nitrogen [3]								
Dugout lakes	T	µg/l	450	--	--	--	--	--
Impoundments	T	µg/l	--	930	740	930	688	350
Natural lakes	T	µg/l	638	--	--	--	--	--
Upground reservoirs	T	µg/l	1,225	--	--	--	--	--
Phosphorus [3]								
Dugout lakes	T	µg/l	18	--	--	--	--	--
Impoundments	T	µg/l	--	34	34	34	34	14
Natural lakes	T	µg/l	34	--	--	--	--	--
Upground reservoirs	T	µg/l	18	--	--	--	--	--
Secchi disk transparency [4]								
Dugout lakes	--	m	2.60	--	--	--	--	--
Impoundments	--	m	--	1.19	1.19	1.19	1.19	2.16
Natural lakes	--	m	1.19	--	--	--	--	--
Upground reservoirs	--	m	2.60	--	--	--	--	--

1 T = total.
2 m = meters; µg/l = micrograms per liter (parts per billion)
3 These criteria apply as lake medians from May through October in the epilimnion of stratified lakes and throughout the water column in unstratified lakes.
4 These criteria apply as minimum values from May through October.

The aquatic life use of a lake is considered to be impaired when the median chlorophyll a concentration of samples collected over the sample period exceeds the chlorphyll a criterion applicable to the lake. Exceedance of the total nitrogen, total phosphorus, and secchi depth criteria will trigger listing on the state's watch list but will not trigger an impairment listing without concurrent exceedance of the applicable chlorophyll a crierion. Table 2 demonstrates the approach for five different lakes based on sampling data from 2008. Highlighted values exceed the applicable criterion.

Table 2. Lake Habitat Use Assessment for Inland Lakes Sampled in 2008 using Nutrient Criteria. Values exceeding the applicable criterion are shaded.

Lake	Ecoregion	Lake Type	Attainment Status	Seasonal Median Values			
				Chl-a (ug/l)	TP (ug/l)	TN (ug/l)	Secchi (meters)
Clear Fork Reservoir	EOLP	Impoundment	Non-support	17.7	17.5	615	1.20
Buckeye Lake	EOLP	Impoundment	Non-support	76.4	67.5	1075	0.57
Swift Run Lake	ECBP	Impoundment	Non-support	72.1	72	550	0.44
Dillon Reservoir	WAP	Impoundment	Non-support	44.7	132	730	0.81
Deer Creek Reservoir	EOLP	Impoundment	Non-support	30.9	29	820	0.66

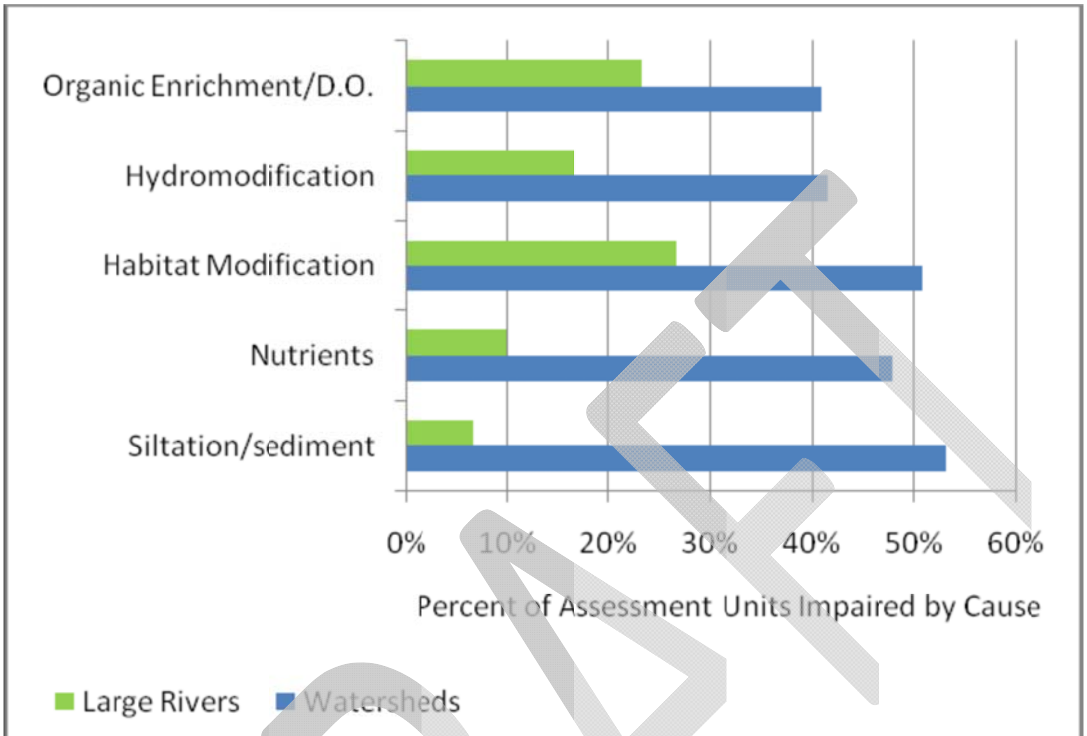
Condition of Ohio Streams and Rivers

Phosphorus Transport in Particulate vs. Dissolved Form

Long term monitoring conducted by the National Center for Water Quality Research at Heidelberg has revealed changes the proportions of particulate vs. dissolved reactive phosphorus delivered to Lake Erie from the Maumee and Sandusky Rivers. Despite the large decline in total phosphorus loadings achieved since 1975 both rivers now deliver greater amounts of bioavailable phosphorus than at any time in the past 34 years of record. Evidence is mounting that this phenomenon is responsible in large part for the resurgence in algal blooms and may be linked to the decline in the walleye fishery. Section 2.3 of the Lake Erie Phosphorus Task Force Final Report provides additional details. Reasons for increased amounts of DRP in surface water runoff events are not fully understood. Further monitoring and research is needed to determine if DRP is increasing in other watersheds in Ohio and what can be done to address the problem.

Status of Aquatic Life Impairment

The Ohio 2010 Integrated Report (Ohio EPA 2010) lists nutrients as one of the leading causes of impairment to rivers and streams in Ohio, with forty-eight percent of listed waters impaired entirely, or in part, by nutrients. Furthermore, two-thirds of near-shore Lake Erie waters are listed as impaired, and though the Integrated Report is not specific with respect to apportioning causes, nutrients are listed as a leading cause of impairment for each of the Lake Erie assessment units.



In contrast, organic enrichment and other forms of pollution (e.g., metals) associated with municipal and industrial point sources have been largely controlled, often with dramatic results (Figure 2), under the aegis of the Federal Water Pollution Control Amendments of 1972, commonly known as the Clean Water Act (CWA). Because pollution control of point sources necessarily centered on abatement of egregious conditions, and because control of NPS pollution initially focused on erosion control measures[1], measured nutrient concentrations in surface waters have remained constant over time (Figure 3). The net result of high seasonal nutrient loads from diffuse sources and constant loads from point sources is that large rivers in Ohio tend to be either enriched or over-enriched (Figure 4).

[1] The effort to reduce sediment pollution from agricultural fields has been measurably successful, as evidence by expansion of sediment-sensitive species, notably the bigeye chub.

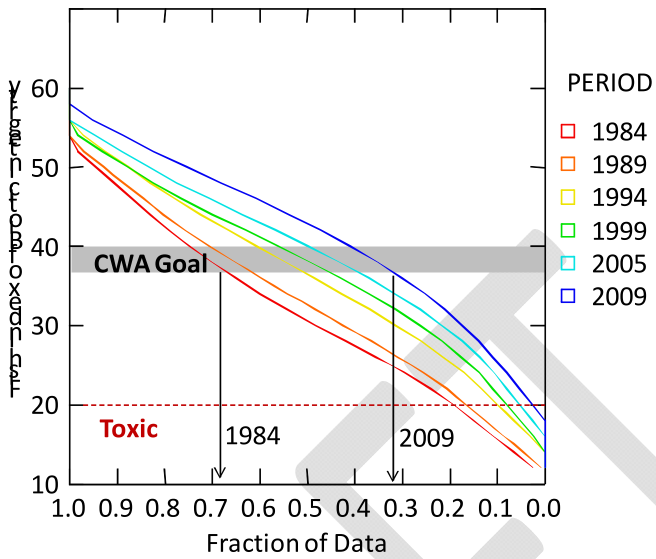


Figure 2. Cumulative frequencies of IBI scores by reporting period. Few scores in 2009 were indicative of toxicity, in contrast to the 1 in 5 observed in 1984.

Clearly, the scope of impairment due to nutrient enrichment is broad and reasonably certain given that the listings, at least for rivers and streams, are founded on measured biological condition, and the causal determinations are based on comparing site-specific data to benchmarks derived from statistical associations between biological condition and nutrient concentrations observed in a large data set (Miltner and Rankin 1998; Ohio EPA 1999). More specifically, a causal determination is not only based on comparisons to statistical benchmarks, but also includes a pseudo-Bayesian analysis of field notes, habitat quality information, the composition of biological indicators, land use, pollution loadings, and where available, data from continuous oxygen monitors.

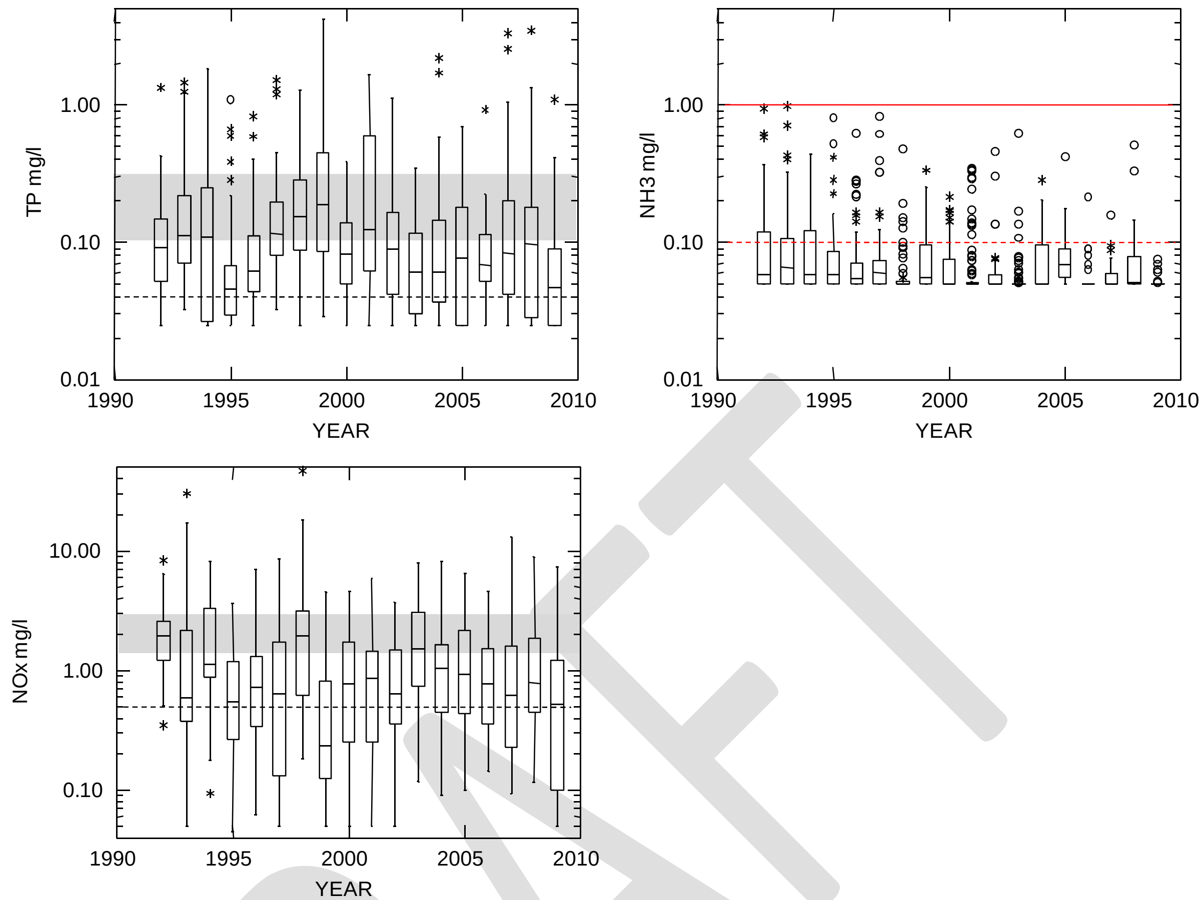


Figure 3. Distributions of total phosphorus (TP), ammonia nitrogen (NH3), and nitrate-nitrite nitrogen (NOx), 1992-2009. Data are from state-wide wadeable streams. The shaded region in the TP and NOx plots spans the range of concentrations from elevated to over-enriched, and the dashed lines represent background concentrations. In the NH3 plot, the lines correspond to chronically and acutely toxic levels. NH3 concentrations showed a significant decreasing trend, TP concentrations showed a non-significant downward trend. No trend was evident for NOX concentrations.

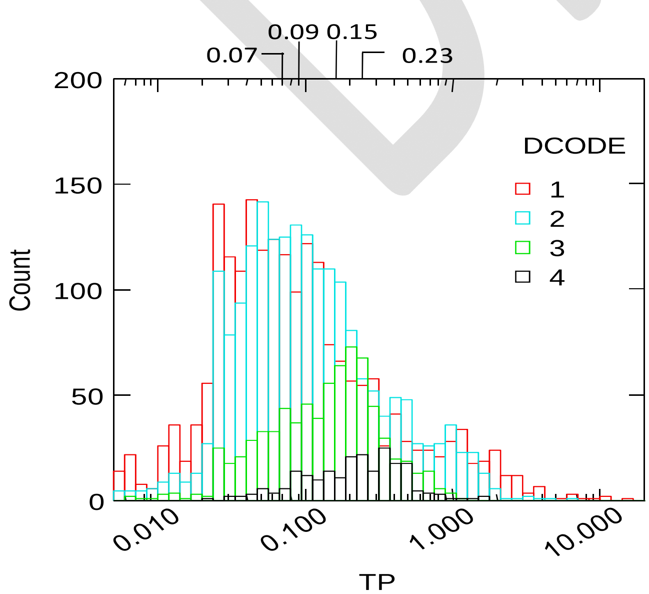


Figure 4. Frequency histograms of total phosphorus (TP) concentrations by stream size category (1 - headwaters… 4 - large rivers). Distributions shift from being strongly right skewed for headwaters and wadeable streams, to significantly left skewed for small rivers owing to the influence of point sources, to log-normally distributed for large rivers, reflecting the net effect of point source and diffuse loadings. Respective medians are shown

Sources of Nutrient Loadings to Surface Waters

Information on the major sources of phosphorus and nitrogen is important in the evaluation of current programs and future strategic direction on abating nutrient pollution. Knowledge about the relative contributions of phosphorus and nitrogen in terms of the total quantity, the chemical form (dissolved vs. total) and delivery aspect (continuous vs. weather dependent) will be essential in making optimum choices regarding how to manage nutrient reduction efforts. Information on source contributions of nutrient loadings has been broken out by the Lake Erie Basin, Ohio River Basin and, where possible, smaller watersheds.

Municipal Wastewater Treatment Facilities

Ohio has issued permits to over 2,000 publicly owned wastewater treatment facilities. While some facilities serve many thousands of people and generate over 1 MGD of wastewater, 72% of the POTWs are small and are designed to treat 0.1 MGD or less of effluent. The design flow represents the effluent volume to be discharged during normal operations and does not include combined sewer overflows. Figure 5 illustrates that the 200 largest POTWs account for 90% of the municipal wastewater design flow in Ohio. This fact has significant strategic planning importance for implementing nutrient controls.

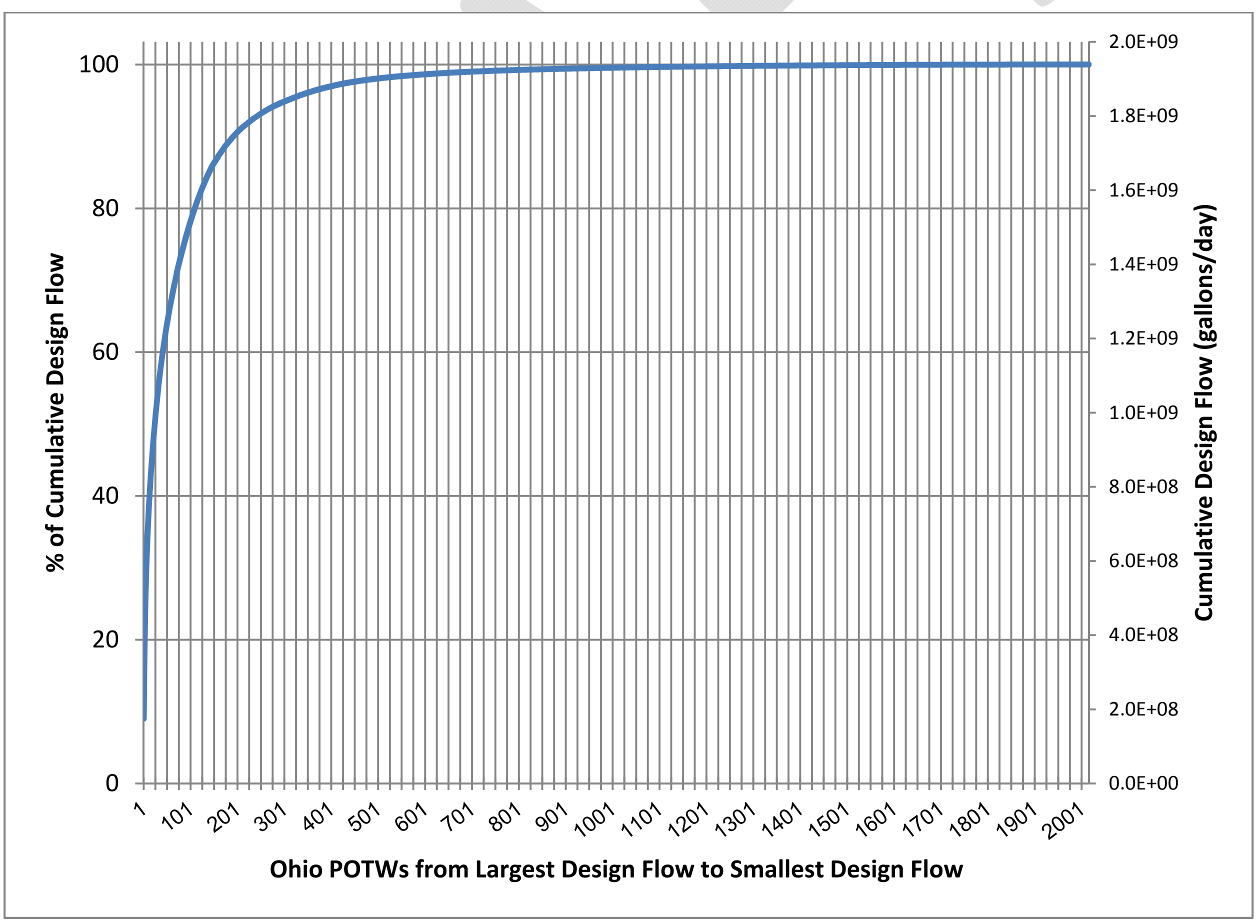


Figure 5. Cumulative effluent design flow at all Publically Owned Treatment Works in Ohio.

As of March, 2011 there were 729 Ohio NPDES permitted public WWTPs discharging to the Ohio Lake Erie watershed. The majority of the flow from the WWTPs to Lake Erie comes from the 12 major WWTPs with a discharge greater than 15 MGD. The Ohio Lake Erie Phosphorus Task Force Final Report (April, 2010) cites an estimate of an average load of 585 MTA of total phosphorus from Ohio WWTPs to Lake Erie. A similar estimate of 502 MTA was produced based on WWTP self-monitoring data submitted to Ohio EPA for calendar year 2010 (see Table 3).

Table 3. Estimated TP loading reported by POTWs in HUC 8 watershed units in the Lake Erie Basin of Ohio.

HUC 8 NAME	# POTWs*	# POTWs >1 MGD	Estimated P Loading from Reporting POTWs (MTA)	# POTW Reporting
Raisin	2	0	4	1
St. Joseph	7	1	13	5
St. Marys	14	1	5	5
Upper Maumee	7	1	2	3
Tiffin	22	2	12	7
Auglaize	58	7	21	24
Blanchard	23	3	9	9
Lower Maumee	43	6	110	15
Cedar-Portage	79	5	21	16
Sandusky	65	9	28	18
Huron-Vermilion	68	4	9	11
Black-Rocky	65	18	85	27
Cuyahoga	95	13	91	27
Ashtabula-Chagrin	106	8	84	22
Grand	64	3	2	24
Chautauqua-Conneaut	8	2	5	2
Lake Erie Basin	730	83	502	216

There are 1,345 Ohio NPDES permitted WWTPs discharging to the Ohio River watershed. The majority of the flow from the WWTPs to the Ohio River comes from the 13 major WWTPs with a discharge greater than 15 MGD. The estimated loading compiled from a query of 2010 data submitted by WWTPs in the Ohio River basin is 1,744 MTA of total phosphorus (Table 4).

Table 4. Estimated TP loading reported by POTWs in HUC 8 watershed units in the Ohio River Basin of Ohio.

HUC 8 NAME	# POTWs*	# POTWs >1 MGD	Estimated P Loading from Reporting POTWs (MTA)	# POTW Reporting
Upper Ohio	52	7	11	15
Shenango	39	2	8	5
Mahoning	123	14	143	25
Upper Ohio-Wheeling	19	2	2	3
Little Muskingum-Middle Island	10	1	18	3
Upper Ohio-Shade	15	1	5	4
Hocking	59	4	27	6
Tuscarawas	166	14	200	47
Mohican	78	4	76	10
Walhonding	68	2	29	17
Muskingum	28	2	61	3
Wills	31	2	7	5
Licking	41	6	23	14
Upper Scioto	156	20	408	42
Lower Scioto	60	7	38	15
Paint	28	4	11	12
Upper Great Miami	102	16	178	33
Lower Great Miami	95	14	253	28
Whitewater	15	0	9	4
Raccoon-Symmes	20	3	6	3
Little Scioto-Tygarts	19	4	19	5
Ohio Brush-Whiteoak	35	1	24	15
Little Miami	65	16	144	33
Middle Ohio-Laughery	11	3	32	4
Upper Wabash	13	1	12	4
Ohio River Basin	1,348	150	1744	355

Table 5 provides information on the number of public NPDES permits in the Ohio River and Lake Erie watersheds with phosphorus monitoring and limits. Figures 6 and 7 provide maps showing the location of WWTPs in Ohio with phosphorus monitoring and limits.

