PRIORITIES FOR REDUCING PHOSPHORUS LOADINGS
AND ABATING ALGAL BLOOMS IN THE
GREAT LAKES – ST. LAWRENCE RIVER BASIN:

OPPORTUNITIES AND CHALLENGES FOR IMPROVING GREAT LAKES AQUATIC ECOSYSTEMS

A Report of the
Phosphorus Reduction Task Force

To the
Great Lakes Commission

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Preface

The impact of phosphorus loadings to the Great Lakes is once again threatening the Great Lakes-St. Lawrence River ecosystem. These impacts are especially pronounced in nearshore areas and embayments, which are often the most ecologically productive and diverse areas of the system. Algal blooms fed by excessive phosphorus from various nonpoint and point sources are occurring in each of the Great Lakes, but especially Lake Erie, Saginaw Bay on Lake Huron, Green Bay on Lake Michigan and nearshore areas of Lake Ontario. In western Lake Erie the re-emergence of harmful algal blooms (HABs) in recent years has been especially troubling, coming after nearly two decades of little or no occurrence of these blooms.

As a result of this alarming trend, the Great Lakes Commission adopted a resolution, *Nutrient Management in the Great Lakes-St. Lawrence River Basin*, on October 12, 2011. This resolution, included as Appendix A, underscored the seriousness of the problem and called for the establishment of a Phosphorus Reduction Task Force consisting of members from each state and province in the Great Lakes region. The states and provinces appointed members to the Task Force in November 2011. The Task Force included representatives from environmental protection, natural resource and agricultural agencies; a list of Task Force members is included as Appendix B.

The Task Force's charge was to develop phosphorus reduction recommendations to guide the Commission's work in this critically important area. The specific charge to the Task Force included:

1. Developing a suite of recommendations for federal, state and provincial actions to reduce phosphorus loadings to the Great Lakes and St. Lawrence River, focused on priorities for clean water infrastructure, research, technical assistance, and outreach and education;
2. Reviewing opportunities for expanding and enhancing programs under the 2012 Farm Bill to reduce phosphorus and improve nutrient management for water quality improvement; and
3. Investigating opportunities to address critical nutrient management issues by working more closely with the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) and its technical committees in each state.

This report addresses the first two of these charges. Task three is ongoing and will be informed by the recommendations in this report. When received by the Commission at its 2012 Annual Meeting, this report will guide interactions with the state technical committees and similar bodies in Ontario and Québec.

The reoccurrence of algal blooms, HABs and eutrophication problems in certain areas of the Great Lakes has prompted federal, regional, state and provincial agencies and organizations to discuss and review their policies aimed at improving and maintaining the ecological integrity of the Great Lakes-St. Lawrence system. The formation of the Commission's Phosphorus Reduction Task Force is one of many efforts focusing on this issue and reflects increasing concern among the states and provinces over the reoccurrence of this threat to the environmental and economic health of the Great Lakes.

The Task Force met monthly via conference call beginning in January 2012. Early in its deliberations the Task Force helped complete a report detailing state and provincial programs that address nutrient management and nonpoint source pollution issues within each jurisdiction. This report was beneficial in helping the Task Force to better understand the programs in place within neighboring jurisdictions and contributed to the findings and recommendations in this report. The programs report, titled *Nutrient Management: A Summary of State and Provincial Programs in the Great Lakes-St. Lawrence River Region*, was prepared as a companion report and will be accessible from the Commission's website.

While completing the programs report, the Task Force considered how to best present the priority issues facing the Great Lakes-St. Lawrence River basin related to phosphorus loadings and impacts. Ultimately, it decided to prepare in-depth summaries describing emerging issues, unmet needs and unanswered questions on the following topics:

1. Phosphorus issues related to nonpoint source pollution;
2. Phosphorus issues related to point source pollution; and
3. Phosphorus issues related to product formulation, innovation, research and regulation.

Subcommittees were established to address each of these topics and their work helped shape this report's recommendations (their issue briefs are included as Appendix D).

Numerous additional experts from U.S. and Canadian federal, state and provincial agencies, and academia contributed to this report and helped the Task Force gain a better understanding of the many issues under discussion. These partners are listed in Appendix C. The involvement of these experts varied from participation in subcommittee conference calls, attending mini-conference calls with staff and one or more Task Force members and/or engaging in private conversations with staff or Task Force members to discuss certain aspects of the report. These experts did not review the full report and were not asked to endorse the report's findings and recommendations.

This report is presented as a product of the Phosphorus Reduction Task Force of the Great Lakes Commission. The Commission appreciates the valuable contributions from the Task Force members, their expertise and the time they devoted to reviewing this report as it was prepared.

Key Recommendations of the Task Force

The Task Force report makes more than 50 recommendations for actions to reduce phosphorus loadings to the Great Lakes-St. Lawrence River system. The Task Force believes these are necessary elements of a comprehensive, binational effort capable of achieving and sustaining meaningful reductions in nutrient pollution to the Great Lakes and St. Lawrence River. However, the Task Force highlights the recommendations below as having special potential to accelerate and target nutrient reduction efforts and achieve near-term results that will reduce the frequency and severity of HABs and related water quality impacts in the Great Lakes and St. Lawrence River.

- The U.S. Environmental Protection Agency (U.S. EPA) under the Great Lakes Restoration Initiative (GLRI) should provide block grants to the Great Lakes states for large-scale watershed projects capable of achieving measurable reductions in loadings of phosphorus and other nutrients to the Great Lakes-St. Lawrence River system. Similarly, the GLRI should support fewer but larger-scale nutrient reduction projects in priority watersheds, especially those where excessive phosphorus loadings have been identified as a problem. These larger projects should also be planned for a longer timeframe.

- NRCS should provide block grants to or establish cooperative agreements with the Great Lakes states to ensure that adequate technical assistance is available to deliver conservation treatment programs designed to reduce phosphorus. Some specific priorities include maintaining the Strategic Watershed Action Teams to provide adequate field personnel to deliver programs at the watershed scale; streamlining technical assistance agreements with the states to facilitate partnerships with Soil Conservation Districts to provide field staff in priority watersheds; and providing NRCS with the flexibility to use financial assistance funding to secure additional technical assistance in priority watersheds.

- The U.S. federal Farm Bill should be reauthorized and funding for the conservation title should remain authorized as close as possible to the current baseline average of $6 billion annually. A new regional conservation partnership program should be developed that enables states, regional organizations and watershed-based organizations to receive funding, on a competitive basis, to implement conservation treatment programs in priority watersheds. In the Great Lakes-St. Lawrence basin, highest priority should be afforded to programs that reduce phosphorus in priority watersheds.

- Using Ohio as a model, the Great Lakes states should establish regulatory authority to designate stressed watersheds and trigger mandatory actions to reduce pollutant loadings.

- Appropriate government agencies should conduct a phosphorus mass-balance study for each of the Great Lakes and develop in-lake criteria for nutrient concentrations based on Great Lakes aquatic eco-zones, such as the western Lake Erie basin, Saginaw Bay and Green Bay. Research agencies and institutions should develop a dissolved (soluble) phosphorus fate and transport model with factors for subsurface drainage discharges. The U.S. Geological Survey (USGS) and state partners should establish a comprehensive phosphorus monitoring network to guide implementation priorities and monitor progress in reducing nutrient loadings.

- NRCS should require soil testing and make the information available on a confidential basis to state agencies for trend analysis for all landowners receiving cost-share funding under Farm Bill conservation programs. Conservation plans should be modified if soil tests indicate high levels of phosphorus in the soil.

- All applications of phosphorus fertilizer on cropland in priority watersheds should be applied below the soil surface or incorporated into the soil immediately after application in a non-erosive manner.

- USDA's Agriculture Research Service (ARS) and farm equipment manufactures should be charged with developing phosphorus fertilizer placement equipment that places the material under the soil surface in a non-erosive manner that virtually eliminates dissolved phosphorus runoff.

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Introduction

Harmful algal blooms (HABs), virtually nonexistent in the 1980s through the mid 1990s in the Great Lakes and St. Lawrence River, have returned in the last several years and once again are threatening the integrity of the region's water resources and aquatic ecosystems.

According to a report from the U.S. EPA Nutrient Innovations Task Group, 78 percent of the assessed continental U.S. coastal areas, including the Great Lakes, exhibit signs of degraded water quality conditions due to excessive nutrient loadings from activities collectively termed nonpoint source pollution. Nonpoint source pollution – pollution that enters waterways mainly as the result of runoff from and through the landscape – is comprised of many constituents, including sediment, bacteria, organic material, pesticides, toxic chemicals, and nutrients. In particular, sedimentation from agricultural and construction activities (among others) plays a major role conveying nutrients and toxic chemicals to the Great Lakes-St. Lawrence River system. Beyond water quality degradation, soil erosion and sedimentation (and the subsequent nutrient runoff) reduce agricultural productivity, degrade fish and wildlife habitat, limit water-based recreation, and damage water treatment and public water supply infrastructure.

In recent years the relationship between land-use activities, nutrient loadings and water quality has been increasingly well documented. Federal, state and provincial governments are becoming ever more concerned about nonpoint source pollution, especially excessive phosphorus loadings to the Great Lakes and St. Lawrence River. Such pollution can potentially have harmful effects on the ecosystem, human activities and public health, such as fish kills resulting from lowered oxygen levels and the production of toxins from cyanobacteria.

The main cause of HABs occurring in various parts of the Great Lakes-St. Lawrence River basin appears to be excessive nutrient loadings (particularly phosphorus) flowing into the lakes as a result of human activities. In the past, nutrients were delivered to the lakes from two main sources: human waste discharge and agriculture runoff. Contributions from human waste were reduced by the construction of wastewater treatment facilities and agriculture runoff was addressed through the installation of soil erosion controls and onsite water management.

Specific improvements in nonpoint source pollution controls developed over the past 30 years include: reductions in sediment and total phosphorus loads with the increased use of conservation tillage practices; the institution of the Phosphorus Index and phosphorus management requirements for manure and biosolids adopted in most Great Lakes states; and the implementation of stormwater controls to reduce phosphorus loads from urban settings. Despite the progress achieved and the mitigation efforts put in place, HABs and other types of excess aquatic growth are once again threatening the Great Lakes-St. Lawrence River ecosystem. While the exact cause of this re-emerging problem is not fully understood, scientists, researchers and government agency staff have noted several distinct changes, both environmental and economic, occurring within the basin that are creating the necessary conditions for HABs, excessive algal growth and eutrophication.

The Role of Nutrients in Great Lakes Water Quality

Water quality in lakes is influenced by many chemical and biological factors, which can in turn be influenced by variables such as temperature, light, depth, volume, oxygen levels, and nutrient inputs, which can come from a variety of sources. In particular, increased nutrients can stimulate the growth of green plants, primarily in the form of algae. Excessive plant growth in a lake can have detrimental effects on the overall ecosystem (e.g., HABs, habitat loss, decreased species diversity) as well as impacts on public health and human uses (e.g., water quality impairments, increased treatment costs, restrictions on recreational uses and tourism related economic impacts).

