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2016 Progress Report of the Parties

U.S. spelling is used throughout this report except when referring to Canadian titles. Units are provided in both metric and U.S. customary units.

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EXECUTIVE SUMMARY

The Great Lakes Water Quality Agreement of 2012 ("Agreement" or "GLWQA") included a new requirement that the United States and Canada prepare a Progress Report of the Parties (Report) "to document actions relating to this Agreement". This reporting requirement strengthened the accountability provisions of the Agreement, with the Report to be provided to the public and the International Joint Commission. Consistent with that requirement, the Parties are pleased to release this first Progress Report of the Parties, documenting the actions taken since the Agreement took effect in February of 2013.

"Operationalizing" the Agreement

Significant effort was required to develop and put into place the organizational structure and processes required to implement the Agreement. The Great Lakes Executive Committee had to be called to order, Annex Subcommittees and their task teams had to be staffed and organized, activities had to be prioritized, policies debated, and responsibilities assigned. Further, given the cooperative approach that underpins the Agreement, these structural activities were not limited to the Parties; they required the very active participation of the Parties' many partners, including states and provinces and indigenous peoples on both sides of the border. Ultimately, as of the writing of this Report, the Parties can state that much of the necessary administrative and organizational work is finished. Consequently, in the upcoming triennial cycle of 2017-2019, the Parties will be able to concentrate more heavily on the implementation of substantive restoration and protection activities.

Key Actions Completed Under the Agreement

Notwithstanding the efforts needed to "operationalize" the 2012 Agreement, during the past three years the Parties, together with the many partners who also play important roles in restoring and protecting the Great Lakes, were able to undertake and complete a host of actions in furtherance of the Agreement's purpose: *restoring and maintaining the chemical, physical, and biological integrity of the waters of the Great Lakes*. It is impossible to describe in detail the full range of actions implemented across the various jurisdictions which share responsibility for the Great Lakes; however, this report provides an overview of activities undertaken since the Agreement took effect. Some accomplishments are especially noteworthy:

- The Parties effectively implemented a new system, under Agreement Article 6(c), of providing notification to the Great Lakes Executive Committee members and observers, as well as other interested parties, of planned activities that could lead to a pollution incident or that could have a significant cumulative impact on the waters of the Great Lakes.

- The United States "delisted" the Presque Isle (Pennsylvania), Deer Lake (Michigan) and White Lake (Michigan) Areas of Concern, signifying that remedial actions were completed and elimination of environmental impairments was confirmed. In addition, all necessary remedial actions were completed at other AOCs in the United States: Sheboygan Harbor (Wisconsin), Waukegan Harbor (Wisconsin), Ashtabula (Ohio), and St. Clair (Michigan).

- Canada completed all required action to restore the Nipigon Area of Concern and began remediation of the Randle Reef contaminated sediment site in the Hamilton Harbour Area of Concern, the largest sediment remediation project ever undertaken in Canada.

- The Parties developed a "Nearshore Framework", which provides a mechanism for undertaking a systematic, integrated and collective approach for assessing nearshore health and identifying and communicating cumulative impacts and stresses.

- The Parties developed a Lakewide Action and Management Plan for Lake Superior.

- The Parties identified eight chemicals as the first *Chemicals of Mutual Concern* so designated under the Agreement.

- The Parties set phosphorus load reduction targets for the western and central basin of Lake Erie after extensive analysis of phosphorous sources and loads and have begun to develop Domestic Action Plans to achieve the 40% reduction.

- The Parties significantly reduced the risk of the introduction of aquatic invasive species to the Great Lakes via ballast water discharges from saltwater vessels. As a consequence of compatible ballast water exchange regulations between Canada and the United States and stringent binational enforcement, no new invasive species attributable to the ballast water of these ships has been reported in the Great Lakes since 2006. In addition, the Parties continue to prevent and address other discharges from vessels that potentially may impact the waters of the Great Lakes.

- The Parties undertook a host of invasive species control and prevention measures (including the development and implementation of an AIS early detection and rapid response initiative) and no non-native species became established in the Great Lakes during the last three years.

- The Parties oversaw the development and implementation of lakewide habitat and species protection and restoration conservation strategies (i.e., Biodiversity Conservation Strategies) for all five of the Great Lakes.

- The Parties led the development of a report entitled *Groundwater Science Relevant to the Great Lakes Water Quality Agreement: A status report*, which summarizes the relevant and available Great Lakes groundwater science and advances understanding of the effects of groundwater on Great Lakes water quality.

- The Parties led the development of a report entitled *State of Climate Change Science in the Great Lakes Basin: A Focus on Climatological, Hydrologic and Ecological Effects* which synthesizes the state of climate change impacts in the Great Lakes basin and identifies key knowledge gaps.

- The Parties updated and revised the suite of ecosystem indicators used to report on the state of

the Great Lakes to align the indicators to the General Objectives of the 2012 GLWQA.

These highlighted actions, while significant, represent only the first concrete steps in restoring and protecting the waters of the Great Lakes under the 2012 Agreement. More importantly, they reflect the vigor with which the Parties intend to implement the Agreement over the next three years.

INTRODUCTION

The Great Lakes contain a significant portion of the world's freshwater, containing one fifth of global fresh surface water. The Great Lakes are immensely important to both Canada and the United States, environmentally, economically, and socially.

The Canada-United States Great Lakes Water Quality Agreement ("GLWQA" or "Agreement") was first signed in 1972. Over the course of its more than forty-year history, the Agreement has served as an important mechanism for coordination of actions by Canada and the United States, working in cooperation with other levels of government, non-governmental organizations, industry, Indigenous peoples, and the public to address threats to Great Lakes water quality and ecosystem health.

Over the last 45 years, Canada and the United States have taken action to address many threats to Great Lakes water quality and ecosystem health. In many locations, water quality has greatly improved. Most notably, releases of many persistent toxic substances (for example, mercury, PCBs, dioxins and furans, as well as banned pesticides such as DDT) in the Great Lakes have been reduced by more than 90 percent. As a result, the frequency of deformities in colonial nesting birds, commonly seen in the 1970s, has now been significantly reduced. Sentinel species such as the Bald Eagle, once extirpated from the Great Lakes, now thrive along Great Lakes shorelines. The rapid recovery of a "dead" Lake Erie is another globally-known success story. In the decades leading up to the 1970s, loadings of nutrients, particularly phosphorus, caused significant algal blooms and degraded Lake Erie. Stirred by public concern, governments responded with vigor to reduce loadings from municipal sewage treatment plants and other anthropogenic sources, resulting in measurable reductions in phosphorus inputs and a steep reduction in algal blooms. These controls represented an unprecedented success in producing environmental results through international cooperation.

Despite these past successes, the lakes continue to face threats posed by nutrient discharges, releases of toxic substances, invasive species, loss of wetland and other habitat, climate change and other factors. Continued action is required to address these existing threats, as well as to anticipate and prevent new threats to water quality and ecosystem health.

In 2012, the GLWQA was amended and strengthened. The 2012 Agreement updates approaches to science and management and reaffirms existing commitments to: restore degraded Areas of Concern; address the threats posed by excess nutrients, chemicals of mutual concern, and discharges from vessels; and undertake vital scientific coordination and research. In addition, the new Agreement includes new commitments to address other significant challenges to Great Lakes water quality, including threats from aquatic invasive species and climate change, as well as the loss of habitat and species.

One of the new commitments made by Governments in the Agreement is to enhance accountability and reporting by, for the first time, requiring the production of a Progress Report of the Parties. In accordance with the GLWQA, this Progress Report of the Parties has been prepared by Canada and the United States, in consultation with representatives of federal governments, state and provincial governments, tribal governments, First Nations, Métis, municipal governments, watershed management agencies, and other local public agencies. The Progress Report of the Parties contains an overview of binational and domestic activities that have contributed to the achievement of GLWQA objectives.

This document represents the first Progress Report of the Parties prepared under the 2012 Great Lakes Water Quality Agreement. Subsequent Progress Report of the Parties will be issued every three years.

Binational activities are coordinated through the Great Lakes Executive Committee. Following signing of the GLWQA in September of 2012, a significant amount of effort was devoted to the establishment of management processes and structures necessary to drive the Agreement's implementation. Annex Subcommittees and Task Teams have been created to engage a large and diverse group of organizations, institutions and experts in carrying out the necessary activities to support undertaking the commitments laid out in the Agreement.

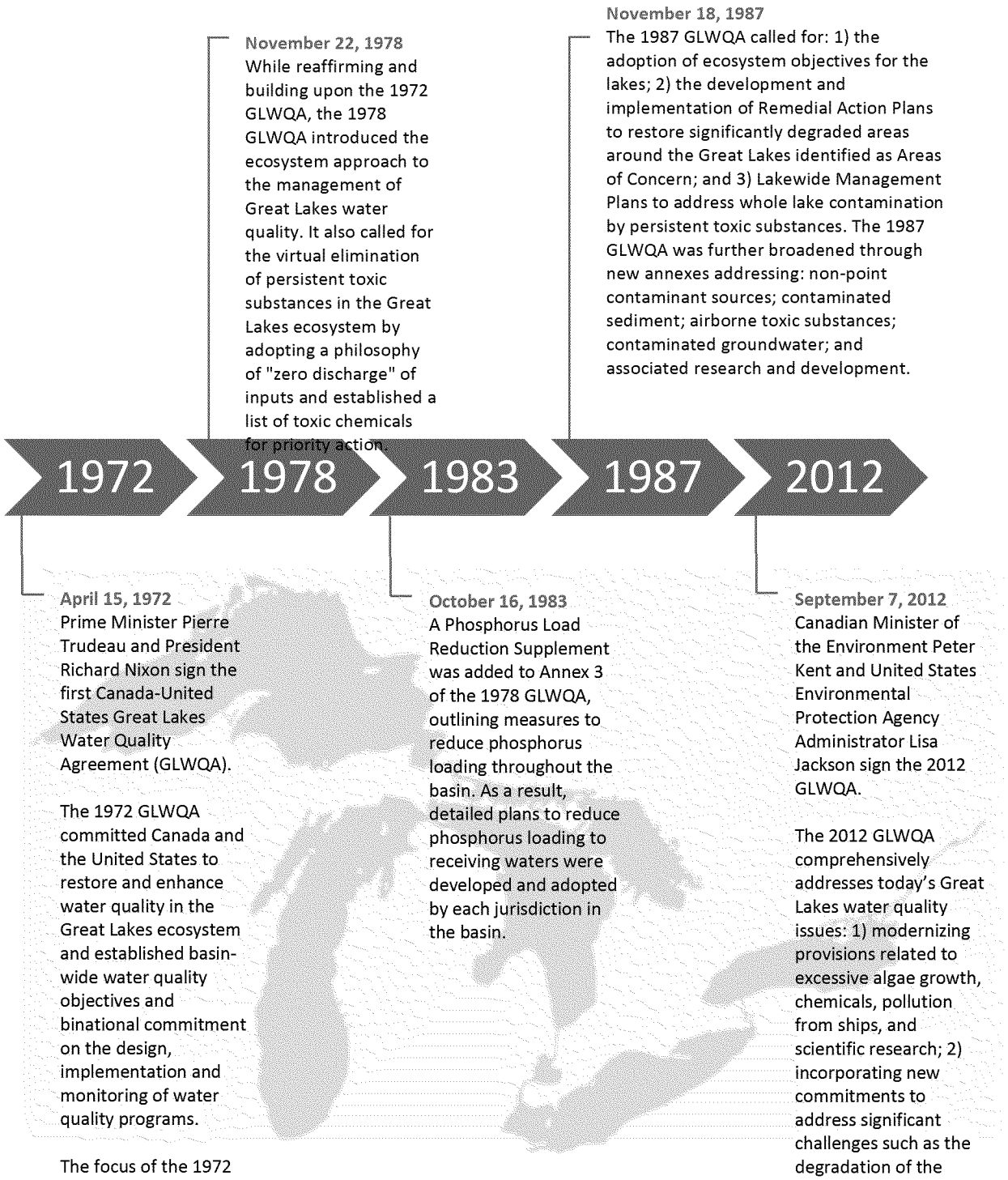
Within Canada, the principal mechanism for coordination of Great Lakes activities is the Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health, 2014 (COA), which entered into force in December, 2014. A series of Canada-Ontario Agreements date back over forty years and have provided a framework for cooperation and coordination of actions between Ontario and Canada to restore, protect and conserve Great Lakes water quality and ecosystem health.

Within the United States the principal mechanism for coordination and implementation of Great Lakes activities is the Great Lakes Restoration Initiative (GLRI). GLRI was initiated in 2010 through a congressional appropriation of $475,000,000 for Great Lakes restoration and protection work and the formation of an Interagency Task Force and Regional Working Group chaired by the United States Environmental Protection Agency. The Interagency Task Force and Regional Working Group consist of sixteen federal departments or agencies, which work closely together to: 1) identify Great Lakes restoration and protection priorities; 2) make project funding decisions, and 3) keep track of and report on project results.

For those wishing additional information on Great Lakes activities, including how to get involved in helping to restore and protect the Great Lakes, additional information is available at the following websites: www.ec.gc.ca/greatlakes; www.epa.gov/greatlakes; and www.binational.net.

This Report follows the structure of the 2012 Agreement. Part one addresses progress of the Parties in relation to the thirteen Articles of the Agreement, which set forth the overall goals and "mechanics" of the Agreement. Part two addresses progress of the Parties in relation to each of the ten Annexes of the Agreement, each of which addresses a particular threat (e.g., invasive species, climate change) or provides specific direction on the implementation of the Agreement (e.g., Lakewide Action and Management Plans, Science).

Figure 1 – The history of the Great Lakes Water Quality Agreement



2012 GREAT LAKES WATER QUALITY AGREEMENT ARTICLES

The GLWQA contains 13 Articles. Articles 3, 5, and 6 contain specific commitments to be delivered by the Parties and are the focus of this section.

Article 3: Progress in achieving General Objectives, Lake Ecosystem Objectives and Substance Objectives.

- The 2012 GLWQA commits the United States and Canada to maintaining a set of comprehensive, science-based ecosystem indicators in order to assess and report to the public on the state of the Great Lakes. Binational reporting on the State of the Great Lakes has been ongoing since 1994. Over the past three years the Parties have updated and revised the suite of ecosystem indicators used to report on the state of the Great Lakes to align the indicators to the General Objectives of the 2012 GLWQA. This significant change to the way in which the Parties assess and report on the state of the lakes allows the State of the Lakes indicators to be used to assess whether progress is being made in relation to accomplishing the objectives set out by the Governments of the United States and Canada in the 2012 GLWQA. Information on the state of the Great Lakes will be presented at the Great Lakes Public Forum in October, 2016 for public review and comment. A final State of the Great Lakes report will be available in 2017.

- The 2012 GLWQA also calls for the development of lake-specific ecosystem objectives, to serve as benchmarks against which to assess status and trends in ecosystem health. Work has begun on development of Lake Ecosystem Objectives for Lake Erie. Finalization of these objectives will include extensive consultation and engagement. Work to develop Lake Ecosystem Objectives for lakes Huron, Ontario, Michigan and Superior will follow.

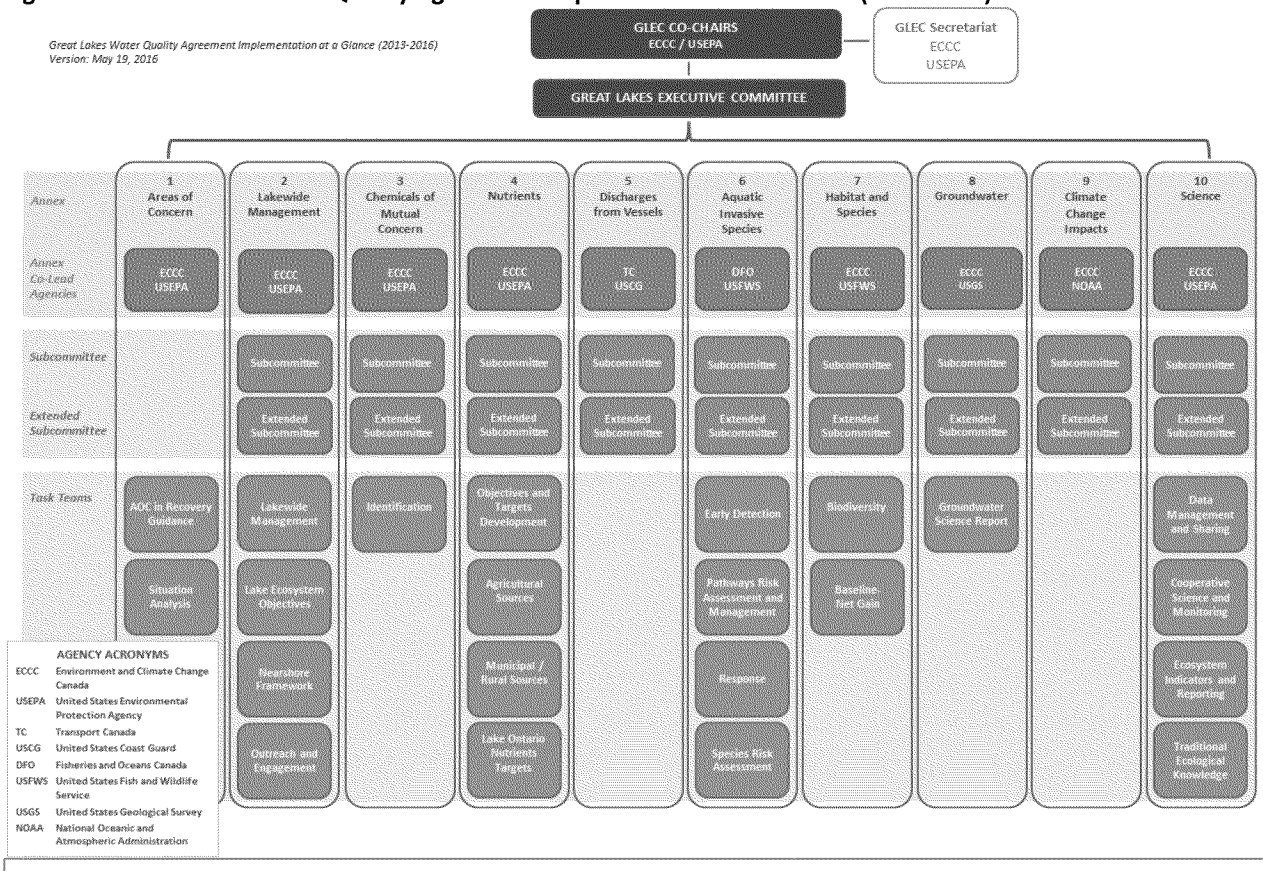
Article 5: Establishing the Great Lakes Executive Committee.