Table 5. Phosphorus Monitoring and Limits associated with NPDES permitted POTWs

Watershed	Lake Erie	Ohio River
Number of POTWs	729	1,345
POTWs with Phosphorus Limits	105	117
POTWs with Phosphorus Monitoring	223	397
Percentage of Permits with Phosphorus Limits/Monitoring	30.6%	29.5%

Source: Ohio EPA, Division of Surface Water Permit Permit Retrieval and Analysis Tool. Query conducted March 2, 2011.

Wet Weather Events and Combined Sewer Overflows

During dry weather and small wet weather events (i.e., rainfall and snowmelt), combined sewers are designed to transport all flows to a treatment plant. During larger wet weather events the volume of storm water entering the combined sewer system may exceed the capacity of the combined sewers or the treatment plant. When this happens, combined sewers are designed to allow a portion of the untreated combined wastewater to overflow into the nearest ditch, stream, river or lake. Ohio has approximately 1,306 known CSOs in 86 remaining communities (as of August 2010), ranging from small, rural villages to large metropolitan areas. *(Ohio EPA CSO website)*

There are few direct measurements of total phosphorus or dissolved reactive phosphorus contributions from CSOs. The Ohio Lake Erie Phosphorus Task Force used measurements from some of the Northeast Ohio Regional Sewer District (NEORSD) CSOs and an estimated total CSO annual flow of 10.9 billion gallons as presented in a 2007 report on sewage overflows to Lake Erie (Environment Ohio, 2007). The Task Force estimated an annual CSO total phosphorus load to Lake Erie of 90.4 metric tons per annum (MTA). (*Lake Erie P Task Force Report, Ohio EPA 2010)* It is very likely that the estimated annual flow and phosphorus load are on the low end as the estimates were based on an incomplete data set and there is a low level of confidence associated with some data (due to factors such as the use of visual estimations of flow instead of the use of flow monitoring equipment).

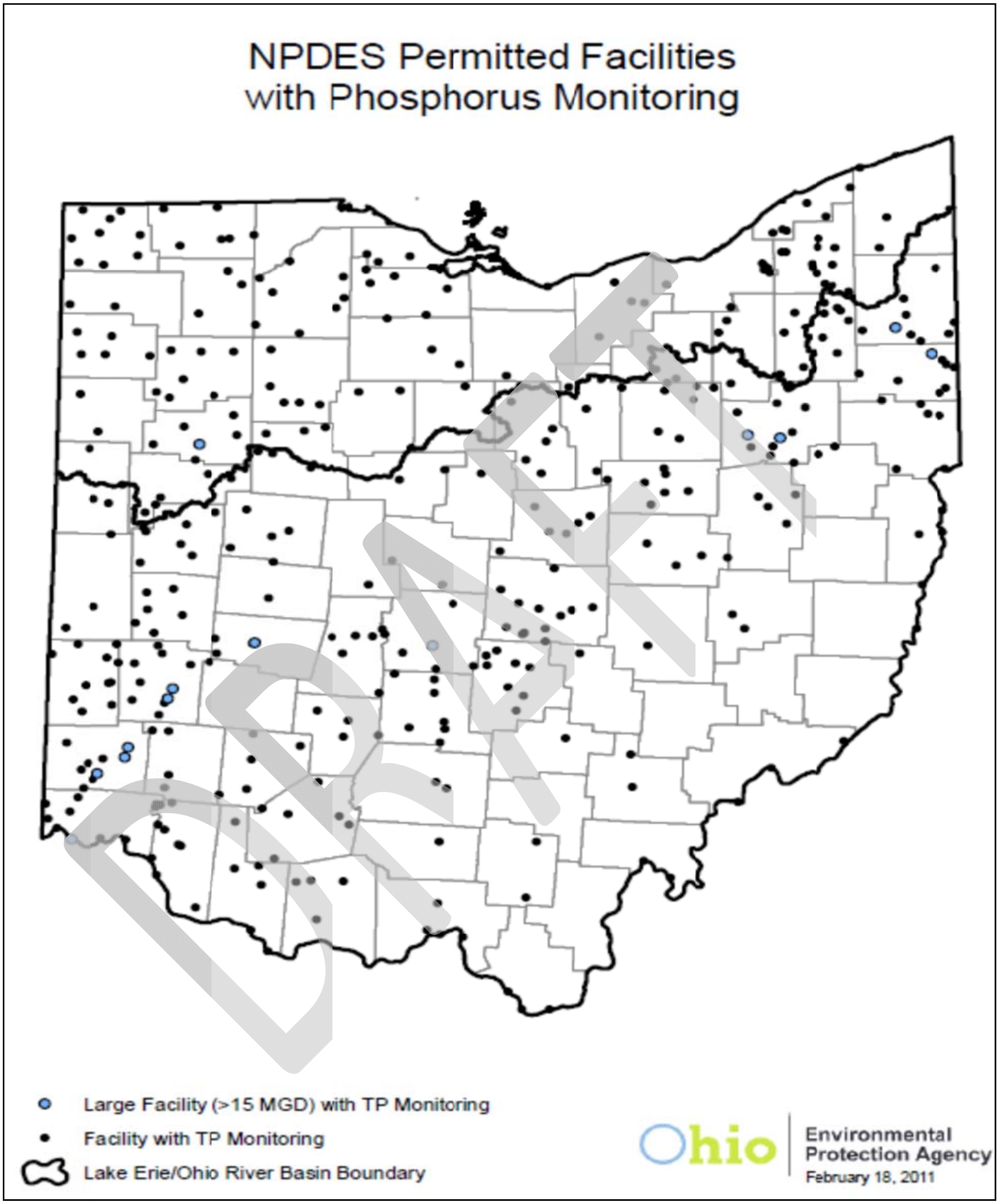


Figure 6. NPDES-permitted WWTPs with total phosphorus monitoring

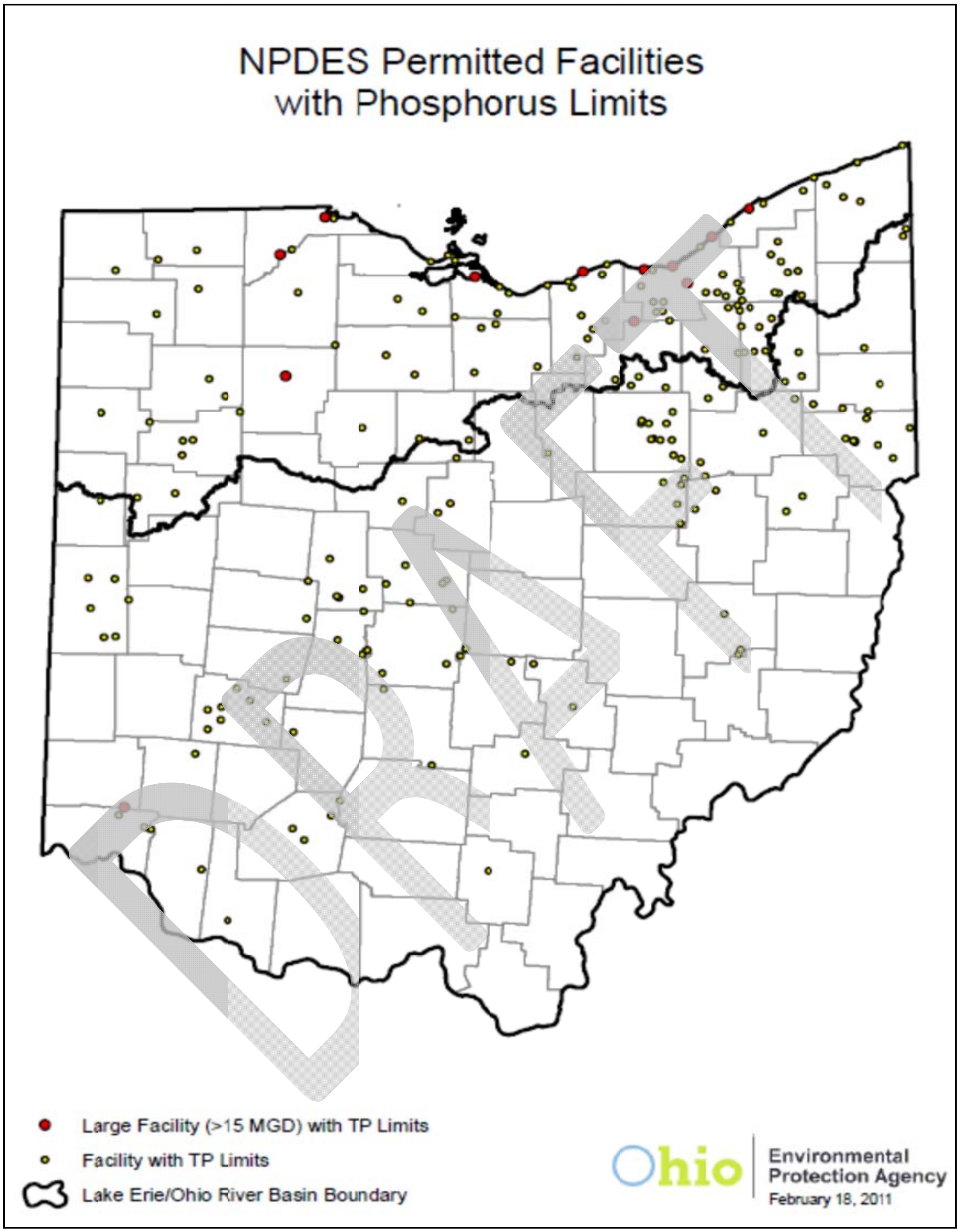


Figure 7. NPDES-permitted WWTPs with total phosphorus limits

It is believed that the estimated annual flow and phosphorus load from Ohio River basin CSO communities is of a similar magnitude as the annual flow and phosphorus load from Lake Erie basin CSO communities. An estimated total annual CSO flow of 5.9 billion gallons to the Ohio River was obtained for calendar year 2010 from an analysis of NPDES permit Discharge Monitoring Report (DMR) data. (Ohio EPA Permit Retrieval and Analysis Tool). However, like the estimate provided in the Environment Ohio Report, the calculations were done on an incomplete data set and there is a low level of confidence associated with some data.

Therefore, it is believed that the estimate likely underestimates the CSO flow to the Ohio River. Additionally, CSO flows vary from year to year depending on the frequency and severity of storm events. Nevertheless, using the Lake Erie Phosphorus Task Force estimate of the annual CSO total phosphorus load to Lake Erie as a baseline provides an estimated phosphorus load of 49 MTA to the Ohio River in calendar year 2010.

Ohio EPA continues to implement CSO controls through provisions included in NPDES permits and using orders and consent agreements when appropriate. The NPDES permits for our CSO communities require them to implement the nine minimum control measures. Requirements to develop and implement Long Term Control Plans (LTCPs) are also included where appropriate.

Conclusion: CSOs contribute significantly to the nutrient loads to the Ohio River and Lake Erie basins. Large data gaps are present which interfere with an accurate quantification of the true nutrient load associated with CSOs. Significant rate increases are generally passed on to citizens in order to pay for the elimination of CSOs. Coupled with possible requirements to upgrade waste water treatment technology in order to comply with more stringent nutrient limits, it is expected that there will be significant opposition and hostility towards these unfunded mandates. While some bigger communities are working towards making a large impact on the overall reduction of their CSO occurrences (and therefore their overall nutrient load), it is expected that CSOs will continue to contribute large nutrient loads to the Ohio River and Lake Erie basins for the foreseeable future.

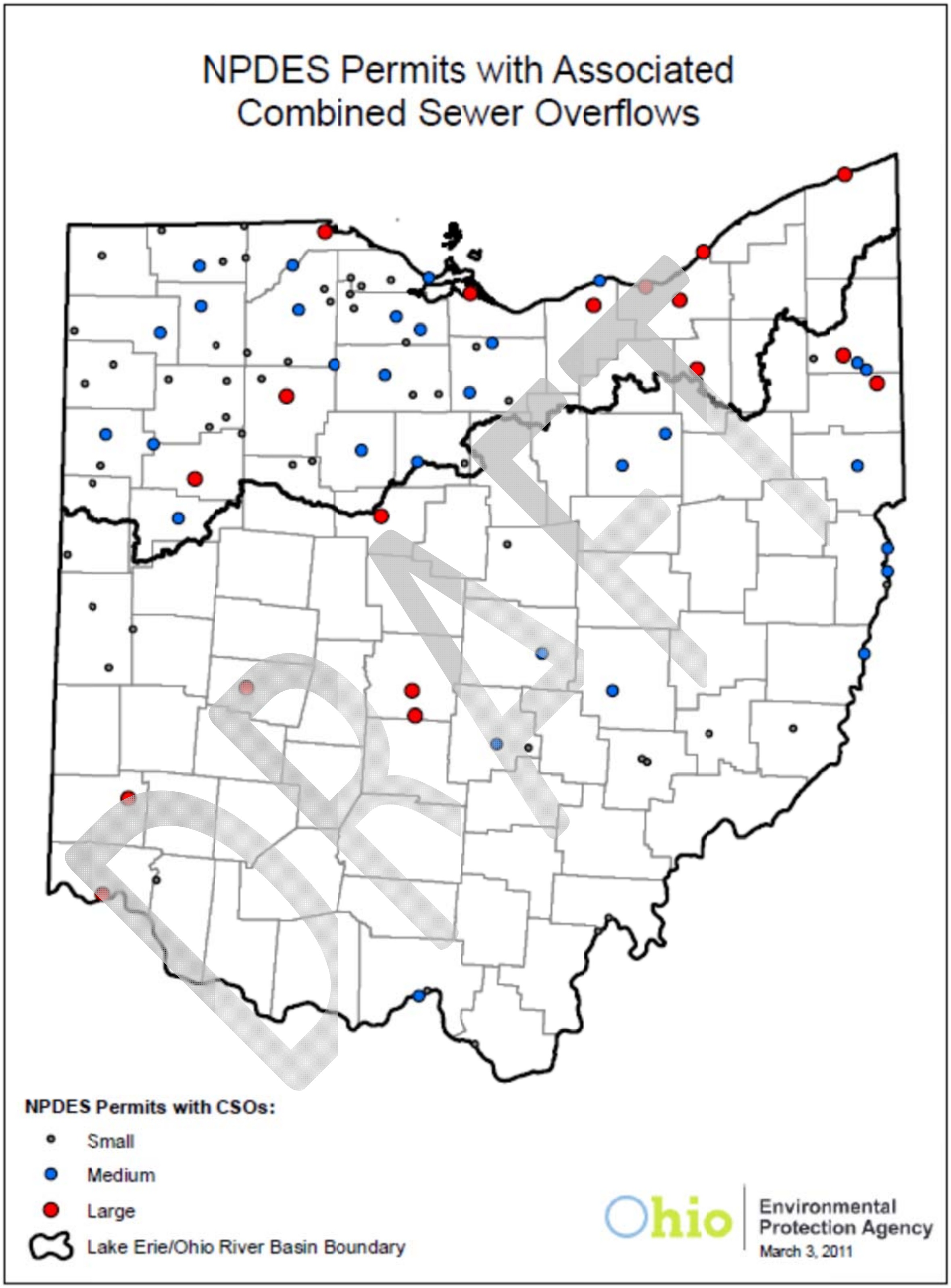


Figure 8. Location of Ohio NPDES permits with CSOs

Industrial Sources

Phosphorus monitoring and limits are less prevalent in industrial NPDES permits as opposed to public NPDES permits. Of the industrial NPDES permits with phosphorus limits and monitoring in the Lake Erie watershed, the Ohio Lake Erie Phosphorus Task Force notes that "it is the few dischargers with a high effluent volume that contribute the majority of the load. Most of those discharges are associated with food processing." However, there are industrial processes that produce high concentrations of total phosphorus and these may be discharged directly to stream or POTWS via sanitary sewers (e.g., processes using phosphoric acid, some food and dairy processing). See Table 6 for a breakdown of industrial sources in the Lake Erie and Ohio River basins.

An estimate compiled from a query of DMR data for industrial NPDES permits in the Ohio River basin provided a five-year average load of 181 MTA of total phosphorus to the Ohio River. *(cite Permit Permit Retrieval and Analysis Tool,3/3/11 query. January 2006 to December 2010, Final outfall, total phosphorus, assuming average reported phosphorus values extrapolated for a one year period).*

An estimate compiled from a query of DMR data for industrial NPDES permits in the Lake Erie basin provided a five-year average load of 27 MTA of total phosphorus to Lake Erie. *(cite Permit RAT,3/3/11 query. January 2006 to December 2010, Final outfall, total phosphorus, assuming average reported phosphorus values extrapolated for a one year period[2]).*

Table 6. Phosphorus Monitoring and Limits associated with Industrial NPDES Permits

Watershed	Lake Erie	Ohio River
Number of Industrial NPDES permits	424	803
POTWs with Phosphorus Limits	11	12
POTWs with Phosphorus Monitoring	120	110
Percentage of Permits with Phosphorus Limits/Monitoring	28.3%	13.7%

Source: Ohio EPA, Division of Surface Water Permit Permit Retrieval and Analysis Tool. Query conducted March 3, 2011.

[2] Loading data reported by Cooper Farms Cooked Meat products was excluded as a reporting error.

Discharging Home Sewage Treatment Systems

Ohio EPA has developed two general NPDES permits for home sewage treatment systems (HSTS). These permits authorize the discharge of treated sewage in certain circumstances for the replacement of older failing on-lot disposal treatment systems (septic tanks) and for new HSTS where on-site dispersal of the wastewaters is not an option. A table displaying the total number of discharges from HSTS with coverage under Ohio EPA general permits OHK000001 and OHL000001 is shown below. A map displaying the location of discharges permitted under the two general permits is shown in Figure 9. Note that the discharges permitted under the two general permits make up a very small percentage of the total number of discharging HSTS in Ohio. In 2008 ODH reported to the Ohio Lake Erie Phosphorus Task Force than there are an estimated total of 147,975 discharging HSTS in the Lake Erie watershed.

Table 7. Discharges permitted under general permits OHK000001 and OHL000001.

General Permit	**Number of Dischargers**
HSTS General Permit OHK000001	4,003
HSTS General Permit OHL000001	286

Source: Household Sewage General Permit List, Ohio EPA. Updated July 12, 2011

The Ohio Lake Erie Phosphorus Task Force commissioned the Ohio Department of Health (ODH) to examine the potential contribution of phosphorus from home sewage treatment systems (HSTS). The average annual total phosphorus load to the environment in the Lake Erie basin was estimated to be 352 MTA. The estimate was made using an incomplete data set and many assumptions were made in order to determine the load. Ohio EPA used additional information that was available on permitted HSTS through August 2010 together with the ODH assumptions to calculate an estimate of 361 MTA. The Ohio Lake Erie Phosphorus Task Force estimated that a quarter of the total load from discharging HSTS eventually reaches downstream nutrient sinks (Lake Erie or inland lakes). Failing HSTS could increase total phosphorus loads from HSTS in the future and also could increase the potential for localized water quality impacts.

Table 8. Estimates of the TP and ammonia (NH_3) generated by home with discharging HSTS and an estimate of the amount reaching downstream surface waters.

Basin	**TP Generated and Discharged (Per capita estimate) (MTA)**	**NH_3 Generated and Discharged (Per capita estimate) (MTA)**	**TP Delivered to Downstream Surface Waters (MTA)**	**NH_3 Delivered to Downstream Surface Waters (MTA)**
Ohio River	**620**	**403**	**155**	**101**
Lake Erie	**361**	**235**	**90**	**59**

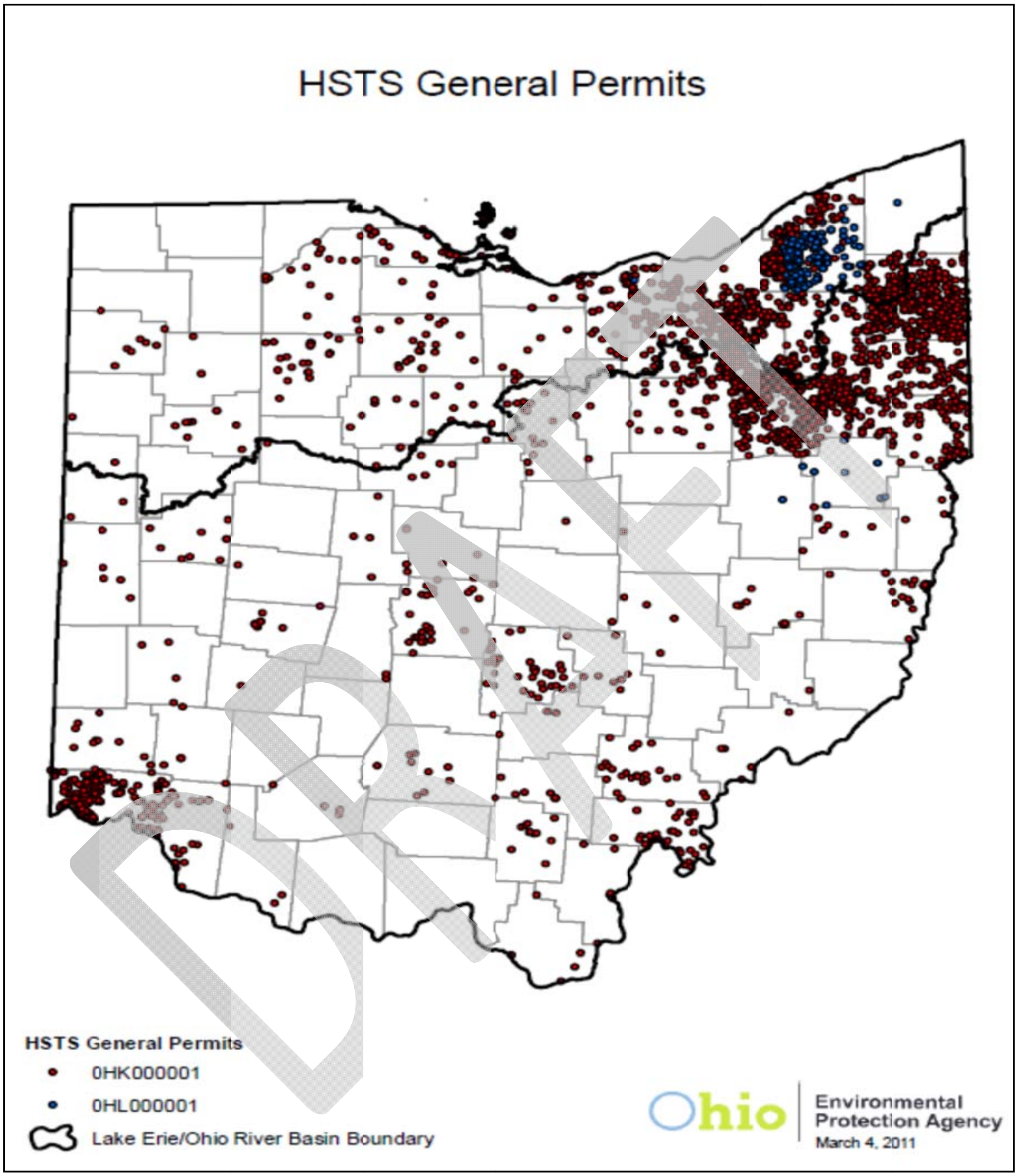


Figure 9. Location of NPDES permitted HSTS as of August 20, 2010

Livestock Feeding Operations

Over time, the trend in livestock farming has been toward fewer, larger farms nationally and in Ohio. The following excerpt and Table 9 from the Ohio Lake Erie Phosphorus Task Force Report describes the changes:

"From 210,000 farms a century ago, Ohio has decreased to 89,000 farms statewide in 1978 and to 75,000 farms in 2007. Because of specialization, the remaining 75,000 farms do not grow nearly the diverse varieties of crops and livestock of 30 years ago. As shown in Table 4 below, Ohio livestock production has undergone the following changes from 1978 to 2007. While the numbers of farms and total animals raised have decreased, the number of animals per farm has increased. "

Table 9. Change in number of farms raising livestock, 1978 2007.