As described by the U.S. EPA and Government of Canada in the publication, *The Great Lakes: An Environmental Atlas and Resource Book,* increased plant life in an aquatic system eventually dies, settles to the bottom and decomposes. During decomposition, organisms that break down dead plant matter use up oxygen dissolved in the water near the bottom. Under normal conditions, when nutrient loadings are low, dissolved oxygen levels are maintained by the diffusion of oxygen into water, mixing by currents and wave action, and by oxygen produced by photosynthesizing plants. However, with more plant growth there is more material to be decomposed, resulting in more oxygen consumption.

Depletion of oxygen through decomposition of organic material is known as biochemical oxygen demand (BOD), which can be generated from two different sources. In tributaries and harbors it is often caused by materials contained in the discharges from treatment plants. The other principal source is decaying algae, which often impacts large embayments and open lake areas, such as the central basin of Lake Erie. As the BOD load increases and oxygen levels drop, certain species of fish can be killed and pollution-tolerant species requiring less oxygen, such as sludge worms and carp, take their place. Changes in species of algae, bottom-dwelling organisms (or benthos) and fish are therefore biological indicators of oxygen depletion. Turbidity in the water, as well as an increase in chlorophyll, also accompany accelerated algal growth and indicate increased biological productivity in a lake.

Phosphorus Inputs to the Environment

Phosphorus is used by plants to produce a strong root system, increase the growth rate and promote flower development. It is a naturally occurring element and can be categorized into two general types: particulate phosphorus (i.e., phosphorus that is attached, or adsorbed, to soil particles or other matter) and dissolved or soluble reactive phosphorus (i.e., phosphorus that is mixed with water).

Phosphorus in its dissolved state is, pound for pound, three times more available for plant growth. However, there is often not enough naturally-occurring phosphorus in soil to economically or satisfactorily grow commercial and residential plants and lawns. Consequently, natural levels of phosphorus are often supplemented through the application of additional amounts of phosphorus from animal waste and manufactured sources commonly referred to as commercial fertilizer.[1] In order to sustain high crop yields and healthy lawns, phosphorus fertilizer is applied annually to

[1] Fertilizers may be comprised of nitrogen, phosphorus and/or potassium; therefore, phosphorus fertilizer is only one type of fertilizer. Farmers often apply fertilizers with nitrogen themselves, but rely on dealers to apply fertilizers containing phosphorus and potassium.

millions of acres of cropland, lawns and commercial areas in the Great Lakes-St. Lawrence River basin.

If not managed properly, this tremendous pool of phosphorus fertilizer can also promote the unintended growth of other plants and organisms. During runoff events phosphorus can be transported through drainage systems, sewers and streams into the Great Lakes and St. Lawrence River, and other bodies of water. Excess phosphorus is of particular concern since it is one of the main contributing factors in the growth of algae, including cyanobacteria (or blue-green algae), in these ecosystems. Extensive algae growth creates algal blooms that may generate unpleasant odors, and/or may reduce the visual appeal of the coastal zone by coloring water an unattractive green as well as producing toxins and causing anoxia.

Lake Productivity
Lakes can be characterized by their biological productivity or trophic state (i.e., the amount of living material supported within them, primarily in the form of algae). The least productive lakes, which are generally clear with little aquatic plant growth, are classified as oligotrophic; those with intermediate productivity are mesotrophic; and the most productive are eutrophic. The variables that determine productivity in lakes are temperature, light, depth and volume, and the amount of nutrients – and in particular, phosphorus – received from the environment.

Except in shallow bays and shoreline marshes, the Great Lakes were oligotrophic before European settlement and industrialization. Their size, depth and the climate kept them continuously cool and clear. The lakes received only small amounts of nutrients such as phosphorus and nitrogen from decomposing organic material in runoff from forested lands. Small amounts of nitrogen and phosphorus also came from the atmosphere.

Phosphorus Terminology

In referring to phosphorus loadings, it is important to differentiate between total phosphorus (TP), particulate phosphorus (PP) and dissolved phosphorus loadings. These terms are often used interchangeably in reports and presentations; however, they should be treated as independent measures as they require different best management practices to mitigate.

Total phosphorus (TP) is comprised of three parts: soluble reactive phosphorus (SRP), soluble un-reactive or soluble organic phosphorus (SUP) and particulate phosphorus (PP) (Rigler 1973). Soluble and particulate phosphorus are differentiated by whether or not they pass through a 0.45 micron membrane filter.

The sum of SRP and SUP is called soluble phosphorus (SP). The sum of all phosphorus components is termed total phosphorus (TP).

Therefore:

TP = SRP + SUP + PP

SP = SRP + SUP

Dissolved reactive phosphorus (DRP) is the fraction of dissolved phosphorus that is 100 percent bioavailable to plants. Almost all dissolved phosphorus is comprised of dissolved reactive phosphorus.

Carlson, R.E. and J. Simpson. 1996. A Coordinator's Guide to Volunteer Lake Monitoring Methods. North American Lake Management Society. 96 pp.

These lake conditions have changed significantly over time from pre-settlement to the present day. Temperatures in many tributaries have increased due to the removal of vegetative shade cover and thermal pollution – both a result of increased development within watersheds. But, more important, the amount of nutrients and organic material entering the lakes has increased with intensified urbanization and agriculture. In particular, nutrient loadings to the lakes increased with the advent of phosphate detergents and inorganic fertilizers. In an attempt to control these inputs, many jurisdictions bordering the Great Lakes and St. Lawrence River have adopted regulatory and management measures to address these sources of nutrient loading.

The Eutrophication of Lake Erie: A Special Case

Lake Erie was the first of the Great Lakes to demonstrate a serious problem with eutrophication (i.e., the gradual increase of lake productivity from oligotrophy to eutrophy), likely because it is the shallowest, warmest and naturally most productive of the lakes. This process can occur naturally as a result of the accumulation of nutrients over time, increased productivity and the accumulation of sediments within the lake basin. However, human activities can dramatically increase the speed of this process, which is sometimes referred to as cultural eutrophication. Notably, Lake Erie also experienced early and intense development of its watershed for agricultural and urban uses, leading to increased human influence on the lake. Presently, about one-third of the total Great Lakes basin population lives within Lake Erie's drainage area.[2]

The central basin of Lake Erie is especially susceptible to oxygen depletion in waters near the lake bottom as a result of lake stratification during the summer. This process forms a relatively thin layer of cool water at the bottom of the water column, called the hypolimnion, which is then isolated from oxygen-rich surface waters. Oxygen is rapidly depleted from this thin bottom layer as its organic matter decomposes. When dissolved oxygen levels reach zero, the waters are considered to be anoxic. By contrast, the western basin of Lake Erie is not generally susceptible to anoxia because the wind keeps the shallow basin well mixed, preventing complete stratification. The eastern basin is deeper and the thick hypolimnion caused by stratification contains enough oxygen to prevent anoxia from occurring.

Oxygen depletion in Lake Erie's central basin was first reported in the late 1920s. Studies showed that the area of oxygen depletion grew larger with time, although the extent varied from year to year owing, in part, to weather conditions; however, eutrophication was believed to be the primary cause. Before controls could be developed, it was necessary to determine which nutrients were most important in causing eutrophication in previously mesotrophic or oligotrophic waters. By the late 1960s, the scientific consensus was that phosphorus was the key nutrient in Lake Erie and the other Great Lakes, and that controlling its input could reduce eutrophication.

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[2] U.S. Environmental Protection Agency and Government of Canada. *The Great Lakes: An Environmental Atlas and Resource Book (Third Edition).* 1995. Available online at: http://www.epa.gov/glnpo/atlas/index.html.

Past Activities and Milestones

In both Canada and the United States, the belief that Lake Erie was 'dying' in the 1960s increased public alarm about water pollution everywhere. Even the casual observer could see that the lake was in trouble. *Cladophora*, a filamentous form of algae that thrives in eutrophic conditions, became the dominant nearshore species covering beaches in green, slimy, rotting masses. Increased turbidity caused the lake to appear greenish-brown and murky.

In response to public concern, new pollution control laws were adopted in both countries to deal with water quality problems, including phosphorus loadings to the lakes. In 1970, both the U.S. EPA and the Canadian Department of Environment (now Environment Canada) were formed. Growing public awareness and concern for controlling water pollution also led to sweeping amendments of the U.S. Federal Water Pollution Control Act in 1972. As amended, the law became commonly known as the Clean Water Act (CWA). The 1972 CWA included many new provisions, including:

- Establishing the basic structure for regulating pollutant discharges into U.S. waters;
- Strengthening the legal penalties for discharging any pollutant from a point source into navigable waters, without a permit;
- Funding the construction of sewage treatment plants under a construction grants program; and
- Recognizing the need for planning to address the critical problems posed by nonpoint source pollution.

The Canada Water Act, passed in 1970, provided for the management of the water resources of Canada, including research and the planning and implementation of programs relating to the conservation, development and utilization of water resources. Importantly for the Great Lakes and St. Lawrence River, the Canada Water Act included a ban on phosphates in detergents.

The passage of the Clean Water Act and the Canada Water Act, along with greater scientific evidence of the damaging effects of nonpoint source pollution to the water quality of the Great Lakes, led to the signing of the Great Lakes Water Quality Agreement (GLWQA) in April 1972. The 1972 GLWQA (renewed in 1978 and amended in 1987) provided the most important regional response yet to the problems of nutrient loadings and excessive eutrophication. Under this landmark agreement, the United States and Canada agreed to initiate joint phosphorus reduction programs for municipal sewage treatment plants in the Lake Erie and Lake Ontario basins. Controls were also agreed upon for industrial discharges and for large, concentrated livestock operations.

The role of different land uses, especially row crop agriculture, as major contributors of phosphorus to the Great Lakes, also became more apparent in the 1970s as a result of two major studies. In 1972, the U.S. and Canadian governments directed the International Joint Commission (IJC) to study the nature, extent and possible remedies for nonpoint source pollution. The resulting binational research effort, organized under the Pollution from Land Use Activities Reference Group (PLUARG),[3] produced a series of reports that essentially launched nonpoint source pollution

[3] Report of the Pollution from Land Use Activities Reference Group is available online at: http://www.ijc.org/php/publications/pdf/ID460.pdf.

research in both countries. These studies also represented the first truly comprehensive effort to address the connection between land use and water quality in the binational Great Lakes-St. Lawrence River region and acknowledge the need to move beyond point sources or "end of pipe" pollution. One of the primary recommendations made by the PLUARG effort was "the development of management plans which would stress site-specific approaches to reduce loadings of phosphorus, sediments and toxic substances derived from agricultural and urban areas." The PLUARG reports further recommended that a mutually satisfactory schedule for the reduction of nonpoint source loadings be annexed to the revised GLWQA.