- A Great Lakes Executive Committee (GLEC) was established to replace the former Binational Executive Committee. The GLEC has a significantly expanded membership and now includes senior-level representatives from the Governments of the United States and Canada, state and provincial governments, tribal governments, First Nations, Métis, municipal governments, watershed management agencies, and other local public agencies. The inaugural meeting of the GLEC was held on December 5-6, 2012 in Toronto, Ontario. The GLEC has met biannually since then, alternating meeting locations between Chicago, Illinois, and Toronto, Ontario. Summaries of the past GLEC meetings are available at binational.net (http://binational.net/category/mtg-ru/).

- The GLEC provides a forum for members to share information and discuss issues relevant to the implementation of the Agreement. The meetings have been instrumental in coordinating the activities of departments, agencies, organizations and peoples represented in the GLEC membership. Meetings are open to the public and regularly attract attendance from observers – such as the International Joint Commission, the Great Lakes Commission, the Great Lakes Fishery Commission, the Province of Quebec, environmental non-governmental organizations, industry representatives and members of the interested public – which have provided significant contributions and advice to the GLEC.

- The GLEC has created a formal subcommittee structure to engage member organizations and others in working binationally to plan and coordinate actions to implement the ten Annexes contained in the 2012 GLWQA. Annex-specific subcommittees are co-led by a United States and Canadian representative. Extended subcommittees have been created to advise and provide input to the Annex Co-Leads and to the Annex Subcommittee; while Task Teams have been formed to perform specific tasks required to meet the Annex's commitments. The Annex Subcommittee structure has allowed a significant amount of work to be accomplished over the first three years of the implementation of the 2012 GLWQA, engaging a large number of organizations and individuals. This work will be discussed in subsequent chapters of this report. Figure 2 depicts the Annex Subcommittees, Extended Subcommittees, and the Task Teams that existed for each Annex between 2013 and 2016.

Figure 2 – Great Lakes Water Quality Agreement Implementation at a Glance (2013-2016)



The Subcommittee, consisting of representatives from GLEC member agencies and organizations, assists the Annex Co-Leads in coordinating and undertaking activities in support of meeting commitments of the Annexes.

An Extended Subcommittee, consisting of representatives from GLEC member agencies and organizations and other entities, advises and provides input to the Annex Co-Leads and Subcommittee.

A Task Team, consisting of representatives from GLEC member agencies and organizations and others entities, may be established to perform specific tasks over a specified period of time, as required to meet Annex commitments.

Article 5: Creating binational priorities for science and action.

- The process of developing binational priorities builds consensus on the essential science and action required to restore and protect Great Lakes water quality and ecosystem health. In addition, communicating clear priorities enables GLEC members to engage others in working cooperatively to achieve the science and action priorities. The United States and Canada presented proposed binational priorities for science and action for public input at the 2013 Great Lakes Public Forum on September 9-10, 2013. The 2014-2016 binational priorities for science and action were subsequently finalized and posted on binational.net (www.binational.net/2014/03/20/psa-pasa-2014) in March, 2014.

- The Parties' proposed binational priorities for science and action for 2017-2019 will be presented at the 2016 Great Lakes Public Forum for public input.

Article 5: Convening a Great Lakes Public Forum.

- The Unites States and Canada held the first Great Lakes Public Forum on September 9-10, 2013. The Forum provided an opportunity for the United States and Canada to discuss and seek public comment on the state of the lakes and binational priorities for science and action. The 2013 Forum also provided an opportunity for the International Joint Commission to discuss the Parties' progress reporting and the Commission's assessment of progress. Further information on the 2013 Forum, including the agenda, and other materials are available at binational.net (www.binational.net/2013/10/01/great-lakes-public-forum-2013).

- The second Great Lakes Public Forum will be held on October 4-6, 2016 in Toronto, Canada. The Forum will provide an opportunity for public input on: progress in relation to the implementation of the 2012GLWQA; the state of the Great Lakes; and priorities for science and action.

Article 5: Convening a Great Lakes Summit.

- The GLWQA commits the United States and Canada to convening a summit meeting between the Parties to the GLWQA and the Great Lakes related commissions: the Great Lakes Commission, the Great Lakes Fishery Commission and the International Joint Commission. The purpose of the Summit is to promote increased coordination and effectiveness in the environmental management of the Great Lakes. The first Summit meeting was held on September 11, 2013, and included discussion of: 1) the missions, roles and responsibilities of the Commissions in relation to the GLWQA; 2) opportunities for enhanced collaboration between the Commissions and the United States and Canada on Lakewide Action and Management Plans; 3) coordination of the science and monitoring undertaken by the United States, Canada and the Commissions; and 4) use of emerging tools and gap analyses in addressing excessive nutrient levels in Lake Erie.

- Building on the commitment to hold formal Summit meetings, the United States and Canada have increased their engagement with the Commissions by holding meetings with the Commissions in conjunction with the biannual GLEC meetings, as well as holding other *ad hoc* meetings to discuss GLWQA-related issues. A special focus of attention has been enhancing coordination and cooperation between the Parties and the Commissions on Lakewide Management activities under Annex 2.

- A 2016 Great Lakes Summit will occur in conjunction with the October, 2016 Great Lakes Public Forum to continue the successful dialogue between the United States and Canada and the Commissions.

Article 6: Providing notification of planned activities that could lead to a pollution incident or have a significant cumulative impact on the Waters of the Great Lakes.

- Pursuant to Article 6(c), the United States and Canada have implemented procedures to provide for notification of planned activities that could lead to a pollution incident or that could have a significant cumulative impact on the Waters of the Great Lakes. Proposed notifications are solicited

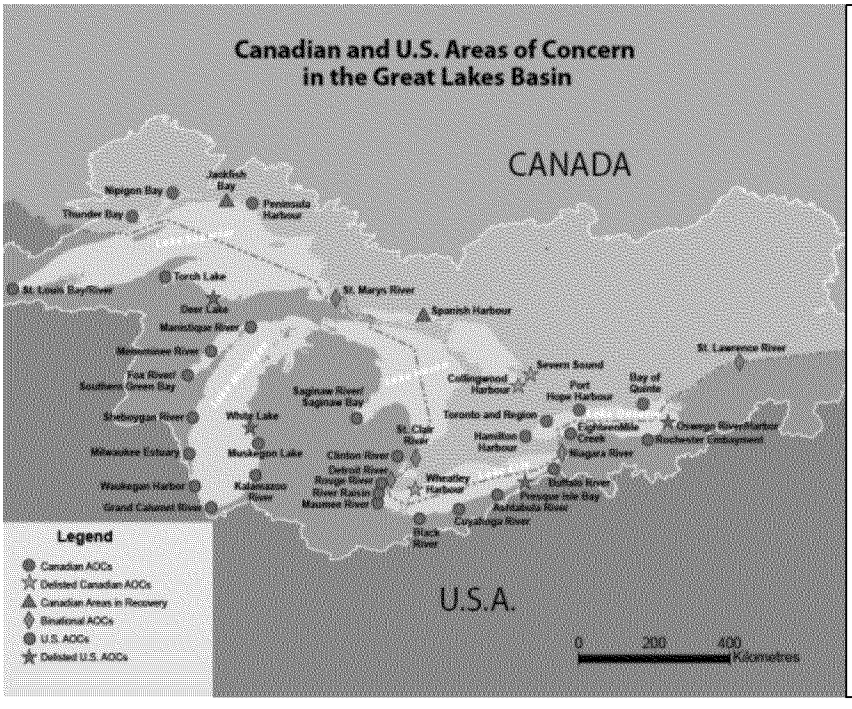
from GLEC members and observers on a quarterly basis. A list of notifications is available at http://binational.net/2015/05/06/notifications/.

- The notification process has been successful in ensuring that GLEC members and observers are aware of significant events and development occurring within the Great Lakes basin and of opportunities to engage in applicable review and approval processes.

AREAS OF CONCERN ANNEX

OVERVIEW

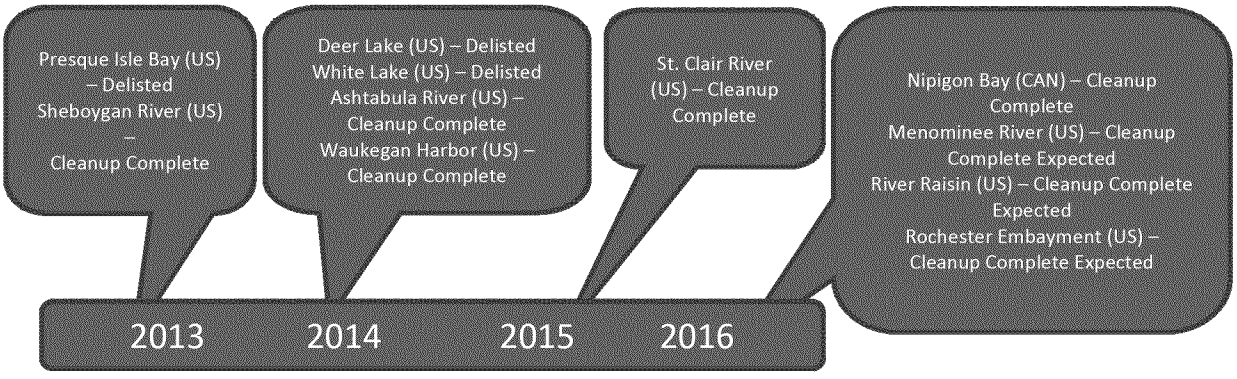
Pursuant to the 1987 GLWQA, the Parties designated a total of 43 Areas of Concern (AOCs), 12 in Canada, 26 in the United States, and five that are shared by both countries. AOCs are regarded as the most environmentally degraded sites within the Great Lakes, based upon a systematic assessment of "beneficial use impairments", and contribute to degradation on a lakewide and Great Lakes ecosystem wide basis. The 2012 GLWQA reaffirms the commitment of Canada and the United States to restore water quality and ecosystem health in Great Lakes AOCs. The Parties have made significant progress under this Annex in the last three years. Implementation of the Area of Concern Annex is co-led by Environment and Climate Change Canada and the United States Environmental Protection Agency.



Fourteen Beneficial Use Impairments (BUIs) contributing to a location's designation as an AOC:

- Restrictions on fish and wildlife consumption;
- Tainting of fish and wildlife flavour;
- Degradation of fish wildlife populations;
- Fish tumours or other deformities;
- Bird or animal deformities or reproduction problems;
- Degradation of benthos (organisms living on lake bottoms);
- Restrictions on dredging activities;
- Eutrophication (undesirable algae);
- Restrictions on drinking water consumption, or taste and odour problems;
- Beach closings;
- Degradation of aesthetics/visual appearance;
- Added costs to agriculture or industry;
- Degradation of phytoplankton and zooplankton populations (organisms that provide a crucial source of food to fish);
- Loss of fish and wildlife habitat.

PROGRESS TOWARD MEETING GLWQA COMMITMENTS



- Prior to 2013, the Parties restored beneficial uses and delisted four of the 43 AOCs: three in Canada (Collingwood Harbour in 1994; Severn Sound in 2003, and Wheatley Harbour in 2010) and one in the United States (Oswego in 2006).

- Canada also designated two Canadian AOCs as AOCs in Recovery prior to 2013 signifying that all remedial actions have been completed and monitoring of natural recovery is in progress (Spanish Harbour in 1999 and Jackfish Bay in 2011).

- Between 2013 and 2016, the United States delisted the Presque Isle (Pennsylvania), Deer Lake (Michigan) and White Lake (Michigan) AOCs, signifying that remedial actions were completed and elimination of beneficial use impairments was confirmed through environmental monitoring and assessment.

- The Parties have completed all remedial actions at five other AOCS: Nipigon Bay in Canada; and Sheboygan Harbor (Wisconsin), Waukegan Harbor (Wisconsin), Ashtabula (Ohio), and St. Clair (Michigan) in the United States. With remedial work completed, these five AOCs are now being monitored to determine when the beneficial use impairments have been fully addressed and delisting can occur.

- Work to restore environmental quality is continuing in all AOCs. By 2019, Canada projects completion of all remedial actions in four additional AOCs: Bay of Quinte, Peninsula Harbour, Niagara River and St. Lawrence River – Cornwall; while the United States plans to complete management actions necessary for delisting in five additional AOCs: Black River, Buffalo River, Clinton River, Manistique River and Muskegon Lake.

BINATIONAL ACTIONS TAKEN

- Efforts to restore the 43 AOCs have been underway for over 25 years. Working with provincial, state and local governments, tribes, First Nations and community members and stakeholders, Canada and the United States have made significant progress in assessing beneficial use impairments, identifying their causes, engaging local communities in developing remedial action plans, and in implementing actions to restore beneficial uses of the environment. Actions to restore Areas of Concern are primarily carried out domestically; however, Canada and the United States share information on approaches and lessons learned on an ongoing basis in order to increase the efficiency and effectiveness of AOC remediation efforts in both countries.

Supporting overall implementation of AOC remediation.

- A guidance document was developed to provide advice on the process, principles, challenges and roles and responsibilities for designating an AOC as an AOC in Recovery. The document identifies five factors to be considered in designating an AOC as an AOC in Recovery: 1) restoration actions needed; 2) achievability of delisting criteria; 3) monitoring; 4) estimated time for recovery; and 5) consideration of stakeholder input. The document will contribute to ensuring a consistent approach in future designations of AOCs in recovery.

- A Situation Analysis report was completed to document how AOC restoration activities are currently being implemented in Canada and the United States, including a review and comparison of agency roles and practices; status of and processes for RAPs, including delisting criteria, BUI removals, AOC delisting and public involvement; key challenges, targets and objectives; and recommendations on guidance needs and information sharing. The document will assist agencies in implementing continuous improvements to current practices.

DOMESTIC ACTIONS TAKEN

CANADA

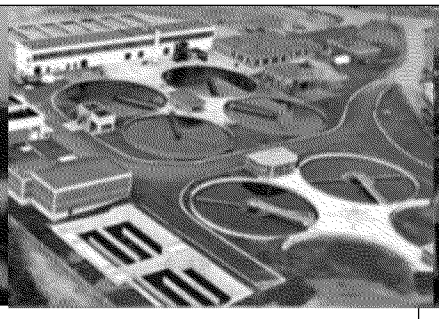
- Within Canada, Environment and Climate Change Canada and the Ontario Ministry of Environment and Climate Change share the lead for implementation of AOC remediation efforts. Progress is being made in all Canadian AOCs. Table 1 shows that a total of 65 impairments of beneficial uses of the environment have been eliminated, with 78 impairments remaining. In 2016 to 2017, Canada anticipates removing up to 15 more beneficial uses currently deemed impaired, which will add to the 65 beneficial use impairments already removed across the 17 AOCs outlined in Table 1. Table 2 shows the categories of remaining actions required in each Canadian AOC and their status.

- In 2015, in-water construction began on the largest contaminated sediment remediation project ever undertaken in a Canadian AOC. It involves the clean-up of 700,000 cubic meters of severely contaminated sediment in the Hamilton Harbour AOC.

- Other notable accomplishments in Canadian AOCs during the 2013 to 2016 period include restoring over 1.1 kilometers of shoreline habitat and enhancing 175 hectares of coastal wetlands and fish spawning grounds; investing almost $562 million in upgrades to municipal wastewater treatment plants to significantly reduce nutrients, suspended solids and pollutants entering AOC waterways; and improving water quality and aesthetics by better managing urban and rural non-point sources of pollution in a number of AOCs. More information on the status of beneficial use impairments in Canadian AOCs, projects completed, and remaining issues to be addressed, can be viewed at www.ec.gc.ca/raps and in Figure 3.

- Placeholder for input from NRCAN on Port Hope AOC.

Figure 3 – Examples of habitat, wastewater and non-point source domestic actions in Canadian AOCs



Habitat	Wastewater	Non-point sources
To help improve aquatic habitat and fish populations, Canada and its partners restored over 1.1 kilometers of shoreline habitat and 175 hectares of coastal wetlands and fish spawning grounds in a number of AOCs, which encompasses: • 19 habitat enhancement projects in the Bay of Quinte AOC that created two ponds and wetlands, 675 meters of vegetative buffer zones, and naturalized 40 meters of shoreline; • restoring 165 hectares of coastal wetland in the St. Clair River AOC; • restoring over 400 meters of shoreline in the Toronto Region AOC and transforming a disposal site for contaminated sediment into 9.3-hectares of prime wetland on the Toronto waterfront once fully completed in 2018; and • through binational collaboration, constructing a second fish spawning reef in the Detroit River AOC adjacent to the existing one at Fighting Island that creates almost one hectare of new spawning habitat for fish.	To help improve water quality and aesthetics Canada, Ontario and local governments invested almost $562 million in upgrades to municipal wastewater treatment plants in a number of AOCs, including: • building a new facility in the St. Clair River AOC ($34.5 million); • upgrading to secondary treatment a facility in the Nipigon River AOC and Detroit River AOC ($9 million and $34 million, respectively); and • upgrading two facilities to tertiary treatment in the Hamilton Harbour AOC ($154 million for one in Burlington, $330 million for one in Hamilton now underway and to be completed in 2021).	To help improve water quality and aesthetics Canada and its partners are addressing non-point sources of pollution in a number of AOCs, including: • implementing stormwater management plans and programs to better manage urban runoff and reduce pollution entering the waterways in the St. Marys River and Bay of Quinte AOCs; • separating storm and sanitary sewers in the St. Clair River AOCs; and • supporting citizen-driven efforts such as septic inspections and targeted Best Management Practices to reduce rural non-point source pollution in the Bay of Quinte AOC and community rain gardens to better manage rainfall and lower pressure placed upon storm sewers and wastewater treatment plants in the Detroit River AOC.

- AOC clean-up efforts in the U.S. are led by United States Environmental Protection Agency, with significant contributions from other federal agencies (i.e., National Oceanic and Atmospheric

Administration, the United State Army Corps of Engineers), states, local governments and communities, and non-governmental organizations. Between 1987 and 2010, only one U.S. AOC was delisted. However, since the inception of GLRI, three additional AOCs have been delisted and management actions have been completed at four additional U.S. AOCs. In addition, the Environmental Protection Agency projects that management actions will be completed at ten more AOCs by 2019. This remarkable pace of AOC restoration is due to the GLRI. First, the GLRI appropriation language makes clear that cleaning up and restoring AOCs is a priority. Second, federal agencies have been able to utilize over $700 million in GLRI funding to pay for this work.