Number of Farms	1978	2007
Cattle	43,000	26,000
Hogs	17,000	3,700
Dairy Cattle	12, 698	3,650

Generally this results in manure being transported further from the source in order to land apply at rates that do not exceed the agronomic need of the crops being grown. To compare the amount of nutrients generated by confined livestock to the amount of nutrients generated by people in Ohio, literature values of nitrogen and phosphorus found in raw waste were used in the tables below.

Table 10. Number of livestock in Ohio and nutrient content of manures produced compared to that produced by people.

	Beef	**Dairy**	**Swine**	**Chickens**	**Turkeys**	**Humans**
# Animals	190,638	271,938	1,831,084	43,870,475	2,074,750	11,542,645
Per capita daily estimates of nutrients excreted						
Phosphorus (P2O5) (lb/day/animal)	0.18	0.13	0.054	0.0026	0.0108	0.0044 lb/day
Nitrogen (lb/day/animal)	0.41	0.387	0.076	0.0034	0.0126	0.0375 lb/day

Table 11. Estimated annual nutrient load attributed to livestock and human origins.

	Beef	Dairy	Swine	Chickens	Turkeys	All Livestock	Humans
Total P (metric tons/year)	2,499	2,575	7,202	8,308	1,632	22,217	8,408
Total Nitrogen (metric tons/year)	12,941	17,424	23,040	24,695	4,328	82,427	71,663

Assumption used in Table 11.

- Number of animals based on 2007 Ag Census
- Nutrient production from OSU bulletin 604, Table 1 (average values used for each category of animal)
- Beef cattle nutrients based on high-energy feed (note more animals on pasture, value may be different)
- Humans values based on 2009 Population Estimates (projection based on 2000 Census) and 2002 USEPA manual for on-site wastewater treatment systems (input to septic systems)
- The production of phosphorus for humans is total phosphorus

The State of Ohio has proposed transferring the CAFO NPDES program from the Ohio EPA to the Ohio Department of Agriculture (ODA). As of March, 2011, the Ohio EPA, Division of Surface Water still administers the CAFO NPDES program while the ODA, Livestock Environmental Permitting Program administers the permit-to-install and permit-to-operate program for large CAFOs.

Ohio EPA currently has 37 active CAFO NPDES permits. The ODA currently has 177 active operating permits for large CAFOs in Ohio. While some long-term monitoring data exists for permitted discharges from the production area of CAFOs (i.e., clean storm water pond discharges), there is very little long-term data for runoff and land application discharges associated with CAFO manure application. These discharges are usually short-duration, high-intensity events and grab samples fail to characterize long-term trends.

A large permitted poultry CAFO in Ohio has installed constructed wetlands in order to treat contaminated runoff from the production area of the facility. The large poultry CAFO is permitted to confine 1,600,000 laying hens. A comparison of influent and effluent DMR data from the constructed wetlands is displayed in Table 12. It is clear that the wetlands have had an impact in reducing the concentration of nutrients which are discharged from this CAFO.

Table 12. Average of Influent and Effluent Data from Poultry CAFO's Wetlands

	Influent	Effluent
NH_3 (mg/l)	11.5	1.73
Total P (mg/l)	1.04	0.78
TKN (mg/l)	11.7	4.89

While much is known about the permitted CAFO universe in Ohio, permitted CAFOs make up less than 1% of the overall number of animal farms in Ohio. Newer permitted CAFOs usually have adequately engineered manure storage and handling facilities and CAFOs are required to have manure management plans based upon agronomic cropping needs (for new large CAFOs, this is a requirement of ODA's CAFO permitting program). However, many smaller unpermitted AFOs were constructed 20 or more years ago without the same attention to today's engineering specifications. These smaller facilities often lack adequate manure storage capacity so the producer encounters more frequent occurrences of manure disposal at inopportune times when the likelihood of manure and nutrient loss to nearby waterways is much higher. In general the smaller unpermitted AFO operations are not required to have manure management plans. However, the recent adoption of Ohio Administrative Code 1501:15-5-20(A) mandates AFOs in the Grand Lake St Marys watershed have manure management plans if they generating more than 350 tons annually. Other rules have been in place for many years governing the handling and management of manure under ODNR's Agricultural Pollution Abatement Program. Under these rules when there is evidence of a discharge (or an imminent discharge) to surface waters the Division of Soil and Water Resources will initiate technical assistance, compliance and enforcement steps. Recalcitrant operators can be ordered to submit and operate in conformance with nutrient management plans.

Conclusion: Using gross average values, nitrogen produced by confined animals exceeds nitrogen produced by people by about 20%, and total phosphorus produced by confined animals is around three times that produced by people. The fate and transport of nutrients produced by animal and human populations must be considered in the development of effective nutrient strategies. While technology exists for reducing the impact of nutrient runoff from the production area of CAFOs, the nature of runoff from manure applied to cropland is much more dynamic and the nutrient load less quantifiable. While Ohio's soil and water conservation districts and USDA partners attempt to reach and assist all livestock producers across the state, more emphasis and resources may be needed here to assist with nutrient management practices, on the feedlot and in the field.

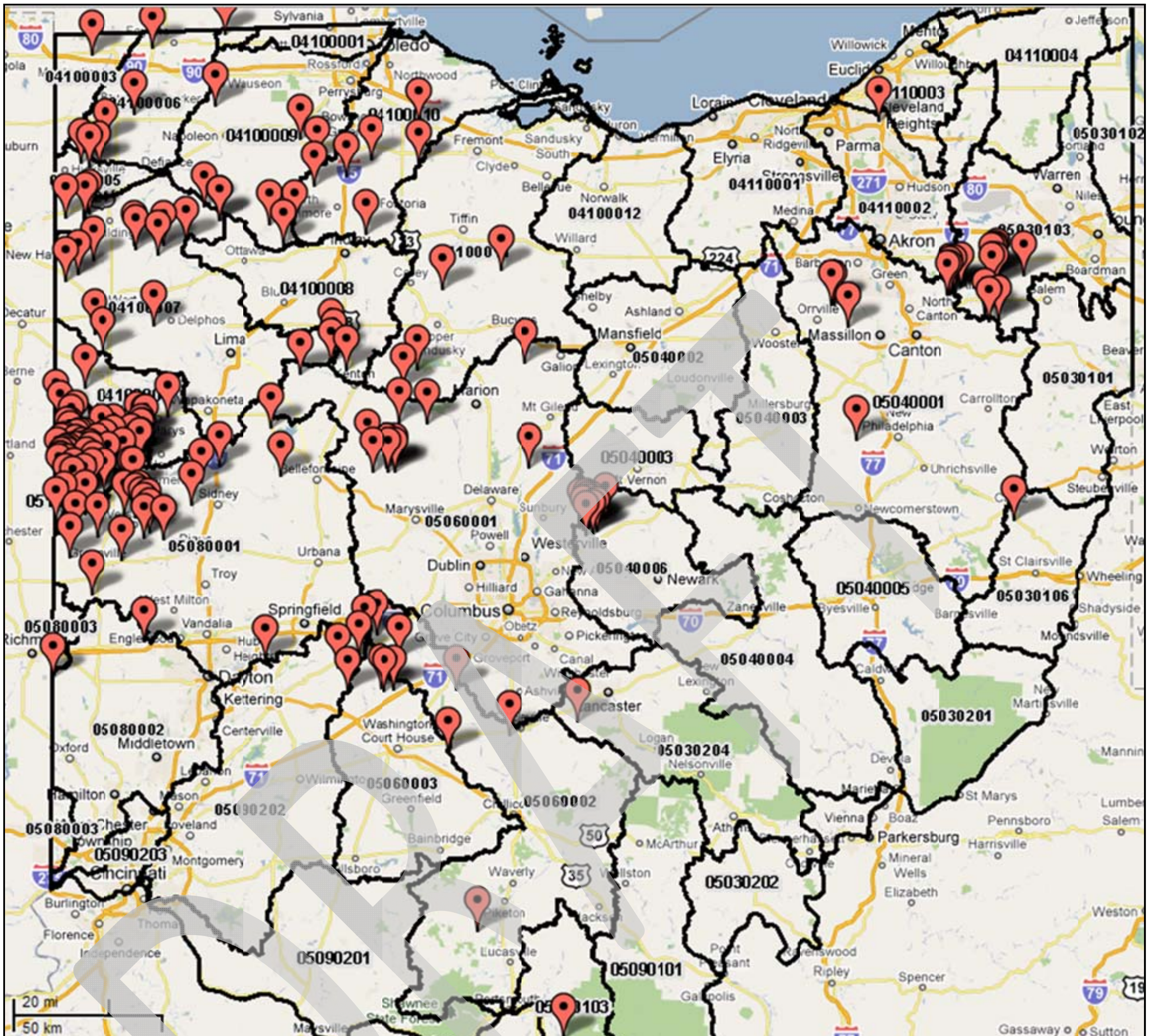


Figure 10 displays a map showing the location of all CAFOs in Ohio currently permitted by either the Ohio EPA or the ODA. A significant majority of the permitted CAFOs in Ohio are located within the Ohio River drainage basin.

Watershed Priorities

To effectively do the most good in the shortest time managers with nutrient program responsibilities should have information on which watersheds have the highest nutrient loadings and what lakes and stream segments have the greatest potential to recover from nutrient pollution. Initial work on compiling nutrient loading rates has been at the HUC 8 watershed level. The information is currently available and is summarized below.

Export of Nutrients to Ohio River and Gulf of Mexico

Analysis performed by USGS using the SPARROW model on nutrient flux (mass per time) delivered to the Gulf of Mexico from States in Mississippi and Atchafalaya River basins indicates Ohio contributes 5.4 and 4.1 percent of the total flux of total nitrogen and total phosphorus respectively. Watersheds within or partially within Ohio that have the highest nutrient flux are located in western, west central Ohio and southwest Ohio. See Figure 11 and Table 13.

Table 13. Watersheds in Ohio with the highest nutrient flux (USGS SPARROW model results).

High Nutrient Flux Category	Watershed (HUC 8 #)	N Flux (kg/km^2)	P Yeild (kg/km^2)	P Flux (kg/km^2)
N & P	Upper Wabash (05120101)	2159	377	254
N	Upper Great Miami (05080001)	1790	231	50
N	Upper Scioto (05060001)	1786	188	88
N & P	Lower Great Miami (05080002)	1735	173	127
N	Little Miami (05090202)	1653	148	99
N	Paint (05060003)	1405	106	65
N & P	Mill Creek (05090203)	1345	188	174
P	Ohio Brush-Whiteoak (05090201)	1218	146	126

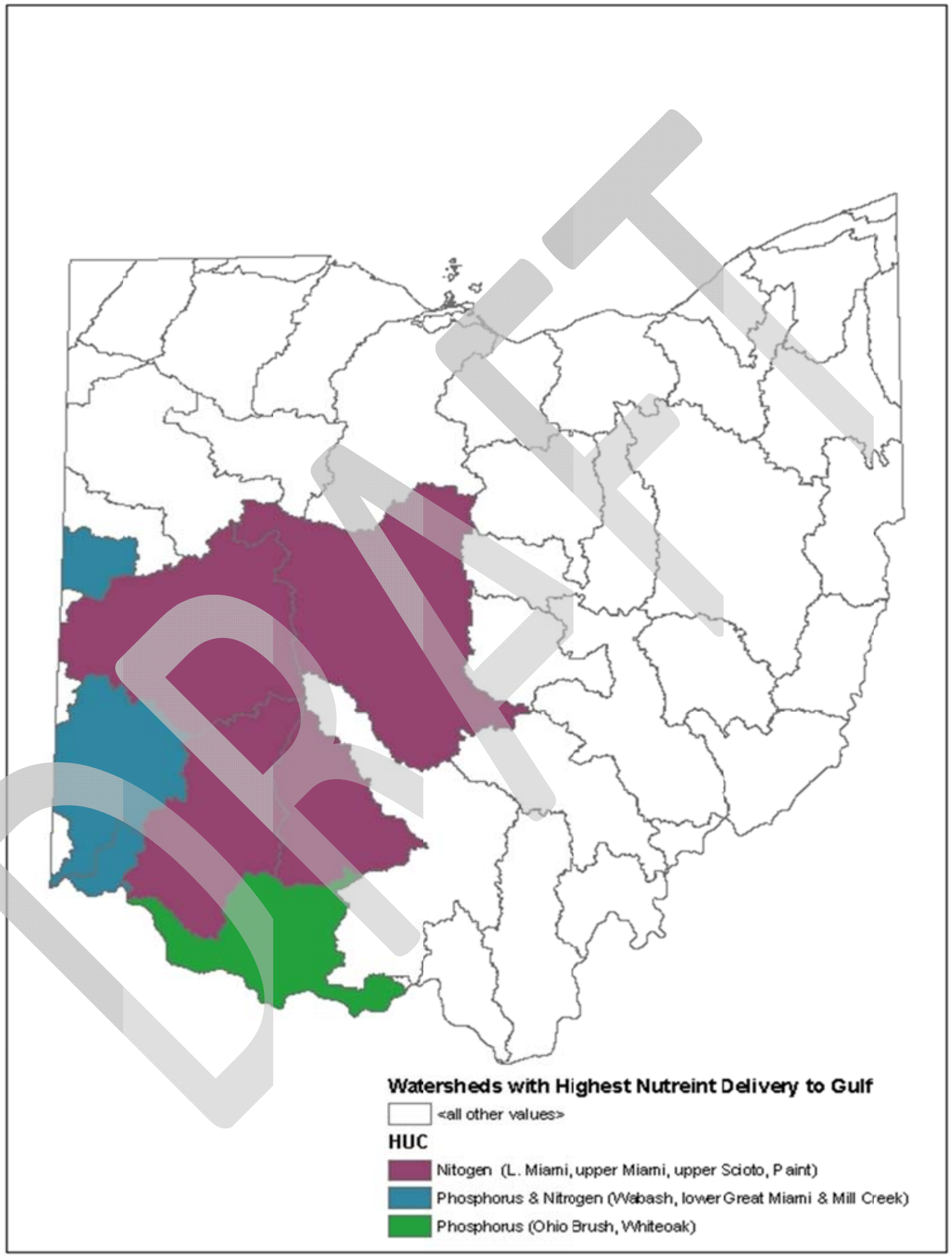
Phosphorus Flux and Incremental Yields within Ohio

SPARROW model output for phosphorus flux and incremental yield generally comport very well with Ohio EPA's field survey based observations regarding watersheds with a high degree of nutrient enrichment.

Recommendations

- Obtain SPARROW model results for the Lake Erie Basin; provide similar information at smaller HUC unit levels.
- Improve estimates of loadings and relative source contributions in as many inland lake watersheds as possible.

Figure 11. Watersheds in Ohio with the highest estimated delivery (flux) of nutrients delivered to the Gulf of Mexico (from USGS SPARROW model output, USEPA web page).



Summary and Conclusion

Water pollution impacts caused by excessive amounts of nutrients are very evident in Lake Erie, Ohio's inland lakes and many stream and rivers. The situation has reached a critical point in Lake Erie and many of Ohio's inlands lakes because lake systems act as nutrient sinks. The amount of phosphorus flowing into a lake environment, as well as the amount cycling in and out of bottom sediments, will determine the degree of enrichment problems. Rainfall amounts and storm patterns in 2011 were such that record amounts of dissolve reactive phosphorus entered western Lake Erie and the resulting algal blooms were widespread and intense. See: http://www.heidelberg.edu/academiclife/distinctive/ncwqr/news/20100722)

This urgent situation requires the immediate attention of State and federal agencies, all affected stakeholders and the public at large. The remainder of this draft framework document describes some of the existing programs that may play a role in responding to the problem. However, an honest assessment of the situation reveals that just doing more of the same will not be good enough. While Ohio EPA and many others have taken actions that have resulted in documented water quality improvements in some areas, the problems with nutrients are mounting and require a fresh look at everything related to the matter: our laws, regulations, educational efforts, research needs, priorities for funding, agency procedures and operations, etc. We present a framework of ideas for future strategy development and suggest a process template for bringing about meaningful change.

Academic Research

There is much we don't know about the causes and source of the nutrient problems now plaguing Lake Erie and other waters in Ohio. Academic research will be a key component of addressing the issues with the best scientific information available. The severity of the problem in Lake Erie has reached an alarming level prompting this statement from the International Joint Commission's 15th biennial report:

> "Given these challenges, the magnitude of the problem and the difficulties in addressing it, and the need for testing causal hypotheses and models, the Commission believes that a major binational scientific effort be undertaken."

Work is already underway to coordinate research efforts aimed at Lake Erie through an organization known as the Lake Erie Millennium Network (LEMN) (see Table 14). The work was initiated in 1998 by scientists at the University of Windsor, National Water Research Institute - Burlington, F.T. Stone Lab of Ohio State University, and US-EPA Large Lakes Lab at Grosse Ile, MI. The goals are to foster and coordinate research that will identify and solve basic ecological questions relevant to the Lake Erie Ecosystem through a bi-national, collaborative network. In June 2011 the Lake Erie Millennium Network Synthesis Team released a report entitled *"Lake Erie Nutrient Loading and Harmful Algal Blooms: Research Findings and Management Implications.*

Understanding the sources, transport and ecological fate dynamics of dissolved reactive phosphorus (DRP) is an especially important area of research. Measurements of phosphorus loadings to Lake Erie performed by the Heidlebrug WQ lab have shown relatively flat trends in annual total phosphorus but an increasing trend in fraction that is measured as dissolved reactive phosphorus. (cite). Large runoff events deliver large volumes of DRP to western Lake Erie. Research done elsewhere indicates that applications of fertilizer, manure and biosolids according to the recommended rates of plant available nitrogen can lead to an accumulation of phosphorus in soils. The LEMN report provides additional findings of recent research in the Lake Erie drainage. In summary, surface and subsurface runoff management practices that effectively reduce levels of DRP appear to be the most promising means of reversing recent trends in loadings and the resulting algal blooms in Lake Erie. Further research is needed to understand relationships between soil test phosphorus (STP) data and the export of DRP from cropland to local waterways and Lake Erie.

In consultation with Heidelberg University, Ohio EPA and Heidelberg University convened the Ohio Lake Erie Phosphorus Task Force in 2007 to review and evaluate the increasing dissolve reactive phosphorus (DRP) loading trends and the connection to the deteriorating conditions in Lake Erie. The report of the Task Force released in 2010 provides some alarming information about the declining water quality conditions of Lake Erie as well as the identification of additional research needs and other recommendations intended to address key issues.

Recommendations:

- *The LEMN report and similar research findings and recommendations should be carefully considered prior to finalizing Ohio's Nutrient Management Strategies for Water Quality Improvements and Protection. Ohio government needs to invest in the research efforts aimed at protecting the State's most valuable water resource.*

Table 14. Partial list of ongoing applied research, investigations and studies focused on nutrients in the Lake Erie basin.

Project	Lead	Funding
Phosphorus Task Force Recommendations	OEPA	
Lake Erie Millennium Network Synthesis	Ohio Sea Grant & Partners	
Western Lake Erie Basin Partnership	NRCS, USACE & Partners	
Sandusky River Soil Stratification Measurements	Heidelberg University	GLPF
Sandusky River Conservation Practices	IPM Team with Heidelberg University and Sandusky Watershed Coalition	GLPF
Lake Erie Algal Source Tracking	University of Toledo	LEPF
Toledo Harbor Sediment Management and Beneficial Re-Use Project	Ohio Lake Erie Commission and Toledo-Lucas County Port Authority	GLRI
Soil Fertility and Fertilizer Recommendations	OSU	LEPF
Connecting Phosphorus Load, Transport, and Biological Use	OSU	LEPF

Program Descriptions and Analysis

Management of public health and water quality issues caused by nutrient enrichment should consider what environmental standards and programs are already in place, how effective they have been and what improvements can be made. Such improvements could take the form of changes in the way current regulations and programs are implemented, or through new or revised laws, rules or program initiatives. This section provides an initial analysis of these questions. At this point we have limited the discussion to rule initiatives that stem from USEPA requirements and new or revised program initiatives that don't require additional legal authorities. Comments from other State agencies, stakeholders and the public are anticipated prior to making final recommendations on future strategic program elements and possible changes in legal authorities.

There are three main regulatory elements that can be brought to bear on nutrient reduction plans designed to attain and maintain good water quality: 1) State Water Quality Standards; 2) Total Maximum Daily Loads; and 3) NPDES permits. Each element is summarized below and programmatic short comings in dealing with nutrient pollutions are listed. Recommended actions are listed in the next section.