The PLUARG study greatly advanced the region's knowledge of large-scale watershed and in-lake processes related to nonpoint source pollution and contributed to the development of a generation of scientists and policymakers who understood the need to address nonpoint source pollution concerns. The PLUARG effort recognized the need to address local (watershed based) nonpoint source priorities rather than being prescriptive basin-wide. In this regard, PLUARG was very successful in providing a vision of the future of nonpoint source control that permitted flexible implementation. Progress since PLUARG can been seen through the subsequent establishment and funding of important nonpoint source pollution reduction programs (e.g., Section 319 of the CWA, U.S. Farm Bill conservation title programs) and the implementation of conservation tillage and integrated pest management practices.

In 2003 and 2004, the Great Lakes Commission, in partnership with several agencies, including the U.S. EPA's Great Lakes National Program Office, the U.S. Army Corps of Engineers (USACE), and the NRCS, assessed post-PLUARG progress in preventing and controlling nonpoint source pollution. The results of this project, summarized in the report *Great Lakes Nonpoint Source Pollution from Land Use Workshop: A Post-PLUARG Review*,[4] informed the findings and recommendations of the Phosphorus Reduction Task Force.

Another important development in the area of nonpoint sources pollution prevention was the creation of Lakewide Management Plans (LaMPs) under the 1987 amendments to the GLWQA. LaMPs are action plans that assess, restore, protect and monitor the health of the five Great Lakes. They are implemented by governmental, tribal/First Nations and nongovernmental partners. The LaMPs use an ecosystem approach to adaptive management, integrating environmental, economic and social considerations to help solve complex environmental problems. LaMPs were originally intended to identify critical pollutants that impair beneficial uses of the lakes and to present strategies, recommendations and policy options to restore those beneficial uses. LaMPs have evolved beyond this focus on critical pollutants to encompass a broader ecosystem approach, integrating environmental protection and natural resource management in such areas as habitat restoration and protection.

With leadership from U.S. EPA and Environment Canada, and in collaboration with other federal, state, provincial and tribal/First Nations agencies, LaMPs have been developed for lakes Erie, Michigan, Ontario and Superior, and a Binational Partnership Action Plan has been developed for Lake Huron. The complete LaMP reports are being updated every two years to incorporate new scientific data, management priorities and work plans. Several of the LaMPs have identified nutrient management and algal bloom reduction as top priorities in their work plans:

[4] The report *Great Lakes Nonpoint Source Pollution from Land Use Workshop: A Post-PLUARG Review* is available online at: http://glc.org/postpluarg/documents/Post-PLUARG_Workshop_Proceedings.pdf.

- The Lake Erie LaMP established a binational nutrient management strategy in 2007, and its Management Committee has established indicator endpoints for total phosphorus concentrations for surface water. These targets are based on the best available science and, when achieved, will reduce problem algal blooms in the lake.

- The Lake Ontario LaMP has a focus on reduction of nutrients, chemicals and sediments impacting the nearshore area. The U.S. EPA and New York State Department of Environmental Conservation are looking at restoring water quality through the development of Total Maximum Daily Loads (TMDLs) to reduce phosphorus loads going into the waters of the Lake Ontario basin. For example, in Port Bay along the lake's south shore, phosphorus buildup in sediments associated with wastewater treatment plant discharges and nonpoint sources has contributed to heavy algae blooms, cyanobacteria and poor water quality.

- The Lake Huron Binational Partnership has identified priority issues to be addressed, including nonpoint source pollution from illicit waste connections to storm sewers or roadside ditches, septic systems, combined and sanitary sewer overflows, stormwater runoff, wild and domestic animal waste, and agricultural runoff.

State and provincial responses to nutrient abatement and nonpoint source pollution prevention and control also occurred as an outgrowth of the PLUARG effort, LaMPs, other CWA programs and the GLWQA. Many nutrient management programs, especially for the control of phosphorus, were developed by the states and provinces in the 1980s and 1990s. These programs authorize the states and provinces to provide technical and financial assistance and education and outreach efforts to implement nutrient reduction efforts. However, funding for these programs generally has been inadequate and inconsistent for the states and provinces to fully address their nutrient management priorities. These programs are described in more detail in the Task Force's programs report.

The 1987 amendments to the CWA established the Section 319 Nonpoint Source Management Program in recognition of the need for greater federal leadership in guiding state and local nonpoint source pollution control efforts. Since 1990, states have been eligible to receive grant money from U.S. EPA under this program, commonly referred to as the "Section 319 program." These funds support a wide variety of activities, including non-regulatory or regulatory programs for enforcement of nonpoint programs, technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of specific nonpoint source implementation projects. Notably, a portion of the Section 319 grant funds have been used by states to support implementation of nonpoint source controls in lake watersheds and to monitor the effectiveness of nonpoint source best management practices (BMPs) in watersheds.

Federal farm policies also changed in the 1980s in reaction to growing environmental concerns and a greater awareness of the need for conservation practices in the agricultural sector. At the time, public awareness was increasing regarding the deleterious effects of farming on not only soil quality, but also on water and air quality and wildlife habitat. The 1985 Farm Bill was the first to have a specific title devoted to conservation. The significance of this legislation is that it identified the importance of soil conservation for reasons other than preserving or enhancing soil productivity. New programs from the 1985 Farm Bill (Sodbuster, Swampbuster, Conservation Compliance and Conservation Reserve Program) were followed by additional conservation programs in the 1996 and

2002 Farm Bills (the Conservation Reserve Enhancement and Environmental Quality Incentive programs, respectively). These programs were created to address environmental issues such as soil erosion, water quality improvement, and wildlife habitat protection and enhancement.

As a result of these activities, the control of total phosphorus in the Great Lakes represents an unprecedented success in achieving environmental results through international cooperation. Total phosphorus loads entering the lakes have been reduced to below the maximum amounts specified in the GLWQA for lakes Superior and Michigan, and at or near the maximum amounts for lakes Erie and Ontario.

An Old Problem Returns as New Concerns Arise

The Great Lakes-St. Lawrence River ecosystem has changed over time due to many factors, both natural and human-influenced. Since the mid-1990s, scientists have documented a return to levels of dissolved phosphorus measured in the early 1970s, even though nutrient controls remain in place. Accompanying this latest return to elevated dissolved phosphorus loadings has been the emergence of HABs, which are of particular concern for human health in the Great Lakes and other coastal regions.

Similar to regular algal blooms, HABs result from an increase in the rate of supply of nutrients to a system, leading to the excessive growth of algae. However, HABs occur when the algal communities consist of microorganisms with inherently harmful qualities,[5] such as cyanobacteria (commonly termed "blue-green algae"). HABs can affect an ecosystem based on sheer population size (i.e., dissolved oxygen depletion), but may also produce toxins that directly or indirectly affect human health and safety.[6] The toxicity of a HAB may be further intensified by filter-feeding invertebrates (e.g., zebra mussels), which selectively remove nontoxic algal species from the water column.[7]

According to the *Ohio Lake Erie Phosphorus Task Force Final Report* published in April 2010, "following extensive phosphorus reduction efforts initiated in the 1970s, algal blooms in Lake Erie had been largely absent. However, blue-green algae (cyanobacteria) blooms began to reappear in the western basin of Lake Erie in the mid 1990s. A particularly massive bloom of *Microcystis aeruginosa* occurred in 2003 and in 2006, the benthic mat-forming blue-green alga *Lyngbya wollei* began growing profusely in Maumee Bay and washing up along the shoreline. Many shoreline areas around Lake Erie are again experiencing nuisance growths of the filamentous green algae *Cladophora*. Coincidental to the increasing degradation of the lake, Heidelberg University's long term tributary monitoring program noted an increasing trend in the concentration and load of dissolved reactive phosphorus (DRP) [the fraction of dissolved phosphorus that is 100 percent available to plants], also beginning in the mid-1990s."

Once again, the impacts of excessive phosphorus loadings and the development of HABs and eutrophication in the Great Lakes have become clearer over the past several years. This realization has prompted the development of several federal, regional and statewide nutrient abatement and

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[5] Gilbert, P.M., D.M. Anderson, P. Gentien, E. Granéli, and K.G., Sellner. 2005. *The Global, Complex Phenomena of Harmful Algal Blooms*. Oceanography 18 (2).

[6] Michigan Sea Grant. *When Blooms go Bad: Harmful Algal Blooms in the Great Lakes.* Accessed 25 June 2012. Available online at: http://www.miseagrant.umich.edu/hab/index.html.

[7] Michigan Sea Grant. *Factors Influencing the Growth of Harmful Algal Blooms (*Thereafter, *Factors*). Accessed 26 June 2012. Available online at: http://www.miseagrant.umich.edu/hab/images/Harmful-Algal-Bloom-illustration-1000w.jpg.

management programs aimed at improving and maintaining the ecological integrity of the Great Lakes-St. Lawrence system. The formation of the Commission's Phosphorus Reduction Task Force is one such effort.

Findings

The Task Force developed a set of findings that guided development of their recommendations. These findings are, in some cases, supported by research and monitoring data, but in many instances are based on observation or are anecdotal in nature and were developed by the Task Force subcommittees through discussions with technical experts. The technical experts listed in Appendix C were identified by the Task Force members and were available as a resource to the Task Force. The experts did not review the report nor were they asked to endorse any of the recommendations.

The Phosphorus Reduction Task Force focused on several keys changes that have occurred in the Great Lakes-St. Lawrence River basin to guide the development of its recommendations. A summary of these changes, described more fully below, include:

- The amount of dissolved phosphorus in several critical watersheds has steadily increased since the mid-1990s and has reached the pre-cleanup levels of the 1970s.
- Discharges from point sources have remained relatively constant during the past two decades; however, point source discharges (e.g., from wastewater treatment plants, combined sewer overflows and other collection systems) are still contributing to the problem.
- There has been an increase in the percentage of urban and suburban land uses in many areas within the basin with a concurrent increase in fertilizer use on suburban lawns, golf courses, parks and other green spaces.
- In most of the southern portion of the basin, a smaller number of farmers are farming a larger number of acres causing changes in fertilizer uses, both the types used and the application methods.
- The numbers of livestock in certain areas in the basin have increased, creating challenges in the management and use of manure.
- Climate change impacts may be contributing significantly to the increase in phosphorus loadings to the Great Lakes, especially in western Lake Erie. The affects of warmer winters, more extreme summer temperatures and changes in timing and amount of precipitation need to be better understood as they relate to understanding land and water ecosystems.
- Zebra and quagga mussels and other aquatic invasive species introduced over the past two decades are changing the aquatic ecosystem in the Great Lakes and may be contributing to the increase in HABs and eutrophication in some areas.
- The legislative and programmatic response to both point source and nonpoint source pollution abatement in the 1970s and 1980s was significant and effective, but new challenges may require new and innovative approaches to the problem.

There has been an observable increase in the incidences of algal blooms, including HABs, in the Great Lakes over the past decade. Monitoring efforts, ongoing in some parts of the basin for 30 years or more, have shown that the total phosphorus loadings were decreasing from the early 1980s until the mid-1990s and have remained relatively constant since that time. However, there has been an increase in dissolved reactive phosphorus loadings in certain tributaries, especially in the western Lake Erie basin. In some tributaries to western Lake Erie, dissolved phosphorus loadings have reached levels that occurred in the 1970s, before the initiation of phosphorus reduction efforts. In

Ontario investigations are underway to examine proportions of dissolved and particulate phosphorous and historic trends.