Table 1 -

Table 2 -

Canadian Areas of Concern – Status of Actions

AOC	Sediment Cleanup / Remediation	Habitat Restoration	Municipal / industrial WW treatment	Non-point-source pollution mgmt.	Studies/ Investigations	BUI Evaluation/ Assessment	Follow-up Monitoring	Year RAP actions were or will be completed	AOC Weblink
Thunder Bay								beyond 2020	For Canadian and binational AOCs, go to: www.ec.gc.ca/raps
Nipigon Bay								Delisting expected in 2016	
Jackfish Bay (in recovery)				N/A				beyond 2020	
Peninsula Harbour				N/A				2019	
St. Marys River								beyond 2020	
Spanish Harbour (in recovery)								beyond 2020	
St. Clair River								2020	
Detroit River								2020	
Niagara River								2019	
Hamilton Harbour								beyond 2020	
Toronto Region								beyond 2020	
Port Hope		N/A	N/A	N/A				beyond 2020	
Bay of Quinte								2019	
St. Lawrence River (at Cornwall)								2019	

These Canadian AOCs are already delisted: Collingwood Harbour (1994), Severn Sound (2003), and Wheatley Harbour (2010).

All Actions Completed (100%) | Majority of Actions Completed (75+%) | Actions Well Underway (50+%) | Actions Required or to be Determined (<50%)

EPA-R5-2017-0002000000634

U. S. Areas of Concern – Status of Actions

Updated 5/11/16

AOC	State	Sediment Remediation	Habitat Restoration	Hydrologic Controls/Diversions Implemented	Safe Drinking Water Provided	Engineering Design	Studies/Investigations	Other Regulatory Action	BUI Evaluation/Assessment	Year all remediation and restoration actions were or will be completed	AOC Weblink
Waukegan Harbor	IL			N/A	N/A					2014	For additional information on United States and binational Areas of Concern; go to : https://www.epa.gov/great-lakes-aocs/list-aocs
Grand Calumet River	IN			N/A	N/A					2020	
Clinton River	MI	N/A		N/A	N/A			N/A		2017	
Deer Lake	MI				N/A					Delisted 2014	
Detroit River	MI			N/A	N/A					2023	
Kalamazoo River	MI			N/A	N/A					2030+	
Manistique River	MI		N/A	N/A	N/A			N/A		2018	
Muskegon Lake	MI			N/A	N/A			N/A		2018	
River Raisin	MI			N/A	N/A			N/A		2016	
Rouge River	MI			N/A	N/A					2021	
Saginaw River & Bay	MI									2030+	
Torch Lake	MI		N/A	N/A	N/A	N/A				2030+	
White Lake	MI			N/A	N/A	N/A		N/A		Delisted 2014	
St. Clair River	MI/ON	N/A		N/A	N/A			N/A		2015	
St. Marys River	MI/ON			N/A	N/A			N/A		2016	
Menominee River	MI/WI				N/A					2016	
Buffalo River	NY			N/A	N/A					2017	
Eighteenmile Creek	NY		N/A		N/A					2026+	
Oswego River	NY	N/A	N/A		N/A	N/A				Delisted 2006	
Rochester Embayment	NY				N/A					2016	
Niagara River	NY/ON			N/A	N/A					2026+	
St. Lawrence River	NY/ON			N/A	N/A					2026+	
Ashtabula River	OH			N/A	N/A	N/A		N/A		2013	
Black River	OH			N/A	N/A			N/A		2017	
Cuyahoga River	OH			N/A	N/A					2021	
Maumee River	OH			N/A	N/A			N/A		2025	
Presque Isle	PA			N/A	N/A	N/A		N/A		Delisted 2013	
Fox River/ S Green Bay	WI				N/A					2026+	
Milwaukee Estuary	WI			N/A	N/A					2026+	
Sheboygan River	WI			N/A	N/A					2013	
St. Louis River & Bay	WI/MN			N/A	N/A					2020	

All Actions Completed (100%) | Majority of Actions Completed (75+%) | Actions Well Underway (50+%) | Actions Required or to be Determined (<50%)

EPA-R5-2017-0002000000634

LAKEWIDE MANAGEMENT ANNEX

OVERVIEW

The Great Lakes are comprised of five of the twenty largest lakes in the world by volume: Superior (3), Michigan (7), Huron (8), Ontario (12) and Erie (18). The Great Lakes are connected and discharge through major river systems: the St. Marys, St. Clair (including Lake St. Clair) Detroit, Niagara and St. Lawrence. Given the size and ecological complexity of the lakes, restoring and protecting Great Lakes water quality and ecosystem health sometimes requires an approach that is specifically tailored to an individual lake.

In the Lakewide Management Annex of the 2012 GLWQA, the United States and Canada commit to establishing Lakewide Action and Management Plans (LAMPs) for each of the five Great Lakes and their connecting river systems. These individualized plans will serve as blueprints for action, as they will identify and prioritize desired restoration and protection activities on each of the Great Lakes.

This Annex's implementation is supported by the Lakewide Management Annex Subcommittee, co-led by the United States Environmental Protection Agency and Environment and Climate Change Canada. Organizations on the subcommittee include: [insert logos]

PROGRESS TOWARD MEETING GLWQA COMMITMENTS

2012	2013	2014	2015	2016
• Published LAMP Annual Reports. • Established Lake Ontario Science and Monitoring Priorities • Finalized Lake Michigan Biodiversity Conservation Strategy.	• Published LAMP Annual Reports. • Established Lake Michigan Science and Monitoring Priorities • Finalized Lake Erie Biodiversity Conservation Strategy	• Published LAMP Annual Reports. • Established Lake Superior Science and Monitoring priorities	• Published LAMP Annual Reports. • Established Lake Huron Science and Monitoring priorities • Finalized Lake Superior Biodiversity Conservation Strategy.	• Published LAMP Annual Reports. • Finalized Lake Superior LAMP. • Finalized Nearshore Framework.

BINATIONAL ACTIONS TAKEN

Developing a nearshore framework to identify areas of high ecological value and those that are or may become subject to severe stress due to the cumulative effects of multiple stressors.

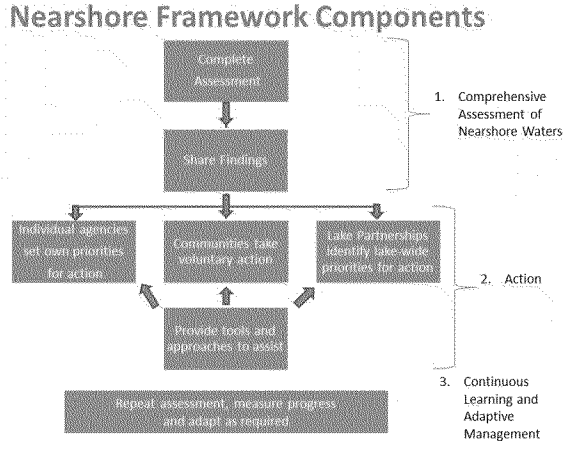
- The fragility of the nearshore as a key issue in the Great Lakes basin was highlighted in 2005 by more than 250 Great Lakes scientists who signed on to a report entitled *Prescription for Great Lakes Ecosystem Protection and Restoration (Avoiding the Tipping Point of Irreversible Changes)* (http://www.miseagrant.umich.edu/downloads/habitat/Prescription-for-the-Great-Lakes-08-2006.pdf).

- To develop the nearshore framework, the United States and Canada undertook a three-year process to engage a wide range of people and organizations throughout the Great Lakes basin. The resulting Nearshore Framework was approved by the United States and Canada in July 2016. The Parties will pilot test implementation of the framework in Lake Erie beginning in 2017.

- The framework provides a mechanism for undertaking a systematic, integrated and collective approach for assessing nearshore health and identifying and communicating cumulative impacts and stresses.

- Building on the information provided by the assessment, federal, state and provincial governments, tribal governments, First Nations, Métis, municipal governments, watershed management agencies, local public agencies and the public, individually and collectively, will be able to identify management priorities, take action to protect nearshore areas of high ecological value, protect water quality, and restore degraded areas.

The Great Lakes Nearshore Framework



Developing the Lake Superior Lakewide Action and Management Plan.

- The schedule for the development and release of Lakewide Action and Management Plans (LAMPs) was confirmed in 2014. The Lake Superior LAMP was approved in June of 2016, and is the first LAMP completed under the 2012 GLWQA and the authoritative source for information on the Lake Superior ecosystem.

- The Lake Superior LAMP was developed with the help of over 30 science-based government agencies and involvement from over 50 other organizations, representing thousands of people and many diverse interests.

- The Lake Superior ecosystem continues to be in good condition, as exemplified by the good condition of the fisheries which is supported by a robust lower food web, in particular the self-sustaining populations of Lake Trout and increasing abundance of Lake Sturgeon; good ecological status of most major habitats on a lakewide scale, including coastal wetlands; and generally decreasing or stable concentrations of legacy contaminants. The LAMP also details ongoing and emerging threats to the ecosystem, including aquatic invasive species, climate change, loss of habitat connectivity, and chemical contaminants.

- Science priorities identified in the Lake Superior LAMP include: confirming lower food-web health and stability; determining progress being made on reducing nine persistent, bioaccumulative and toxic substances; determining progress being made on Lake Sturgeon rehabilitation; providing information needed to support implementation of fish rehabilitation plans; assessing baseline water quality conditions in areas of critical habitat and potential significant land-use change; and identifying vulnerable cold-water tributaries to Lake Superior from various stressors such as climate change.

- To maintain the good condition of the Lake Superior ecosystem, and address threats to water quality and ecosystem health, the LAMP includes priority actions in the form of 29 projects that will be undertaken over the next five years through cooperative implementation among government agencies and others. Actions that the public can take are also identified.

Establishing Lake Ecosystem Objectives for each Great Lake, including its connecting river systems, as a benchmark against which to assess status and trends in water quality and lake ecosystem health.

- In October of 2014 a draft guidance document for the development of Lake Ecosystem Objectives (LEOs) and a draft framework linking the LEOs to the Agreement's General Objectives and the State of the Great Lakes Indicators were developed.

- The guidance suggests that LEOs should:
  - be practical and attainable or achievable within a 20-year timeframe;
  - provide sufficient direction for implementing LAMP actions;
  - have support from the agencies that implement the programs used to achieve the objective;
  - be based on sound, readily available data, so they can be reported on every five years; and,
  - taken together, be a comprehensive suite which addresses each 2012 GLWQA General Objective and lake stressor.

- A binational team has been formed to develop a draft suite of LEOs for Lake Erie for consultation.

- LEOs for the other lakes will be developed during the next reporting cycle (2017 to 2019).

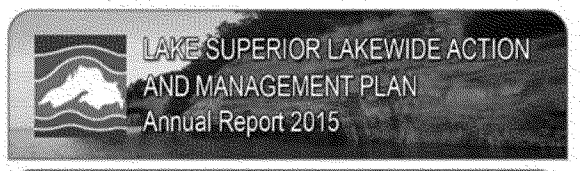
Undertaking the lakewide management actions in cooperation and consultation with others.

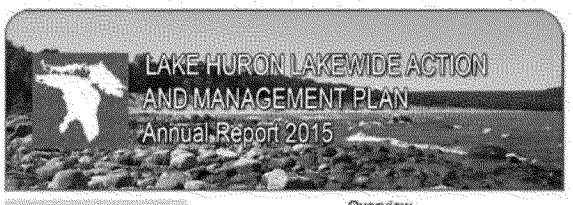
- The United States and Canada have undertaken outreach and engagement activities through the work of the Lake Partnerships and the Annex Subcommittee.

- In 2015, eight webinars involving over 800 participants were held to update the basin-wide and individual lake stakeholder communities about progress under the Lakewide Management Annex, and to discuss possible approaches to outreach and engagement. Outreach and Engagement sub-committees were formed under each Lake Partnership to develop and implement an outreach and engagement strategy for each lake.

- In 2016, the Parties solicited interest from stakeholders in participating with the Lake Partnerships, including providing input on LAMP development and other Partnership activities to simply being kept apprised of Lake Partnership activities and receiving notice of requests for input on specific issues. The solicitation was sent through existing Great Lakes-related email distribution lists including GLIN-Announce, and the United States Environmental Protection Agency's and Environment and Climate Change Canada's Great Lakes email databases in order to reach a wide breadth of stakeholders.

- In 2013, 2014, and 2015, LAMP Annual reports were issued to provide an overview of accomplishments and challenges facing each lake.





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What Is the Lake Huron LAMP?

Under the Great Lakes Water Quality Agreement, the governments of Canada and the United States have committed to restore and maintain the physical, biological and chemical integrity of the waters of the Great Lakes.

The Lake Huron Lakewide Action and Management Plan (LAMP) will be a binational action plan for restoring and protecting the Lake Huron ecosystem. The LAMP will be developed and implemented by the Lake Huron Partnership, which is led by the U.S. Environmental Protection Agency and Environment Canada and which facilitates information sharing, sets priorities, and assists in coordinating binational environmental protection and restoration activities. The first Lake Huron LAMP will be

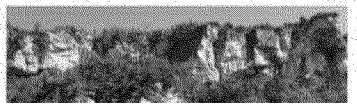
Overview

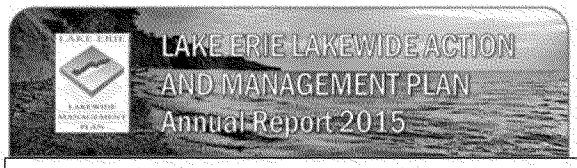
With its land and waterscapes evolving through the interacting forces of water, geology and climate, Lake Huron and its watershed have been shaped into an area of global ecological significance. Lake Huron is renowned for its beaches, dunes, rugged shorelines, coastal wetlands, diverse river systems, forests and more than 30,000 islands. Conserving this precious resource is important to maintaining its enormous social, recreational and economic benefits.

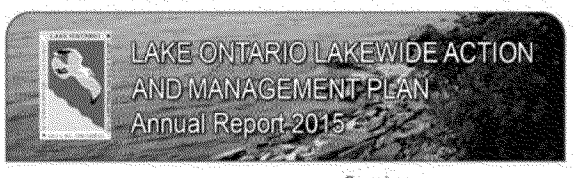
The Lake Huron Partnership is expanding its work to be fully consistent with all other Great Lakes in preparing its first Lakewide Action and Management Plan (LAMP) in 2016. The priorities of the Partnership are to continue to study, report on, and address key issues such as contaminants in fish and wildlife, biodiversity and ecosystem change, fish and wildlife habitat, and localized domestic water quality issues including beach closings and algal fouling.

The Lake Huron Partnership's 2015 Annual Report provides information and updates on:

- Turning community interest into environmental action;
- Restoring fish populations and spawning habitat;
- Cleaning up of contaminated sediment in the Tittabawassee River Floodplain; and
- The St. Marys River Area of Concern and the Spanish Harbour Area in Recovery.







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What Is the Lake Ontario LAMP?

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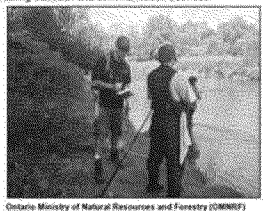
The Lake Ontario Lakewide Action and Management Plan (LAMP) is a binational action plan for restoring and protecting the Lake Ontario ecosystem. The LAMP is developed and implemented by the Lake Ontario Partnership, which is led by the U.S. Environmental Protection Agency and Environment Canada and which facilitates information sharing, sets priorities, and assists in coordinating binational environmental protection and restoration activities. The next Lake Ontario LAMP will be issued in 2017; in the interim, the Lake Ontario Partnership will be assessing the state of the lake, measuring progress against existing LAMP goals and objectives, and providing management actions to address identified problems.

This 2015 annual report highlights accomplishments and progress in achieving LAMP goals during the past year and identifies LAMP-related activities including outreach, monitoring, and protection and restoration actions.

Overview

In 2015, the Lake Ontario Partnership continued its efforts to address important lakewide stressors and worked cooperatively to protect and restore water quality and ecosystem health. This was accomplished through a series of priority actions and programs, including the Binational Biodiversity Conservation Strategy (BBCS), the Cooperative Science and Monitoring Initiative (CSMI), reducing critical pollutants, restoring fish species and a productive food web, improving environmental quality of nearshore ecosystems and coastal wetlands, and undertaking outreach and communication activities.



Ontario Ministry of Natural Resources and Forestry (OMNRF) staff member interviewing tributary angler for the Lake Ontario Tributary Survey.
Credit: OMNRF.

Accomplishments

Fisheries Research and Monitoring in Lake Ontario

Lake Ontario is home to an exceptional and diverse salmon and trout fishery. Chinook Salmon, Rainbow Trout, Brown Trout and Coho Salmon are important species in both the open waters of Lake Ontario and its tributaries (as fish migrate up the tributaries to spawn). The Ontario Ministry of Natural Resources and Forestry (OMNRF) and New York State Department of Environmental Conservation (NYSDEC) have regularly surveyed the amount of fishing activity on the open waters of Lake Ontario for over 30 years. The NYSDEC surveyed the amount of fishing activity in New York's Lake Ontario tributaries from 2005–2007 and in 2011–2012. OMNRF just completed the first-ever comprehensive survey of the amount of fishing activity on Canadian tributaries to Lake Ontario. These surveys show that fishing activity on Lake Ontario's tributaries has increased, while fishing activity on Lake Ontario itself has decreased. In fact, the most recent NYSDEC survey showed that the amount of annual fishing activity on tributaries is two times greater than the amount of fishing activity on the lake itself. The Salmon River (Oswego County, N.Y.) is by far the largest fishery on the U.S. side of the lake, accounting for approximately 50% of the total fishing activity in New York tributary waters.