Water Quality Standards

Ohio and the other Great Lake States were faced with very serious cultural eutrophication impacts in the 1960s and 1970s. This challenge was successfully met through an international effort of collaborative research and bi-national agreements to control phosphorus. However, the initial successes have been tempered in the past several years by worsening observations about the conditions of Lake Erie and Ohio's inland waters. Long term success in meeting this second wave of nutrient enrichment impacts must be based on technically sound regulations and strategies that have the power to correctly diagnosis and treat all significant sources of nutrient loading. This section presents a summary of ongoing work to develop new tools to meet this challenge.

Federal and State Water Quality Standard Framework

Under the CWA States must adopt WQS that meet minimum program content requirements. The principle requirements are:

- include to adopt standards that promote the "fishable swimmable" goals of the Act;
- to identify beneficial uses for each body of water;
- to have criteria to protect those uses; and,
- to have an antidegradation policy that prevents unnecessary lowering of water quality and that protects all existing water body uses.

USEPA publishes national water quality criteria recommendations. States may adopt these national criteria or develop their own technically defensible criteria. Over the past decade USEPA has consistently urged States to adopt criteria for nutrients. Ohio and 43 other States have established long term WQS program work plans that outline the steps being taken to develop and adopt water quality criteria for nutrients. The most recent work plan is presented in Appendix 1.

Ohio Regulations Resulting from International Agreements

The United States and Canada are parties to the Boundary Waters Treaty[3] of 1909, a protocol document that has served to resolve water quality and quantity disputes and concerns that have arisen in the shared waters along the border. It was under this protocol that the cultural eutrophication problems seen in the Great Lakes in the 1960s gave rise to the Great Lakes Water Quality Agreement of 1978. Among provisions of the Agreement are specific actions to reduce the loadings of phosphorus to the Great Lakes[4]. First, municipal wastewater treatment facilities over 1 MGD should achieve a monthly average 1 mg/l phosphorus effluent limit. This requirement was include in Ohio's WQS regulations[5] in 1978. All municipal wastewater facilities in Ohio's Lake Erie drainage basin and discharging more than one million gallons per day have this limit included in their NPDES permit. Under Ohio's TMDL program permit limits for phosphorus for facilities in the Ohio River basin are also being imposed, along with phosphorus limits for certain smaller facilities in the Lake Erie basin.

The Agreement also committed the parties to pursue programs or mechanisms that would reduce phosphorus in household detergents to 0.5 per cent or less by weight. It took Ohio 12 years to pass legislation that banned the sale of most commonly used high phosphorus content detergents in the Lake Erie basin. In 2008 legislation was passed that extended this ban to include dishwasher detergents[6] .

Current Nutrient Standards

Ohio's current water quality criteria that address the problems caused by nutrient enrichment are presented in Appendix 2. These are narrative standards for the protection against adverse aesthetic conditions and harm to aquatic life. In 1999 Ohio EPA published an implementation mechanism that translates the narrative standard into target phosphorus and nitrogen concentrations that are protective of aquatic life (Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams Ohio EPA Technical Bulletin MAS/1999-1-1). TMDLs prepared by Ohio EPA have used these target nutrient values on water impaired by nutrient enrichment for the past 12 years.

Draft Nutrient Standards and Implementation Tools

<u>Lakes</u>

Ohio EPA has been working to develop nutrient standards for inland lakes and streams since 2003. Ohio EPA has used the regional reference approach to develop criteria for inland lakes. These draft standards

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[3] Treaty between the United States and Great Britain relating to boundary waters, and question arising between the United States and Canada

[4] Agreement between Canada and the United States of America on Great Lakes quality, 1978

[5] Ohio Administrative Code 3745-1-07

[6] Ohio Revised Code 6111.10 & .11

were released for interested party review in 2008 (see Table 1). The comment period closed June 6, 2011. If adopted these standards would apply to all inland lakes in Ohio. Lakes will be listed as impaired on the Ohio 303(d) list using a methodology that considers data on the stressor variables (phosphorus and nitrogen) and the response variables (chl a, secchi disk transparency). A lake will be listed as impaired if the median chlorophyll a concentration exceeds the applicable chlorophyll a criterion. Total phosphorus, total nitrogen and secchi depth parameters are used to flag potential impairment of the aquatic life use designation. Exceedances of the criteria for these parameters will trigger listing on the state's "watch list" rather than a determination of use impairment. Lakes listed on the watch list will be factored into the prioritization process for additional monitoring.

Streams

For streams and rivers Ohio EPA has collected data that provides information on the biological and chemical/physical responses of nutrient enrichment in streams ecosystems[7]. Macro-habitat features and light regime affect a stream's ability to assimilate and process nutrients. These factors determine whether or not a given nutrient loading scenario is expressed as a large or small impact on chemical/physical stream properties and the overall biological health of the stream. Ohio EPA and Region V WQS personnel have developed a multi-metric scoring system that aggregates results from separate evaluations of primary productivity, biological health and in stream nutrient concentrations. We have called the resulting output of the multi-metric scoring system the Trophic Index Criterion (TIC). Numerous published studies on the effects of nutrient enrichment in streams, along with our own experience from over 30 years water quality survey work, leads us to conclude that decisions regarding major pollution control initiatives should be based upon multiple line of evidence as embodied by the TIC. It provides an integration of "stressor" data (nitrogen and phosphorus concentrations) that potentially causes stream degradation and "response" data from the organisms that inhabit the stream. The conceptual approach is summarized in the following decision flow charts. The numeric water quality criteria for TP and DIN that are triggered and used in TMDLs are listed below.

Aquatic Life Use and QHEI	**TP (ug/l)**	**DIN (ug/l)**
Exceptional warmwater habitat	60	3,000
Warmwater habitat and QHEI score = 12 to 64	160	3,000
All other aquatic life uses and QHEI scores	300	3,000

[7] Statistical analysis techniques were used to test relationships between variables. Miltner, Robert J. 2010. A Method and Rationale for Deriving Nutrient Criteria for Small Rivers and Streams in Ohio. Environmental Management. Vol. 45 pgs 842-855.

Figure 12. Flow chart illustrating concept of the Trophic Index Criterion.

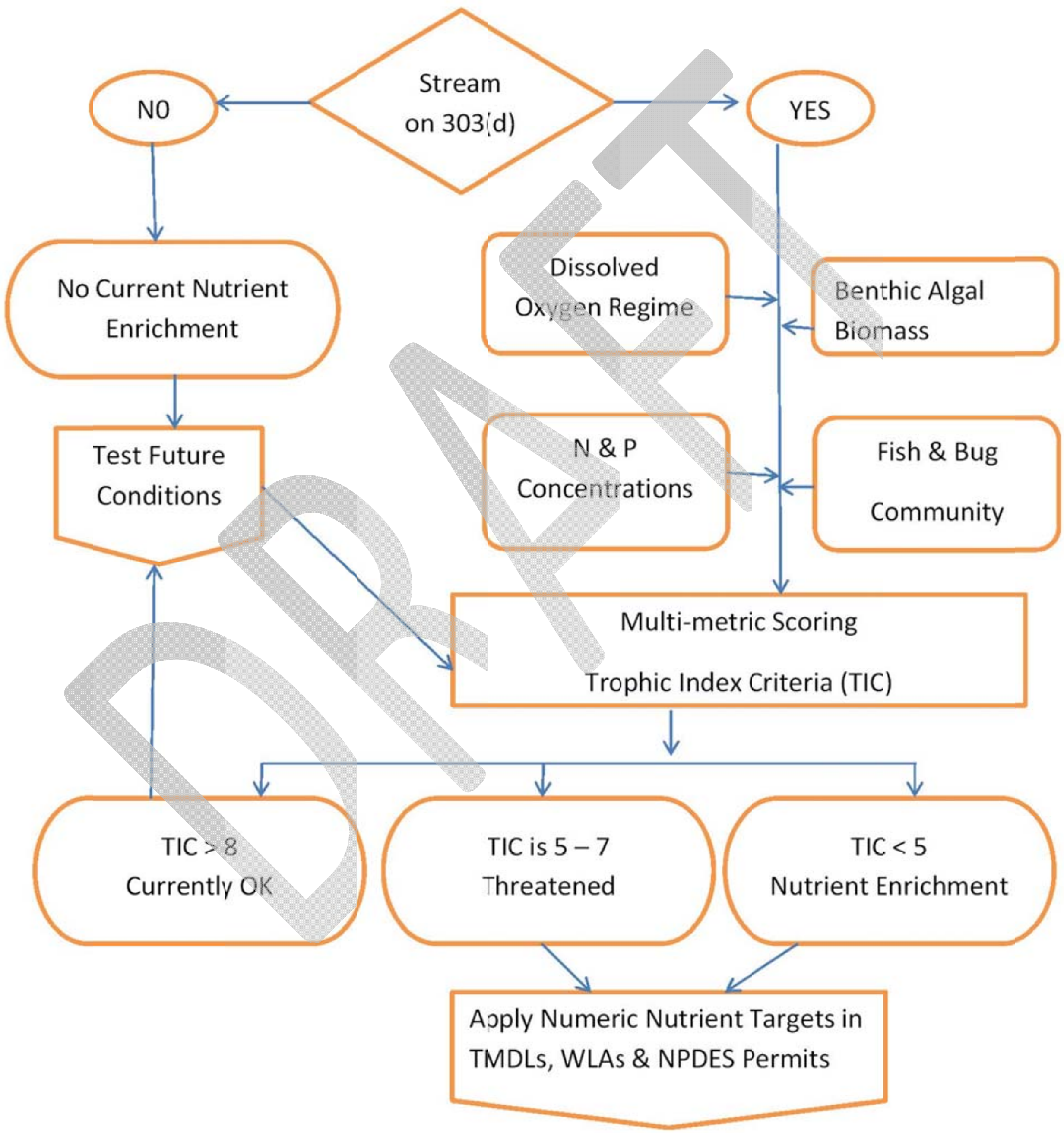
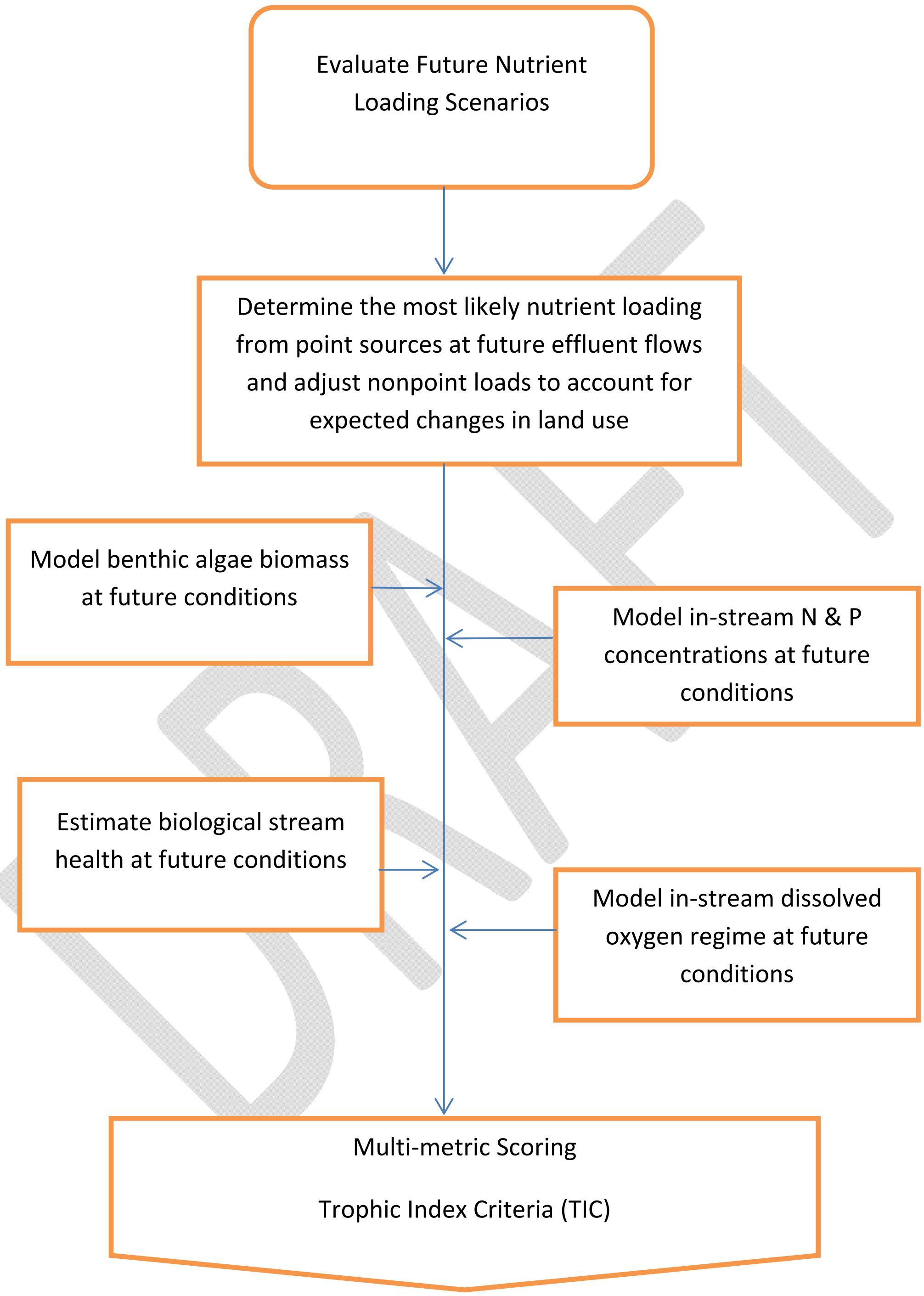


Figure 13. Flow chart illustrating concept of the Trophic Index Criterion, part 2 – future conditions.



Specific Shortcomings in WQS

There are a number of shortcomings and risks associated with the current Ohio nutrient WQS.

- The current standards are narrative and rely upon a “translator” mechanism developed with data that is over ten years old; newer data is available that support the use of different in-stream nutrient target concentrations.
- USEPA expects Ohio’s nutrient standards to be updated with newer information; the adoption of numeric criteria is strongly encouraged.
- There is a risk of a third party citizen’s law suit filed under – part of the CWA – seeking federal intervention and forcing USEPA to adopt standards for Ohio.
- The current “translator” mechanism is conservative and does not include the latest available information on response variables. Continued reliance upon the current “translator” mechanism may result in Ohio EPA taking overly stringent actions to control nutrients in some waters.
- The use of current narrative nutrient WQS for generating the Section 303(d) list of impaired waters relies upon the best professional judgment of individual Ohio EPA staff to associate observed impairment of aquatic life uses with excessive nutrient enrichment. The process could be made a lot more objective by using a multi-metric Trophic Index Criterion based upon newer available data on response variables and in-stream nutrient concentrations.
- Some NPDES permit holders have, or will in the future, appeal their limits for nutrients. There is always a risk of losing appeals. That risk might be higher under the current situation because the “translator” mechanism was never included in a rule making. The risk of losing NPDES appeals of nutrient limits would likely be diminished to some degree by adopting new more explicit nutrient criteria in a WQS rule making.

Total Maximum Daily Loads

The Total Maximum Daily Load (TMDL) program, established under Section 303(d) of the Clean Water Act (33 U.S.C. 1313), focuses on identifying and restoring polluted rivers, streams, lakes and other surface waterbodies. A TMDL is a written, quantitative assessment of water quality problems in a waterbody and contributing sources of pollution. It specifies the amount a pollutant needs to be reduced to meet water quality standards (WQS), allocates pollutant load reductions, and provides the basis for taking actions needed to restore a waterbody.

Ohio's TMDL process is evolving. After benchmarking with other states and U.S. EPA and analyzing our own rules and programs, the Division of Surface Water developed a 12-step project-management-based TMDL process to accomplish TMDLs. The process builds on existing monitoring, modeling, permitting, and grant programs and works within our "five-year monitoring strategy." The process contains four broad, overlapping phases:

- *Assess* waterbody health: biological, chemical, habitat
- *Develop* a restoration target and a viable scenario
- *Implement* the solution: inside/outside Ohio EPA
- *Validate* to monitor progress: delist or relist.

Data from the stream assessment surveys and the sampling conducted by the district water quality staff are used in a variety of mathematical models to determine the maximum allowable loads for the specific stream that will result in attainment of the use designation and biological criteria of that stream. Models are used to assess sources, develop linkages between sources and indicator response, and assist in the allocation process.

Loading models are used to predict pollutant movement from land surfaces to waterbodies over a particular time scale. Simple loading models (e.g. GWLF) rely on large scale aggregations and generalized sources of data and result in annual mean loadings; complex loading models (e.g. HSPF) require site-specific data and can predict loadings on a continuous basis (e.g. per minute).

Receiving stream models (e.g. QUAL2K) simulate the in-stream concentration of a parameter based on the in-stream fate and transport processes that occur and on pollutant loadings. These models can be used to define the linkage between sources and targets.

WQ models also assist in the load allocation process. Loading models can predict what the pollutant load would be based on a particular control action. Receiving water models can take this input and determine if the target is met in the waterbody. Together they address the question of whether or not a particular restoration plan will result in attainment of the target (e.g. water quality standard).

Ohio EPA most typically uses the stream water quality model QUAL2K,or watershed models such as GWLF, SWAT or HSPF for analyzing and predicting nutrient loads. QUAL2K is used where point source dischargers are the primary cause of nutrient enrichment, or to predict whether a discharger can increase their nutrient load without causing impairment. GWLF, SWAT or HSPF are more commonly used where the nutrient enrichment is more widespread and known or believed to be caused by a variety of non-point sources, or a combination of point sources and non-point sources. In some simple situations with limited sources and mostly high flow impacts, a load duration curve may be used to establish total maximum daily loads for a single nutrient as a surrogate (usually phosphorus).

Additional specialized monitoring that includes water quality modeling surveys and wasteload allocation development is conducted annually to support the TMDL program and the NPDES permitting program. The former effort involves development of watershed-scale point and nonpoint load allocations for pollutants impairing beneficial uses as identified through the watershed biosurveys while the latter activity involves the development of water quality based effluent limitations (WQBELs) for point sources. Monitoring for TMDL modeling usually takes place the year following the biosurvey while monitoring in support of WQBEL development occurs in advance of NPDES permit reissuance. Data collection for stream modeling surveys involves chemical, physical, and biological measurements. Comprehensive (i.e., watershed-wide) surveys using time-continuous, multi-parameter sensors of bulk chemistry are deployed to support the integrated biosurvey identified in A.1.1.

Data collection required to calibrate and validate watershed models involves year-around monitoring of stream flows and water quality data at selected sites in the study areas. Monthly (or more frequent) monitoring is typically required to define seasonal flow condition and water quality fluctuations. Enhanced spatial (e.g., sub-watershed) and temporal (e.g., rain event) monitoring frequency improves the definition of TMDL restoration scenarios. Detailed sampling is used to address in-site waste stream assimilation and instream decay rates for nonconservative pollutant parameters. The surveys are conducted between the months of May and October depending upon stream flow conditions. Oxygen model calibration and verification are completed using these monitoring results. In streams where simplified modeling is appropriate, sampling consists of composite and/or grab measurements, flow, diurnal dissolved oxygen measurements, and time-of-travel collected during a single survey. In complex modeling situations, stream flow, time of travel, reaeration, composite chemical sampling, algal biomass and metabolism, and sediment oxygen demand may be determined over a period of one to four days. Multiple surveys are required to fulfill the data requirements of model calibration and verification.

The BATHTUB model has been used for the limited number of lake evaluations performed to date. This model is fairly simplistic and a good general nutrient model, but does not adequately address in-lake phosphorus recycling for instance. There are two support programs: FLUX allows estimation of tributary nutrient loadings from sample concentration data and continuous flow records. PROFILE facilitates analysis and reduction of in-lake water quality data. Results from other loading models such as GWLF can also be used to better estimate tributary loading. For best results, lake and tributary sampling should be conducted in tandem.

Short comings in TMDLs

- Lack of complete data sets for some streams (esp. chlorophyll)
- Lack of good lake modeling options (capable of addressing internal P cycling without large resource requirements)
- Resources to evaluate every new or expanding discharger
- Difficulty in identifying sources in accurate quantities (esp nutrients from the land) with no soil nutrient data, no records of fertilizer application, etc.
- Difficulty in accurately portraying BMPs used in the basin and how effective they are

Point Source Discharge Permits (NPDES)

The framework to regulate pollution under the Clean Water Act, and State law in Ohio, rests on the premise that it is illegal to discharge pollutants to surface waters without a permit to authorize the amounts and kinds of substances discharged. [Note that most agricultural activities are exempted from this regulation, see discussion under the NPS section]. Two types of discharge limitation are possible: 1) technology based effluent limits applicable to categories of industries or public facilities; and 2) water quality based effluent limits (WBQELs) that are necessary whenever BAT limits cannot achieve the desired in-stream water quality conditions set by the State's WQS. With respect to nutrients there are presently no nationally promulgated BAT limits for total phosphorus and nitrogen. The reasons for this likely stem from multiple lines of programmatic decisions made at USEPA over many years. Suffice it to say that it would relatively straightforward to create technology based TP and TN effluent limits for POTWs and key industry sectors.

Remainder of this section summarizes components of Ohio's current NPDES permit program that address nutrients. Additional information is provided on nutrient removal technologies and Ohio's draft proposal to define a level of Best Available Demonstrated Control Technology for nutrients applicable to certain POTWs. Basic information is also provided on readily available and technically feasible nutrient removal technologies.

Nutrient Removal Technology

Nutrient removal at POTWs is generally facilitated through three regimes: biological, chemical, and physical. The removal of ammonia nitrogen and nitrate from wastewater is primarily accomplished through biological nitrification and denitrification processes. Particulate organic nitrogen is removed through solids separation processes; there is no common removal mechanism for soluble organic nitrogen.

Biological nutrient removal (BNR) removes total nitrogen (TN) and total phosphorus (TP) from wastewater through the use of microorganisms under different environmental conditions in the treatment process (Metcalf and Eddy, 2003).

Table 14. Mechanisms for Removal of Total Nitrogen

Form of Nitrogen	Common Removal Mechanism	Technology Limit (mg/L)
Ammonia-N	Nitrification	<0.5
Nitrate-N	Denitrification	1 – 2
Particulate organic-N	Solids separation	<1.0
Soluble organic-N	None	0.5 – 1.5

Source: Jeyanayagam (2005).