Contributions of phosphorus from point sources have remained relatively constant since the mid-1990s. Many of the region's larger urban areas have experienced very slow or negative growth in the past ten years. Through state and provincial statutes, phosphorus is gradually being eliminated from most lawn fertilizers.

Storm events appear to be occurring more frequently and with greater intensity in many parts of the basin. This is causing increased runoff and perhaps increased loadings from agriculture and urban areas.

Data on phosphorus loadings for most major sub-basins of the Great Lakes-St. Lawrence River are not comprehensive, detailed or historic.

There has been an increase in the concentration of livestock in certain areas in the Great Lakes-St. Lawrence River basin, which has led to waste disposal issues, such as the spreading of manure at rates that far exceed the minimum phosphorus needs for optimal plant growth.

Commercial phosphorus fertilizer application rates in the Great Lakes-St. Lawrence River basin have remained level or decreased over the past 20 years. There are regional differences in the formulations of phosphorus fertilizer applied to farm fields throughout the basin. From observation, there also appears to be differences in the type and timing of fertilizer applications, as well as in the methods of application used between small- and large-scale farms. Since the mid-1990s many farms have become larger, often comprising thousands of acres per farm. As a result, it appears that these larger farm operations either hire local fertilizer dealers to apply their fertilizer or apply fertilizer themselves using their own equipment. These larger operations often apply phosphorus to the soil surface after harvest and before spring planting. Small-scale farmers typically continue to apply their phosphorus using traditional methods (i.e., below the soil surface at the time of planting). The fertilizer application practices of large farm operations need to be researched, including the extent to which these operations hire fertilizer dealers versus applying fertilizer themselves, as well as the amounts, formulation types and timing of applications. The practices of smaller farm operations also need to be better documented.

There has been an increase in the amount of no-till and minimum-till farming taking place in portions of the Great Lakes-St. Lawrence River basin, especially in the western Lake Erie basin. In the western Lake Erie basin, almost the entire soybean crop is being planted with the no-till method.

A significant but anecdotal observation has been made concerning the relationship between terrestrial runoff and the formation of HABs. In 2011 abnormally high rainfall – about fifty percent greater than normal – fell in the western Lake Erie basin and loads of dissolved phosphorus to the basin rose significantly. During the summer, HAB production was two to three times greater than previous occurrences. In 2012, however, just the opposite occurred. The area experienced a severe drought; there was little runoff, small phosphorus loads and HAB growth was minimal. Discharges from point sources remained relatively constant during both years. This supports the assumption that tributary loadings are the critical input of phosphorus to the lake and agriculture is one of the main contributors to the increased loadings.

The effects of climate change appear to be contributing to the scenario described above. Climate change adds uncertainty about the hydrology of the Great Lakes, water demand forecasts, and in-lake processes. Over the past decade and a half, storms in the Great Lakes-St. Lawrence River basin have become more intense, more frequent and of shorter duration. Another climate change effect is the number of freeze/thaw events; particularly snow melt and rain on frozen ground. The environmental consequences of more intense rainfall, snowmelt and runoff from these storms include increased soil erosion and sedimentation and increased runoff and flooding leading to increased nonpoint source pollution. In agricultural areas, the more intense runoff that occurs during larger storm events also has the ability to transport significant amounts of other materials applied to the soil surface, including fertilizers, pesticides, organic matter and other harmful items. The more intense storms also affect riverine and lake habitat. More runoff creates larger volumes of stream flow with increased velocities, which may destroy aquatic habitat and displace important aquatic species from their preferred habitat.

In addition to the ecosystem impacts associated with climate change and variability and land-use changes, there are other major drivers of change to aquatic ecosystems and the services they provide. For example, aquatic invasive species – non-native species that can cause significant environmental or economic damages or impacts to human health – are affecting ecosystem change. Results from several research studies suggest that recent algal blooms in western Lake Erie are linked to nutrient loading, nutrient releases by zebra mussels, and selective feeding by zebra mussels. Specifically, research performed by NOAA's Great Lakes Environmental Research Laboratory (GLERL) with water from Saginaw Bay and Lake Erie have shown that zebra mussels selectively filter and reject phytoplankton in a way that promotes and maintains *Microcystis* blooms.[8] Using special video equipment, GLERL showed that mussels filter water whether or not *Microcystis* is present, but they spit *Microcystis* back into the water while at the same time eating other algae. Thus, the competitors of *Microcystis* are removed. This likely explains why *Microcystis* has been a dominant alga in many summers. At the same time this selective feeding process is occurring, the mussels are excreting nutrients (phosphate and ammonia) derived from the phytoplankton they eat as part of digestion and metabolic processes. These nutrients, in turn, serve to fertilize further growth of *Microcystis*. Additional research is needed in this area, however.

[8] Vanderploeg, H.A., J.R. Liebig, W.W. Carmichael, M.A. Agy, T.H. Johengen, G.L. Fahnenstiel, and T.F. Nalepa. 2001. *Zebra mussel (Dreissena polymorpha) selective filtration promoted toxic Microcystis blooms in Saginaw Bay (Lake Huron) and Lake Erie.* Canadian Journal of Fisheries and Aquatic Sciences. 58: 1208-1221.

Recommendations

While the Task Force work focused primarily on the three subcommittees (phosphorus inputs from point sources; phosphorus inputs from nonpoint sources; and phosphorus issues related to product formulation, innovation, policy and regulation issues), it also developed findings and recommendations to reduce phosphorus through federal, state and provincial actions related to funding for clean water infrastructure; research; technical assistance; outreach and education; and expanding and enhancing programs proposed under the 2012 Farm Bill. With these overarching themes in mind, the Task Force's recommendations are grouped under the following headings: Policy and Programmatic Actions; Implementation; Research and Science; Innovation of Technologies and Equipment; Communication and Coordination; and Information, Education and Outreach.

1. Policy and Programmatic Actions

Great Lakes Restoration Initiative

Issue: The GLRI is an unprecedented, multi-year program to restore the Great Lakes. One of the Initiative's five priority areas – Nearshore Health and Nonpoint Source Pollution – is designed to restore ecosystem integrity of the Great Lakes through efforts to reduce phosphorus loadings and runoff. Priority watersheds have been identified under the GLRI and U.S. EPA (which administers the program) is interested in targeting the program's resources in a way that maximizes ecosystem improvement through the reduction of HABs. The GLRI is halfway through its expected program life and U.S. EPA is eager to show progress on this highly visible and highly publicized issue that, if left unchecked, has the potential to overshadow progress made in other areas of the program. A key challenge is showing measurable results from projects implementing BMPs in a three-to-five-year timeframe. Often these projects require long periods of time to demonstrate ecosystem improvements from the conservation practices implemented.

Background: The GLRI is supporting implementation of a comprehensive, bipartisan restoration strategy that is broadly endorsed by the Great Lakes states, cities, tribes, conservation groups, and business and industry. The Initiative seeks to translate regional goals into site-specific actions that achieve specific performance measures outlined in the Initiative's Action Plan. Nearly 700 projects are underway (as of early 2012) to address serious problems facing the Great Lakes, including controlling polluted runoff and cleaning up beach pollution; restoring degraded wetlands; and enhancing valuable fish and wildlife resources. The states also provide substantial resources to the GLRI effort. Providing funding for them to carry out their responsibilities is a critical need.

Recommendation: The GLRI should continue to support projects that emphasize nearshore health and nonpoint source pollution prevention in order to reduce phosphorus runoff and eliminate HABs. Specifically, the Administration should consider the following GLRI-related recommendations:

a. Providing block grants to states for large-scale watershed projects in high-load areas that will show measurable reductions in phosphorus runoff and HABs.

b. Providing additional support for targeted outreach and education projects that promote changes in behavior or practices designed to reduce phosphorus runoff and HABs.

c. Supporting larger-scale projects in priority watersheds under the GLRI, especially those where excessive phosphorus loadings have been identified as a problem. These larger projects should also be planned for a longer timeframe (e.g., five to ten years).

d. Extending the timeframe for the GLRI program from beyond 2014 to 2019. This extended timeframe will allow projects funded under the Nearshore Health and Nonpoint Source priority area to be fully implemented and show measurable results.

Clean Water Infrastructure – State Revolving Loan Funds

Issue: Aging wastewater infrastructure allows the release of inadequately treated sewage into local waterways every year. Wastewater treatment plants that are outdated and in need of improvement can be an important source of phosphorus to receiving water bodies and may ultimately contribute to HABs, increased eutrophication, and related problems.

Background: Storm and sanitary sewer discharges continue to close Great Lakes beaches, threaten public health and damage local economies. Similarly, degraded drinking water infrastructure is a costly challenge for many communities. Many of these aging facilities have been coping with increased treatment costs as a result of HABs occurring near their water intakes. The Clean Water and Safe Drinking Water State Revolving Fund (SRF) programs assist states and local communities in upgrading water infrastructure and it is important to maintain these programs to help address the HABs and related problems in the Great Lakes and St. Lawrence River.

Recommendation: Congress must appropriate adequate funding for the Clean Water and Safe Drinking Water SRFs programs. This funding must include provisions for low-interest loans as well as grants to assist economically struggling communities. This funding is needed to:

a. Upgrade older water infrastructure, including separating combined sewers that are still a problem in many systems in the Great Lakes.

b. Upgrade sewage treatment plants to reduce the release of nutrients that may contribute to HABs in the Great Lakes.

Farm Bill Conservation Title Priorities

Issue: The U.S. Farm Bill, up for reauthorization in 2012, is one of the most important vehicles for NRCS to help improve and protect soil and water resources by providing financial and technical assistance to land owners that implement farm and ranchland conservation plans. However, the conservation title of the Farm Bill needs to be expanded and refocused to provide greater emphasis and flexibility to protect the Great Lakes from excessive amounts of sediment and nutrient loadings from agricultural practices that contribute to impairments to water quality, HABs, loss of fish and wildlife habitat, and the cost of stream channel and harbor maintenance.

Background: The conservation title of the Farm Bill, which includes voluntary conservation programs and conservation compliance provisions first established in 1985, have delivered great benefits to farmers and have supported and enhanced the ecological integrity of the nation's land and water resources, including those of the Great Lakes basin, over the last 25 years. These benefits have included increased farmland sustainability, a reduction in soil erosion of more than 40 percent nationwide, a dramatic decrease in net wetlands loss on farmlands, and the preservation and enhancement of critical habitat for endangered species, among many others. Specific Farm Bill programs such as the Conservation Reserve Program, Conservation Reserve Enhancement Program, Wetland Reserve Program, Environmental Quality Incentive Program, Wildlife Habitat Incentives Program, and Great Lakes Basin Program for Soil Erosion and Sediment Control have been valuable tools for the Great Lakes-St. Lawrence River region for improving habitat, managing sediment and advancing soil and water conservation efforts.