CHEMICALS OF MUTUAL CONCERN ANNEX

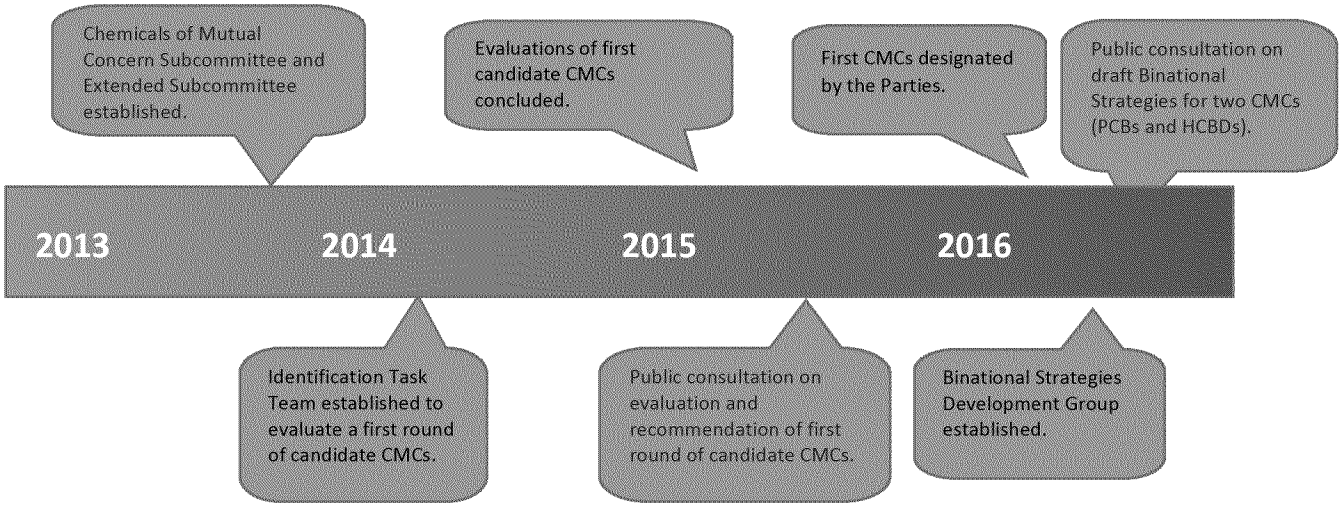
OVERVIEW

Due to the high population density and concentration of industrial activity in the Great Lakes region, as well as long-range atmospheric transport and deposition from out-of-basin sources and the long residence times of chemicals in the environment, chemical pollution has long been a serious concern in the Great Lakes. Toxic chemicals can harm aquatic ecosystems and negatively impact habitats and biodiversity in the Great Lakes. Some chemicals are also persistent and can bioaccumulate in the food web, potentially exposing humans through fish consumption. As such, addressing the threats posed to the Great Lakes by chemicals in the environment has been a priority of Canada and the United States since the late 1970's.

The purpose of the Chemicals of Mutual Concern Annex is to contribute to the achievement of the general and specific objectives of the Agreement by protecting human health and the environment through cooperative and coordinated measures to reduce anthropogenic releases of chemicals of mutual concern (CMCs) into the waters of the Great Lakes.

Under the Annex, the Parties have committed to identify CMCs on an ongoing basis and to take specific actions for CMCs, including the development of binational strategies, which may include pollution prevention, control and reduction actions as well as research, monitoring and/or surveillance activities.

PROGRESS TOWARD MEETING GLWQA COMMITMENTS



The implementation of this Annex is supported by the Chemicals of Mutual Concern Annex Subcommittee, co-led by Environment and Climate Change Canada and the United State Environmental Protection Agency, and supported by an Extended Subcommittee with representation from non-government organizations and industry. Organizations on the Subcommittee include: the Ontario Ministry of Environment and Climate Change (OMOECC), the Indiana Department of Environmental Management (IDEM), the Minnesota Department of Health (MDH), Wisconsin Department of Natural Resources (WDNR) and the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) - insert logos

BINATIONAL ACTIONS TAKEN

Pollution prevention and control of chemicals in Canada and the United States occurs through a number of programs and under different legislation at the federal, provincial, state and local levels. Recognizing this, the 2012 GLWQA focuses attention on those chemicals present in the Great Lakes for which additional effort is warranted and can be advanced through binational coordination and cooperation.

Identifying chemicals of mutual concern that originate from anthropogenic sources, which are potentially harmful to human health or the environment.

- A series of criteria, the *Binational Considerations*, were developed to evaluate candidate CMCs. Using these criteria, a first round of candidate CMCs were evaluated, with detailed reports for eight candidate CMCs posted to binational.net for public input (http://binational.net/2015/05/13/cmc-cand-pcspm/ – the *Binational Considerations* can be found in Appendix A of each of these eight reports for candidate CMCs).

- Taking into consideration the information in the reports and input provided by the Chemicals of Mutual Concern Subcommittee, Extended Subcommittee, the Great Lakes Executive Committee and the public, on May 31, 2016, Canada and the United States designated the following eight chemicals as the first CMCs under the 2012 GLWQA:
  1. Mercury;
  2. Polychlorinated biphenyls (PCBs);
  3. Perfluorooctanoic acid (PFOA),
  4. Perfluorooctane sulfonate (PFOS),
  5. Long-chain perfluorinated carboxylic acids (LC-PFCAs);
  6. Polybrominated diphenyl ethers (PBDEs)
  7. Hexabromocyclododecane (HBCD); and
  8. Short-chain chlorinated paraffins (SCCPs)

- To foster enhanced stakeholder engagement, the Parties created a process by which stakeholders, including non-government organizations, industry, academia and the public, can propose specific chemicals for consideration as potential candidate CMCs. A support document for the external nominations process is available on binational.net (https://binational.net/2015/05/13/cmc-pro-pcspm/), which describes the information to be submitted by stakeholders in support of a nomination.

Targeting these identified Chemicals of Mutual Concern for action.

- Draft *Binational Strategies*, which may include research, monitoring, surveillance and pollution prevention and control actions, are being developed for two CMCs, Polychlorinated Biphenyls (PCBs) and Hexabromocyclododecane (HBCD). Stakeholders, including the public, will contribute to the development binational strategies via specific input and review opportunities.

- The development of *Binational Strategies* for the remaining CMCs will take into account lessons-learned while developing the first two *Binational Strategies*.

- Existing relevant Canadian and United States environmental quality guidelines for CMCs are being compiled and will be made available on binational.net, as *Binational Strategies* are developed. These guidelines can be considered in conjunction with other information (e.g., from state of the environment reporting) to evaluate progress towards the implementation of *Binational Strategies* for CMCs.

Coordinating science priorities, research, surveillance and monitoring activities, as appropriate related to CMCs.

- Through mechanisms such as the Cooperative Science and Monitoring Initiative under the Science Annex, monitoring of CMCs in relevant environmental media of the Great Lakes is being pursued in a collaborative and coordinated manner, whenever possible.

- Monitoring of CMCs supports the commitments of the Chemicals of Mutual Concern Annex, and is also critical for the development of the triennial State of the Great Lakes Indicators report, in which levels of these chemicals in the Great Lakes are reported.

- Canada and the United States have comprehensive national monitoring and surveillance programs, as well as regional, Great Lakes-specific programs and activities, which evaluate a broad suite of chemicals, including more recent chemicals of potential concern (e.g., organic flame retardants and perfluorinated chemicals).

DOMESTIC ACTIONS TAKEN

CANADA

- The Government of Canada continues to assess and manage the risks posed by chemicals through the national Chemicals Management Plan. Under the Chemicals Management Plan, 2,740 substances have been assessed, and 363 substances or groups of substances have been concluded to be toxic. For these toxic substances, 76 final risk management instruments covering 325 substances or groups of substances have been developed, and additional risk management instruments are being developed.

- All designated CMCs are listed under the Schedule 1 – List of Toxic Substances of the *Canadian Environmental Protection Act, 1999*. As such, all CMCs are subject to federal risk management in Canada, for example through the *Polychlorinated Biphenyl Regulations* and the *Prohibition of Certain Toxic Substance Regulations*. Additionally, Environment and Climate Change

Canada has developed federal environmental quality guidelines and supported the development of federal-provincial guidelines, for many of the first CMCs.

- Canada is a Party to many Multilateral Environmental Agreements aimed at globally addressing environmental and human health impacts of chemicals. Examples of relevant Multilateral Environmental Agreements include the Minamata Convention on Mercury and the Stockholm Convention on Persistent Organic Pollutants.

- Environment and Climate Change Canada also delivers a number of foundational water quality monitoring and surveillance activities in the Great Lakes watershed, including the Great Lakes Surveillance Program and the Great Lakes Fish Contaminant and Sediment Monitoring and Surveillance Programs, through which CMCs will continue to be monitored in the Great Lakes.

UNITED STATES

- The United States Environmental Protection Agency delivers a number of foundational water quality monitoring and surveillance activities in the Great Lakes watershed, including the Great Lakes Fish Monitoring and Surveillance Program and the International Atmospheric Deposition Network.

- The Environmental Protection Agency also has funded, and continues to fund, research on the presence, effects, and trends of emerging chemicals, including CMCs, in a variety of media through the Great Lakes Restoration Initiative and its partners. As a result of the identification of hexabromocyclododecane (HBCD) as a CMC, it has been added to the routine monitoring program of the Agency's Great Lakes Fish Monitoring and Surveillance Program. These activities provide data and information to regulatory offices within the Environmental Protection Agency for consideration and incorporation into decision making processes.

- In the United States, CMCs are regulated under a combination of multiple federal, state and local statutes and regulations, depending on the source, use and release of the respective CMC. The Environmental Protection Agency generally addresses CMCs through the Toxic Substances Control Act, which seeks to address the human health and environmental impacts of chemicals in industrial use within the Great Lakes basin through a combination of voluntary and regulatory risk management activities. However, these risk management actions are taken at a national level, focusing on specific substances and their specific uses in commerce.

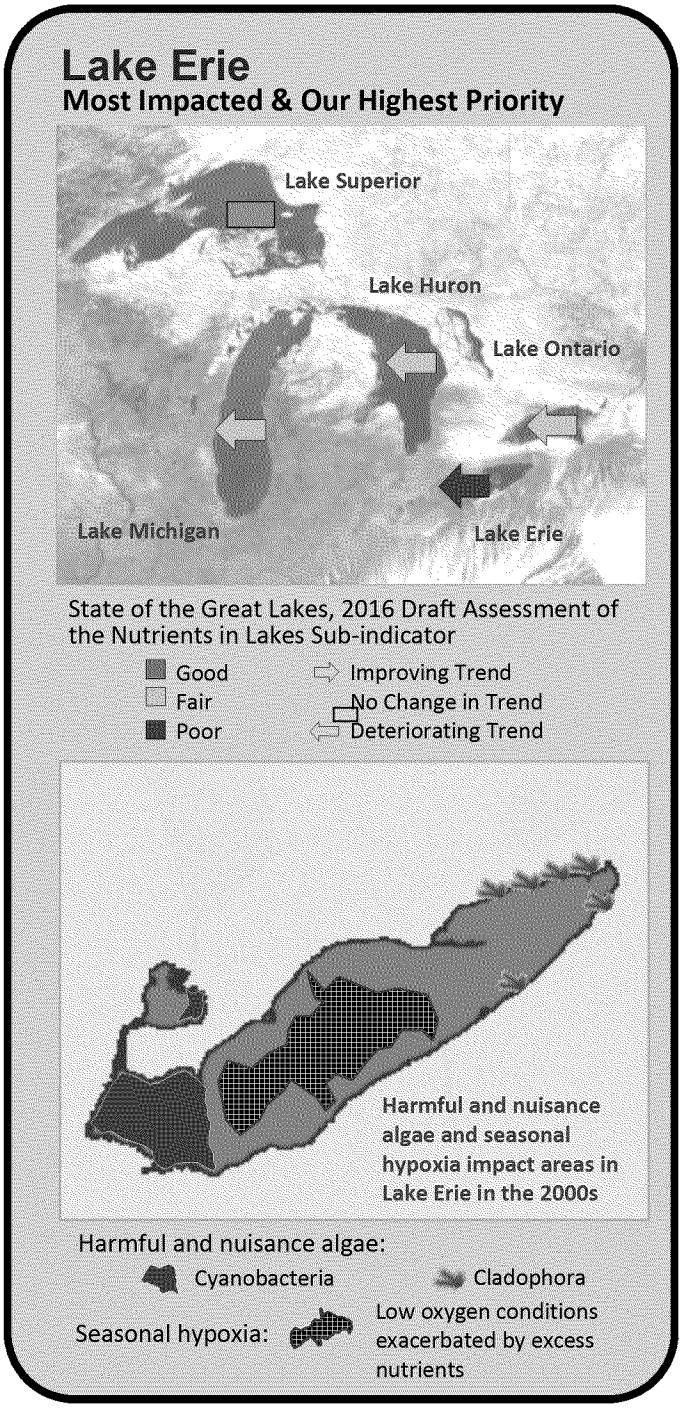
- As implementation of the Chemicals of Mutual Concern Annex proceeds toward the development of Binational Strategies and ensuing actions, the United States will seek to more closely align its actions at the federal, state and local levels to better support CMC-oriented actions that are specific to the Great Lakes basin, as appropriate.

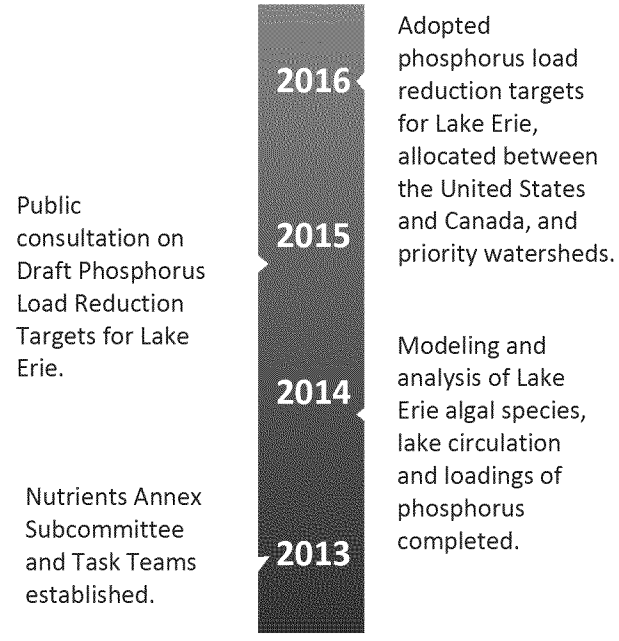
NUTRIENTS ANNEX

OVERVIEW

In Lake Erie in particular and some other areas of the Great Lakes, excess phosphorus loadings threaten the water quality and ecosystem health by contributing to harmful and nuisance algal blooms that can cause drinking water impairments, exacerbate low oxygen conditions, and drive beach closures that result in loss of recreational opportunities. Recognizing the magnitude of the threat to Lake Erie, the 2012 Agreement requires Canada and the United States to establish phosphorus load reduction targets, allocated by country for the nearshore and open waters of Lake Erie, by 2016, and development of Domestic Action Plans to achieve the Lake Erie targets by 2018.

On February 22, 2016, following a robust binational science-based process and an extensive public consultation, the United States and Canada adopted new phosphorus reduction targets for major tributaries and priority watersheds in the Lake Erie basin. The Parties and multiple partner agencies and are now working to develop Domestic Action Plans to meet the 2018 deadline.


Lake Erie
Most Impacted & Our Highest Priority
Lake Superior
Lake Huron
Lake Ontario
Lake Michigan
Lake Erie
State of the Great Lakes, 2016 Draft Assessment of the Nutrients in Lakes Sub-indicator
Good
Fair
Poor
Improving Trend
No Change in Trend
Deteriorating Trend
Harmful and nuisance algae and seasonal hypoxia impact areas in Lake Erie in the 2000s
Harmful and nuisance algae:
Cyanobacteria
Cladophora
Seasonal hypoxia:
Low oxygen conditions exacerbated by excess nutrients



This Annex's implementation is supported by the Nutrients Annex Subcommittee, co-led by the United States Environmental Protection Agency and Environment and Climate Change Canada. Organizations on the subcommittee include:

BINATIONAL ACTIONS TAKEN

By 2016, develop binational substance objectives for phosphorus concentrations, loading targets, and loading allocations for Lake Erie.

- The Parties led an extensive binational effort to increase understanding of the Lake Erie algae problem in relation to the three main basins of the Lake – the Western Basin, the Central Basin and the Eastern Basin. Information on algal patterns and species, lake circulation, and sources and loadings of phosphorus were studied. Modeling experts from Canada and the United States used nine different computer simulation models to correlate changes in phosphorus levels with levels of algal growth. By comparing and contrasting the results of these models, draft phosphorus load reduction targets to achieve the Lake Ecosystem Objectives for Lake Erie were developed.

- The Parties then led extensive consultations of the draft targets. Information about the draft targets was made available online, for approximately 60 days up to August 31, 2106, through www.binational.net, and Environment and Climate Change Canada and United States Environmental Protection Agency websites. The Parties also reached out through a number of binational and domestic face-to-face meetings with interested stakeholders and partners including agricultural

commodity groups, municipalities, Conservation Authorities, First Nations, non-government organizations, and others. Feedback received included both technical comments on the targets as well as ideas for action.

- Following this robust science-based process and public consultation, Canada and the United States adopted the following phosphorus reduction targets for Lake Erie (based on a 2008 baseline year):

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

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

  - **To maintain cyanobacteria biomass at levels that do not produce concentrations of toxins that pose a threat to human or ecosystem health in the waters of the western basin of Lake Erie:** a 40 percent reduction in spring total and soluble reactive phosphorus loads from the Maumee River in the United States.

- Further science and analysis is underway to establish targets that will minimize impacts from nuisance algae in the eastern basin of Lake Erie.

By 2018, develop binational phosphorus reduction strategies and domestic action plans to meet the objectives for phosphorus concentrations and loading targets in Lake Erie.

- The United States and Canada are working with multiple partner agencies, tribes, First Nations, Métis, and stakeholders to develop a binational phosphorous reduction strategy and Domestic Action Plans. These plans will identify the actions required to meet the agreed to load reduction targets. Stakeholders are being engaged during the development process, and the draft plans will be available for further consultation in 2017.

Assessing, developing, and implementing programs to reduce phosphorus loadings from urban, rural, industrial and agricultural sources.

- Ongoing efforts to limit excess phosphorus loading to the Great Lakes – through detergent bans, optimizing sewage treatment, and implementing best management practices on agricultural lands – must continue and be enhanced with better targeting and adoption. Work is underway to evaluate existing programs in Canada and the United States, identify opportunities to maximize current phosphorus reduction efforts, and propose new programs and approaches to manage phosphorus

loadings from municipal and agricultural point and nonpoint sources.

Identifying priority watersheds that contribute significantly to local algae development, and implementing management plans to achieve phosphorus load reduction targets and controls for these areas.

- While phosphorus reductions are required from all watersheds entering Lake Erie, the United States and Canada identified eight priority watersheds (as seen in Figure 4) – two in Canada and six in the United States – where phosphorus control is required in order to address algal blooms occurring in the nearshore waters of Lake Erie.