Particulate phosphorus can be removed from wastewater through solids removal. Biological phosphorus removal relies on phosphorus uptake by aerobic heterotrophs capable of storing orthophosphate in excess of their biological growth requirements.

Phosphorus can also be removed from wastewater through chemical precipitation. Chemical precipitation primarily uses aluminum and iron coagulants or lime to form chemical flocs with phosphorus. These flocs are then settled out to remove phosphorus from the wastewater (Viessman and Hammer, 1998).

Table 15. Mechanisms for Removal of Total Phosphorus

Form of Phosphorus	Common Removal Mechanism	Technology Limit (mg/L)
Soluble phosphorus	Microbial uptake Chemical precipitation	0.1
Particulate phosphorus	Solids removal	<0.05

Source: Jeyanayagam (2005).

Some common configurations of BNR systems are listed below in Table 16.

Table 16. Common BNR system configurations

Process	Description
Modified Ludzack-Ettinger (MLE) Process	Continuous-flow suspended-growth process with an initial anoxic stage followed by an aerobic stage; used to remove TN
A^2/O Process	MLE process preceded by an initial anaerobic stage; used to remove both TN and TP
Step Feed Process	Alternating anoxic and aerobic stages; however, influent flow is split to several feed locations and the recycle sludge stream is sent to the beginning of the process; used to remove TN
Bardenpho Process (Four-Stage)	Continuous-flow suspended-growth process with alternating anoxic/aerobic/anoxic/aerobic stages; used to remove TN
Modified Bardenpho Process	Bardenpho process with addition of an initial anaerobic zone; used to remove both TN and TP
Sequencing Batch Reactor (SBR) Process	Suspended-growth batch process sequenced to simulate the four-stage process; used to remove TN (TP removal is inconsistent)
Modified University of Cape Town (UCT) Process	A^2/O Process with a second anoxic stage where the internal nitrate recycle is returned; used to remove both TN and TP
Rotating Biological Contactor (RBC) Process	Continuous-flow process using RBCs with sequential anoxic/aerobic stages; used to remove TN
Oxidation Ditch	Continuous-flow process using looped channels to create time sequenced anoxic, aerobic, and anaerobic zones; used to remove both TN and TP.

Source: EPA-823-R-07-002 (2007)

A comparison of relative nutrient removal efficiencies for the common BNR configurations is listed in Table 17. It can be seen that all of the configurations are capable of satisfactory nitrogen removal but that phosphorus removal varies depending on the chosen configuration.

Table 17. Comparison of common BNR system configurations

Process	Nitrogen Removal	Phosphorus Removal
MLE	Good	None
A^2/O	Good	Good
Step Feed	Moderate	None
Four-Stage Bardenpho	Excellent	None
Modified Bardenpho	Excellent	Good
SBR	Moderate	Inconsistent
Modified UCT	Good	Excellent
Oxidation Ditch	Excellent	Good

Source: Jeyanayagam (2005).

Generally speaking, as nutrient limits are reduced the capital and operating costs associated with nutrient removal increase. Costs are difficult to estimate because they fluctuate with market conditions, inflation, geographic location, and the technology employed to facilitate nutrient removal. Capital costs also vary depending on whether the cost is associated with a new treatment plant or with a retrofit of an existing treatment plant.

Table 18 displays the average cost of retrofitting existing Maryland and Connecticut waste water treatment plants to BNR technologies. Note that as the size of the treatment plant increases, unit costs generally decrease due to economies of scale. (cite EPA)

Table 18. Average Unit Capital Costs for BNR Upgrades at Maryland and Connecticut Wastewater Treatment Plants (2006)[1]

Flow (mgd)	**Cost/mgd**
>0.1 – 1.0	$6,972,000
>1.0 – 10.0	$1,742,000
>10.0	$588,000

Source: Based on MDE (2006) and CTDEP (2007).

[1] Calculated from cost information from Maryland Department of the Environment for 43 facilities and Connecticut Department of Environmental Protection for 23 facilities; costs updated to 2006 dollars based on project completion date using the ENR construction cost index (2006 index = 7910.81).

Operation and maintenance costs at waste water treatment plants must take into account factors such as labor, maintenance, electricity use, chemical use, and sewage sludge management.

Assuming that the limit of technology for phosphorus removal allows for a final concentration of 0.05 mg/L in treated effluent, one estimate finds that reducing phosphorus limits from 0.5 mg/L to 0.05 mg/L would result in operating costs increasing anywhere from a factor of two to fifteen. In any case, it is clear that operation and maintenance costs will increase when advanced technology is employed to meet stricter nutrient limits.

Table 19. Phosphorus removal operating cost estimates depending on limit

Phosphorus Limit	Cost ($/lb P removed)
0.5 mg/L	$2.60-$18.00
0.05 mg/L	$37.00

Source: Peggy Glass, Plummer & Associates

Conclusion - Several technologies exist which can facilitate the removal of nutrients to very low levels. As state and federal cost-share assistance for waste water infrastructure dries up, it is expected that significant rate increases would be passed on to ratepayers in order to pay for the upgraded technology needed to comply with more stringent nutrient limits. Without adequate financial support from the state and federal government, it is expected that there will be significant public opposition to requirements to upgrade treatment technology.

Industrial, Construction and Municipal Storm Water Programs

Urban storm water runoff washes chemical contaminants, including nutrients, from relatively impervious hard surfaces and delivers these pollutants via catchments, ditches and pipes to nearby waterways. In the early years of the Clean Water Act this urban storm water runoff was considered non-point source pollution and was not subject to permitting. That changed in 1987 when Congress amended the CWA to require the U.S. EPA to establish phased NPDES requirements for storm water discharges. Although there are no explicit requirements regarding nutrient reduction several aspects of the program requirements indirectly act to reduce the delivery of nutrients to surface waters. The details of program are described below.

U.S. EPA published its Phase I regulations in the Federal Register on November 16, 1990 (40 CFR 122.26). Those regulations included permit application requirements and deadlines for certain categories of storm water discharges associated with industrial activity, and discharges from municipal separate storm sewer systems (MS4s) serving populations of 100,000 or more. U.S. EPA published its Phase II regulations in the Federal Register on December 8, 1999 which amended 40 CFR 122.30 through 122.37. Phase II created requirements for some MS4s serving populations less than 100,000, ended an exemption for publically owned industrial facilities, and revised the industrial program (which includes construction). As an NPDES delegated state, Ohio EPA is responsible for implementing the federal storm water program.

Activities that take place at industrial facilities, such as material handling and storage, are often exposed to the weather. As runoff from rain or snowmelt comes into contact with these activities, it can pick up pollutants and transport them to a nearby storm sewer system or directly to surface waters. To minimize the impact of storm water discharges from industrial facilities, the NPDES program includes an industrial storm water permitting component that requires certain industrial activities to be subject to the requirements. Applicable facilities must either obtain an NPDES industrial storm water permit or submit a No Exposure Certification which certifies that industrial materials and activities are not exposed to storm water. The list of storm water discharges associated with industrial activity is very extensive and is defined by standard industrial classification (SIC) codes or narrative descriptions. The following identifies the number of industrial facilities covered under Ohio's industrial storm water general permit or have submitted a No Exposure Certification.

Ohio's Industrial Storm Water Program		
	# of Facilities	Applicability
Industrial Storm Water General Permit	2,918	Statewide
No Exposure Certification	2,408	

Facilities covered under the industrial storm water general permit are required to develop and implement a Storm Water Pollution Prevention Plan (SWP3). The goal of the SWP3 is to minimize or eliminate the potential for contamination of storm water discharges from the facility. For No Exposure Certifications, facilities must re-certify no exposure every 5 years.

Ohio EPA's construction storm water program applies statewide and from 1,200 to 2,500 sites per year are granted permit coverage (see Table 20). Projects disturbing 1 or more acres of ground must obtain a NPDES permit to discharge storm water from the site. In addition, projects which disturb less than 1 acre but are part of a larger common plan of development or sale are also required to obtain permit coverage.

Table 20. The number of construction storm water general permits Ohio EPA issued annually since 2003.

Total Construction General Permits Issued		
Year	# Issued	Applicability
2003	2,150	Statewide
2004	2,540	
2005	2,571	
2006	2,623	
2007	1,627	
2008	1,504	
2009	1,240	
2010	1,405	

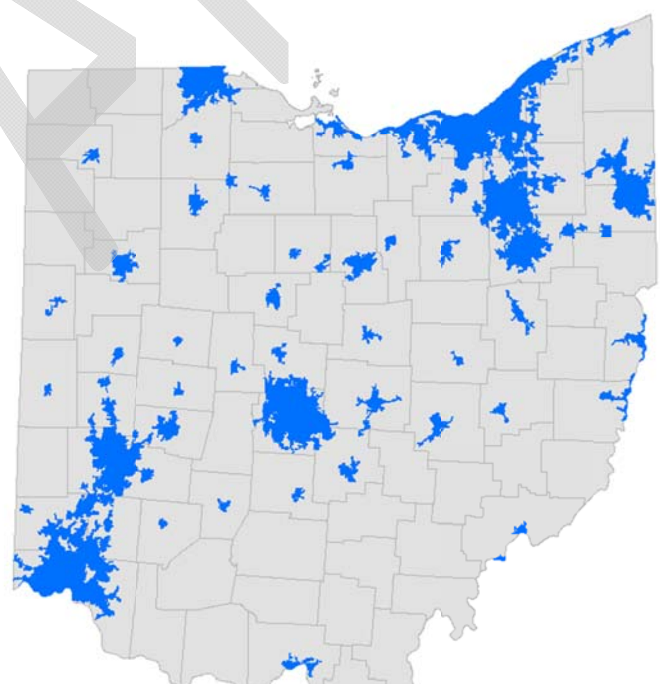
Ohio EPA administers the construction storm water program with the use of three general permits. The following describes each:

- Statewide Construction Storm Water General Permit. This general permit is applicable statewide, except for the special watersheds listed below, and requires operators to develop a Storm Water Pollution Prevention Plan (SWP3). The SWP3 requires that proper sediment and erosion controls be implemented to reduce sediment laden storm water from leaving the site. In addition, this general permit contains requirements for operators to implement post-construction controls to assure that storm water runoff from developed land does not negatively impact receiving streams, either through hydrologic impacts or pollutant discharges.

- Big Darby Creek Watershed Construction Storm Water General Permit. This general permit is applicable to the Big Darby Creek Watershed. In addition to the conditions found within the statewide general permit, this alternative general permit contains conditions for riparian setbacks and ground water recharge. Ohio EPA reviews and approves all SWP3s to ensure conditions of this alternative general permit are satisfied.
- Olentangy River Watershed Construction Storm Water General Permit. This general permit is applicable to portions of the Olentangy River Watershed. In addition to the conditions found within the statewide general permit, this alternative general permit contains conditions for riparian setbacks. Ohio EPA reviews and approves all SWP3s to ensure conditions of this alternative general permit are satisfied.

On the municipal side, the Phase I regulations covered discharges of storm water from large and medium MS4s. Large municipalities with a separate storm sewer system serving populations greater than 250,000 and medium municipalities with a service population between 100,000 and 250,000 had to obtain NPDES permits. Initial application deadlines for large and medium municipalities were November 16, 1992 and May 17, 1993, respectively. Ohio has four Phase I MS4s which consist of Akron, Columbus, Dayton and Toledo. These MS4s had to develop and implement a Storm Water Management Program (SWMP).

The Phase II regulations address storm water runoff from MS4s serving populations less than 100,000, called small MS4s. More particularly, small MS4s located partially or fully within urbanized areas (UAs), as determined by the U.S. Bureau of the Census, and also on a case-by-case basis for those small MS4s located outside of UAs that Ohio EPA designates into the program. The State of Ohio is comprised of 26,415,998 acres. The area served by regulated MS4s is 2,317, 769 acres; therefore, 8.8% of Ohio is regulated under the MS4 program as illustrated in Figure 14.



The MS4 program requires the development and implementation of a SWMP. A SWMP is comprised of six minimum control measures that, when administered in concert, are expected to result in reduction of the discharge of pollutants into receiving waters. In addition, to the six minimum control measures, Phase I MS4s are also required to develop and implement an industrial program and conduct storm water monitoring.

Operators of regulated MS4s are required to design their programs to do the following: reduce the discharge of pollutants to the "maximum extent practicable" (MEP), protect water quality and satisfy the appropriate water quality requirements of the Clean Water Act. Implementation of the MEP standard will require the development and implementation of BMPs and the achievement of measurable goals to satisfy each of the following six minimum control measures:

1. **Public Education and Outreach**. This requires the distribution of educational materials and performing outreach to inform citizens about the impacts polluted storm water runoff discharges can have on water quality.
2. **Public Participation/Involvement**. This requires that MS4s provide opportunities for citizens to participate in program development and implementation, including effectively publicizing public hearings and/or encouraging citizen representatives on a storm water management panel.
3. **Illicit Discharge Detection and Elimination**. This requires the development and implementation of a plan to detect and eliminate illicit discharges to the storm sewer system. In addition, the plan must include a storm sewer system map with discharging HSTSs and a program informing the community about hazards associated with illegal discharges and improper disposal of waste.
4. **Construction Site Runoff Control**. This requires MS4s to develop, implement and enforce an erosion and sediment control program for construction activities that disturb 1 or more acres of land (controls could include silt fence and temporary sediment ponds).
5. **Post-Construction Runoff Control**. This requires MS4s to develop, implement and enforce a program to address discharges of post-construction storm water runoff from new development and redevelopment areas. Applicable controls could include preventive actions such as protecting sensitive areas (e.g., riparian areas) or the use of structural BMPs such as extended detention basins.
6. **Pollution Prevention/Good Housekeeping**. This requires MS4s to develop and implement a program with the goal of preventing or reducing pollutant runoff from municipal operations. The program must include municipal staff training on pollution prevention measures and techniques (e.g., regular street sweeping, reduction in the use of pesticides or street salt, and frequent catch-basin cleaning).

Ohio's Regulated MS4s			
	Permitting Mechanism	**# of MS4s**	**Applicability**
Phase I	NPDES Individual Permits	4	Statewide
Phase II	NPDES General Permits	524	Currently, 8.8% of Ohio regulated

Framework for Point Source Nutrient Reduction Strategies

It should be evident that industries and municipal governments have basic legal and public welfare responsibilities to treat wastewater to levels that are shown to fully protect water quality. That said a regulatory agency also has a public responsibility to guard against imposing unnecessarily stringent and costly treatment that won't result in environmental gains. Ohio needs sound, scientifically supported regulations and implementation protocols to provide consistent and cost effective point source nutrient controls.

This section describes Ohio EPA's current thinking about WQS regulations and an approach for implementing those standards through the TMDL program and the issuance of water quality based effluent limits in the NPDES permit program. The objective is to provide a scientifically based protocol for testing the likelihood of meaningful and positive aquatic system responses when nutrient removal technologies are installed at point sources. The matter of economic reasonableness is a question that is best examined on a case by case basis. Ohio EPA is committed to the principle that all substantial investments in nutrient removal technologies at point sources have a reasonable expectation of improving the condition of stream biological health and/or significantly contributing to the annual load reduction targets established for downstream nutrient sink water bodies.

Recommended Standards for Nutrients

Recommended Actions

The standards in place today rely upon the basic narrative "free from" water quality criteria and a "translator" mechanism published by Ohio EPA in 1999 (cite). New information is available that will support the adoption of a more refined, predictable and accurate Trophic Index Criterion (TIC). This multi-metric criterion could serve as the numeric nutrient water quality criterion for Ohio streams and rivers. Water quality target concentrations for TP and DIN included within the WQS rule would replace the former "translator" mechanism. In 2008 Ohio EPA release draft WQS that included a new aquatic life use designation for inland lakes (Lake Habitat) and numeric nutrient criteria were included. Fully addressing nutrient enrichment problems in Ohio's lakes, streams and rivers in a cost-effective manner will not happen without having these improved standards in place.

The following actions regarding Ohio WQS for nutrients need to occur:

- Propose and adopt the Lake Habitat use and associated nutrient criteria.
- Ohio EPA & USEPA agree upon an acceptable conceptual approach to the stream nutrient WQS rule package.
- Organize and conduct stakeholder education and discussion of the draft rule package. This should occur prior to and during the Interested Party Review (IRP) period.
- Release proposed rule package using IPR feedback for public comment
- Adopt revised WQS nutrient package using public comment feedback
- Apply final WQS rule in TMDL, NPDES and the 303(d) water assessment programs

Recommended TMDL and NPDES Program Actions

Ohio has a strong track record with regard to the identification of waters impaired by nutrients and doing the follow-up work to complete nutrient TMDLs and issuing NPDES permits with phosphorus limits. By applying knowledge and experience already gained we can hone an effective strategy that retains what has worked and modifies procedures that produce little added value. The objective is become more effective in producing WLA results that work best in the NPDES program. Additional consideration must be given to the question of how to translate the load allocation results for nonpoint sources into more meaningful information that has practical applications in getting nutrient reduction practices implemented.

One significant change in the program is needed: an improved ability to incorporate the evaluation of the downstream impacts of nutrient loadings. Traditionally Ohio EPA's stream survey work is conducted at a watershed level made up of multiple adjacent HUC 10 units. Nutrient TMDLs are produced that meet target levels at the outlet of the combined drainage. Additional consideration may be needed to consistently evaluate whether inland lake nutrient standards will be met with for lakes within the study area as well as lakes located downstream.

Nutrient Loading Strategies for Streams and Rivers - Near Field Impacts

The first step in deciding to implement nutrient removal at point sources is to confirm that one of the following holds true:

- Based on the most recent and comprehensive data available the stream segment is currently impaired or threatened by nutrient enrichment. The Trophic Index Criterion (TIC) is designed to answer this question; or
- Based on the most reliable forecast of future conditions modeling projections of chl a, dissolved oxygen and biological stream health the TIC outcome indicates an impaired or threatened stream condition.

Both of these outcomes represent situations where explicit WLA values would be calculated to meet all applicable water quality criteria for protection of all beneficial uses. The strategy continues this practice for the purpose of preparing TMDL reports and assigning TP and DIN WLA numbers to all point sources of nutrients. Several program operational facts are acknowledged:

- WLAs in TMDLs can be removed only by re-doing TMDL (attaining WQS does not alleviate WLA in approved TMDL);
- Permits must be consistent with TMDL WLAs; and
- All facilities must be assigned a load in the WLA, or no discharge of that pollutant is allowed.

Accepting the facts listed above the strategy incorporates these guiding principles:

- If there is impairment, then meaningful reductions are needed; and
- We should be able to articulate what will be gained for the expenditures we request.

Ohio EPA has prepared the following guidelines for assigning phosphorus WLAs in TMDLs. These guidelines do not replace regulations or policy, for example 3745-33-06, which regulates discharges to publicly owned lakes or reservoirs and their tributaries.

Table 21. Guidelines for assigning phosphorus WLAs in TMDLs, POTWs discharging 1 MGD per day or more. If no effluent data available to estimate load, use a concentration of 3 mg/l.

	Condition of Water	**WLA and NPDES Permit Content**
Lake Erie Basin	Not impaired for nutrients	1.0 mg/l at design flow, per long-standing Lake Erie policy
	Impaired for nutrients; this source is predominant contributor to impairment	When new WQS (including TIC analysis) in place: Allocate as low as 0.5 mg/l (with compliance schedule, trading option, habitat fixes)
		Until new WQS in place: Allocate the lower of 1.0 mg/l at design flow or existing load* (with trading option, habitat fixes).
	Impaired for nutrients; this source is one of multiple contributors to impairment	When new WQS (including TIC analysis) in place: Allocate as low as 0.5 mg/l (with compliance schedule, trading option, habitat fixes)
		Until new WQS in place: Allocate at 1.0 mg/l at design flow*
Ohio River Basin	Not impaired for nutrients	Include existing effluent load in WLA in TMDL. No phosphorus permit limit; monitoring per guidance
	Impaired for nutrients; this source is predominant contributor to impairment	When new WQS (including TIC analysis) in place: Allocate as low as 0.5 mg/l (with compliance schedule, trading option, habitat fixes)
		Until new WQS in place: Allocate the lower of 1.0 mg/l at design flow or existing load*(with trading option, habitat fixes).
	Impaired for nutrients; this source is one of multiple contributors to impairment	When new WQS (including TIC analysis) in place: Allocate as low as 0.5 mg/l (with compliance schedule, trading option, habitat fixes)
		Until new WQS in place: Allocate at 1.0 mg/l at design flow* (with compliance schedule, trading option, habitat fixes)

* However, if rigorous, calibrated model that simulates instream processes indicates need: Allocate as low as 0.5 mg/l at design flow (with compliance schedule, trading option, habitat fixes).

Table 22. Guidelines for assigning phosphorus WLAs in TMDLs, POTWs discharging less than 1 MGD per day or more. Actions are the same in the Lake Erie and Ohio River basins. If no effluent data available to estimate load, use a concentration of 3 mg/l.

Design Flow (MGD)	Condition of Water	WLA and NPDES Permit Content
0.15 to 1.0	Not impaired for nutrients	Include existing effluent load in WLA in TMDL. No phosphorus permit limit; monitoring per guidance
	Impaired for nutrients; this source is predominant contributor to impairment	When new WQS (including TIC analysis) in place: Allocate as low as 0.5 mg/l (with compliance schedule, trading option, habitat fixes)
		Until new WQS in place*: • Allocate at 1.0 mg/l and design flow if reducing phosphorus load would likely result in attaining biological WQS (e.g., habitat is good, other stressors will be addressed) • Allocate at existing load if there are confounding causes of impairment that will not be addressed
	Impaired for nutrients; this source is one of multiple contributors to impairment	When new WQS (including TIC analysis) in place: Allocate as low as 0.5 mg/l (with compliance schedule, trading option, habitat fixes)
		Until new WQS in place*: apply the next step in progression: no effluent monitoring → effluent monitoring → WLA at 1.0 mg/l → a more stringent limit based on rigorous model.
0.025 To 0.15	Not impaired for nutrients	Include existing effluent load in WLA in TMDL. No phosphorus permit limit; monitoring per guidance
	Impaired for nutrients; this source is predominant contributor to impairment	• Allocate at 1.0 mg/l and design flow if reducing phosphorus load would likely result in attaining biological WQS (e.g., habitat is good, other stressors will be addressed) • Allocate at existing load if there are confounding causes of impairment that will not be addressed
	Impaired for nutrients; this source is one of multiple contributors to impairment	Include existing effluent load in WLA in TMDL. No phosphorus permit limit; monitoring per guidance
Less than 0.025	Any impairment situation	Include existing effluent load in WLA in TMDL. No phosphorus permit limit; monitoring per guidance

* If rigorous, calibrated model that simulates instream processes indicates need: Allocate as low as 0.5 mg/l at design flow (with compliance schedule, trading option, habitat fixes)

The next strategic issue to consider is whether or not reductions in point source loadings will result in attainment of the designated aquatic life use designation and in what time frame. Conceptually, attainment of designated aquatic life uses occurs when WLA and LA loading rates are achieved. However, because it is the inherent nature that most NPS loadings are associated with wet weather runoff events, the LA target set in the TMDL program is not directly correlated with the stress exerted by NPS on aquatic life in small streams and most rivers in Ohio.