Recommendation: The U.S. Farm Bill should be reauthorized in 2012 with a strong conservation title that protects the nation's soil and water resources. Specific priorities for the conservation title include:

a. Farm Bill funding should be maintained at a level adequate to continue important conservation programs at robust levels. Congress should prioritize the conservation title by funding it as close as possible to the current baseline average of $6 billion annually.

b. The Farm Bill should include a regional conservation partnership program that provides opportunities for states, regional organizations and other watershed-based organizations to receive funding, on a competitive basis, to implement conservation treatment programs in priority watersheds. In the Great Lakes, the highest priority programs should be those that emphasize phosphorus reduction.

c. The Farm Bill conservation title should mandate an ecosystem-based outcomes approach in the delivery, reporting and evaluation of NRCS programs.

d. The Farm Bill should be flexible to allow the NRCS, in collaboration with each state, to target soil and water conservation and nutrient management programs in priority watersheds.

e. The Farm Bill should require commodity and crop insurance subsidy program participants farming in critical Great Lakes watersheds to develop and implement nutrient management plans.

f. The Farm Bill should allow NRCS to enter into cost-share agreements with fertilizer dealers in priority watersheds who are willing to change their products and/or practices to help reduce phosphorus fertilizer runoff to the Great Lakes.

Role of the International Joint Commission in Phosphorus Reduction

Issue: The IJC has had an historic role in organizing government study and action in the area of nonpoint source pollution prevention and control. The IJC can and should play a leadership role in galvanizing governments to address the issue of phosphorus runoff and HABs.

Background: In 1972, the U.S. and Canadian governments, through a formal reference to the IJC, called for a study of pollution in the Great Lakes from agricultural, forestry and other land-use activities. In response, the IJC established the binational PLUARG, consisting of scientists and other experts, to assist the IJC's Great Lakes Water Quality Board in studying the extent and cause of pollution from land-use activities and to develop recommendations on possible remedies. The PLUARG reports stand today as the most comprehensive study of nonpoint source pollution in the Great Lakes-St. Lawrence River basin. Recently, the IJC identified HABs as one of its top priorities for work under the GLWQA. The Nuisance and Harmful Algal Bloom Work Group presented a report to the IJC at its 2011 Biennial Meeting to assess and better reflect the objective under the GLWQA to eliminate nuisance algae growth. The Work Group developed findings in the area of Management, Science and Communications and presented recommendations for IJC and government action.

Recommendation: The IJC must continue its leadership in working with the U.S. and Canadian governments to reduce phosphorus runoff and prevent HABs. Specifically, the IJC should focus on the following priorities:

a. Implementing recommendations from the Nuisance and Harmful Algal Bloom Work Group presented at the 2011 Biennial Meeting.

b. Completing the Lake Erie Ecosystem Priority (LEEP), established in 2012, to assist in the development of recommendations to the United States and Canada on phosphorus reduction and HABs abatement. The IJC must fully involve the states and provinces in the development of its recommendations.

c. Partnering with the Great Lakes Commission, through the Great Lakes Water Quality Board, to develop recommendations under LEEP and ensure that the two Commissions' approaches are well-coordinated and complementary.

d. Continuing to promote binational research into the mitigation of excess nutrient loadings into the Great Lakes and St. Lawrence River, and their environmental effects.

Actions to be Pursued by the States and Provinces

Issue: The states and provinces have many programs addressing nonpoint source and nutrient management issues in areas related to regulation, financial support, technical assistance, education, outreach and monitoring. These programs are often managed by different agencies within each jurisdiction and in most cases are not comprehensive and address only a portion of the nonpoint source problem. The Phosphorus Reduction Task Force believes that states and provinces will benefit from reviewing these programs and identifying opportunities to create efficiencies, build synergies, fill gaps, and eliminate redundancies.

Background: State and provincial governments have the jurisdictional authority to provide financial and technical assistance as well as regulate the discharge of phosphorus from point sources and the application and discharge of phosphorus from nonpoint sources in certain instances. Under Section 303 (d) of the CWA, states are also required to develop lists of impaired waters. The law requires that states prioritize these impaired waters and develop a schedule for development of Total Maximum Daily Loads (TMDLs) based on the severity of pollution and the sensitivity of uses among other factors. States then submit a plan to U.S. EPA for completing TMDLs within 8 to 13 years from the time the water body is listed. The Phosphorus Reduction Task Force discussed the importance of developing emergency regulatory authority to address severe nonpoint source pollution problems in watersheds where phosphorus pollution is contributing to increases in algal blooms and other water quality problems. Another example is the ability of the states to utilize resources under the Clean Water SRF program for nonpoint source pollution reduction projects. Many of the Great Lakes states do not take full advantage of this authority.

Recommendation: The states and provinces should review their policies and practices to determine if programmatic gaps or redundancies exist and if additional regulations are required to reduce phosphorus loadings to the Great Lakes and St. Lawrence River. Specifically, the states should review whether current practices and authorities can be adjusted to provide a better legal and technical framework for implementation programs and policies. The types of actions that states and/or provinces should pursue individually or collaboratively include:

a. Establishing emergency regulatory authority for designating stressed watersheds (in addition to federal requirements, such as those stipulated under CWA Section 303 (d)), and triggering mandatory actions by landowners and communities to reduce unpermitted pollutant loadings.

b. Developing in-lake criteria for nutrient concentrations based on the Great Lakes aquatic eco-zones, such as western Lake Erie basin, Saginaw Bay and Green Bay.

c. Reviewing and amending nutrient management programs, authorities and regulations to create greater efficiencies and build synergies while also eliminating redundancies and filling program gaps.

d. Requiring all permitted facilities, where appropriate, to monitor and report on their discharge water for phosphorus, including soluble phosphorus, in order to evaluate total loading and BMP effectiveness.

e. Utilizing the authority under the Clean Water SRF program to install agricultural BMPs, in particular those designed to help landowners upgrade animal waste management systems and implement conservation treatment programs to reduce phosphorus runoff, especially in stressed watersheds.

f. Finalizing Ontario's draft Great Lakes Protection Act and accompanying Great Lakes Strategy to coordinate efforts to reduce phosphorus loadings from point and nonpoint sources.

g. Encouraging Ontario and Québec to work cooperatively with its federal and binational partners to develop programs to address phosphorus reduction in the Great Lakes-St. Lawrence River basin.

h. Collaborating on investigations on the proportion of dissolved and total phosphorus in the loadings to the lakes.

Actions for Canada/Ontario

Issue: The Canada-Ontario Agreement (COA) Respecting the Great Lakes Basin Ecosystem (COA) expired in June 2012.

Background: Since 1971, the COA has guided Canada and Ontario in their work to improve the environmental quality of the Great Lakes. Along with the efforts of the basin's residents, COA has contributed to reducing the amount of pollution that enters the Great Lakes, improving and protecting fish and wildlife habitat, ensuring water is safe for swimming and drinking, and fostering ongoing stewardship efforts.

Recommendation: Canada and Ontario should renegotiate the Canada-Ontario Agreement and include specific phosphorus reduction components in agreement language. Once the new agreement is negotiated, Ontario should review its other programs addressing nonpoint source pollution to ensure that they are consistent with the new COA.

2. Implementation

Financial Assistance and Management Practices

Issue: The Task Force identified implementation programs as a key component in the collective effort to reduce phosphorus inputs to the Great Lakes and St. Lawrence River. Implementation is the installation of physical structures to reduce phosphorus sources and loadings and use of management and production techniques that promote phosphorus reduction. Without implementation programs there would be no change in the overall phosphorus inputs to the Great Lakes and St. Lawrence River.

Background: Implementation programs, activities and BMPs are designed to change the sources and transport of phosphorus. These BMPs, when installed, reduce the sources and movement of phosphorus to receiving water bodies, thereby also reducing phosphorus loadings to the lakes. These can be implemented on the landscape, such as implementing a reverse auction incentive program where landowners submit bids on the amount of funding they will accept to install load-reduction practices or in a National Pollutant Discharge Elimination System (NPDES)-permitted municipal or commercial facility. Small permitted facilities, such as sewage treatment plants for towns under 5,000 in population and small local food processing facilities, such as cheese processors and dairies, often do not have the personnel or the finances to improve their operations.

Recommendation: State, provincial and federal (U.S. and Canada) agencies that implement programs to reduce phosphorus loadings to the Great Lakes and St. Lawrence River should continue these programs, with sufficient funding to install adequate numbers and types of practices to reduce phosphorus input levels below concentrations that initiate algal blooms and HABs. Cost-share funding should be provided for stakeholders able to participate in the transfer of technologies aimed at reducing phosphorus losses, including nontraditional stakeholders such as fertilizer dealers and application equipment manufacturers. Specific recommended actions include:

a. Initiating innovative incentive programs, at federal, state and provincial levels, such as the reverse auction concept, to implement phosphorus reduction activities.

b. Improving phosphorus load reductions at permitted facilities through audits of equipment and operations.

c. Providing more funding under the CWA Section 319 program for phosphorus reduction implementation in priority areas of the Great Lakes and St. Lawrence River.

d. Engaging watershed organizations in developing and implementing federal, state or provincial watershed management strategies.

e. Providing cost-share funding, through U.S. EPA or NRCS programs, for landowners or fertilizer dealers to purchase newly developed, minimally erosive, phosphorus fertilizer injection application equipment.

f. Establishing a special program at the state level, using Clean Water SRF dollars, to cost-share with smaller permitted facilities to improve their phosphorus removal technology.

Technical Assistance

Issue: Technical assistance has been identified by the Task Force as a potential limiting factor in the delivery of conservation treatment programs to reduce phosphorus inputs to the Great Lakes and St. Lawrence River.

Background: Programs managed by NRCS under the Farm Bill and the GLRI require that an adequate number of field personnel be available to deliver programs and show results. With phosphorus loadings and HABs receiving attention both regionally and nationally, additional resources are being made available through Farm Bill programs to combat the problem. A common theme voiced by Great Lakes state and federal partners is that technical assistance (e.g., field staff) is inadequate to fully deliver the programs for maximum result.

Specifically, concerns are being expressed that the additional Environmental Quality Incentive Program dollars recently appropriated for the western Lake Erie Basin may not provide the additional field personnel needed to do the work.

Recommendation: NRCS should provide block grants or execute cooperative agreements with the Great Lakes states to ensure that adequate technical assistance is available to deliver conservation treatment programs designed to reduce phosphorus. The Task Force also urges NRCS to ensure that program dollars for implementation also include funding for technical assistance. Canadian federal and provincial agencies should also explore options to enhance technical assistance within existing programs as appropriate. Specific additional priorities directed at the NRCS include:

a. Maintaining the Strategic Watershed Action Teams (SWATs) to ensure adequate field personnel are available to deliver programs at the watershed scale under the GLRI and permanently establish these teams in the new Farm Bill.
b. Streamlining technical assistance cooperative agreements with states to make it easier for them to partner with Soil Conservation Districts to provide additional field staff in priority watersheds.
c. Establishing the flexibility to use financial assistance (FA) dollars designated for priority watersheds for additional technical assistance (TA).