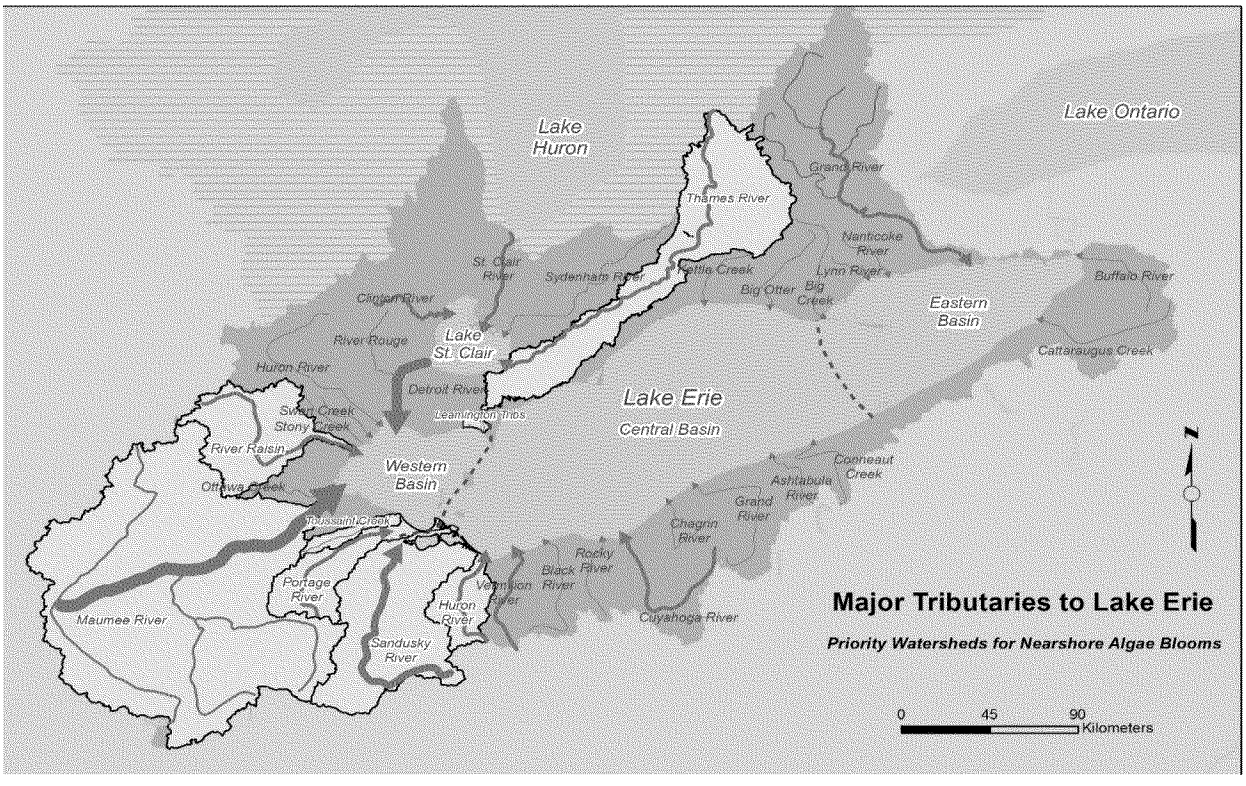


Figure 4: Major tributaries to Lake Erie and the priority watersheds for nearshore blooms. Tributary size indicates magnitude of phosphorus loading to the Lake in 2008.

Undertake and share research, monitoring and modeling necessary to establish, report on and assess the management of phosphorus and other nutrients and improve the understanding of relevant issues associated with nutrients and excessive algal blooms.

- Canada and the United States engaged many scientific experts in the development of the new phosphorus loading targets for Lake Erie, and are currently developing an approach to monitor and track progress towards the new targets. The following priorities for research, monitoring and modeling have been identified:

- Monitoring of total phosphorus and dissolved reactive phosphorus loads and harmful algal blooms and hypoxia extent and duration to evaluate effectiveness of load reduction efforts and the lake's response over time;
- Research on factors that contribute to toxin production by harmful algal blooms;
- Better understanding of internal phosphorus loads, including factors controlling the growth of the nuisance alga, *Cladophora* and improvement of ecosystem models to assist in understanding the relationship between external and internal phosphorus loads and the occurrence of algal blooms.

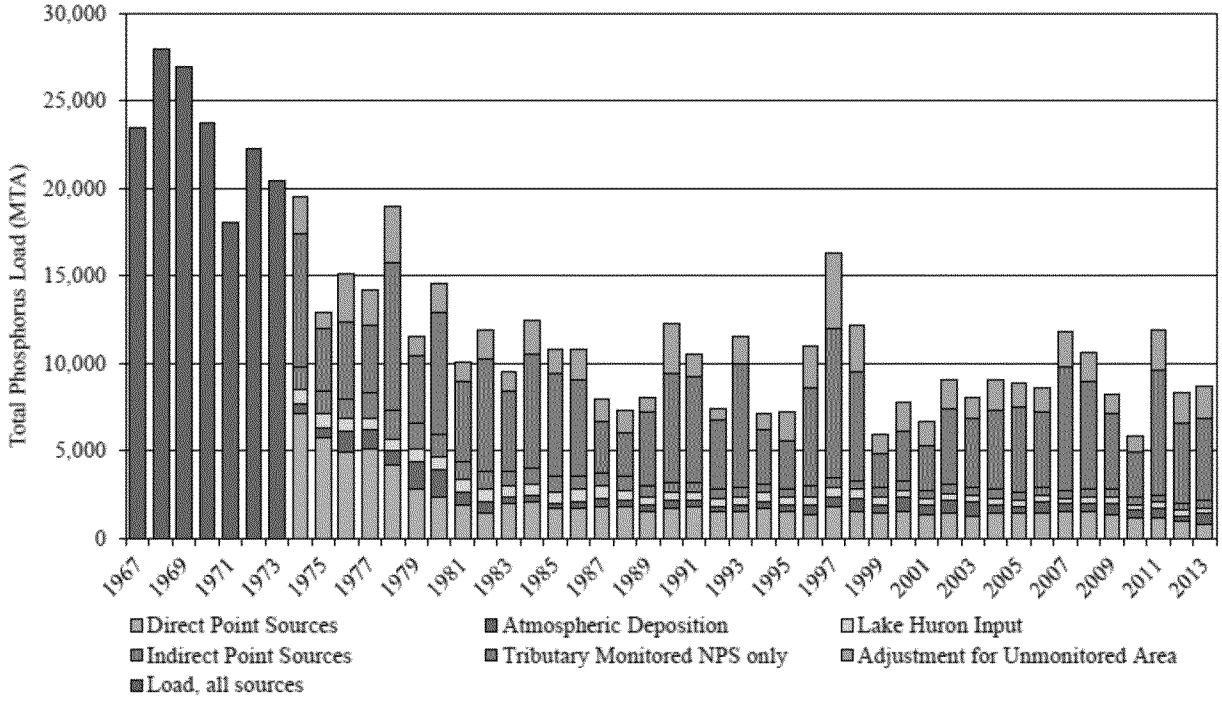


Figure 5 – Total phosphorus loads to Lake Erie by source type, 1967 – 2013.

- Figure 5 shows phosphorus loadings data collected in support of the previous targets. Canada and the United States tracked phosphorus loads and sources on a whole-lake basis. The new targets for Lake Erie are refined to specific locations, forms of phosphorus, and time of year. Going forward, tracking and assessments related to these new targets will need refinement and appropriate data collection will be critical to the evaluation of implementation efforts and the Lake's response over time.

DOMESTIC ACTIONS TAKEN

- The United States has several permitting and funding programs to reduce phosphorus loadings from municipal, industrial and agricultural sources. For example, state environmental and agricultural programs establish discharge limits and comprehensive nutrient management plans to manage nutrient pollution. Since 2008, $314 million in Farm Bill funding has supported conservation activities on 2.5 million acres of private land throughout the Great Lakes region. Since 2010, hundreds of millions of dollars have been allocated for a wide array of projects that will reduce the loading of nutrients to the Great Lakes - nutrients that can fuel HABs. For example, more than 680 projects and $60 million of GLRI funds were invested in the Lake Erie Basin from 2010 through 2015 to reduce phosphorus, nutrient, and nonpoint source pollution and to support related science and monitoring work. A new United States Department of Agriculture Natural Resources Conservation Service initiative launched in 2016 will help landowners reduce phosphorus runoff from farms by more than 640,000 pounds each year by effectively doubling the acres under conservation in the Western basin over the course of the three-year investment.

- Through the GLRI, federal agencies and their partners are reducing nutrient loads into the Great Lakes. During fiscal year 2015, federal agencies and their partners funded nutrient and sediment reduction projects on over 100,000 acres of targeted watershed in the Great Lakes Basin. These projects are projected to prevent over 160,000 pounds of phosphorus from entering the Great Lakes annually. During fiscal year 2015, federal agencies and their partners also funded urban runoff projects that are anticipated to capture an average annual volume of more than 37 million gallons of untreated urban runoff per year. These projects reduce flooding, increase green space in urban areas, and return vacant properties to productive use.

- The Unites States Geological Survey has installed 22 GLRI-funded edge-of-field monitoring stations on farms in the Maumee River basin, the Fox River basin, the Saginaw River basin and the Genesee River basin. These stations will gather weather data and sample runoff water during storm events. The water samples will be analyzed for their phosphorus, nitrogen, and sediment content. The United States Department of Agriculture-Natural Resources Conservation Service staff will assist the cooperating farmers with installing conservation practices in the field above the stations. This analysis will help quantify the value of conservation practices in reducing sediment and nutrient delivery from these fields, under these conditions, in order to improve water quality.

- The GLRI is also funding the implementation of conservation practices including cover crops, silage leachate containment areas, a waste storage structure, and nutrient management on conservation demonstration farms in the Fox River basin. The farms are open for annual tours where other farmers in the watershed can view the installed practices, hear farmers' opinions on the value that conservation farming practices can add to their farming operations, and ask questions.

- GLRI-funded research led by the National Oceanic and Atmospheric Administration's Great Lakes

Environmental Research Laboratory, in collaboration with partners from the University of Michigan's Cooperative Institute for Limnology and Ecosystems Research, is investigating impact of land use changes on algal bloom development in the western basin of Lake Erie and in Lake Huron's Saginaw Bay. The Great Lakes Environmental Research Laboratory combines remote sensing, monitoring, and modeling to produce weekly forecasts of *Microcystin* bloom concentration and transport in Lake Erie, which are distributed to regional stakeholders. National Oceanic and Atmospheric Administration researchers, with their partners at Heidelberg University, have also initiated early season projections of the seasonal harmful algal bloom severity in western Lake Erie.

- During fiscal year 2015, GLRI partners established a network of four real-time continuous observing buoys to track detailed water quality conditions to support modeling, forecasting, and public warnings of harmful algal bloom conditions throughout western Lake Erie. The observing buoys are capable of tracking water quality and bloom conditions and measuring dissolved phosphorus concentrations at hourly intervals. During the 2015 bloom season, these buoys collected over 7,000 in-lake nutrient and water quality measurements, providing unprecedented spatial and temporal details of internal lake dynamics and bloom development. In addition to providing real-time tracking of harmful algal bloom conditions for water intake managers and recreational users, the observing data will be used to improve ongoing forecasting efforts covering a range of spatial and temporal scales including seasonal harmful algal bloom forecasts, 5-day forecasts, and vertical distribution forecasts.

- In June 2015 Governor Rick Snyder of Michigan, Premier Kathleen Wynne of Ontario and Lieutenant Governor Mary Taylor of Ohio signed the Western Basin of Lake Erie Collaborative Agreement which establishes a collaborative initiative that will use adaptive management to achieve a recommended 40 percent total load reduction in the amount of total and dissolved reactive phosphorus entering the WLEB by the year 2025 with an aspirational interim goal of a 20 percent reduction by 2020. Each state and province commits to developing, with stakeholder involvement, a plan outlining their proposed actions and time lines toward achieving the phosphorus reduction goal.

- Michigan finalized its 2016 Implementation Plan, which is the first step in achieving a 40% phosphorus reduction by 2025, for the Western Lake Erie Basin Collaborative (http://glc.org/projects/water-quality/lent/). The 2016 Implementation Plan can be found at Michigan's Department of Environmental Quality's Water Resources Division (http://www.michigan.gov/documents/deq/wrd-western-lake-erie_503547_7.pdf).

- Also in support of the Western Lake Erie Basin Collaborative, Ohio released its draft Western Lake Erie Basin Collaborative Implementation Plan to reduce phosphorus entering Lake Erie by 40 percent by 2025. The plan was developed with input from various stakeholder groups and state agencies and is available at epa.ohio.gov/Portals/33/documents/WLEBCollaborative.pdf.

- Indiana is working with landowners in the communities to help improve the water quality of our streams and inland rivers, and ultimately Lake Erie. A summary of the Indiana Western Lake Erie Basin Initiatives can be found at the Indiana State Department of Agriculture (http://www.in.gov/isda/3261.htm).

- In coordination with the Pennsylvania Lake Erie Harmful Algae Bloom (HAB) Task Force,

Pennsylvania DEP began a strategic partnership with the Regional Science Consortium at Presque Isle to complete comprehensive monitoring of PA Lake Erie beaches and public areas for the presence of HAB conditions throughout the 2016 season.

- In June 2014, Congress reauthorized the Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA) by passing the Harmful Algal Bloom and Hypoxia Research and Control Amendments Act of 2014 (HABHRCA 2014, P.L. 113-124). The reauthorization of HABHRCA acknowledged concerns related to HABs and hypoxia, extended the scope of the legislation to include freshwater HABs and hypoxia, and recognized the need for further coordinated action across the Federal sector to address these issues. Additionally, the legislation called for Federal agencies to provide integrated assessments on the causes and consequences of and approaches to reducing HABs and hypoxia nationally, with particular emphasis on the Great Lakes. Finally, the reauthorization included a specific focus on the needs of stakeholders, requiring that Federal agencies engage with stakeholders around the country.

- On August 7th, 2015, the President signed H.R. 212 (Drinking Water Protection Act) which directs EPA to develop and submit a strategic plan for assessing and managing risks associated with algal toxins in drinking water provided by public water systems. The resulting *Algal Toxin Risk Assessment and Management Strategic Plan for Drinking Water*, released in November 2015, includes steps and timelines to asses: algal toxins and their human health effects, health advisories, factors likely to cause HABs, treatment options, analytical methods, frequency of monitoring, treatment options, and source water protection practices.

CANADA

- Canada and Ontario are taking action under the Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health, 2014, to reduce phosphorus loads to Lake Erie through urban, agricultural, rural and industrial or commercial point and non-point initiatives including ongoing infrastructure and agricultural stewardship programs. To further improve the effectiveness of current and future phosphorus reduction actions in Lake Erie, Canada and Ontario, along with their partners and stakeholders are working to review and where necessary implement changes to the existing program, policy and legislative phosphorus management frameworks.

- Canada's Great Lakes Nutrient Initiative (2012-2016) enhanced Environment and Climate Canada funding to support the critical science and policy development needed to support the establishment of new phosphorus reduction targets for Lake Erie. Initiative activities included:
    - enhanced water quality monitoring at key locations in the Lake Erie basin – including the Thames River, the Sydenham River, the Detroit River and the Grand River – in order to measure of phosphorus concentrations and loads from the Canadian portion of the Lake Erie basin;
    - new modeling and research to enhance understanding of the factors contributing to the reoccurrence of large scale outbreaks of toxic and nuisance algae in Lake Erie;

- an assessment of current Canadian best practices and policy options for reducing loadings of phosphorus to Lake Erie in order to achieve targets;
- an assessment of socio-economic costs of algal blooms in Lake Erie;
- the development of inventories of phosphorus management programs;
- cost-benefit modeling of phosphorus management in the Grand River basin; and,
- an assessment of future trends and demographics in urban and agriculture landscapes in the Lake Erie basin.

- Canada's 2016 Federal Budget announced $5.0 billion over five years for investments in water, wastewater and green infrastructure projects across Canada. These funds will contribute to addressing phosphorus loads from municipal wastewater, as well as other priorities.

- Canada's 2016 Federal Budget also allocated $3.1 million in 2016 to 2017 to Environment and Climate Change Canada to continue to improve nearshore water and ecosystem health by reducing phosphorus and the resulting algae in Lake Erie. With these resources, the focus will shift from setting phosphorus targets to achieving them, including developing a domestic action plan in collaboration with Ontario and other partners, and monitoring and reporting on progress.

- Canada has also launched discussions with provinces on determining toward renewing Canada's Agricultural Policy Framework (APF). Discussions on priorities for a renewed Framework will take into consideration agricultural contributions to phosphorus loadings.

- The governments of Ontario and Canada, through the Great Lakes Agricultural Stewardship Initiative (http://www.ontariosoilcrop.org/oscia-programs/glasi/), are supporting farmers in the Lake Erie and Lake St. Clair watersheds, and in Lake Huron's southeast shores watershed, implement Better Management Practices that reduce phosphorus loading to the Great Lakes.

- Ontario government researchers are adding to the understanding of harmful algal blooms and nuisance algae by monitoring nearshore water quality at 17 drinking water intake sites in the Great Lakes, including five locations in Lake Erie. The Government of Ontario also monitors 70 sites in nearshore areas of the Great Lakes to track long-term trends in Great Lakes water quality. These long-term data sets, together with special studies in the lakes and their tributaries, advance our understanding of nearshore responses to climate change and other stressors, including changes in nutrient loading.

- In 2013, the government of Ontario launched the Multi-Watershed Nutrient Study. The seven-year study will examine the management of agricultural land and the extent of nutrient runoff in 11 agricultural watersheds in the basins of Lakes Erie, Ontario and Huron. This will be an ongoing study to determine the role agriculture can play in resolving a very complex issue. Comparative data from previous studies will be used to track changing climate conditions, to develop a "then-and-now" analysis and to model future scenarios.