All continuously discharging point sources within a watershed need to be evaluated with respect to whether or not their effluent exerts a predominate influence on the chemical physical attributes of the stream at typical summer base flow regimes. If a stream is effluent dominated then adverse impacts from pollutants in the effluent are more likely. The effects of nutrient enrichment are also influenced by other factors including stream habitat, shading, gradient, temperature and ground water inflow.

To look at the direct association between nutrient concentrations and probability of aquatic life use attainment in streams, logistic regression was applied in a retrospective analysis of historical Ohio EPA data. Data were limited to streams < 500 mi2 in drainage area, and sites with mean ammonia-nitrogen concentrations exceeding 0.1 mg/l were culled from the data set. Table 23 illustrates the general relationship between stream habitat conditions (as measured with the Qualitative Habitat Evaluation Index (QHEI), in-stream total phosphorus concentrations and the probability of attaining the Warmwater Habitat aquatic life use biological criteria under these conditions. This tool provides a means to gage the likelihood of seeing tangible environmental improvements as a result imposing NPDES permit limits and phosphorus removal at POTWS in concert with other decisions that might affect management of the stream habitat and the prevailing NPS contributions to in-stream TP concentrations over the summer base flow regime.

Table 23. Probability of attaining WWH biological criteria at specified habitat conditions (QHEI) and total phosphorus concentrations.

	In-stream TP at Summer Base Flow Conditions (ug/l)			
QHEI Score	50	100	300	500
40	18%	14%	11%	9%
60	48%	42%	33%	30%
65	57%	51%	42%	38%
80	80%	76%	68%	63%

The appropriate application of this relationship tool is to inform the decision maker on the likelihood of seeing improvement is stream biological health in one or multiple NPDES permit renewal cycles. The stream with a QHEI score of 40 is very unlikely to respond to the installation of nutrient removal unless dramatic and potentially costly stream habitat restoration is undertaken. Inclusion of WLA based TP limits should be delayed until such plans materialize[8]. Conversely if a stream with excellent habitat

[8] TP limits might be imposed on a faster time schedule to protect downstream uses.

(QHEI =80) is impaired by nutrients one can be fairly confident that improvement will be realized through imposing nutrient reductions that result in in-stream TP concentrations near 100 ug/l. And for boarder- line habitat values (60-65) the chances of seeing attainment of WWH after imposing TP limits can be bolstered if paired with concurrent projects that improve habitat conditions.

Nutrient Loading Strategies for Lakes and Other Far Field Sinks

All significant contributors to the annual pollutant loading generated within a watershed need to be evaluated with respect to the impact of that load on downstream aquatic environments that function as nutrient sinks.

Recommendations:

The following actions regarding Ohio WQS for nutrients need to occur:

- Expand SOPs and study design to include benthic chl a and continuous DO monitoring
- Select most cost effective modeling tools to provide data to forecast TIC values under future point source loading and land use scenarios
- Develop a review protocol that will set reasonable expectations for stream habitat improvements on a case by case basis

Framework for NPS Nutrient Reduction Strategies

Overview

The efforts of the past 30 years to control soil erosion through agricultural and storm water BMPs have been successful in addressing a couple of important impacts on aquatic systems. Reductions in soil loss from cropland and construction sites results in less sediment and attached nutrients delivered to Ohio's streams and lakes. ADD SPECIFIC ON DECLINES IN LE LOADING The expanding range and abundance of certain of sediment sensitive fish species such as the bigeye chub may reflect the positive benefits of no-till and reduced tillage agricultural production practices and the storm water NPDES program. In order to maintain these water quality improvements, government programs and producers should continue to install BMPs that control soil erosion and reduce the delivery of sediment to streams.

Unfortunately, simply doing more of the same practices won't address the current water quality problems in Ohio that stem from too many nutrients entering our streams and lakes. The condition of aquatic life in 48 percent of our small and medium sized rivers is impaired by high nutrient levels during summer base flow conditions. During runoff events, peak nutrient loads are flushed through small streams and rivers and reach lake ecosystems where excessive nutrient levels result in harmful algae blooms, increased water treatment costs and in some cases public health hazards. Data indicate that the amount of dissolved phosphorus reaching Lake Erie has increased even though loadings of total phosphorus have remained constant. This new information requires major adjustments in the way we think about agricultural and urban storm water BMPs.

We need to rethink traditional practices by which nutrients are applied to the land surface and rethink the rate and methods currently employed for draining excess water from agricultural fields, urban streets and suburban lawns. A number of efforts are already underway to engage agricultural producers and other stakeholders in this effort (see last chapter). This section presents a framework for addressing NPS pollution in a manner designed to result in meaningful improvements in water quality. Details on how the approaches and practices get implemented at either a State-wide or watershed level basis is yet to be determined.

Strategic Framework

There are two basic strategies that can be employed to address Ohio's nonpoint source nutrient loading issues. The first is to reduce nutrient loadings to Ohio's rivers and streams. This strategy employs practices and actions that are designed to reduce the "sources" of nutrients and include such things as reducing the use of manure and commercial fertilizers. A second often overlooked strategy includes actions that are designed to physically improve a streams capacity to assimilate the nutrient load that is already in the waters. Decades of channelization, damming of rivers and other alterations to a stream's natural flow have severely decreased the natural assimilation of nutrients.

With these strategies serving as an important foundation for dealing with Ohio's nonpoint sources of nutrients, we have further refined recommended actions to specifically address two general sources of excessive nutrients: those nutrients coming from agricultural sources and those from urban and residential storm water runoff. Ohio's approach is reasonably organized in such a manner as to identify the various sources of nonpoint source nutrient pollutants and to specify fundamental strategic actions that need to be implemented. We further elaborate on recommended practices and tools for implementing and measuring progress in meaningful ways. A general outline of these strategies is listed below with more detailed information in the pages that follow.

Agricultural Nutrient Reduction Strategies for Water Quality Protection

1. Improve Upland Management Practices
2. Improve Livestock Management Practices
3. Improve Drainage Water Management Practices
4. Practice Sound Riparian Area Management
5. Improve In-Stream Management Practices

Urban and Suburban Nonpoint Nutrient Reduction Strategies

1. Improve Storm Water Management Practices
2. Enhance leadership role to address nonpoint source nutrient problem in the urban/suburban setting

Recommended Management Practices to Prevent Agricultural Nutrient Losses to Surface Waters.

Considerable improvements are needed for on-the-ground conservation practices that specifically focus on nutrient reduction and water quality protection and improvement. In addition to traditional goals to reduce erosion, it is quickly becoming apparent that a concerted effort is needed to improve drainage water management. The increased percentage of cropland that is receiving systematic subsurface drainage is causing significant alterations to the physical integrity and hydrology of Ohio's streams. Management practices that improve a stream's capacity to assimilate existing pollutant loads also are needed to round out a comprehensive strategy for reducing the impact of nutrients running of the agricultural landscape and into Ohio's rivers and streams, and ultimately our lakes. Following are specific examples of management practices that are recommended:

Upland Management Strategies

1. ***Increase whole farm conservation planning so that water quality related resource concerns are prioritized for agricultural best management practices (BMP) selection and implementation.***

Whole farm conservation planning and conformance with such plans has given way to more specialized plans such as nutrient management plans and/or grazing plans. Although hundreds if not thousands of individual land-owner consultations occur each year in Ohio reduced staffing levels make it very difficult for local NRCS or SWCD personnel to meet with farmers specifically to examine their operations as a whole in order to define critical areas where specifically targeted best management practices should be deployed. Operations need to be looked at holistically so that all necessary BMPs are installed and working together to maximize nutrient reductions. Critical locations where nutrient losses occur must also be identified so that appropriate conservation measures can be implemented or where appropriate conservation practices can be designed and installed according to a whole farm conservation plan.

2. Erosion and sediment loss are significant contributors of nutrients to surface waters. Further reducing erosion continues to be a critical goal in achieving measurable improvements in water quality.

A variety of best management practices have been designed and deployed for the control of erosion and to prevent the loss of soils from the agricultural landscape. Specific practices that are recommended for achieving measurable soil erosion reduction include:

- **Grassed Waterways (412)**: Provided that they are strategically located in areas where ephemeral gully erosion is occurring, grassed waterways may be effective practices to reduce erosion and sediment loss, thereby reducing the input of nutrients into streams. It is imperative that design and installation of these practices be done to enable their full nutrient reduction capabilities to be achieved.

- **Treatment Filter Areas (393):** For decades the grass filter strip (CP21) has been the conservation practice of choice for many agricultural producers as well as conservation professionals. However, the common "filter strip" practice of placing 50 to 300 foot wide bands of grass vegetation parallel to streams and water ways should not be equated with filter areas designed under NRCS 393 specifications. Treatment Filter Areas are designed and installed in areas where flow concentrates so that such runoff can successfully be dispersed and passively treated as it flows into and passes through these filter areas. Conservation professionals agree that in Ohio most common filter strips have not been designed to 393 standards (memorandum from Ohio State Farm Services Agency, State Executive Director, January 18, 2010). *There is opportunity to improve the effectiveness of the streamside conservation cover (filter strips) by installing appropriately designed treatment areas where field runoff occurs.*

- **Cover Crops (340):** A resurgence in the use of cover crops as a tool for managing excessive nutrients began in 2008 and has been increasing throughout the agricultural community. Ohio's nonpoint source nutrient reduction strategy encourages the planting of cover crops post- harvest as part of long term conservation crop rotations. However, Ohio EPA does not advocate *the use of cover crops solely to promote the ability of livestock producers to spread manure on ground where nutrient levels exceed agronomic crop need, or when the ground is frozen or snow-covered.*

Cover crops provide multiple benefits including:

- Increasing soil organic matter to improve soil moisture holding capacity
- Maintaining a living root in the soil most of the year to uptake or scavenge excess nutrients
- Adding crop diversity to improve microbial communities
- More effective assimilation of applied nutrients in soils

- **<u>Minimally Invasive Tillage Practices:</u>** Minimally invasive tillage practices (also known as conservation tillage) such as no-till, strip till and/or mulch tillage are effective tools for reducing soil erosion and therefore retaining nutrients on harvested farm ground. Minimally invasive tillage such as strip till disturbs only 10-15% of the soil surface allowing for improved fertilizer efficiency and less soil erosion than traditional tillage practices.

USDA-NRCS practices that encourage minimally invasive tillage include:

- No Till/Strip Tillage (329)
- Mulch Tillage (345)

- **<u>Install Retention Devices to Interrupt Surface Runoff and Drainage Tile Discharges:</u>** Current agricultural drainage practices are designed to remove water quickly from fields through both surface and subsurface drains. Drainage has resulted in significant alterations to the hydrology and physical integrity of streams throughout Ohio. Any effort to reduce erosion and improve water quality requires a commitment to better manage the flow of this nutrient rich drainage water. Retention structures such as passive treatment wetlands, storm water ponds and/or structures are encouraged. Several USDA-NRCS eligible best management practices that meet this need include:

- Structure for Water Control (587)
- Sediment Basin (500)
- Water and Sediment Control Basin (638)
- Constructed Wetland (656)
- Wetland Restoration (657)
- Wetlands Creation (658)
- Wetland Enhancement (659)
- Drainage Water Management (554)

3. Manure and fertilizer application should be limited to only those levels that meet agronomic need of the crop(s) being grown.

The application of manure from livestock operations should be focused on utilizing the manure as a nutrient substitute to commercial fertilizer. Manure has high levels of phosphorus. If manure is applied in excess amounts, in vulnerable locations, or shortly before snowmelt or rainfall, the result may be very high levels of dissolved phosphorus moving from the field application site and into nearby waterways. This can result in fish kills and algae blooms. Nutrient inputs, whether from manure or commercial fertilizer sources should be applied using the following guidelines:

- Develop and implement a nutrient management plan
- Manage fertilizer using the “4Rs” (right source, right time, right place and right rate)
- Use precision nutrient management practices and methods
- Only apply manure and fertilizer based upon up-to-date soil sample tests
- Do not apply phosphorus if soil test levels are already greater than agronomic need (E.g., greater than 40 ppm for corn and soybeans and 50 ppm for wheat and alfalfa)
- Eliminate broadcast application of fertilizer unless readily incorporated or applied to a growing crop
- Where appropriate incorporate manure

4. Increase the retirement of marginal and highly vulnerable lands

Challenging economic conditions in recent years have contributed to continuing production on lands that are marginally productive and/or highly vulnerable riparian areas. With increased risk to flooding and high levels of nutrient loss the retirement of these vulnerable lands should become a priority. Land rental rates and cost-share amounts provided by USDA either through programs such as the Conservation Reserve Program (CRP), Wetlands Reserve Program (WRP) and others typically are not competitive enough to provide a true incentive for land retirement. These programs and associated land rental rates need to be re-evaluated and updated to reflect levels that encourage and provide meaningful incentive for marginal land retirement to increase. Following are recommendations to increase retirement of marginal lands:

- Enroll agricultural lands that are marginally productive and/or vulnerable to frequent flooding and/or high nutrient losses in CRP, WRP or the Conservation Reserve Enhancement Program (CREP) and retire them from ongoing production.
- Once retired, Environmental Quality Improvement Program (EQIP) and other cost-share programs should be revised to allow these lands to be converted to appropriate hydraulic buffers such as riparian plantings, wetlands and/or drainage retention or filter areas.

Livestock Management Strategies

1. Dramatically improve manure management practices

The improper management of livestock manure and continued over application of manure on soils that are already saturated with nutrients is a significant challenge in some watersheds where livestock numbers are high. Soils in some watersheds have soil phosphorus levels that would allow generations to pass before needing additional phosphorus inputs—yet each year some of these same soils continue to receive nutrient applications. Effective manure management is critical if we are to see water quality improvements and/or measurable reductions in nutrient loadings to our streams. At a minimum, manure management should be conducted to conform to the following guidelines:

- Apply manure at rates based on agronomic need and as determined by up-to-date soil tests
- Manure application should be based on phosphorus need for subsequent cropping cycle and USDA NRCS standard
- When appropriate, applied manure should be incorporated into soils as soon as possible to facilitate optimum microbial assimilation into soil
- Manure should not be applied when precipitation is imminent
- Maintain records of all manure application
- Eliminate manure application in critical areas (as identified in up-to-date conservation plan)where high risk of loss is likely
- Eliminate the application of manure on snow covered and/or frozen ground

Approved USDA-NRCS best management practices when applied to strategic critical areas that may help to improve manure management include:

- Waste Utilization (633)
- Waste Storage Facility (313)
- Waste Treatment Lagoon (359)

2. Effectively manage runoff in livestock production areas

Runoff from livestock feeding areas or other livestock production areas such as feedlots, loafing pads and milking parlors is typically highly nutrient-enriched, often flowing directly into ditches and/or small streams. Runoff management in any areas where large numbers of livestock congregate is extremely important for preventing nutrient loadings to streams and waterways. Managing runoff from livestock congregating areas should be conducted using the following guidelines:

- Clean water should diverted from contact with accumulations of manure
- Manure and other solids should be scraped regularly and stored under roof
- Runoff flowing from feedlots etc. should be diverted from waterways and handled appropriately (e.g., disposal via land application or treatment via wetland or filter areas,)
- Install appropriate storage to manage silage and milk house parlor wastewater
- Eliminate uncovered feeding areas

USDA-NRCS best management practices that may be useful in improving the management of runoff from livestock production areas include:

- Waste Storage Facility (313)
- Heavy Use Area Protection (561)
- Livestock Use Area Protection (757)
- Roof Runoff Structure (558)

3. Improve Grazing Practices

Improperly managed grazing is a source of both erosion and nutrient loading into streams and other waterways. As a growing number of farmers enhance their operations by adding livestock the potential for poorly managed grazing to impact water quality increases. Grazing practices should be developed using the following guidelines:

- Develop and implement a prescribed grazing plan factoring water quality concerns
- Eliminate uncontrolled livestock access to streams and drainage ways
- Maintain heavy use and other high traffic areas
- Provide shade and watering sources away from streams

A variety of grazing related best management practices are eligible for cost-share funding under the NRCS-Environmental Quality Improvement Program (EQIP) and when they are strategically installed in critical areas vulnerable to runoff and nutrient loss, they can be effective. These include:

- Prescribed Grazing (528)
- Heavy Use Area Protection (561)
- Spring Development (574)
- Watering Facility (614)
- Water Well (642)
- Livestock Exclusion Fencing (472)

4. Reduce phosphorus content in animal feed

An emerging tool in influencing the nutrient content in livestock manure is reducing phosphorus content within the feed that animals are provided. The adage “less going in means less coming out” has merit in some applications. Reducing nutrients by adjusting animal feed should consider the following:

- Adjust feed nutrition content to meet herd production, size, age and sex needs
- Reduce nutrient content in feed based upon the Natural Resource Council recommended rates (found in NRC technical notes)
- Measure nutrient percentages in feed and account for increases of phosphorus content in manure generated by animals fed Dry Distillers Grain
- Incorporate the microbial enzyme phytase into diets

Drainage Water Management Strategies

1. Reduce the rate and amount of runoff

Perhaps the single most important action that can be taken to reduce nutrient loadings and impacts on Ohio streams is to reduce the rate and amount of runoff from agricultural production areas. For decades, grass filter strips (CP-21) have been advocated as important tools to provide a buffering media for sheet flow runoff and cost-share funding has resulted in the installation of many thousands of acres of these practices. Unfortunately, a significant percentage (estimated at between 25-75% in any given year, N. Fausey, USDA-ARS personnel communication) of the total drainage from farm fields in Ohio is flowing through sub-surface tiles and discharges directly into waterways without ever passing through a filter strip. There is a real need to design and install more effective buffers—filtering areas rather than strips specifically designed to capture, retain or disperse runoff. The challenge is convincing farmers and other landowners that these alternative drainage designs can be installed while still maintaining the overall functionality of the drainage systems. Reducing the rate and amount of runoff will require:

- Designing and installing more effective edge of field buffer areas to retain and/or disperse storm water runoff from fields (E.g. Filter Strips/Areas per Standard 393)
- Install water control devices that retain nutrient laden waters in subsurface drain tiles prior to release into streams
- Increase cover crop planting as part of a long-term conservation crop rotation designed to rebuild the soil's organic matter and increase the soil's water holding capacity
- Install drainage water devices on surface and subsurface tile drains

Drainage water management practices, also known as controlled drainage are an important emerging set of tools for dealing with field runoff and mitigating the impacts of tile drainage. Several NRCS approved practices that help with drainage water management include:

- Drainage Water Management (554)
- Structure for Water Control (587)
- Filter Strips/Areas (393)
- Wetland Creation (658)
- Discharge Ponds

2. Increase treatment of field runoff

It is neither practical nor likely that runoff from agricultural fields can be prevented or eliminated. What is encouraged is to install practices that increase assimilative treatment of runoff prior to its discharge into streams. For example, runoff from a livestock feeding area should be diverted through infiltration areas and/or wetlands so that nutrients can be assimilated via extended detention and/or vegetative uptake. Following are guidelines and recommendations for increasing the treatment of field runoff:

- Direct concentrated field runoff and drainage from livestock feeding areas through wetland and/or infiltration areas.
- Increase the use of fixed bed bioreactors containing coarse sand and organic carbon such as tree bark or wood chips.
- Increase the use of soil amendments such as alum, gypsum or water treatment residuals to increase the absorption of phosphorus and decrease the amount of phosphorus in runoff.

USDA-NRCS eligible practices that will assist landowners with implementing this recommendation include the following:

- Wetlands Restoration (657)
- Wetlands Creation (658)
- Filter Strips/Areas (393)
- Organic Bioreactors (NRCS standards are currently being prepared)

Riparian Management Strategies

1. Increase riparian wetland retention areas.

The buffering capacity of riparian areas has steadily declined as riparian forested and wetland areas have shrunk under increasing pressure to increase production acres. Combined with hydromodification, the alteration of riparian habitat are the two highest magnitude nonpoint causes of aquatic life use impairment in Ohio. Re-establishing, restoring and enhancing existing riparian wetlands to serve as detention areas for tile discharges and other drainage from agricultural fields is critical to reducing the impact of nutrient laden discharge water. Riparian wetland areas are highly effective at assimilating nutrients through infiltration and/or vegetative update. Numerous USDA programs offer generous cost-sharing incentives for increasing and/or restoring riparian wetland areas that meet the needs of an effective nutrient reduction strategy.

2. Increase riparian forested acres.

Like riparian wetland areas, Ohio's riparian forests have been in steady decline as agricultural equipment and production has expanded in size. The capacity for a riparian corridor of at least 120 feet wide (the equivalent of the canopy of just **<u>two</u>** mature trees) to store water and assimilate nutrients is considerable. Riparian corridors provide important streamside habitat for wildlife, important shading to the water thereby reducing algae blooms and water temperatures. Numerous USDA-NRCS based programs such as Conservation Reserve Enhancement Program (CREP); the Conservation Reserve Program (CRP), EQIP and others provide generous cost-share incentives for the re-establishment and expansion of riparian forests. Program eligible best management practices include:

- Riparian Forest Buffer (391)
- Tree/Shrub Establishment (612)
- Upland Wildlife Habitat Improvement (645)
- Windbreak/Shelterbelt Establishment (380) and Renovation (650)

3. Establish "no-plow" zones in riparian areas.

This strategy needs careful consideration because while the approach of protecting stream banks and riparian areas has obvious water quality benefits the concept carries negative images of unwanted "land use control". The fact is there are currently many tracts of land where riparian areas are plowed or cultivated up to the stream's edge. The resulting bank slippage, sediment loss and potential nutrient loadings from such poor land management damages the soil and water resources of the State. Educational efforts targeting landowners and conservation incentive packages are needed to aggressively promote the benefits of "no plow zones"—those riparian areas where cultivating and plowing are carefully restricted along waterways. Farmers should strongly consider enrolling all riparian areas into programs such as CRP or CREP where annual rental payments may help offset the loss of income that would come with establishing "no plow zones".