3. Research and Science

Issue: In its resolution forming the Task Force the Great Lakes Commission highlighted the need for an improved understanding of the fate and transport of phosphorus as a critical component in the effort to reduce algal blooms and HAB formation in the region. The Task Force has concluded that more data and analysis is necessary to assist in formulating and refining phosphorus reduction policies and implementation efforts.

Background: An ongoing, binational commitment to conduct research of the physical and chemical components of the processes and damages caused by phosphorus loadings to the Great Lakes and St. Lawrence River is critical to developing the best policies and implementation programs to achieve the greatest results. Often this type of research requires extended periods of time to determine trends and results. In the absence of this long-term investment in research and monitoring, policies and programs are often initiated without a clear understanding of the problem. Modeling is a valuable tool that can be used to overcome timeframe difficulties, but models also require statistically accurate data. Further, phosphorus research projects are often scattered and uncoordinated among federal agencies, universities, research institutions and private organizations. This results in overlaps and gaps in available and potential data.

More research is needed is in the areas of dissolved and particulate phosphorus fate and transport. Monitoring of Lake Erie tributaries has shown increases in dissolved phosphorus. It is three times more available to plants than other forms of phosphorus, making it an important factor in the formation of algal growths and HABs. It will also be valuable to know how much phosphorus is entering the lakes and from what sources, and how much is leaving the lakes and by what methods. This information could be gathered as part of a mass balance study that might be conducted by one or more federal agencies or universities. This information will assist the prioritization of future research and implementation activities.

Recommendation: A comprehensive binational research program on the fate and transport of phosphorus loadings and activities is needed in the basin. The program should include the development of a more systematic monitoring system and the integration of research priorities with the needs of policymakers and implementers, as follows:

a. Research agencies and institutions should develop a phosphorus fate and transport model which includes factors for dissolved (soluble) phosphorus and subsurface drainage discharges.

b. Appropriate governmental agencies, such as U.S. EPA, the USGS, IJC, USACE, and Environment Canada (EC), should conduct a phosphorus mass-balance study for each of the lakes and sub-basins.

c. U.S. EPA should initiate a research program to develop new technologies, management practices and methodologies to reduce phosphorus discharges from permitted facilities.

d. The ARS and land grant universities should update the current soil testing methodologies in light of continuing changes in farming practices and climate over the past two decades.

e. USGS and state partners should establish a comprehensive phosphorus monitoring network that includes monitoring sites on all eight-digit Hydrologic Unit Code (HUC) watersheds within GLIR-identified priority watersheds of the Great Lakes. The results will be used to set priorities for implementation and assessing progress, among other uses.

f. Appropriate government agencies should collect and report information on the use of fertilizer in the Great Lakes and St. Lawrence River basin geo-referenced at the watershed level. A center for research activities, perhaps an online system, should be established to coordinate research activities and provide a readily available point of access to research results and needed information.

g. The states and provinces should establish a research program to assess the magnitude of the issue of bioaccumulation of phosphorus by mussels.

4. Innovation of Technologies, Programs and Equipment

Issue: The Task Force found that innovation of technologies and equipment is needed to help reduce phosphorus loadings and eliminate HABs. The lack of innovative activities and technologies available to mitigate phosphorus loadings is an impediment to achieving water quality and ecosystem improvements in the Great Lakes and St. Lawrence River. Many of the activities currently being implemented no longer meet the needs required to reduce algal blooms and HABs as the result of social, economic, cultural, climate and technological changes that have occurred in our region.

Background: Implementation programs managed by USDA, U.S. EPA and the states and provinces are relying on outdated technology and antiquated design criteria that is no longer sufficient to achieve desired reductions in phosphorus loadings. Many of the implementation activities were designed decades ago under different climate conditions. The more intense rainfall and runoff, higher temperatures and longer growing seasons being experienced over the past 10 years or more may be overwhelming the existing design capacities of mitigation activities, thereby reducing their effectiveness. The culture of farming has changed with farms becoming larger and less family operated. This has caused a change in production techniques, such as the hiring of commercial manufacturers and dealers to apply fertilizer. Also, permitted facilities, especially small operations, are operating with older and less efficient equipment. Soil testing techniques and guidelines do not reflect changes in climate and farming practices that have occurred during the past several decades. Also, opportunities to use soil testing results to support conservation planning and program implementation have not been fully investigated.

Recommendation: Innovation in the type and implementation of practices and activities should be encouraged by states, provinces and federal governments. Areas of innovation that should be pursued are:

a. NRCS should require soil testing (and the reporting of summary results) for all landowners receiving cost-share funding under all conservation title Farm Bill programs. Conservation plans should be modified if soil tests indicate higher than necessary levels of phosphorus in the soil. Ontario should examine program options to encourage more soil testing.

b. Fertilizer dealers applying fertilizer on cropland in the Great Lakes-St. Lawrence River basin should hire certified crop advisors to develop fertilizer recommendations based on local conditions.

c. ARS and large farm equipment manufactures should be charged with developing phosphorus fertilizer placement equipment that places the material under the soil surface in a non-erosive manner.

d. The fertilizer manufacturers and ARS should develop a more stable form of phosphorus fertilizer that could be surface applied while being resistant to runoff events.

e. The USACE's Great Lakes Tributary Modeling Program should conduct a review of in-stream channel BMPs to determine the best-performing practices to reduce phosphorus loadings and sediment to the Great Lakes.

f. NRCS should approve installation, where applicable, of in-flow (both stream and drainage systems) phosphorus scrubbers, using either gypsum or ferrous materials, as a substrate to remove dissolved phosphorus from waterways and drainage systems.

g. An innovation center, supported by Great Lake states, federal and provincial governments, should be established in the Great Lakes-St. Lawrence River region to promote cooperative binational research and experimentation.

5. Communication and Coordination

Issue: The Task Force identified the need for improved communication, coordination and cooperation between and among federal, state and provincial agencies, research institutions and universities, local units of government, watershed groups and other nongovernmental organizations and funders to avoid duplication of effort, increase understanding of the phosphorus and HABs issue, and share scientific knowledge and lessons learned to inform management and policy issues and approaches.

Background: Phosphorus loadings and their associated impacts on the Great Lakes and St. Lawrence River know no political boundaries. What one jurisdiction does or does not do to control phosphorus loadings affects the waters of neighboring jurisdictions. Therefore, it is imperative that the United States and Canada, as well as the Great Lakes-St. Lawrence states and provinces, communicate and coordinate their efforts to reduce phosphorus loadings and eliminate HABs. Good communication, coordination and cooperation among and between agencies and jurisdictions will be critical to sustaining the effective management activities needed to achieve substantial water quality improvements in the Great Lakes-St. Lawrence River basin.

Recommendation: Opportunities to improve communication, coordination and cooperation between and among agencies and jurisdictions should be explored. Formal methods for promoting more and continued cooperation and coordination should be encouraged including Memoranda of Agreement and Understanding between the United States and Canada and the states and provinces, as appropriate. Specifically, recommended actions include:

a. Convening an annual nonpoint source/phosphorus reduction conference. This might be organized by U.S. EPA under the GLRI, or by the USACE in partnership with the Great Lakes Commission under the Great Lakes Tributary Modeling Program.

b. Establishing a website or public wiki (managed through subscription) to help manage information, house reports, provide a forum for exchanging ideas and soliciting comments on programs and initiatives.

c. Creating an electronic bulletin board (possibly through the wiki) to post information on meetings, workshops and conferences related to phosphorus reduction and HABs.

d. Creating a regional database of aggregated geo-referenced soil test results to help management agencies set priorities for phosphorus reduction.

e. Encouraging Ontario and Québec to convene a joint conference and establish a website or public wiki to post relevant information and reports on nonpoint source/phosphorus reduction.

6. Information, Education and Outreach

Issue: The Task Force has identified education and outreach efforts targeted at key audiences, including farmers and fertilizer dealers, as an important unmet need.

Background: Education is a key factor in raising awareness and changing behaviors. In the case of reducing phosphorus inputs to the Great Lakes and St. Lawrence River, behavioral changes will be necessary to achieve the desired results. As an example, behaviors and practices associated with fertilizer dealers and farmers will be difficult to influence, but necessary in order to mitigate future harmful effects of phosphorus runoff. Fertilizer dealers and landowners have standard ways of using and applying products that, in some cases, may be grounded in generations of established practices. Promoting behavioral change in these instances is a challenge because dealers and landowners are often comfortable with, and reluctant to change, current practices. Education and outreach efforts are needed to promote positive behavioral changes related to agricultural practices. There is also a critical need for educational opportunities for experts in the phosphorus management fields to exchange ideas and techniques.

Recommendation: A comprehensive and coordinated information, education and outreach program should be established addressing phosphorus reduction in the Great Lakes-St. Lawrence River system. This recommendation should be pursued by an organization or institution with a mandate in education and outreach. Specifically, the entity should consider implementing the following priorities:

a. Developing an outreach strategy to coordinate educational efforts with other federal, state, provincial and watershed-based groups with an education mandate, including a pilot continuing education program for fertilizer applicators.

b. Coordinating education and outreach efforts with similar lead agencies in Canada.

c. Planning and convening a Great Lakes-St. Lawrence River Phosphorus Reduction Education Summit involving educators, managers and researchers to promote information sharing and coordination of information and education efforts.

d. Revising and updating U.S. EPA's permitted facilities technical guide. It is out of date for current technological standards used in the industry.
e. Assembling technical advisory teams at the state and provincial levels to provide training and advice to operators of smaller permitted facilities.
f. Engaging key community, sector, academic, municipal provincial, federal and First Nation stakeholders in the LaMP and other actions for phosphorous reduction.