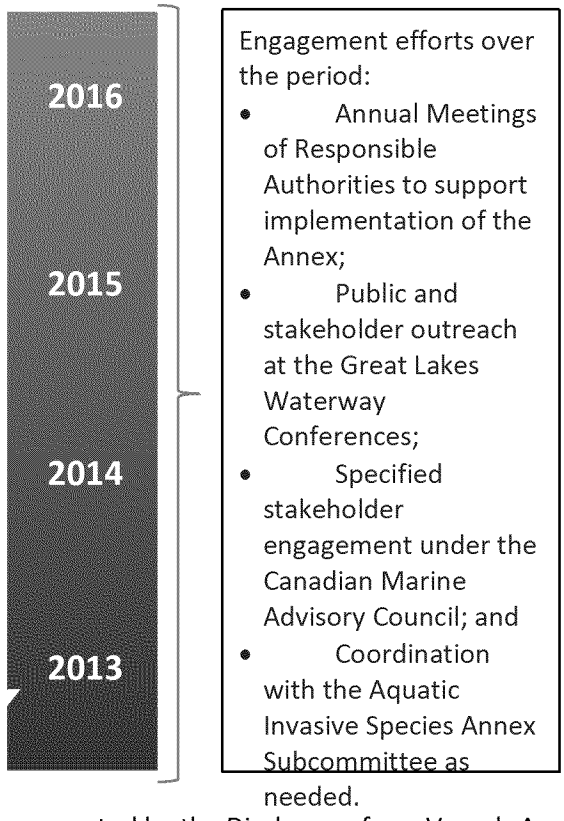
DISCHARGES FROM VESSELS ANNEX

OVERVIEW

The Great Lakes and St. Lawrence Seaway System is a binational trade route that supports tens of thousands of jobs on both sides of the border and serves as a critical transportation corridor for commodities such as iron ore, coal, minerals and grain. Canada and the United States recognize the environmental and economic importance of this system and ensuring it is safeguarded. The Discharges from Vessels Annex of the 2012 GLWQA commits the responsible authorities in Canada and the United States (Transport Canada, Fisheries and Oceans Canada, the Canadian Coast Guard, the United States Coast Guard, and the United States Environmental Protection Agency) to prevent and control vessel discharges that are harmful to the waters of the Great Lakes, including: Oil and hazardous Polluting Substances; Garbage; Wastewater and Sewage; Biofouling; Antifouling Systems; and Ballast Water.

Under the 1987 GLWQA, biennial reports to the International Joint Commission from the responsible Canadian and the United States agencies (last submitted in 2012) consistently indicated that potential discharges of oil and hazardous substances, garbage, wastewater, ballast water and sewage from vessels are well regulated and that sufficient reception facilities are available to receive discharges ashore. This continues to be the case as enforcement of Canadian and United States domestic regulatory regimes and applicable international conventions has reduced the risk of discharges of concern from vessels. Canada and the United States are committed to the continued prevention and reduction of threats to the waters of the Great Lakes from all vessel discharges.

PROGRESS TOWARD MEETING GLWQA COMMITMENTS



This Annex's implementation is supported by the Discharges from Vessels Annex Subcommittee, co-led by Transport Canada and the United States Coast Guard. Organizations on the subcommittee include: [Confirm following Subcommittee membership with Co-Leads: Transport Canada, Fisheries and Oceans Canada, Canadian Coast Guard, Ontario Ministry of Transportation, United States Coast Guard, United States Environmental Protection Agency, Wisconsin Department of Natural Resources, Indiana Department of Environmental Management, United States Maritime Administration]

BINATIONAL ACTIONS TAKEN

Preventing the discharge of Oil and Hazardous Polluting Substances from vessels.

- Transport Canada and the United States Coast Guard have a compatible and effective port and flag state regulatory regime in place to prevent the discharge of oil or hazardous substances on the Great Lakes from vessels and maritime transportation-related facilities that transfer oil or hazardous substances in bulk. The countries' port state control initiatives are risk-based vessel examination programs focused on foreign-flag vessels (non-Party) that operate in their respective waters to ensure compliance with international conventions and the Parties' laws and regulations. The Parties' flag-state programs ensure comparable compliance by the Canadian or United States flag fleets.
- In response to the possibility of the maritime transportation of crude or other heavy oils on the Great Lakes, Canada and the United States created a working group on Maritime Transportation of Hydrocarbons and their by-products. This multi-agency group, chaired by the Transport Canada and the United States Coast Guard, serves as a binational forum to facilitate discussions regarding maritime shipments of hydrocarbons and their by-products (defined initially as crude oil and

associated bulk liquids) and address any concerns that may arise in a coherent and consistent manner. The initial focus of this work is on freshwater, including the Great Lakes and its tributaries, and the St. Lawrence River and Seaway. A phased workplan has been developed and will focus on areas of mutual interest in preparedness, response, liability, and compensation.

Addressing the discharge of Garbage from vessels.

- The illegal discharge of Garbage from commercial vessels in the Great Lakes continues to be a rare event. For the Great Lakes and the coasts, the majority of marine debris entering the water comes from shore side sources.

- No enforcement events for violations of the International Convention for the Prevention of Pollution from Ships Annex V (MARPOL V) or other garbage-related incidents were reported between 2013 and 2016.

Ensuring adequate reception facilities for Garbage from vessels.

- Both Parties indicate there are sufficient and adequate MARPOL V reception facilities on the Great Lakes. There has not been a validated report of an inadequate reception facility on the Great Lakes since 2006.

Addressing the discharge of Wastewater and Sewage from vessels.

- Several Great Lakes states have established "no discharge zones" of sewage in their respective waters in accordance with the United States Clean Water Act. Since Marine Sanitation Devices on most vessels are designed for continuous operations, it has been reported that some vessels with no or insufficient holding tanks have been forced to divert untreated sewage or treated effluent to ballast tanks to remain in compliance. Both Canada and the United States are in agreement that ballast tanks are not an appropriate place to store sewage – treated or untreated.

Preventing harm from vessels' Antifouling Systems.

- Both Canada and the United States have regulations or policies in place implementing the International Convention on the Control of Harmful Anti-Fouling Systems on Ships (IAFS), which ensures anti-fouling paint applied to vessels is free of tributyltin. Anti-fouling paint containing tributyltin is not available for sale on either side of the border. Both countries issue IAFS certificates to their flag state vessels and incorporate the IAFS in their respective Port State Control enforcement programs.

Addressing the discharge of Aquatic Invasive Species in the Ballast Water from vessels.

- The risk of the introduction of aquatic invasive species (AIS) to the Great Lakes via ballast water discharges from vessels arriving from outside of Canada's Exclusive Economic Zones[1] has been substantially reduced. Because of compatible ballast water exchange regulations between Canada and the United States and stringent binational enforcement, no new AIS attributable to the ballast water of these ships has been reported in the Great Lakes since 2006. For the past several years, the Ballast Water Working Group[2] has examined 100% of these vessels. During these ballast management exams, 100% of the vessels' ballast tanks are examined to ensure that tanks have been fully exchanged or sufficiently flushed with sea water. Vessels that had not exchanged their ballast water or flushed their ballast tanks were required to either retain the ballast water and residuals onboard, treat the ballast water in an environmentally sound and approved manner, or return to sea to conduct a ballast water exchange. Vessels that were unable to exchange their ballast water or residuals and that were required to retain them onboard received a verification exam during their outbound transit, prior to exiting the Seaway. The Ballast Water Working Group verification efforts indicated that there was no non-compliant ballast water discharged in the Great Lakes. The Ballast Water Working Group annual reports for the past three years can be accessed at:
    - http://www.greatlakes-seaway.com/en/pdf/2014_BW_Rpt_EN.pdf
    - http://www.greatlakes-seaway.com/en/pdf/2013_BW_Rpt_EN.pdf
    - http://www.greatlakes-seaway.com/en/pdf/2012_BW_Rpt_EN.pdf

- Significant work is underway to move the current exchange-based programs to binationally compatible technology-based regimes that will require treatment of all ballast water to a common discharge standard and address the risk of spreading organisms. As agreed in the 2012 GLWQA, both Parties are taking into account, as appropriate, the standards set forth in the International *Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004* (the "BWM Convention") and its associated guidance. Canada has acceded to the BWM Convention while the United States Environmental Protection Agency, the United States Coast Guard, and the American Great Lakes States have established requirements under the *National Invasive Species Act* and the *Clean Water Act.* While there are differences between these approaches, the United States and Canada continue to work closely together – including bilaterally through annual meetings of the responsible authorities outlined in the Discharges from Vessels Annex and at the International Maritime Organization – towards maintaining compatible, fair, practicable and environmentally protective ballast water requirements in both countries.

Preventing the discharge of Biofouling from vessels.

- Both Canada and the United States have participated in the development of the International Maritime Organization's *2011 Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species*.

[1] In relation to the Great Lakes, the Exclusive Economic Zones stretches 200 nautical miles from Atlantic coast and includes the Gulf of St. Lawrence.

[2] The Ballast Water Working Group is comprised of representatives from the United States Coast Guard, the U.S. Saint Lawrence Seaway Development Corporation, Transport Canada, and the Canadian St. Lawrence Seaway Management Corporation. Created in 2006, the group's mandate is to develop, enhance, and coordinate binational compliance and enforcement efforts to reduce the introduction of aquatic invasive species by transoceanic ships via ballast water and residuals.

DOMESTIC ACTIONS TAKEN

Ballast Water

- Were the BWM Convention to enter into force now, technical and regional compatibility factors would pose challenges to ships operating primarily on the Great Lakes-St. Lawrence Seaway system. As this Convention has not yet entered into force, Canada will continue to monitor these challenges and is considering options in case these challenges persist upon the Convention's entry into force. Canada remains committed to the Convention and will continue to work with the United States and other stakeholders towards compatible, fair, practicable and environmentally protective Great Lakes requirements meeting Canada's international obligations.

- Canada also continues to actively conduct ballast water research applicable to the Great Lakes. Results of a recent national risk assessment indicate that the ballast water transported by Great Lakes ships poses a high risk for spreading aquatic invasive species between ports in Canada and the United States when compared with the ballast water transported by international vessels (which are subject to regulations in both countries focused on lowering the risk of introductions from foreign ports). The following ballast water research studies undertaken by Canada since 2012:
  - Combining ballast water exchange and treatment to maximize prevention of species introductions to freshwater ecosystems (http://pubs.acs.org/doi/abs/10.1021/acs.est.5b01795)
  - Are the Great Lakes at risk of new fish invasions from trans-Atlantic shipping? (http://www.sciencedirect.com/science/article/pii/S0380133015001422)
  - Relative Invasion Risk for Plankton across Marine and Freshwater Systems: Examining Efficacy of Proposed International Ballast Water Discharge Standards (http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0118267)
  - National risk assessment for introduction of aquatic nonindigenous species to Canada by ballast water (http://www.dfo-mpo.gc.ca/csas-sccs/Publications/ResDocs-DocRech/2013/2013_128-eng.html)
  - Evaluating efficacy of a ballast water filtration system for reducing spread of aquatic species in freshwater ecosystems (http://www.reabic.net/journals/mbi/2014/3/MBI_2014_Briski_etal.pdf)
  - Domestic ships as a potential pathway of nonindigenous species from the St. Lawrence River to the Great Lakes (http://link.springer.com/article/10.1007%2Fs10530-013-0537-5)
  - Physical dispersion and dilution of ballast water discharge in the St. Clair River: Implications for biological invasions (http://onlinelibrary.wiley.com/doi/10.1002/wrcr.20201/abstract)
  - Taxon- and vector-specific variation in species richness and abundance during the transport stage of biological invasions (http://www.aslo.org/lo/toc/vol_58/issue_4/1361.html)
  - A multi-dimensional approach to invasive species prevention (http://pubs.acs.org/doi/abs/10.1021/es3029445)

- Role of domestic shipping in the introduction or secondary spread of nonindigenous species: biological invasions within the Laurentian Great Lakes (http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2664.2012.02186.x/full)
- Efficacy of NaCl brine for treatment of ballast water against freshwater invasions (http://www.sciencedirect.com/science/article/pii/S0380133011002176)
- Risk assessment for ship-mediated introductions of aquatic nonindigenous species to the Great Lakes and freshwater St. Lawrence River (http://www.dfo-mpo.gc.ca/csas-sccs/Publications/ResDocs-DocRech/2011/2011_104-eng.html).

UNITED STATES

Oil and Hazardous Substances

- On August 28, 2015, the marine archaeological group, Cleveland Underwater Explorers (CLUE), discovered the barge ARGO (which had sunk during a storm in 1937 while carrying approximately 200,000 gallons of petroleum product – believed to be benzol and/or a light petroleum variant) approximately nine miles east of Kelleys Island and two miles south of the international border with Canada in approximately 13 meters of water. On September 8, 2015, CLUE notified the United States Coast Guard of the discovery. The GLEC was notified of a suspected minor discharge of product from the barge in accordance with Article 6 (a) of the 2012 GLWQA, and soon after, a Unified Command consisting of the Ohio Environmental Protection Agency and the United States Coast Guard was established. Assistance was provided by the United States Environmental Protection Agency, Ohio Department of Natural Resources, National Oceanic and Atmospheric Administration, Ohio Emergency Management Agency, Canadian Coast Guard, and Environment and Climate Change Canada. Over the following six weeks, the Unified Command oversaw the survey of the tank barge, preparations for the safe removal of several thousand gallons of a benzene-type hazardous substance from two of the barge's tanks.

Ballast Water

- The United States Coast Guard continues to implement its rulemaking that established a performance standard for the allowable concentration of living organisms in ballast water discharged from ships in waters of the United States. Five independent laboratories are in the process of testing 18 systems for type approval[3]. Numerous additional vendors have filed a Letter of Intent to begin type approval testing.
- Additionally, the Coast Guard currently has issued 56 interim Alternative Management System determinations for ballast water treatment systems and the Coast Guard expects type approval applications from several of these manufacturers. These designations are intended as a bridging strategy to allow for the use of Ballast Water treatment systems that are type-approved by foreign administrations in accordance with the International Maritime Organization Ballast Water

[3] Type Approval is the primary process for equipment and materials to receive United States Coast Guard approval. See http://www.uscg.mil/hq/cg5/cg5214/eqpt_approval.asp for further information.

Management Convention of 2004.

- The first four ballast water management systems (BWMSs) type approval applications submitted to the Coast Guard proposed using an alternative test method of determining the efficacy of the ultraviolet BWMSs. A subsequent Coast Guard review concluded that the alternative test method was not equivalent because it does not measure the efficacy of the BWMSs to the required performance standard required by the regulations and the BWMSs were not approved.

- Through the Great Lakes Restoration Initiation, the United States supported the independent performance testing of ballast water systems for use in freshwater ecosystems. During 2013 to 2015, over 20 ballast water systems were tested at the Great Ships Initiative facility in Superior, Wisconsin. The Great Ships Initiative (www.greatlakesinitiative.org) mission is to accelerate research, development and implementation of effective ballast water management systems (BWMSs) on board commercial vessels that visit the Great Lakes region from abroad.

- In addition, the following ballast water research studies undertaken by the United States:
  - Investigation Of Ballast Water Treatment's Effect On Corrosion (http://www.dtic.mil/get-tr-doc/pdf?AD=ADA613423)
  - Ballast Water Treatment, U.S. Great Lakes Bulk Carrier Engineering and Cost Study, Volume 1: Present Conditions (http://www.dtic.mil/get-tr-doc/pdf?AD=ADA589870)
  - Ballast Water Treatment, U.S. Great Lakes Bulk Carrier Engineering and Cost Study, Volume 2: Analysis of On-Board Treatment Methods, Alternative Ballast Water Management Practices, and Implementation Costs (http://www.dtic.mil/get-tr-doc/pdf?AD=ADA589362)
  - Results of Shipboard Approval Tests of Ballast Water Treatment Systems in Freshwater (http://www.dtic.mil/get-tr-doc/pdf?AD=ADA613767)
  - Efficacy of Ballast Water Treatment Systems: A Report by the EPA Science Advisory Board (http://www.dtic.mil/get-tr-doc/pdf?AD=ADA550605).

AQUATIC INVASIVE SPECIES ANNEX

OVERVIEW

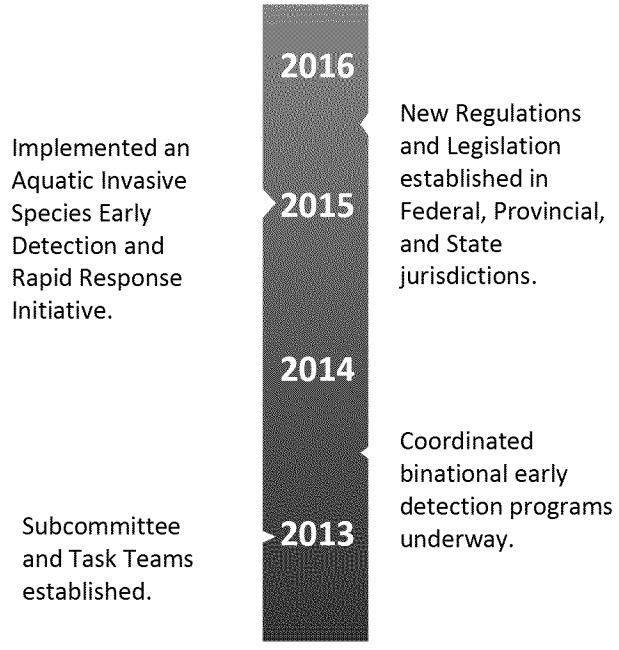
Aquatic invasive species (AIS) currently in the Great Lakes are undermining efforts to restore and protect ecosystem integrity and water quality. These organisms are altering the way nutrients and chemical contaminants move within the ecosystem, affecting the productivity of the lakes and integrity of the aquatic food web.

In addition, possible future invaders, such as Asian Carps, could further disrupt ecosystem integrity.

After invasive species become established in the Great Lakes, they are costly to control and nearly impossible to eradicate. Consequently, prevention is the most effective approach to dealing with this threat. The 2012 GLWQA commits the United States and Canada to: 1) preventing the introduction of AIS; 2) controlling or reducing the spread of existing AIS; and 3) eradicating, where feasible, existing AIS within the ecosystem.

The United States and Canada are working to minimize the risk of Asian carps and other species invading the Great Lakes by a combination of species and pathway risk assessment and by implementing risk management actions. A second line of defence has been also created by establishing an early detection and rapid response initiative with the goal of finding new invaders and preventing them from establishing self-sustaining populations. This basin wide effort resulted in several new detections of grass carp and associated agency rapid responses. As a result of actions undertaken during the previous three years, no new AIS are known to have become established in the Great Lakes. However, the recently detected evidence of Grass Carp reproduction in the Sandusky River, a tributary to Lake Erie in north-central Ohio in the United States, is of great concern. The United States and Canada are committed to further improving and strengthening the AIS actions and initiatives under the Aquatic Invasive Species Annex.