Certification or licensure for all nutrient applicators

Consider requiring all nutrient applicators operating in Ohio to be trained and certified. Whereas many details would need ironed out, this can be accomplished under a program similar to the pesticide training at the Ohio Department of Agriculture or to an industry led training program similar to the Livestock Environmental Assurance Program (LEAP).

Targeted Watersheds and Implementation Strategies

The implementation of agricultural practices designed to reduce nutrient loadings to Ohio's streams has up to this point in time generally followed a traditional USDA-NRCS system of "countywide distribution" of EQIP dollars and similar program funding. This often results in conservation practices spread "too thin over too big an area". And the practices selected for implementation may do not always have the expected degree of water quality benefit. For example, over the past eleven years Lake Erie CREP funding has installed more than 67,000 acres of conservation practices such as grass filter strips. While these practices reduce sediment and particulate forms of phosphorus they don't address the emerging problems associated with the delivery of dissolved reactive phosphorus to waterways.

To become more effective in targeting available conservation funding will require real adjustments in federal, state and county level programmatic thinking. What is needed is a highly targeted effort consisting of a wide array of effective conservation practices concentrated in a small geographic area where nutrient enrichment is a known water quality problem (as identified in watershed action plans or TMDL reports). Using this framework Ohioans needs to identify innovative methods for implementation that will lead to more tangible results. First of all, our focus areas need to shrink to more manageable geographical areas. To initiate this effort the following guidelines are offered for implementing highly targeted nutrient reduction strategies:

1. All activities shall be limited to a single 12-digit HUC unit. Typically this size HUC covers a drainage area of only 25 to 30 square miles or about 18,000 acres.
2. Within this HUC demonstration area, all farm operations within the HUC would have a whole farm conservation plan completed and in place.
3. All farms will have grassed waterways wherever appropriate drainage ways or areas highly vulnerable to erosion exist.
4. 50% of all farms in the HUC are using cover crops as part of a conservation crop rotation.
5. All farms are using soil tests on a 3-year basis PRIOR to applying fertilizer and/or animal manure.
6. 50% of all farms have wetland areas and/or riparian zones enrolled in long term land retirement programs such as CRP and/or CREP.
7. All operations with livestock have manure management plans completed.
8. All operations with livestock exclude stock from streams and drainage ways.

9. 10% of farms within the HUC have or are committed to installing drainage water management practices.
10. Farmers in HUC agree to maintain riparian areas in natural vegetation, including trees. Farmers agree to maintain riparian areas as "No Plow Zones".

Local SWCDs will be a major part of this proposed process. These local offices, and their buy in, are an important key to successful implementation of the targeted strategy described above, or any future agreed upon modifications to the targeting strategy. Such demonstration areas would be funded using a combination of USDA Farm Bill programs, Conservation Innovation Grants and/or Ohio EPA section 319 and/or DEFA Linked Deposit funds. It is anticipated that five or six of these "Demonstration Watersheds" could be implemented statewide. Comprehensive water quality monitoring would be conducted annually for the demonstration period to be able to document any water quality improvements that are resulting from these concentrated practices.

Sandusky River Recommended Nutrient Reduction Implementation Strategy: Implementation should focus on one or two 12-digit HUC units (@25 miles^2 drainage) within the watershed that are identified in the Sandusky River Total Maximum Daily Load Study (TMDL) and/or the endorsed watershed action plan as possessing relatively high quality habitat conditions, but are in non-attainment due primarily to nutrients.

Urban and Suburban Nonpoint Nutrient Reduction Strategies

There are many challenges communities are facing with respect to storm water infrastructure. In the past, cities have used gray infrastructure to address water resource concerns. Mounting challenges that communities face today include reducing the impact storm water has on combined sewer discharges, water quality issues associated stream bank failures, and water quantity issues associated with stream flashiness and flooding. Continued reliance on aging gray infrastructure in many cases will not sufficiently meet the necessary water quality and quantity improvements needed today. As such, the state of Ohio is already embracing emerging "green" infrastructure practices and technologies, and shall continue to do. Following is a strategy the state can utilize to help communities in Ohio realize the social, economic, and environmental benefits of improving water quality with green storm water infrastructure and proactive regulatory oversight, education and outreach. Descriptions and concepts provided below in the "Improve Storm water Management Practices" section are largely borrowed from U.S. EPAs "National Menu of Storm water Best Management Practices." A more comprehensive listing is provided by U.S. EPA available at: http://cfpub.epa.gov/npdes/storm water/menuofbmps/index.cfm .

Improve Storm Water Management Practices

1. **Municipal development-innovative site planning storm water BMPs including low impact development (LID) and other green design strategies.**

Urban development significantly alters the natural features and hydrology of a landscape. Development and redevelopment usually creates impervious surfaces like concrete sidewalks and asphalt roadways, commercial and residential buildings, and even earth compacted by construction activities. Prevented from soaking into the ground, rainwater runs across parking lots and streets, collecting used motor oil, pesticides, fertilizers, and other pollutants.

In most cities, a complex system of piping usually feeds contaminated storm water flows directly into streams and coastal waters. More recently, storm water control structures (sometimes called Best Management Practices or BMPs) like dry extended detention ponds or wet retention ponds have been installed, most in new development, to intercept storm water on its way to surface waters.

Historically, the goal of storm water planning has been to prevent localized flooding by moving large amounts of water offsite as quickly as possible. However, experience has shown that traditional storm water management has many limitations.

Expensive, ever-expanding storm sewer systems strain municipal budgets. Fast moving storm water discharges cause downstream flooding, erode stream banks, and contribute to water quality violations. Bacteria and other pathogens carried in storm water contaminate coastal waters, often requiring beach closures. Rainwater diverted or otherwise unable to soak into the soil cannot recharge aquifers. This reduces stream base flows, which can cause streams to dry-up for extended periods of time. Storm water that collects in detention basins or flows over impervious surfaces is often much warmer than the streams into which it flows. This is a problem because a temperature increase of just one or two degrees can stress fish and other aquatic organisms.

- **Low impact development (LID)-**Like other alternative development strategies, LID seeks to control storm water at its source. Rather than moving storm water offsite though a conveyance system, the goal of LID is to restore the natural, pre-developed ability of an urban site to absorb storm water.

- **Conservation Easements**-Conservation easements are voluntary agreements that allow individuals or groups to limit the type or amount of development on their property. A conservation easement can cover all or just a portion of a property and it can either be permanent or temporary. Easements typically describe the resource they are designed to protect (e.g., agricultural, forest, historic, or open space easements), and they explain and mandate the restrictions on the uses of the particular property. Easements can relieve property owners of the burden of managing these areas. They do so by shifting responsibility to a private organization (land trust) or government agency better equipped to handle maintenance and monitoring issues. Furthermore, in some cases, tax benefits might be realized by property owners who place conservation easements on some or all of their property.

Conservation easements may indirectly contribute to water quality protection. Land set aside in a permanent conservation easement has a prescribed set of uses or activities that generally restrict future development.

The location of the land held in a conservation easement may be evaluated to determine its ability to provide water quality benefits. Property along stream corridors and shorelines can act as a vegetated buffer that filters-out pollutants from storm water runoff. The ability of a conservation easement to function as a stream buffer depends on the width of the easement and in what vegetated state the easement is maintained.

- **Eliminate curbs and gutters-** This practice promotes grass swales as an alternative to curbs and gutters along residential streets. Curbs and gutters are designed to quickly convey runoff from the street to the stormdrain and, ultimately, to a local receiving water. Consequently, they provide little or no removal of storm water pollutants. Indeed, curbs often act as traps where deposited pollutants remain until the next storm washes them away. Many communities require curbs and gutters as standard elements of road sections. In fact, many communities discourage the use of grass swales. Revisions to current local road and drainage regulations are needed to promote greater use of grass swales along residential streets.

- **Green Parking-** Green parking refers to several techniques that applied together reduce the contribution of parking lots to total impervious cover. From a storm water perspective, green parking techniques applied in the right combination can dramatically reduce impervious cover and, consequently, reduce the amount of storm water runoff. Green parking lot techniques include: setting maximums for the number of parking lots created; minimizing the dimensions of parking lot spaces; utilizing alternative pavers in overflow parking areas; using bioretention areas to treat storm water; encouraging shared parking; and providing economic incentives for structured parking.

- **Green Roofs-** Green roofs can be effectively used to reduce storm water runoff from commercial, industrial, and residential buildings. In contrast to traditional asphalt or metal roofing, green roofs absorb, store, and later evapotranspire initial precipitation, thereby acting as a storm water management system and reducing overall peak flow discharge to a storm sewer system. Furthermore, conventional roofing can act as a source for numerous toxic pollutants including lead, zinc, pyrene, and chrysene (Vane Metre and Mahler, 2003).

  Green roofs have the potential to reduce discharge of pollutants such as nitrogen and phosphorous due to soil microbial processes and plant uptake. However, initial studies conflict as to the removal efficiency of nutrients, particularly nitrogen, by green roofs. If implemented on a wide scale, green roofs will reduce the volume of storm water entering local waterways resulting in less in-stream scouring, lower water temperatures and better water quality. In urban areas with combined sewer systems, storm water and untreated human and industrial waste are collected in the same pipe. During periods of heavy rainfall and snow melt, these systems can become overwhelmed by the volume of water and overflow into nearby waterbodies resulting in combined sewer overflows (CSOs). Since green roofs can reduce the volume of storm water discharged, CSOs can also be reduced, thus preventing the discharge of millions of gallons of sewage into local waterways.

2. ***Slow down, store and infiltrate runoff from impervious surfaces with municipality orientedted BMPs.***

Municipal BMPs include those that promote ground infiltration., filtration, and/or water storage of runoff for impervious surfaces, such as roofs, streets, parking lots and sidewalks. Many municipalityiesare starting to see the value of improved green infrastructure. Some traditional and emerging technologies are listed below.

Infiltration

- **Grassed Swales**-In the context of BMPS to improve water quality, the term swale (a.k.a. grassed channel, dry swale, wet swale, biofilter, or bioswale) refers to a vegetated, open-channel management practices designed specifically to treat and attenuate storm water runoff for a specified water quality volume. As storm water runoff flows along these channels, it is treated through vegetation slowing the water to allow sedimentation, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Variations of the grassed swale include the grassed channel, dry swale, and wet swale. The specific design features and methods of treatment differ in each of these designs, but all are improvements on the traditional drainage ditch. These designs incorporate modified geometry and other features for use of the swale as a treatment and conveyance practice.

- **Infiltration Basin**- An infiltration basin is a shallow impoundment which is designed to infiltrate storm water into the soil. This practice is believed to have a high pollutant removal efficiency and can also help recharge the ground water, thus increasing baseflow to stream systems. Infiltration basins can be challenging to apply on many sites.

- **Permeable pavers** - Permeable interlocking concrete pavement (PICP) consists of manufactured concrete units that reduce storm water runoff volume, rate, and pollutants. The impervious units are designed with small openings between permeable joints. The openings typically comprise 5% to 15% of the paver surface area and are filled with highly permeable, small-sized aggregates. The joints allow storm water to enter a crushed stone aggregate bedding layer and base that supports the pavers while providing storage and runoff treatment. PICPs are highly attractive, durable, easily repaired, require low maintenance, and can withstand heavy vehicle loads.

- **Porous concrete and porous asphalt-**Pervious concrete, also known as porous, gap-graded, or enhanced porosity concrete, is concrete with reduced sand or fines and allows water to drain through it. Pervious concrete over an aggregate storage bed will reduce storm water runoff volume, rate, and pollutants. The reduced fines leave stable air pockets in the concrete and a total void space of between 15 and 35 percent, with an average of 20 percent. The void space allows storm water to flow through the concrete and enter a crushed stone aggregate bedding layer and base that supports the concrete while providing storage and runoff treatment. When properly constructed, pervious concrete is durable, low maintenance, and has a low life cycle cost.

Porous asphalt, also known as pervious, permeable, "popcorn," or open-graded asphalt, is standard hot-mix asphalt with reduced sand or fines and allows water to drain through it. Porous asphalt over an aggregate storage bed will reduce storm water runoff volume, rate, and pollutants. The reduced fines leave stable air pockets in the asphalt. The interconnected void space allows storm water to flow through the asphalt and enter a crushed stone aggregate bedding layer and base that supports the asphalt while providing storage and runoff treatment. When properly constructed, porous asphalt is a durable and cost competitive alternative to conventional asphalt.

Filtration

- **Bio-retention (i.e., rain gardens)-** Bioretention areas, or rain gardens, are landscaping features adapted to provide on-site treatment of storm water runoff. They are commonly located in parking lot islands or within small pockets of residential land uses. Surface runoff is directed into shallow, landscaped depressions. These depressions are designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems. During storms, runoff ponds above the mulch and soil in the system. Runoff from larger storms is generally diverted past the facility to the storm drain system. The remaining runoff filters through the mulch and prepared soil mix. The filtered runoff can be collected in a perforated underdrain and returned to the storm drain system.

- **Filter strips/areas-**Vegetated filter strips (grassed filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and filtering out sediment and other pollutants, and by providing some infiltration into underlying soils. Filter strips were originally used as an agricultural treatment practice, and have more recently evolved into an urban practice. With proper design and maintenance, filter strips can provide relatively high pollutant removal. One challenge associated with filter strips, however, is that it is difficult to maintain sheet flow, so unless concentrated flow is properly disperse through entirety of the strip or area, the practice may be "short circuited" by concentrated flows, receiving little or no treatment.

Detention/Retention

- **Dry Detention Ponds-** Dry detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain storm water runoff for some minimum time (e.g., 24 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool of water. However, they are often designed with small pools at the inlet and outlet of the basin. They can also be used to provide flood control by including additional flood detention storage.

- **Wet Ponds-** Wet ponds (a.k.a. storm water ponds, wet retention ponds, wet extended detention ponds) are constructed basins that have a permanent pool of water throughout the year (or at least throughout the wet season). Ponds treat incoming storm water runoff by allowing particles to settle and algae to take up nutrients. The primary removal mechanism is settling as storm water runoff resides in this pool, and pollutant uptake, particularly of nutrients, also occurs through biological activity in the pond. Traditionally, wet ponds have been widely used as storm water best management practices.

- **Storm water wetlands (a.k.a. constructed wetlands)-** Storm water wetlands are structural practices similar to wet ponds that incorporate wetland plants into the design. As storm water runoff flows through the wetland, pollutant removal is achieved through settling and biological uptake within the practice. Wetlands are among the most effective storm water practices in terms of pollutant removal and they also offer aesthetic and habitat value. Although natural wetlands can sometimes be used to treat storm water runoff that has been properly pretreated, storm water wetlands are fundamentally different from natural wetland systems. Storm water wetlands are designed specifically for the purpose of treating storm water runoff, and typically have less biodiversity than natural wetlands in terms of both plant and animal life. Several design variations of the storm water wetland exist, each design differing in the relative amounts of shallow and deep water, and dry storage above the wetland.

A distinction should be made between using a constructed wetland for storm water management and diverting storm water into a natural wetland. The latter practice is not recommended because altering the hydrology of the existing wetland with additional storm water can degrade the resource and result in plant die-off and the destruction of wildlife habitat. In all circumstances, natural wetlands should be protected from the adverse effects of development, including impacts from increased storm water runoff. This is especially important because natural wetlands provide storm water and flood control benefits on a regional scale.

3. Control Erosion from construction sites and barren ground

Exposed and barren ground (especially sloped ground) is especially vulnerable to storm related erosion. Where land is left exposed in the absence effective management practices, one large storm can erode significant amounts of silty, clayey and/or sandy soil into Ohio's waterways. Controlling erosion is most readily done by promoting vigorous growth of rooted vegetation, but temporary controls are sometimes needed to protect from erosion while vegetation is being established. Following is a select listing of BMPs designed to minimize erosion in urban and suburban settings.

- **Sodding**- Sodding is a permanent erosion control practice and involves laying a continuous cover of grass sod on exposed soils. Sodding can stabilize disturbed areas and reduce the velocity of storm water runoff. Sodding can provide immediate vegetative cover for critical areas and stabilize areas that cannot be readily vegetated by seed. It also can stabilize channels or swales that convey concentrated flows and reduce flow velocities.

- **Seeding**- Seeding is used to control runoff and erosion on disturbed areas by establishing perennial vegetative cover from seed. It reduces erosion and sediment loss and provides permanent stabilization. This practice is economical, adaptable to different site conditions, and allows selection of a variety of plant materials.

- **Compost Blanket-**A compost blanket is a layer of loosely applied compost or composted material that is placed on the soil in disturbed areas to control erosion and retain sediment resulting from sheet-flow runoff. It can be used in place of traditional sediment and erosion control tools such as mulch, netting, or chemical stabilization. When properly applied, the erosion control compost forms a blanket that completely covers the ground surface. This blanket prevents storm water erosion by (1) presenting a more permeable surface to the oncoming sheet flow, thus facilitating infiltration; (2) filling in small rills and voids to limit channelized flow; and (3) promoting establishment of vegetation on the surface. Composts used in compost blankets are made from a variety of feedstocks, including municipal yard trimmings, food residuals, separated municipal solid waste, biosolids, and manure.

  Compost blankets can be placed on any soil surface: rocky, frozen, flat, or steep. The method of application and the depth of the compost applied will vary depending upon slope and site conditions. The compost blanket can be vegetated by incorporating seeds into the compost before it is placed on the disturbed area (recommended method) or the seed can be broadcast onto the surface after installation (Faucette and Risse, 2001).

- **Geotextiles**- Geotextiles are porous fabrics also known as filter fabrics, road rugs, synthetic fabrics, construction fabrics, or simply fabrics. Geotextiles are manufactured by weaving or bonding fibers that are often made of synthetic materials such as polypropylene, polyester, polyethylene, nylon, polyvinyl chloride, glass, and various mixtures of these materials. As a synthetic construction material, geotextiles are used for a variety of purposes such as separators, reinforcement, filtration and drainage, and erosion control (USEPA, 1992). Some geotextiles are made of biodegradable materials such as mulch matting and netting. Mulch mattings are jute or other wood fibers that have been formed into sheets and are more stable than normal mulch. Netting is typically made from jute, wood fiber, plastic, paper, or cotton and can be used to hold the mulching and matting to the ground. Netting can also be used alone to stabilize soils while the plants are growing; however, it does not retain moisture or temperature well. Mulch binders (either asphalt or synthetic) are sometimes used instead of netting to hold loose mulches together. Geotextiles can aid in plant growth by holding seeds, fertilizers, and topsoil in place. Fabrics come in a wide variety to match the specific needs of the site and are relatively inexpensive for certain applications.

- **Temporary stream crossing-** A temporary steam crossing is used to provide a safe, stable way for construction vehicle traffic to cross a watercourse. Temporary stream crossings provide streambank stabilization, reduce the risk of damage to the streambed or channel, and minimize sediment loading from construction traffic. The crossing might be a bridge, a culvert, or a ford.

  Temporary stream crossings are appropriate where heavy construction equipment must be moved from one side of a stream channel to the other. They can also be used where lighter construction vehicles will cross the stream repeatedly during construction.

  A bridge or culvert is the best choice for most temporary stream crossings because each can support heavy loads. The materials used to construct most bridges and culverts can be salvaged after they are removed. A ford is a shallow area in a stream that can be crossed safely. Fords are appropriate in steep areas where flash flooding might occur and where normal flow is shallow or intermittent across a wide channel. Fords should be used only where stream crossings are expected to be infrequent.

4. Control runoff from construction sites

Runoff controls slow down water in order to reduce erosive force, and to allow for soil to drop out from suspension. Runoff can also be controlled by diverting water away from or around barren soil.

- **Permanent Slope Diversions**-Permanent slope diversions are designed to transport runoff down a slope in a manner that minimizes the potential for erosion. Diversions can be constructed by creating channels laterally across slopes to intercept the down-slope flow of runoff. The channels have a supporting earthen ridge on the bottom sides to reduce slope length, collect storm water runoff, and deflect the runoff to outlets that convey it without causing erosion.

- **Earthen Perimeter Control Structures**-These control practices are called temporary diversion dikes, earth dikes, and interceptor dikes. No matter what they are called,, all earthen perimeter controls are constructed in a similar way with a similar objective--to control the velocity or route (or both) of sediment-laden storm water runoff.

- **Check Dams-** Check dams are relatively small, temporary structures constructed across a swale or channel. They are used to slow the velocity of concentrated water flows, a practice that helps reduce erosion. As storm water runoff flows through the structure, the check dam catches sediment from the channel itself or from the contributing drainage area. However, check dams should not be used as a substitute for other sediment-trapping and erosion-control measures. Check dams are typically constructed out of gravel, rock, sandbags, logs or treated lumber, or straw bales. They are most effective when used with other storm water, erosion, and sediment-control measures.

5. Control Sediment

Streams can be protected from the detrimental effects of sediment and attached nutrients by slowing down or detaining runoff, or by filtering sediment from runoff.

- **Filter Berms, Organic Berms, Barriers and Socks-** A gravel or stone filter berm is a temporary ridge made up of loose gravel, stone, or crushed rock. Organic berms are often made from compost. Organic material may also be placed in to socks for reduced chance that material washout could occur. Berms and socks slow and filter flow and divert it from an open traffic area. They act as an efficient forms of sediment control. One type of filter berm is the continuous berm, a geosynthetic fabric berm that captures sand, rock, and soil.

- **Sediment Traps**-Sediment traps are small impoundments that allow sediment to settle out of construction runoff. They are usually installed in a drainageway or other point of discharge from a disturbed area. Temporary diversions can be used to direct runoff to the sediment trap (USEPA, 1993). Sediment traps detain sediments in storm water runoff to protect receiving streams, lakes, drainage systems, and the surrounding area. The traps are formed by excavating an area or by placing an earthen embankment across a low area or drainage swale. An outlet or spillway is often constructed using large stones or aggregate to slow the release of runoff (USEPA, 1992).