Appendix A: Great Lakes Commission Resolution

RESOLUTION: Nutrient Management in the Great Lakes-St. Lawrence River Basin

Whereas, record hot temperatures and heavy spring rains in much of the Great Lakes - St. Lawrence River basin over the past two years, combined with the effects of nonpoint source runoff, invasive species and other potential contributing factors have created severe water quality problems in several areas of the Great Lakes-St. Lawrence River basin; and

Whereas, water quality problems stemming from both point and nonpoint sources of pollution is a major contributor to the degradation of the Great Lakes-St. Lawrence River ecosystem and other parts of North America, resulting in oxygen starved dead zones, excessive algal blooms and the closing of beaches due to high levels of bacteria; and

Whereas, Lake Erie's western and central basins in particular have been impacted by these problems; and

Whereas, in July 2011 HR 2484 (*the Harmful Algal Blooms and Hypoxia Research and Control Act of 2011*) was introduced in the U.S. House of Representatives to provide programmatic support, funding and technical assistance to address and reduce algal blooms and oxygen starved dead zones nationwide; and

Whereas, phosphorus has been identified as the critical element and limiting factor in freshwater ecosystems which contributes to dead zones and unsightly algal blooms; and

Whereas, phosphorus is contained in some dishwashing detergents and household cleaning products and in animal wastes and commercial fertilizers that are applied to agricultural, urban and suburban lands throughout the basin; and

Whereas, point source contributions of phosphorus from wastewater treatment plants is still a concern in some areas of the Great Lakes – St. Lawrence River basin; and

Whereas, there is a need to better understand the relationship between total phosphorus loadings and levels and dissolved-reactive phosphorus loadings and levels especially since total lake wide phosphorus levels continue to decline in most of the Great Lakes; and

Whereas, the federal governments along with the states and provinces have many laws, regulations, programs and tools available to help landowners manage their lands sustainably and in a manner that can protect water resources; and

Whereas, the Great Lakes – St. Lawrence River region has been at the center of many successful phosphorus related research, regulatory, outreach and education efforts dating back to the 1960s;

Whereas, education and outreach programs aimed at landowners to educate them on the proper methods of animal waste management and phosphorus fertilization application have recently been underemphasized and appear to lack the connection between the practices and the impacts to the ecosystem; and

Whereas, many initiatives and partnerships are in place to help scientists, managers and policymakers better understand the complexities of how phosphorus (especially dissolved phosphorus) degrades freshwater ecosystems and contributes to eutrophication, dead zones and algal blooms; and

Whereas, several of these efforts such as the Western Lake Erie Basin Partnership, the Ohio Lake Erie Phosphorus Task Force, the Canada-Ontario Agreement (COA), the Great Lakes Nonpoint Abatement Coalition in Wisconsin, the Finger Lakes – Lake Ontario Watershed Protection Alliance in New York, the Conservation Technology Information Center in Indiana, the Lake Huron Binational Partnership among others provide forums for addressing phosphorus related pollution issues on a geographically-based or sector-based basis; and

Whereas, federal programs in the U.S. and Canada such as those under the Clean Water Act, the Farm Bill, the Coastal Zone Management Act have individually proven to be effective in helping to improve soil and water quality, reducing sediment runoff and improving wildlife habitat; and

Whereas, the Farm Bill, up for reauthorization in 2012, will in concert with other federal, state and binational programs be an important tool to continue progress in the area of Great Lakes Water quality improvement.

Therefore, Be It Resolved, that the Great Lakes Commission applauds the federal governments and the Great Lakes States and Provinces for the variety of programs and initiatives that have contributed to the progress made in the area of phosphorus reduction over the past 30-plus years; and

Be It Further Resolved, that the Great Lakes Commission, recognizing that phosphorus pollution occurs from many sources including point source discharges from aging infrastructure, reiterates its previous request of the federal governments of the U.S. and Canada to provide adequate funding for clean water including support for the State Revolving Loan Fund (SRF) on the U.S. side; and

Be It Further Resolved, that any federal legislation addressing issues associated with toxic algal blooms and dead zones recognize the importance of these problems in the Great Lakes; and

Be It Further Resolved, that the Great Lakes Commission applauds the work of the International Joint Commission (IJC) through its Science Advisory Board to convene the region's leading scientists to better understand the role of phosphorus in the degradation of water quality and urges the IJC to expand its efforts in this area; and

Be It Further Resolved, that the Great Lakes Commission directs its staff to establish a regional phosphorus reduction task force that includes at least one member from each of its member states and provinces to develop a suite of recommendations for federal, state and provincial actions to reduce phosphorus and that its recommendations be focused in areas related to funding for clean water infrastructure, research, technical assistance, outreach and education, especially of land owners; and

Be It Finally Resolved, that this task force review opportunities for expanding and enhancing programs under the 2012 Farm Bill to reduce phosphorus and improve nutrient management for water quality improvement as well as investigate opportunities to address these critical nutrient management issues by working more closely with the NRCS-led technical committees in each state under the current Farm Bill.

Adopted at the 2011 Annual Meeting of the Great Lakes Commission, Detroit, Mich., Oct. 11-12, 2011.

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Regulation

American Bar Association and State Bar Associations – Environmental Law sections

Other

http://www.sera17.ext.vt.edu/Meetings/greatlakespforum/introductions.shtml

Appendix D: Subcommittee Issue Briefs

Nonpoint Source Issue Brief

Problem Statement and Background: Nonpoint source pollution – pollution that enters waterways mainly as the result of runoff from and through the landscape – has been identified as a major cause of degraded water quality in the Great Lakes – St. Lawrence River basin. Nonpoint source pollution can be comprised of many and varied constituents, including sediment (eroded soils), bacteria, organic material, pesticides, toxic chemicals and nutrients. Of the various types of nonpoint source pollutants, federal, state and provincial governments are becoming increasingly concerned about increased nutrient loadings – phosphorus in particular – to the Great Lakes-St. Lawrence River system. High levels of nutrients can have harmful effects on the ecosystem (e.g., HABs, significant habitat loss, decreased species diversity) as well as impacts on public health and other human activities (e.g., water quality impairments, increased treatment costs, recreation and tourism economic impacts). See sidebar discussion on Page 3 for an additional description of phosphorus loadings and terminology.

The U.S. EPA's Nutrient Innovations Task Group Report, published in August 2009, reports "as the United States population expands, nutrient pollution from urbanization and stormwater runoff, municipal wastewater discharges, air deposition, and nitrogen and phosphorus from agricultural livestock and row-crop activities is expected to grow as well. Increased public health risks and treatment costs from contamination of drinking water supplies is a major concern. Nationally, according to the U.S. EPA, nutrient pollution is one of the top causes of water quality impairment and is linked to over 14,000 water segments listed as impaired. Over two million acres of lakes and reservoirs across the country are impaired and not meeting water quality standards due to excess nutrients. Seventy-eight percent of the assessed continental U.S. coastal areas [including the Great Lakes] exhibit some symptoms of eutrophication."

Although this issue appears to be gaining greater visibility within scientific and regulatory communities and, to some extent, the general population, the problem of increased nonpoint source pollution is not new to the region. In the early 1980s, the IJC's PLUARG study identified particulate phosphorus (i.e., phosphorus attached to soil particles eroded from the landscape as the result of different land use activities) as a major issue. As a result, an extensive effort was instituted by USDA, U.S. EPA and the Great Lakes states to reduce sediment related phosphorus loadings, primarily to Lake Erie, but also to the other Great Lakes. Consequently, the levels of total phosphorus were reduced to below the 800 metric ton goal set for the agricultural industry in Lake Erie through the 1980s and early 1990s.

Challenges and Emerging Issues: Despite reaching and maintaining this goal for phosphorus reduction, a past problem has recently returned: the reappearance of HABs in the western and central basin of Lake Erie. Algal blooms and increased algal growth are also now occurring in other areas of the Great Lakes in addition to Lake Erie.

Since the mid 1990s, levels of dissolved reactive phosphorus (DRP) have been increasing in the tributaries of Lake Erie. In fact, the levels have increased almost to the 1970s pretreatment levels. It is believed that the installation of secondary and tertiary wastewater treatment plants (i.e., a point source, rather than a nonpoint source) since the 1970s provided a substantial portion of the dissolved phosphorus reductions through the mid-1990s. Since that time, the levels of discharge from these sources have remained relatively constant due to the installation of wastewater treatment systems. Therefore, the increase of DRP is thought by many researchers and agency personnel to be the result of recognized changes to agriculture production activities and other trends within the last fifteen years, including: the consolidation of farming units into larger farms, the increased use of bulk surface-applied phosphorus fertilizer after harvest and before planting, a decrease in the amount of phosphorus applied with the planter, an increase in no-till planting of soybeans, an increased use of chisel plowing (i.e., minimum tillage), an increase in installations of subsurface drainage, a change in the type of phosphorus formulation used, milder winters and more intense rainfall.

Additional emerging issues include:

Application of Animal Wastes: The increase in application of liquid manure on smaller quantities of land as animal feeding operations consolidate has become a large but localized issue. Animal waste has traditionally been spread on lands owned or farmed by the livestock producer as a fertilizer. However, shifts in the industry over time have shown a trend toward operating larger facilities with hundreds of animals on smaller areas of land. These facilities produce a larger amount of waste material which often requires disposal elsewhere (e.g., on neighboring farmlands and beyond). If the volume of waste materials is large enough to require a permit (based on a phosphorus standard), such permitting can substantially limit the amount that can be applied per acre. This is beneficial in preventing the build-up of phosphorus in the soil, but can result in additional costs to truck or pump the waste to distant fields, miles away. This places an added cost burden on many facilities. Alternatively, facility operators may need to reduce the number of livestock produced, increase the amount of waste applied per acre, or install technology to reduce the volumes of waste material being disposed in this manner.

Open-Lake Disposal of Dredged Materials: Disposal of dredged material in open lake environments is becoming more common as space in confined disposal facilities for the placement of dredged material diminishes. During such disposal, dredged materials which may contain phosphorus can be re-suspended and dispersed throughout the water column where the phosphorus can then support the growth of algae. Additionally, there is some evidence that suspended sediment or dispersed dredged material can reduce the transparency of the lake water, allowing less sunlight to reach plant life within the water column. This can result in less growth of beneficial algae and more growth of cyanobacteria or blue/green algae, which are considered HABs. Similarly, resuspension (by storm events) of previously deposited material is also a factor in open-lake disposal of dredged materials.

Urban Storm Water: Urban storm water or runoff can contain phosphorus from many sources, including some that are not normally recognized as being harmful to the environment such as lawn fertilizer products, pet wastes, and motor oils. Even though many lawn fertilizer products no longer contain phosphorus, the products that still do contain phosphorus pose a problem when introduced to waterways through runoff. Similarly, like domesticated livestock, pet manure in sufficient quantities can also increase phosphorus loadings. Some motor oils contain phosphorus as a cleaning agent, which, if dripped onto the driveway or parking lot, can be carried into nearby streams during a runoff event.

Septic Systems: Phosphorus exists in human waste, soaps and detergents (although not in laundry detergents), and food waste. Thus, septic systems, even if functioning properly, discharge phosphorus to the environment. Many home sewage treatment systems in the basin are over 50 years old (installed during the rural housing boom of the 1950s and 1960s), and most are at least twenty years old. Similarly, many systems, especially in the lower lake basins are installed in high clay content soils that are not sufficiently permeable for proper treatment. Maintenance is costly and system failures often occur because they have either reached the end of their intended life span or because of poor or inadequate maintenance. Because septic systems are buried underground, they are also not subject to visual inspections. In a properly functioning system, phosphorus from waste materials are trapped in the soil surrounding the leach field; but in a failed, inadequately maintained, or overloaded system it can directly enter the waterways and end up in the lakes. During rain events, these leach fields become saturated and the sewage either seeps into the waterways or becomes so saturated that it flows over the surface to the waterways.

Particulate Phosphorus: Streambank, bluff and coastal erosion directly deposits soil material into the water. Tons of soil can be deposited from a small eroded area. Almost all soils have phosphorus adsorbed to the soil particles, termed particulate phosphorus. When a soil particle is transported to a water body, it carries this phosphorus along with it.