PROGRESS TOWARD MEETING GLWQA COMMITMENTS



This Annex is being implemented by the Aquatic Invasive Species (AIS) Annex Subcommittee, co-led by the United States Fish and Wildlife Service and Fisheries and Oceans Canada. The AIS Annex Subcommittee delivers its work in close cooperation with the Great Lakes Panel on Aquatic Nuisance Species, which is supported by the Great Lakes Commission and is partially funded by the United States Fish and Wildlife Service. Organizations on the subcommittee include: [Insert logos from: Fisheries and Oceans Canada, U.S. Fish and Wildlife Service, 1854 Treaty Authority, Canadian Aquatic Invasive Species Network, Chippewa-Ottawa Resource Authority, First Nation / Metis – Chiefs of Ontario, Great Lakes Indian Fish and Wildlife Commission, Great Lakes Commission, Great Lakes Fishery Commission, Great Lakes St. Lawrence Cities Initiative, Michigan Department of Environmental Quality, Minnesota Department of Natural Resources, New York Department of Environmental Conservation, Ohio Department of Natural Resources, Ontario Federation of Anglers and Hunters, Ontario Ministry of Natural Resources, Ontario Invasive Species Centre, The Nature Conservancy, U.S. Environmental Protection Agency, and U.S. National Oceanographic and Atmospheric Administration.]

BINATIONAL ACTIONS TAKEN

Conducting risk assessments on Aquatic Invasive Species for their entry into the Great Lakes.

- The United States and Canada undertook an assessment of existing species risks assessments, in coordination with Great Lakes jurisdictions and their partners. Based on this analysis, a binational assessment of the ecological risks and impacts related to Grass Carp establishment was completed, and is being peer reviewed.

- Members of the Aquatic Invasive Species Annex Subcommittee are also supporting work of the Conference of Great Lakes Governors and Premiers Aquatic Invasive Species Task Group to harmonize species risk assessments across the basin.

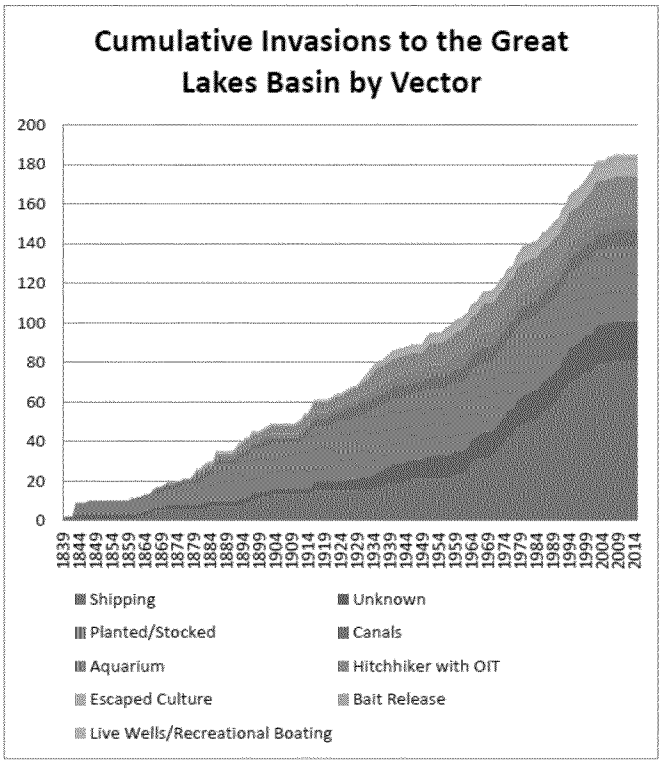
- A risk analysis of illegal trade and transport into Great Lakes jurisdictions was completed and a report of these findings was delivered to the Great Lakes Fishery Commission's binational Law Enforcement Committee. The report recommends risk management efforts to address the unacceptable risks documented for species regulated by state, provincial, and federal agencies in the internet, live bait, live food, aquaculture, private pond/lake stocking, water garden, aquarium/pet, and cultural release pathways. The AIS Subcommittee will continue to work with the Law Enforcement Committee to address risk management needs described in the risk analysis report.

- A new web-based tool called, *Great Lakes Detector of Invasive Aquatics in Trade*, has been developed by the Great Lakes Commission to better quantify the threat posed by the internet commerce pathway. The tool is available to managers in the United States and Canada to inform and help target risk assessment, monitoring and surveillance, and enforcement.

- In the United States, a government-industry partnership is working toward development of new U.S recreational boat design standards for building new "AIS-Safe Boats," and development of U.S. standards for AIS removal from existing recreational boats.
- In Canada, a National Recreational Boating Risk Assessment, with focus on the potential movement of AIS within Canadian and United States waters of the Great Lakes, was carried out during 2015, and the products of this assessment will assist in identifying areas to focus on minimizing risk of recreational boaters spreading AIS.

Success preventing invaders

Historically, an average of one non-native species was found to be established in the Great Lakes about every 8 months. Most of those introductions resulted from ballast water discharge. No ballast-mediated introductions, and no additional introductions from other pathways, have resulted in establishment of a non-native species since 20088. The success of joint United States and Canada ballast water exchange management has been a major contributor, with no new introductions attributable to ships since 2006.



Source R. Sturtevant, GLANSIS-NOAA

Undertaking outreach and engagement in support of meeting various annex commitments.

- While most outreach and engagement efforts are implemented domestically, experts from government agencies and non-government groups are working across jurisdictional lines to share resources and approaches that modify human behavior so as to minimize risk of people spreading AIS.

- To support this work, the binational Great Lakes Panel on Aquatic Nuisance Species' Information and Education Committee developed a synthesis of communication and education campaigns, programs, and products, which support prevention efforts for a variety of pathways, including recreational boating.

By 2015, develop and implement an Aquatic Invasive Species early detection and rapid response initiative.

- The United States and Canada developed an AIS early detection and rapid response initiative as a part of a number of strategies being applied to prevent the introduction and spread of AIS. Early detection and rapid response provide a strong second line of defense to prevention efforts by finding AIS populations, including Asian Carps, while they are still within a small area and preventing them from becoming established. This effort marks the first basinwide early detection effort in the history of the Great Lakes, an effort that will be strengthened and enhanced in the future. A full account of the achievements to date under the initiative is available at www.binational.net (http://binational.net/2015/02/23/ais-early-detection/).
- Key components of the AIS early detection and rapid response initiative include:
    - An "AIS species watch list" of those species of the highest priority of risk of invading the Great Lakes.
    - A list of priority locations to undertake surveillance for the potential introduction of species on the "AIS species watch list";
    - Protocols for monitoring and surveillance methodologies (such as environmental DNA sampling and sampling using gears that collect fishes and bottom-dwelling invertebrates) so that a potential invader is promptly observed and reported;
    - The sharing of relevant information amongst the responsible departments and agencies to ensure prompt detection of invaders and prompt actions to respond to them; and
    - The coordination of plans and preparations for any response actions necessary to prevent the establishment of newly detected AIS.

- Asian carps are a key focus for binational early detection and rapid response with priority assessment locations established guided by risk assessments, with shared protocols for sampling, coordinated communication of detection results, and response planning efforts.

- Detections of Asian Carps in Canadian waters triggered several coordinated response efforts under the incident command system. Those responses successfully tested the Canadian domestic response framework.

- The Conference of Great Lakes Governors and Premiers has also provided critical leadership with the establishment of their Mutual Aid Agreement as the basis for the states and provinces to share resources to deal with AIS.

Implementing early detection and rapid response.

- [Placeholder for additional text to come/decision on adapting and moving text below "A performance evaluation of…": Lake Superior lake-wide early detection efforts. States, tribes, United States Fish and Wildlife Service and Ontario are carrying out a coordinated early detection effort on Lake Superior.]

Conducting research to develop and test Aquatic Invasive Species detection, containment, and control technologies.

- The sea lamprey mating pheromone, 3kPZS, was official registered in the United States and Canada as the first ever vertebrate pheromone biopesticide. Like an alluring perfume, the mating pheromone is a scent released by male sea lampreys to lure females onto nesting sites. The pheromone could be used to lure male sea lamprey into traps. Research and development of the mating pheromone was funded by the Great Lakes Fishery Commission, with additional support from the Great Lakes Restoration Initiative, in collaboration with federal governments, university, and private industry partners.

DOMESTIC ACTIONS TAKEN

Conducting risk assessments on Aquatic Invasive Species for their entry into the Great Lakes.

- Approximately 160 risk assessments were conducted by the United States on non-native species and published on www.fws.gov (http://www.fws.gov/fisheries/ANS/species_erss_reports.html) These risk assessments have identified high risk fish, crustaceans, and mollusks that thrive in climates similar to the Great Lakes Basin and could become established if they are introduced in large enough numbers.

- The risk of barge shipping-related transport of fishes, within the Chicago Area Waterway System, was evaluated, and the resulting report delivered to the Asian Carp Regional Coordinating Committee. Results indicate that free-swimming surrogate fish, both wild fish and fish placed in and around barges by researchers, can remain between barges for substantial distances. In one trial, live fish were transported more than nine miles on the Illinois River through Brandon Road Pool,

Lockport Lock, and the United States Army Corps of Engineers' electric dispersal barriers. Further studies on the susceptibility of actual juvenile Asian carp to becoming entrained, methods to clear these junctions of all fish, and improvements in barge operation best management practices are being pursued to reduce this risk.

Preventing introduction and spread of Aquatic Invasive Species through regulations.

- Based on risk assessments and supporting science, the state of Michigan amended its prohibited species list to include several new invasive species. Additional information can be found at: http://www.michigan.gov/invasives/0,5664,7-324-68071---,00.html.

- The United States Fish and Wildlife Service has proposed adding 11 non-native freshwater species to the list of injurious species under the Lacey act. Ten fishes (Crucian Carp, Eurasian Minnow, Prussian Carp, Roach, Stone Moroko, Nile Perch, Amur Sleeper, European Perch, Zander, Wels Catfish) and one crayfish (common yabby) are included in the proposed rule making. A final rule is planned for release in 2016.

Implementing early detection and rapid response.

- Great Lakes states are have been actively monitoring and responding to detections of invasive species, including recent responses for invasive Water lettuce, New Zealand Mudsnail, Parrot Feather, Red Swamp Crayfish, Water Hyacinth, Water Chestnut, European Frogbit, Starry Stonewort, Northern Snakehead, and small killifish (Mummichog).

- The invasive species Hydrilla was discovered in the Cayuga Lake Inlet and Erie Canal, New York. An aggressive eradication projects started at both of these locations in response to concerns about the spread of this invasive plant species throughout the Great Lakes basin. Despite signs of a successful control, eradication may take several more years due to ability of root systems to lay dormant in the sediment. More information about Hydrilla can be found at http://stophydrillawny.org/.

- A performance evaluation of early detection monitoring surveillance programs on Lake Superior revealed new opportunities to substantially increase the speed and sensitivity of detecting newly-introduced species. By focusing efforts on areas within ports known to carry rare and invasive species, and by increasing the use of sampling equipment that captures a wide diversity of organisms, the effectiveness at detecting invasive species has nearly doubled. To continue improvement in the future, the United States Environmental Protection Agency and United States Fish and Wildlife Service have implemented an adaptive cycle of surveillance assessment, refinement, and implementation.

Conducting research to develop and test Aquatic Invasive Species detection, containment, and control technologies.

- The Great Lakes Restoration Initiative provides support to the multi-agency and binational Asian Carp Regional Coordinating Committee, which has implemented the Asian Carp Control Strategy

Framework — including surveillance, response actions and testing of new control technologies. More information about the Asian Carp Regional Coordinating Committee is available at http://www.asiancarp.us.

- U.S. federal partners supported the development and testing of a near-real-time environmental DNA surveillance tool that is being used to support law enforcement efforts for interdicting illegal transport of Asian carp species into Great Lakes jurisdictions.
- The United States tested the use of carbon dioxide as an environmentally sound approach to help contain Asian carps in the Mississippi River system. The results demonstrate that this containment technology may help at limiting the spread of Asian carps.
- Work was initiated in the United States on the development and testing of a system to deliver a piscicide (Antymicin) that can kill Bighead and Silver Carps while not harming other fishes. This technology could be used to reduce populations in the Chicago Area Waterway System and Illinois River, which would further reduce the risk of Asian carp establishment in the Great Lakes.

- New molecular genetic techniques are being developed for detecting rare invasive species. Current research efforts funded by the Great Lakes Restoration Initiative (GLRI) have focused on: 1) expanding the use of environmental DNA (i.e. "free" DNA found in water); 2) genetic analyses of larval fish samples to detect the reproduction of invasive fishes; and 3) genetic analyses of lake sediments or benthos for detection of invasive species such as the Zebra Mussel, Quagga Mussel, and New Zealand Mudsnail. The current trend of advancing molecular genetic methods coupled with decreasing costs is highly promising.

- Based on extensive testing, the commercial product "Zequanox" was approved for open-water use to control invasive Zebra and Quagga mussels in lakes and rivers. U.S. agency and academic partners are exploring its strategic use in the Great lakes and inland lakes. Zequanox is composed of dead cells derived from a naturally occurring soil microbe, and it controls invasive mussels in all life stages. Its active ingredient has low toxicity and presents little risk to non-target organisms.

- The United States is funding and supporting new methods to control the spread of invasive *Phragmities* including:
  - Research at Cornell University to identify insects that kill *Phragmites*. The researchers are evaluating the host-specificity of each insect species in preparation for wide-spread releases of insects that may help control *Phragmites* populations.
  - Work by the United States Geological Survey and its partners to identify the fungal microbes that help provide nutrients to nonnative Phragmites, and work to find ways to slow Phragmites growth by disrupting this symbiotic relationship.
  - Work by Wayne State University and United States Geological Survey scientists to silence important genes in Phragmites (e.g., those for flowering, seed set, and photosynthesis) in an effort to reduce its competitive advantage. Cooperating scientists are testing gene silencing of photosynthesis in *Phragmites*. The next step will be to test the technology in the field and develop an application method that will be feasible over a large scale.
  - More information about Phragmities can be found at http://greatlakesphragmites.net/research/control-options/.

Assessing the potential impacts of climate change on Aquatic Invasive Species.

- A climate change projection tool was developed that can project the AIS climate niche, within the Great Lakes basin, under several climate change scenarios published by the Intergovernmental Panel on Climate Change (http://www.ipcc.ch/) for the years 2050 and 2070.

CANADA

Conducting risk assessments on Aquatic Invasive Species for their entry into the Great Lakes.

- During 2013, a national risk assessment of ballast water introductions of AIS species was completed with focus on the Great Lakes and St. Lawrence River. That risk assessment identified the need to reduce risk by incorporating ballast water treatment into systems of ships that discharge ballast into the Great Lakes.

- During 2013, a peer review of available tools was carried out, and science advice was published, about screening-level risk assessment protocols for nonindigenous freshwater organisms in trade in Canada that provides guidance to evaluating risks to support prevention actions.

Preventing introduction and spread of Aquatic Invasive Species through regulations.

- With extensive public and government consultation, Canada established new aquatic invasive species regulations under the Fisheries Act in June 2015 creating new prohibitions for species based on risk and enabling new measures for prevention and control of AIS in Canada and at its borders.

- The Province of Ontario, based on broad stakeholder input, gave royal assent in November 2015 to Bill 37 – the new Invasive Species Act – which will come into force within one year, providing tools and authorities needed to prevent and respond to all invasive species including prohibitions for high risk species.

Implementing early detection and rapid response.

- Canada, working closely with Ontario and United States jurisdictions, has delivered its Asian Carp Program based on four pillars: prevention, early warning, response, and management. The program includes extensive early detection surveillance activities in close conjunction with environmental DNA monitoring carried out by Ontario. More information can be found at http://asiancarp.ca/.

- Canada, in coordination with the Ontario Federation of Anglers and Hunters, the Invasive Species Centre, and Royal Ontario Museum carried out a large-scale outreach campaign specific to raise awareness and public understanding of best practices to prevent transporting Asian carps.

- Findings of Grass Carp in lakes Erie and Ontario between 2013 and 2015 have triggered successful coordinated response efforts under the incident command system testing the domestic response framework established for Asian carps.

- [Placeholder for additional text to come: Invading plant species have initiated response efforts. Water Soldier in the Trent River. Water Chestnut in Lake Ontario.]

Conducting research to develop and test Aquatic Invasive Species detection, containment, and control technologies.

- Research has been completed about the capacity for invasive fish species, including Asian Carp, to move through the Welland Canal and the St. Mary's River canals to help better understand the risk of spread and opportunities for control.

- Research on repulsion devices to potentially contain and control fish species, including Asian carps, has been carried out in a large-scale mesocosm.

- Canada continues to actively research monitoring and treatment technologies to advance efforts to prevent AIS movement in the ballast water of ships.

[Placeholder for additional text to come: Molecular techniques – CDN research by OMNRF.]

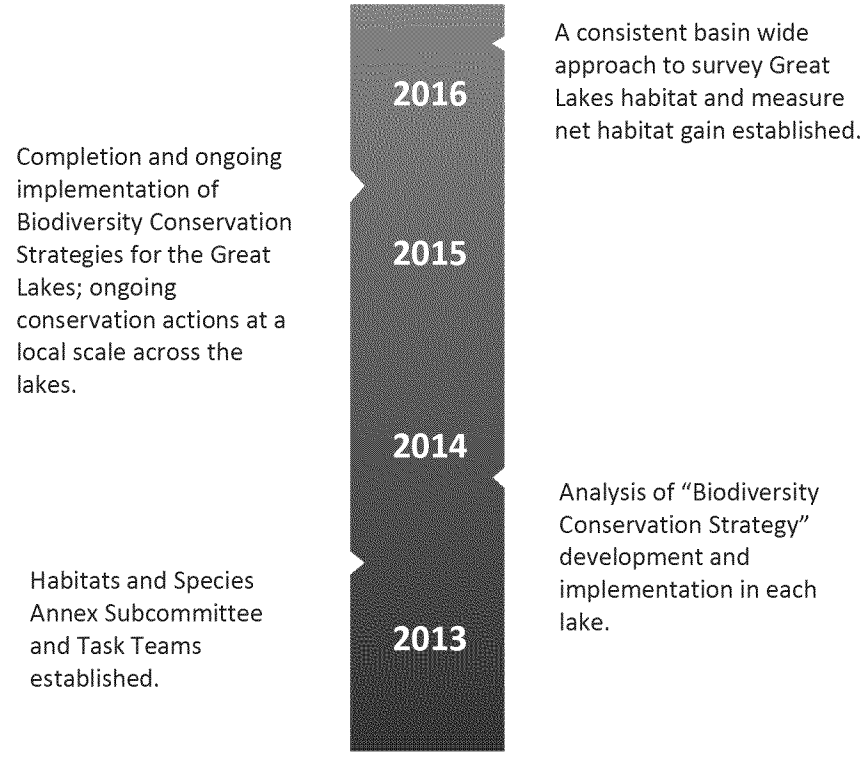
HABITAT AND SPECIES ANNEX

OVERVIEW

The Great Lakes basin is surrounded by more than 10,000 miles of shoreline that supports globally rare habitats and species. The Great Lakes ecosystem's sand dunes, coastal marshes, rocky shorelines, lakeplain prairies, savannas, forests, fens, wetlands and other landscapes contain features that are unique to the basin and support numerous fish and wildlife species. These expansive habitats and numerous native species face a range of ecological threats impacting both aquatic and terrestrial domains.