- **Silt Fence and Straw Bales**-Silt fences are used as temporary perimeter controls around sites where construction activities will disturb the soil. They can also be used around the interior of the site. A silt fence consists of a length of filter fabric stretched between anchoring posts spaced at regular intervals along the site at low/downslope areas. The filter fabric should be entrenched in the ground between the support posts. When installed correctly and inspected frequently, silt fences can be an effective barrier to sediment leaving the site in storm water runoff.

  Straw or hay bales have historically been used on construction sites for erosion and sediment control as check dams, inlet protection, outlet protection, and perimeter control. Many applications of straw bales for erosion and sediment control are proving ineffective due to the nature of straw bales, inappropriate placement, inadequate installation, or a combination of all three factors (Fifeld, 1999). In addition, straw bales are maintenance-intensive and can be expensive to purchase. Because many applications of straw and hay bales have been ineffective, EPA recommends that other BMP options are carefully considered. This fact sheet provides more information and options for alternatives to straw and hay bales.

- **Vegetated Buffers-** Vegetated buffers are areas of natural or established vegetation maintained to protect the water quality of neighboring areas. Buffer zones slow storm water runoff, provide an area where runoff can permeate the soil, contribute to ground water recharge, and filter sediment. Slowing runoff also helps to prevent soil erosion and streambank collapse.

- **Storm Drain Inlet Protection**-Storm drain inlet protection measures prevent soil and debris from entering storm drain drop inlets. These measures are usually temporary and are implemented before a site is disturbed.

There are several types of inlet protection:

  - *Excavation around the perimeter of the drop inlet*: Excavating a small area around an inlet creates a settling pool that removes sediments as water is released slowly into the inlet through small holes protected by gravel and filter fabric.
  - *Fabric barriers around inlet entrances*: Erecting a barrier made of porous fabric around an inlet creates a shield against sediment while allowing water to flow into the drain. This barrier slows runoff while catching soil and other debris at the drain inlet.
  - *Block and gravel protection*: Standard concrete blocks and gravel can be used to form a barrier to sediments that permits water runoff to flow through select blocks laid sideways.
  - Sandbags can also be used to create temporary sediment barriers at inlets. For permanent inlet protection after the surrounding area has been stabilized, sod can be installed. This permanent measure is an aesthetically pleasing way to slow storm water near drop inlet entrances and to remove sediments and other pollutants from runoff.

Enhance leadership role to address nonpoint source nutrient problem in the urban/suburban setting

Listed below are concepts or strategies for Ohio agencies to provide leadership in furthering community involvement in partnerships that involve improved storm water management and green infrastructure. Many of these strategies listed below were gleaned from the document "Barriers and Gateways to Green Infrastructure"- Clean Water Alliance, September 2011. This document is available at: http://www.cleanwateramericaalliance.org/pdfs/gireport.pdf.

- **Community and Institutional:**
  - Overcome and embrace paradigm shifts to leverage green infrastructure. Recognizing that highly visible green infrastructure can be dual purposed (I.e., providing recreational opportunities with flood protection).
  - Highly visible green infrastructure creates opportunity for public conversation and education (e.g., value of water, infrastructure life cycle, detrimental effects of storm water, healthy watersheds).
  - "Every city needs at least one demonstration project… These projects should be visible and attractive to a wide range of residents." "Information should be visual, continual, and easy to access."
  - Establish a sustainability coordinator or otherwise a leader at the local level to build relationships amongst city agencies, business community and residents. Create and advertise incentives with private-side developer.

- Continue to work at state level with National Association of Counties and International City/County Management Association to inform these decision makes. Recognize the professional contributions of landscape architects. Seek development pioneers to educate and recruit early adopters.
  - One example of leadership in this area is the is at the Ohio Department of Transportation in the Ohio Local Technical Assistance Program (LTAP) which has sponsored the Low-Impact Develoipment (LID) Storm water Educational Workshop in 2011.

- **Financial**
  - Continue to seek additional and more financing opportunities at federal and state level. (e.g., use transportation funding to install green infrastructure such as bioswales alongside new or existing roads)
- **Technical and Physical:**
  - Seek out, learn from, and distribute performance and cost data from various projects in our climate and soils.
  - Encourage development of a BMP repository with designs and specifications. Improve repository by providing guidance on how to design around site constraints, and BMP advantages weighed against disadvantages.
- **Legal and Regulatory**:
  - Encourage developing a local leader or "ombudsman" with knowledge of the regulatory roadmap to steer projects through what may be conflicting policies or unique local constraints, and also to identify how green infrastructure can be inserted into building code and street ordinances.
  - The state can better promote green infrastructure in permits, TMDLs, and consent decrees. Give appropriate credit to those entities who engage in green infrastructure projects.

Converting the Framework into an Effective State-wide Strategy

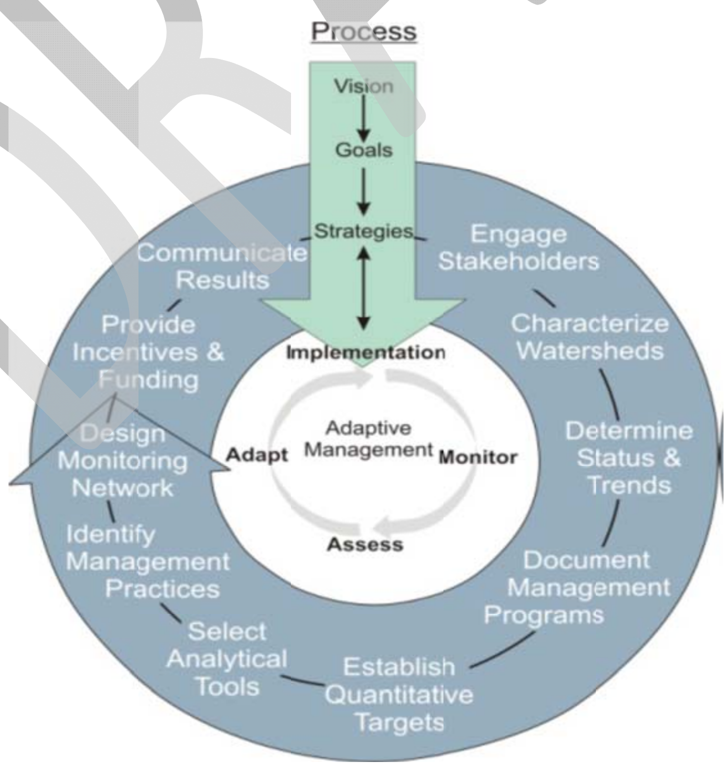
The draft framework presented in this report is intended to be the jumping off point on a multi-year effort to reduce nutrient pollution in Ohio's surface waters. Clean water is important to Ohio's economy and we cannot allow present trends in nutrient pollution to continue. From the information presented here it is clear that sustained action is needed and it must involve many diverse sectors of Ohio's economy: farmers, agri-business, industry, trade associations, municipal and county governments, environmental groups as well as the general public. The task ahead is to find cost effective means to reduce the delivery of nutrients present in point source effluents and in NPS runoff from urban and agricultural land use. And this must occur in a manner that does not interfere with Ohio's overall economic recovery.

Other States are facing the same issues. The Governors of the Gulf coast states, through the Gulf of Mexico Alliance, have produced a template for the development of state nutrient reduction strategies based upon this concept:

> "Effective nutrient reduction strategies must be adaptable enough to be used in watershed-based nutrient reduction plans addressing a wide range of conditions and scale, with outreach to, and buy-in from, the appropriate stakeholders within the state." (GMOA, 2010)

We believe the GMOA template (Figure 15), guiding principles and building blocks can serve as a useful model as Ohio moves forward in this effort.

Figure 15. Process template for development of a State nutrient reduction plan (GMOA, 2010).



Template Foundation – Guiding Principles

Five principles guide the *Governors' Action Plan II* (GOMA 2009). These five principles also guide coastal nutrient reduction strategies:

1. Encourage voluntary, incentive-based, practical, cost-effective actions.
2. Use existing programs.
3. Follow adaptive management.
4. Identify existing and additional funds needed and funding sources.
5. Identify opportunities for innovative, market-based solutions.

Building Blocks

A number of building blocks on which to develop nutrient reduction strategies for Gulf coastal watersheds were identified for the template:

1. Use collaborative, inclusive teams of stakeholders (i.e., governmental agencies, non-governmental organizations, academic, businesses, and agricultural producers) to prepare strategies.
2. Leverage resources (budgetary, personnel, expertise, and projects).
3. Formulate integrated, comprehensive nutrient reduction strategies and implementation plans, and, where possible, incorporate them into ongoing state programs.
4. Make strategic decisions on where the greatest benefits can be obtained using existing funds, recognizing that, through adaptive management, additional priorities can be addressed over time.
5. Emphasize local watershed nutrient reductions and water quality improvements, which collectively provide cumulative, regional benefits for downstream waterbodies and the Gulf of Mexico.
6. Include both water quality protection and restoration activities in the strategies.
7. Recognize that small catchments are nested within watersheds, which are nested within river basins, which are nested within large drainage basins connected to the Gulf of Mexico, including the Mississippi River drainage basin. Multiple time and space scales must be considered in formulating comprehensive nutrient reduction strategies.
8. Focus on sustainability. While short-term successes are important, the focus must be on long-term sustainable solutions.

Ohio Plan to Build an Effective Nutrient Reduction Strategy

Ohio will be able to build on the concepts of the GMOA model using the products of several ongoing work groups already discussing nutrient issues in Ohio. A brief description of each is presented here.

- Lake Erie Phosphorus Task Force - Convened in 2007 and comprised of experts from academia, government agencies, agri-business and other stakeholders. Broad range of goals centered on finding solutions to nutrient related problems in western Lake Erie. Report released in 2010.
- Lake Erie Phosphorus Task Force, Phase II – Scheduled to convene in February 2012 under provisions and funding from a US EPA grant. Intent is to focus on the means of implementing practices that will reduce the delivery of dissolved reactive phosphorus to Lake Erie. Final grant report due Spring 2014
- Directors' Agricultural Nutrients and Water Quality Working Group – Convened in August 2011 and comprised of all interest groups. Given the charge of developing recommendations regarding steps to take on reducing nutrients reaching surface waters from agricultural production practices. Cooperative venture between three State agencies (ODA, Ohio EPA and DNR), the Directors are scheduled to take recommendations to the Governor in February 2012.
- Directors' Point Source / Urban Work Group. Director Nally announced intent to from the work group in October 2011; currently in the formation stage.
- Others?

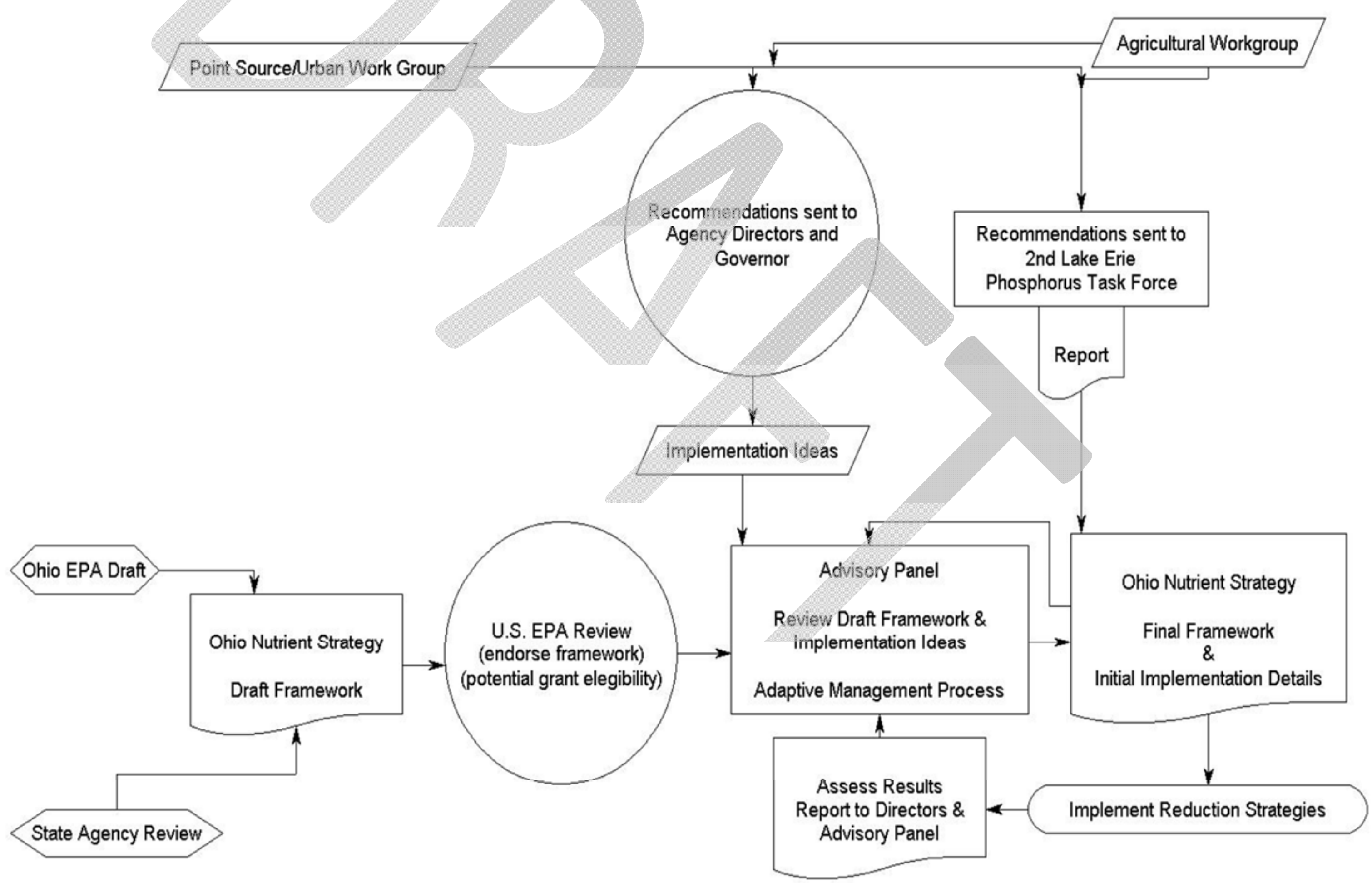
Formation of Advisory Panel

Figure 16 illustrates the overall vision for pulling together this draft framework, the products from the workgroups mentioned above and forming a broad based Advisory Panel that will review these products, create and continually update a Nutrient Reduction Strategy for Ohio with the aid of the GMOA template model.

Advisory Panel Charter and Members

It is recommended that the Directors of Ohio EPA, Ohio Department of Natural Resources and Ohio Department of Agricultural develop a charter for the advisory panel and appoint members who are capable and willing representatives of all the various business sectors, government and other interest groups with a stake in water quality and nutrient reduction efforts undertaken by the State of Ohio. This Advisory Panel should advise the Director of Ohio EPA as the lead agency for water quality.

Figure 16. A schematic to illustrate the relationship of ongoing efforts to develop a nutrient reduction strategy for Ohio.



Appendix 1

Ohio EPA Division of Surface Water
Schedule for Adopting Water Quality Criteria for Nutrients
August 31, 2009

Background

Ohio EPA initiated a concerted effort to develop nutrient criteria specific to Ohio waters in 2002. A decision was made early on to use existing data in the development of criteria for inland lakes. Pilot methods for streams were tested in 2003 and full field studies of streams ensued from 2004 through 2007. Sufficient data now exists to develop nutrient criteria associated with healthy vs. impaired stream biology. However, it has been determined that additional sampling of large rivers (greater than 500 sq. mi. drainage area) is necessary and limited work on large rivers is ongoing as circumstances and resources allow.

The current status and remaining steps needed to adopt nutrient criteria for lakes, streams and large rivers in the Ohio Administrative Code (OAC) is summarized below.

Status and Remaining Steps

1.0 Lakes (OAC 3745-1-07 & 43)

The Agency began to re-establish a modest inland lakes program in 2006 and officially launched it in the summer of 2008 at eight lakes around the state. A workgroup comprised of central office and district office personnel plan and conduct lake sampling. This group has helped draft WQS rules for inland lakes, which include a set of new use designations and criteria. The new criteria include a suite of nutrient parameters (chlorophyll a, total phosphorus, total nitrogen and secchi depth).

Draft rules for lake nutrient criteria were released for initial public review (a.k.a. Interested Party Review, IPR) in August of 2008 as part of the triennial WQS rule package. A separate rule package on antidegradation and a related set of surface water rules for Section 401 water quality certifications were also released for IPR in the fall of 2008. Objections from the regulated community soon became evident through a collation of interests under the umbrella of the Ohio Chamber of Commerce. The Agency agreed to keep the IPR comment period for all 3 rule packages open until such time that a revised set of rules for stream mitigation was made available. Little progress or communication with the regulated community regarding the issues occurred between December of 2008 and July 2009. We anticipate this will change when the stream mitigation rules are released later in 2009.

1.1 Release remaining rules for IPR

Rules on stream mitigation are scheduled to be drafted and released for a second round of IPR in October 2009. The IPR comment period will close for the complete set of surface water rules (including nutrient criteria for lakes) in 2009. Public comments submitted during the IPR comment period will be assessed and the rules will be revised as appropriate.

1.2 File proposed rules

After revising the rules in response to IPR, the Director of Ohio EPA will formally file proposed rules. There is a second opportunity for public comments, a public hearing and a legislative review by the Joint Committee on Agency Rule Review (JCARR). This process should occur in the first six months of 2010. Public comments will once again be reviewed and the rules will be revised as appropriate.

1.3 Adopt rules

Final rules could be adopted by November 2010 (best case scenario).

1.4 Ohio Attorney General certification; effective date

A four month time delay is built in between the adoption date and the effective date to obtain AG certification and U.S. EPA approval of the state adopted rules; therefore, lake nutrient standards could be effective in March 2011.

<u>2.0 Streams (OAC 3745-1-07 & 44)</u>

Ohio EPA has completed four years of field work and now has adequate data for nutrient criteria applicable to streams and rivers with less than 500 square mile watersheds. Bob Miltner, the primary investigator, will publish a research paper in *Environmental Management*. Draft "technical guidance" for implementing the stream nutrient criteria has been prepared and is under internal review. Draft WQS rule language is also being circulated for internal review.

The nutrient criteria for phosphorus, nitrogen and benthic chlorophyll a have been developed to apply in concert with measurements of the existing biological criteria and data on dissolved oxygen minimums and diurnal changes. As such, it is critical that the long standing objection from U.S. EPA regarding the biological criteria narrative be resolved. Work began on this subject with draft revisions in OAC 3745-1-07 released as part of the August 2008 IPR. Region V supplied comments on the draft and offered an alternative suggestion that the key language be moved to Ohio EPA's WQS implementation chapter (OAC 3745-2). Ohio EPA has agreed to do this. A working draft of this new rule (OAC 3745-2-03) and the language proposed to remain in OAC 3745-1-07 was sent to Region V staff in August 2009.

Ohio EPA plans to release the new version of the biological criteria implementation rule language for IPR in October 2009. The steps and timeline to adopt this rule will follow those listed above under "lakes".

If adequate internal review and agreement on the stream nutrient criteria rule and implementation guidance are obtained in the next several months Ohio EPA will likely release these documents as preliminary working drafts over the next year as the large rule making packages are underway. However, the schedule presented here assumes that the actual IPR step will not occur until 2010.

2.1 Release rules for IPR

Ohio EPA plans to release draft stream nutrient criteria rules for IPR in the summer of 2010. A 60-day comment period will be given, after which the comments will be assessed and the rules will be revised as appropriate.

2.2 File proposed rules

Proposed rules could be filed in early 2011. Another 60-day public comment period will be given after which the comments will be assessed and the rules will be revised as appropriate.

2.3 Adopt rules; effective date
Final rules could be adopted in the summer of 2011 and effective by the end of 2011.

3.0 Large Rivers (OAC 3745-1-07 & 44)

Additional data collection and analysis is necessary to develop appropriate nutrient criteria applicable on large rivers (greater than 500 square miles drainage area). Three additional field seasons (2010 – 2012) are set aside for this work. Adoption of nutrient criteria for large rivers is forecast to be completed in 2013.

In the intervening years Ohio EPA will continue to determine if direct point sources on large rivers cause or contribute to biological impairment and the symptoms of nutrient enrichment. Situations where this is confirmed will be addressed on a case-by-case basis and the imposition of best available treatment for nutrient removal will be imposed as necessary to ensure attainment of the aquatic life use designation.

Appendix 2

Ohio's current water quality criteria that address the problems caused by nutrient enrichment are listed below.

Narrative Criteria: OAC 3745-1-04 **Criteria applicable to all waters.**

The following general water quality criteria shall apply to all surface waters of the state including mixing zones. To every extent practical and possible as determined by the director, these waters shall be:

D) Free from substances entering the waters as a result of human activity in concentrations that are toxic or harmful to human, animal or aquatic life and/or are rapidly lethal in the mixing zone;

(E) Free from nutrients entering the waters as a result of human activity in concentrations that create nuisance growths of aquatic weeds and algae;

Aesthetic Criteria: OAC 3745-1-07

Table 7-11. Statewide water quality criteria for the protection against adverse aesthetic conditions.

Chemical	Form[1]	Units[2]	IMZM[3]	OMZM[3]	Drinking
2-Chlorophenol	T	µg/l	--	--	0.1[a]
2,4-Dichlorophenol	T	µg/l	--	--	0.3[a]
MBAS (foaming agents)	T	mg/l	--	0.50	--
Oil & grease	T	mg/l	--	10[b]	--
Phenol	T	µg/l	--	--	1.0[a]
Phosphorus	T	mg/l	C	--	C

[1] T = total.

[2] mg/l = milligrams per liter (parts per million); µg/l = micrograms per liter (parts per billion).

[3] IMZM = inside mixing zone maximum; OMZM = outside mixing zone maximum.

[a b] .....

[c] Total phosphorus as P shall be limited to the extent necessary to prevent nuisance growths of algae, weeds, and slimes that result in a violation of the water quality criteria set forth in paragraph (E) of rule 3745-1-04 of the Administrative Code or, for public water supplies, that result in taste or odor problems. In areas where such nuisance growths exist, phosphorus discharges from point sources determined significant by the director shall not exceed a daily average of one milligram per liter as total P, or such stricter requirements as may be imposed by the director in accordance with the international joint commission (United States-Canada agreement).