Soil Chemistry: The closer that soil gets to neutral on the pH scale, its ability to adsorb phosphorus (hold on to) diminishes. pH is a measurement of an object's acidity or alkalinity. In soil, the level of Ph affects the chemical properties of the soil and how soil particles will react to the addition of other chemicals. In the pH neutral state, the phosphorus is no longer adsorbed to the soil particle and transitions to a dissolved state. As a fertilizer, this characteristic is beneficial since dissolved phosphorus is more easily utilized by plants. However, this same dissolved phosphorus is potentially detrimental to ecosystems when introduced to nearby water bodies. Most of the Great Lakes basin's soils are slightly acidic, having been formed from Canadian granite and limestone during the retreat of the last ice age some 10,000 years ago. However, as landowners add acid neutralizing products, such as lime, to the soil, to produce more dissolved phosphorus, more dissolved phosphorus will be available to be transported to the lakes.

Mussels: It appears from several research studies that recent algal blooms in western Lake Erie are linked to nutrient loading, nutrient releases by zebra mussels, and selective feeding by zebra mussels, but much more work needs to be done.

Point Source Issue Brief

Problem Statement and Background: The U.S. EPA defines point source pollution as any single identifiable source of pollution from which pollutants are discharged, such as a pipe, ditch, ship or factory smokestack. Factories and sewage treatment plants are two common types of point sources in the Great Lakes-St. Lawrence River region, with human wastes from wastewater acting as the primary contributor of dissolved phosphorus prior to the 1970s. However, since the mid 1990s, nonpoint sources of nutrients, such as that found in runoff from agricultural production, have also contributed to these loadings and related effects; whereas, loadings from wastewater treatment plans have remained relatively constant over this timeframe.

To fully understand the role of point sources in nutrient loadings, one need only look back as far as the 1950s when water quality in most of the Great Lakes had begun to decline as a result of excessive phosphorus loadings and other pollutants to the lakes. Most notably, in Lake Erie, algal blooms were becoming increasingly more common, anoxic zones (i.e., areas depleted of oxygen) in the central and western basins were spreading, and taste and odor problems from public water supplies were prevalent.

A series of events including the unsightly algal blooms along the shores of Lake Erie and Lake Ontario, a massive alewife die off in Lake Michigan and the infamous scene of the Cuyahoga River on fire prompted new action on the part of governments in both Canada and the United States to combat pollution and protect the Great Lakes. During the 1970s, the U.S. EPA and the Canadian Department of the Environment (now Environment Canada) were formed to mitigate the pollution; the two countries negotiated and signed the GLWQA to facilitate binational action to clean up the Great Lakes; and the CWA, was reorganized and expanded in 1972 to require, among other things, the treatment of industrial and commercial wastes in response to the nearly unchecked dumping of pollution into the nation's waterways.

Under the GLWQA, the United States and Canada agreed to initiate phosphorus reduction programs for municipal sewage treatment plants in the Lake Erie and Lake Ontario basins. Controls were also agreed upon for industrial discharges and for large, concentrated livestock operations. Further, under the 1972 amendments to the CWA, contributors of point sources were now required to obtain discharge permits, limits for chemical and organic discharges were set, and treatment facilities and equipment were installed to reduce pollutant levels. Additionally, the construction of wastewater treatment systems, to include up to tertiary treatment, substantially reduced both total phosphorus loads and dissolved phosphorus loads to the Great Lakes.

Discharge permits added under the CWA provide for monitoring and tracking of the point source pollutant loads. Therefore, it is possible to calculate the portion of phosphorus loads attributed to nonpoint sources by subtracting the monitored point sources from the total loads. According to a report released by the Ohio Phosphorus Task Force, the discharge of point sources of phosphorus to Lake Erie has remained constant for almost two decades following many of these changes enacted through the CWA amendments. It is assumed that other Great Lakes would have similar results.

Additionally, the portion of the total phosphorus load represented by point sources in a normal rainfall year is relatively small, perhaps no more than twenty five percent. During years with lower rainfall, the percentage of point source relative to the total increases; however, the actual amount remains constant.

Challenges and Emerging Issues: To achieve additional reductions in dissolved phosphorus from point sources within the Great Lakes-St. Lawrence River basin, changes and improvements to the existing infrastructure may be required. However, such changes can be resource-intensive, both from a financial perspective and with respect to construction timeframes. This is particularly true if additional or new infrastructure is required. Building additional or improved wastewater treatment facilities would likely require an investment of multiple years of effort and millions of dollars. Therefore, it may be more feasible to review and upgrade the current systems for greater efficiencies.

Another challenge to current infrastructure within the basin is that wastewater systems were not adequately designed to manage the peak loads that have been occurring more frequently within the past several decades. New or replacement facilities will need to be designed to handle more frequent and higher peak loads.

Product Formulation/Innovation/Research/Regulation Issue Brief

Problem Statement and Background:

Product Formulations: The formulation, or chemical makeup, of phosphorus fertilizers used in commercial farming and landscaping businesses may have an effect on the amount and transportability of dissolved phosphorus. From an end user's perspective, phosphorus should be immediately available to support optimal plant growth. Therefore, the fertilizer industry provides the user with formulations that are, or can be quickly converted to, a dissolved form (water soluble) that is more easily used by the plant. Unfortunately, dissolved phosphorus is also easily transported by runoff from the point of application to nearby water bodies, and is readily utilized by most forms of algae and cyanobacteria, possibly leading to HABs.

The four major formulations of phosphorus fertilizer used in the Great Lakes-St. Lawrence River basin are (from the Ohio State University Extension Agronomy Guide):

Analysis of Phosphate (P_2O_5)						
Fertilizer Material (Phosphorus Carriers)	**Formula**	**Approximate %**				
		N	**P_2O_5**			**K_2O**
			Total	**Available**	**Water Soluble**	
Concentrated superphosphates	$Ca(H_2PO_4)_2$	0	47	45	85	0
Monoammonium phosphate	$NH_4H_2PO_4$	11	49	48	92	0
Diammonium phosphate	$(NH_4)_2HPO_4$	18	47	46	90	0
Ammonium polyphosphate	$[NH_4PO_3]n$	10	34	34	100	0

Phosphorus fertilizers are often distinguished by the percentages of different types of phosphorus within each product: water soluble, citrate soluble, citrate insoluble, and total phosphorus. Citrate soluble phosphorus is referred to as "available" phosphorus, and the portion of citrate soluble phosphorus that dissolves in water is water-soluble phosphorus. Most commercial fertilizers contain 50 percent or greater water-soluble phosphorus and are suitable for row application (Ohio Agronomy Guide 14th edition).

Over the last few decades, ammonium formulations of fertilizers have become the predominate source of phosphorus in agricultural production in the Great Lakes-St. Lawrence River region. This trend is likely a result of the end-user's desire for greater percentages of water soluble phosphorus for plant growth. For instance, 85 percent of the P_2O_5 of triple superphosphate is water soluble, whereas 100 percent of the P_2O_5 in ammonium polyphosphate is water soluble. As a result, more water soluble phosphorus is entering the Great Lakes-St. Lawrence River system from commercial phosphorus use.

Innovation: Innovations in the production, application and management of phosphorus containing products can help to reduce the amount of phosphorus introduced to surrounding environments through runoff and other means. Innovations can be encouraged by removing impediments and providing funding for the development and marketing of tools that fill those needs. In the short term, innovations are likely to occur in the timing and placement of phosphorus products in crop production. Longer term innovations are likely to occur in time-release formulations and precision application equipment.

Research: A large amount of research has been conducted by federal agencies (e.g., ARS), universities and research institutions, and private researchers (e.g., lawn fertilizer manufacturers) in the areas of type, effectiveness, transportability and offsite damages of phosphorus fertilizer. However, much of the agronomic research was conducted decades ago under conditions that are no longer representative of current industrial farming operations and changes in climate. Also, sparse research exists on the relationship between levels of dissolved phosphorus in large lake systems and aquatic habitat and species.

Regulation: Point source phosphorus pollution has long been regulated. For instance, point sources require discharge permits which limit the volume of pollutant to be discharged at any given location. Similarly, large animal feeding operations (where animals are concentrated in one location) require a permit to discharge wastes on adjacent crop fields. Lawn fertilizer, soaps and detergents are also regulated to reduce or eliminate phosphorus contained in these products. Conversely, most nonpoint activities associated with phosphorus are not regulated.

Challenges and Emerging Issues:

Product Formulation: The primary challenge to changing the current formulations of commercial fertilizers from being more soluble to less is that current formulations provide the user with the most efficient phase of phosphorus for plant use (i.e., water soluble phosphorus). In fact, the trend over recent decades has been in the opposite direction: from less dissolved phosphorus formulations (e.g., ground rock phosphate), to formulations with more dissolved phosphorus (e.g., diammonium phosphate). Thus, users and manufacturers would likely resist changing formulations back to one that is less efficient for optimal plant growth, and which would require a massive change in manufacturing infrastructure. Also, the current formulations provide some nitrogen for plant growth as well as phosphorus. A potential solution that will also be challenging to achieve, will be to develop a formulation with a temporary inhibitor to stabilize the material during the critical runoff periods but then allow the dissolved phosphorus to be available to plants during the growing season.

Innovation: Management strategies are needed that provide for efficient application of fertilizer material, by both the farmer and fertilizer dealers, in a manner that does not result in excess phosphorus runoff. This may require the development of innovative application equipment before management strategies can be altered significantly. It is also assumed that new equipment will be required to inject the material below the soil surface (incorporation) to provide more contact with the soil particles, enabling them to more effectively adsorb the phosphorus. To prevent soil erosion, the injection would have to be accomplished without a complete disruption of the soil surface.

Research: One of the challenges in this area is to coordinate and implement research activities to provide information needed by agencies and concerned organizations to develop appropriate policies and responses to phosphorus issues. Research on phosphorus in the ecosystem heretofore, by necessity and design, has been accomplished over short periods of time and, seemingly, without sufficient coordination by multiple entities. This ad hoc approach to what is being researched is not suitable for the fast changing economic and environmental conditions.

Another challenge is the ability to communicate research results. The Great Lakes Commission has encountered problems obtaining research documentation because of the proprietary nature of the research periodicals. Research papers published in private periodicals either charge a per-paper fee to obtain the published results or a subscription to the periodical is required to gain access to the entire published results. Conversely, the National Agricultural Library is a good example of a free resource for research activities conducted by some federal agencies and land grant universities.

Areas in which additional research is needed include: transportation of dissolved phosphorus, reformulation, improved application equipment and environmental impacts.

Regulation: Instituting a new regulatory scheme to control all agricultural fertilizer applications would, admittedly, be complex. However, some new regulatory approaches could be adopted to address many of the concerns identified above. For instance, application of fertilizer materials could be banned during the winter months or when the ground is frozen. Similarly, soil tests could be required prior to fertilizer application, with application amounts limited to specific recommendations based on test results. Another approach would be to regulate the type of application equipment used by fertilizer dealers, since they are already regulated. However, regulation is not without its problems; if a regulation is to prohibit a particular action, it has to be clearly defined and not left to individual interpretation.