The 2012 GLWQA commits Canada and the United States to conserve, protect, maintain, restore and enhance the resilience of native species and their habitats. Actions taken by the Parties are contributing to the recovery of populations of species at risk and the restoration of degraded native habitat and species.

PROGRESS TOWARD MEETING GLWQA COMMITMENTS

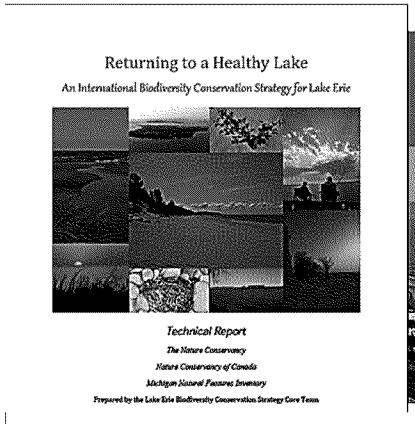


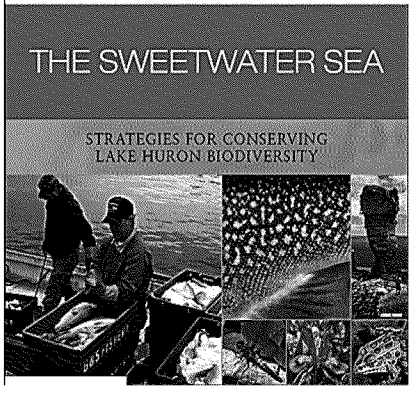
This Annex's implementation is supported by the Habitat and Species Annex Subcommittee, co-led by Environment and Climate Change Canada and the United States Fish and Wildlife Service. Organizations on the subcommittee include: [Confirm and insert logos from: Environment and Climate Change Canada; United States Fish and Wildlife Service; United States Environmental Protection Agency; United States National Oceanic and Atmospheric Administration; United States Geological Survey; Parks Canada;

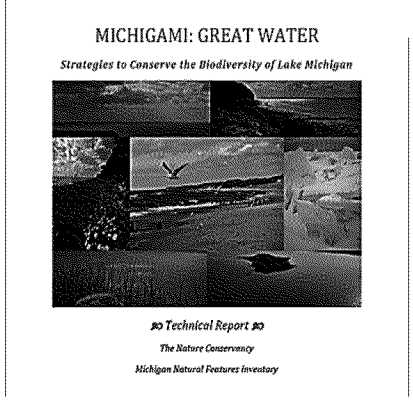
Ontario Federation of Anglers and Hunters; New York State Department of Environmental Conservation; Ontario Ministry of Natural Resources and Forestry; Michigan Department of Natural Resources; United States National Park Service; Indiana Department of Environmental Management; Wisconsin Department of Natural Resources; United States Army Corps of Engineers; Great Lakes Fishery Commission; Fisheries and Oceans Canada.]

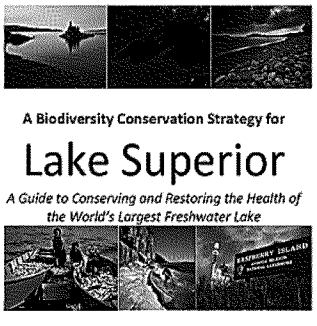
BINATIONAL ACTIONS TAKEN

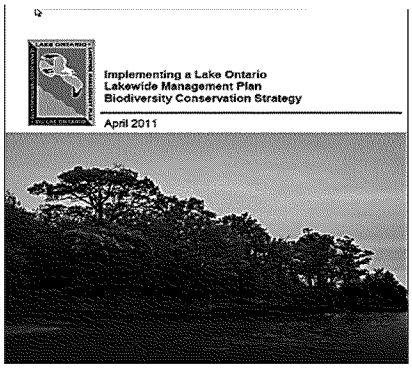
By 2015, develop Biodiversity Conservation Strategies for all of the lakes, including connecting channels, and begin implementing priority actions identified in the Strategies through existing programs and agreements.











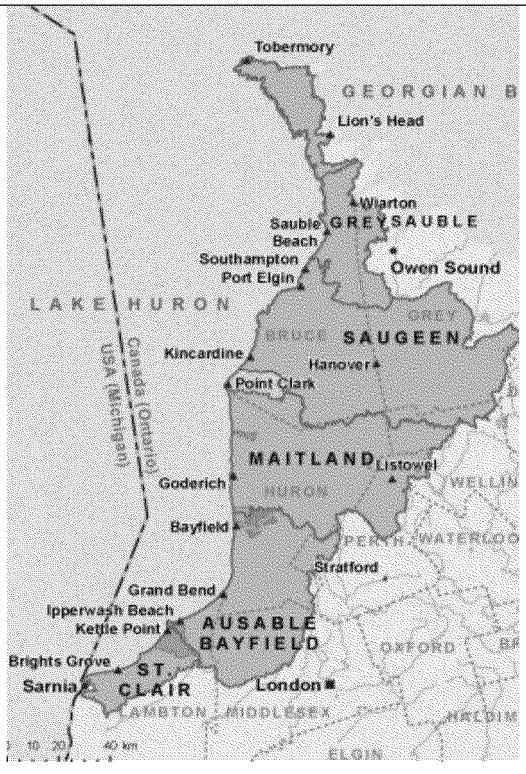
- Lakewide habitat and species protection and restoration conservation strategies, also called Biodiversity Conservation Strategies (Strategies), were developed for all five of the Great Lakes as of February 12, 2015. The Strategies assess the status and threats to lakewide biodiversity and recommend conservation priorities for native species and their habitats. The Executive Summaries are available on binational.net (www.binational.net/2015/02/23/habitat-and-species-strategies).

- Each Strategy is a product of extensive collaboration among lakewide regional and local stakeholders. They serve as tools to foster and guide shared implementation of priority conservation actions among federal, state, provincial, tribal, academic, municipal and watershed management agencies. Adaptive management is applied to the planning, application and

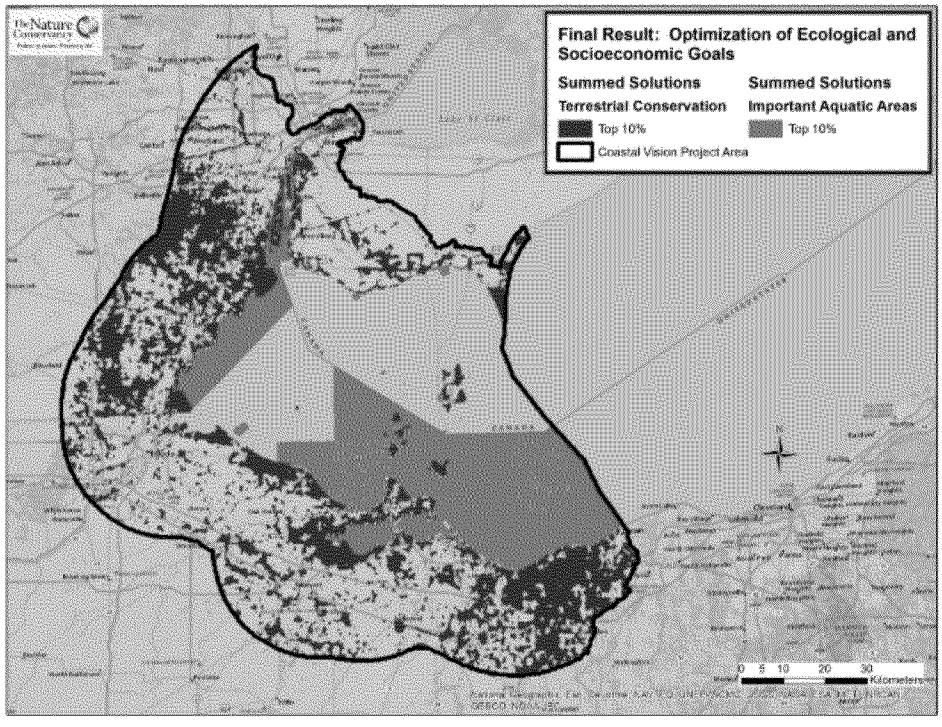
implementation of the Strategies across the lakes.

- The Lake Superior Partnership is currently preparing watershed-level plans to further guide and support implementation of the recently released (2015) Biodiversity Conservation Strategy at a local level. The Lake Ontario Partnership used the broader Lake Ontario Biodiversity Strategy to produce an implementation plan to focus effort on priority actions. Other Lake Partnerships are promoting implementation by identifying regional scale and watershed based biodiversity objectives and outlining the specific actions required to address habitat and species issues on a sub-basin scale.

- Table X illustrates several examples of how the Strategies are being used in each lake basin to inform and implement priority conservation actions.

Lake Huron: Healthy Lake Huron Healthy Lake Huron is a team of dedicated Canadian environmental professionals who coordinate actions aimed at improving overall water quality along the southeast shores of Lake Huron. Healthy Lake Huron is taking actions to address the issue of non-point source pollution, which has been identified as a critical threat in their Biodiversity Conservation Strategy.	 Membership of the Healthy Lake Huron group (www.healthylakehuron.ca)
Lake Superior: Superior Streams The Lake Superior Biodiversity Conservation Strategy classified dams and barriers as a high threat to meeting biodiversity targets. Dams and barriers are also critical in prevention of spread of aquatic invasive species. For example, the	

pictured dam on the Black Sturgeon River is identified as limiting Lake Sturgeon and Walleye spawning habitat but is also critical preventing significant Sea Lamprey infestation. Critical work on understanding these trade-offs is underway by Lakehead University and by the Aquatic Habitat Connectivity Collaboration supported by the Great Lakes Fishery Commission. Decisions about maintaining or removing dams require the necessary engagement with all stakeholders and Indigenous peoples to ensure that all views and objectives are considered.	The Camp 43 Dam on the Black Sturgeon River, Ontario (Photo Credit: Ontario Ministry of Natural Resources and Forestry)
Lake Ontario: Bloater Fish Stocking In Lake Ontario, the Binational Lake Partnership identified the restoration of native preyfish species as a priority for the implementation of the Biodiversity Conservation Strategy. Canadian and United States agencies have initiated a program to reintroduce bloater to the lake in 2012. The program is ongoing, and nearly 62,000 bloaters were released in November, 2015.	Dale Hanson from the Green Bay Fish and Wildlife Conservation Office assists with bloater egg collection (Photo Credit: United States Fish and Wildlife Service)
Lake Michigan: Lake Herring Restoration	

Restoration of the native Lake Herring is a priority identified in the Lake Michigan Biodiversity Conservation Strategy. To help restore the species to its historical status as a primary prey fish in Lake Michigan, the Little Traverse Bay Bands of Odawa Indians released nearly 50,000 summer fingerling and 8,000 fall fingerling into Little Traverse Bay, Michigan, in 2014. The Little Traverse Bay Bands of Odawa Indians is currently evaluating the success of the fingerling releases.	Lake Herring (Photo Credit: United States Environmental Protection Agency)
Lake Erie: Western Basin Conservation Vision Targets and goals from the Lake Erie Biodiversity Conservation Strategy were used in the development of a regional implementation plan called the Western Basin Conservation Vision. This plan identifies and maps areas to focus local conservation investments to meet regional conservation goals.	 Final Results of the Optimization of Ecological and Socioeconomic Goals (https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/wholesystems/greatlakes/coasts/wle/Pages/default.aspx)

Conducting a baseline survey of the existing habitat against which to establish a Great Lakes Basin Ecosystem target of net habitat gain and measure future progress

- The Parties released a draft report titled *Conducting A Baseline Survey of Great Lakes Habitat: Assessing and Measuring Progress toward a Great Lakes Ecosystem Target of Net Habitat Gain,* released in May 2016, identifying an approach to measure baseline conditions of habitat and monitor change over time. The report was developed with support from experts and partners around the lakes through a series of binational workshops, meetings and webinars.

- The Baseline Survey approach is built upon existing Great Lakes monitoring programs and emphasizes the use of remotely sensed information for maximum data coverage. The physical characteristics of the lakes will be used to map different habitat types and the condition of the habitats will then be assessed. The baseline survey will be conducted on a reoccurring basis to track changes in the ecosystem over time and to monitor progress.

DOMESTIC ACTIONS TAKEN

CANADA

- Canada and Ontario have multiple programs that contribute to the ongoing goals of the Habitats and Species Annex. In addition, there are many non-governmental partners making significant contributions to habitat and species conservation, including the Nature Conservancy of Canada, Conservation Ontario and the many individual Conservation Authorities in the province, the Ontario Federation of Anglers and Hunters, Ducks Unlimited, and Stewardship Councils.

    - Canada's National Conservation Plan, which was launched in 2014, includes a $50 million National Wetland Conservation Fund to support on-the-ground action that restores drained, degraded or lost wetlands across the country. Funding support has been provided to 39 projects in the Great Lakes basin, supporting actions that restore, protect, and conserve habitats for waterfowl, waterbirds and shorebirds. In the 2014 to 2015 fiscal year, 135 hectares of wetland habitat were restored and 6,440 hectares of wetland habitat were enhanced.
    - The Lake Superior National Marine Conservation Area Legislation, received Royal Assent in 2015, establishing one of the world's largest fresh water marine protected areas. The Lake Superior National Marine Conservation Area encompasses a 10,000 square kilometer area of the biologically diverse lake and includes lakebed, islands, and shore lands. This project contributes to Canada's National Conservation Plan to conserve Canada's land and waters. The development of a management plan for this area by Parks Canada is ongoing.
    - In 2015, the Ontario Eastern Habitat Joint Venture (OEHJV) published a revised Implementation

Plan which defines the objectives, priorities, programs and actions that Ontario EHJV partners will work to achieve between 2015 and 2020 to conserve wetlands and migratory bird habitat in Ontario. Environment and Climate Change Canada supports OEHJV partners in the implementation of priority conservation programs, with a particular focus on wetlands and associated habitats identified within Ontario EHJV Priority Habitat Conservation Areas.

- Environment and Climate Change Canada completed biodiversity and aquatic habitat monitoring at more than 40 Great Lakes coastal wetlands each year, including surveys on fish, marsh birds, aquatic invertebrates, vegetation, and water quality. Additionally, Environment and Climate Change Canada developed GIS mapping products to support reporting of Great Lakes Basin biodiversity.
- The Government of Canada's Ecological Gifts program provides a way for Canadians with ecologically sensitive land to protect nature through donations of land, or a partial interest of land, for conservation in exchange for significant tax benefits. In the 2015 to 2016 year alone 26 Ecological Gifts were completed in the Great Lakes Basin for total of 1,247.48 hectares valued at $8,853,800.
- The Province of Ontario is implementing a Land Stewardship and Habitat Restoration Program. Since its 2013 launch, the program's $300,000 annual fund has helped improve, restore or create more than 4,662 acres of habitat including plantings of over 105,000 trees and shrubs, supporting the hiring of 182 people and leveraging over $2.3 million in project-partner funding.
- Fisheries and Oceans Canada supports habitat restoration and enhancement through its Recreational Fisheries Conservation Partnerships Program. The program was established in June 2013 to support multi-partner projects at the local level aimed at restoring recreational fisheries habitat in order to enhance the sustainability and productivity of Canada's recreational fisheries.

- In the United States, multiple federal and state agencies, as well as local and regional conservation entities, non-governmental organizations, and myriad conservation partners conduct a wide range of activities related to fish, wildlife and habitat. Many of these activities support goals and priorities of the Habitats and Species Annex. In addition to base-funded activities conducted by federal agencies, the Great Lakes Restoration Initiative (GLRI) has boosted funding in recent years to supplement agency budgets to allow them to pursue high priority conservation and restoration needs throughout the Great Lakes Basin, including fish and wildlife habitat.

- In 2015, GLRI agencies and their partners implemented 57 habitat and species projects resulting in more than 875 habitat and species projects underway or completed since the 2010 inception of the GLRI. Ten 2015 GLRI projects were directed towards protecting, restoring, and enhancing Piping Plover habitats. Over 40 projects have improved conditions for numerous federally and non-federally listed species in the Great Lakes such as Lake Sturgeon.

- GLRI funding implemented protection, restoration and enhancement projects that have reopened over 3,800 miles of Great Lakes tributaries, and increased aquatic connectivity for numerous fish

species. Additionally, more than 36,000 acres of habitat in targeted watersheds were protected, restored and enhanced in order to sustain Great Lakes habitats and species populations. 300 miles of Great Lakes shoreline and riparian corridors, and 7,000 acres of Great Lakes coastal wetlands were protected, restored, and enhanced in 2015 alone.

- GLRI partners have completed the removal of the Cass River Dam during 2015. The dam at Frankenmuth, Michigan initially blocked the passage of fish to more than 1,700 miles of upstream spawning habitat on the Cass River and connecting tributaries since it was built in the 1850s. It is now placed with a rock ramp with a series of rock weirs to allow passage of fish species, such as walleye and lake sturgeon. Fourteen separate weirs and adjacent "resting pools" have been constructed over a span of approximately 350 feet to provide a roughly 3% grade for non-jumping targeted species.

- In 2015, GLRI partners reconnected the previously isolated Ottawa National Wildlife Refuge wetlands to Crane Creek and Lake Erie in Ohio. For the first time since the 1940s, the reconnected wetlands now function as a productive spawning ground and nursery area. Less than one week after re-establishing connectivity, Longnose Gar were found spawning in one of the pools. Thirteen species of fish not previously found entered through the structure and actively use the reconnected wetlands.

- The Fond du Lac Band of Lake Superior Chippewa developed better ways to control water levels and protect sustainable wild rice populations with GLRI funds. Projects included water control structures, beaver dam removals and channel obstruction removal that resulted in the protection of 855 acres of ecologically and culturally important wild rice habitat on the Fond du Lac Reservation in northeastern Minnesota. Federal partners and local Chippewa removed 97 acres of competing aquatic plan species from Big Rice Lake and 59 acres of aggressive perennial vegetation from Perch Lake. In the St. Louis River Estuary partners reseeded 121 acres with wild rice. During the 2015 GLRI fiscal year, federal agencies and their partners restored and protected a total of 1,132 acres of wild rice habitat in Fond du Lac waters.

GROUNDWATER ANNEX

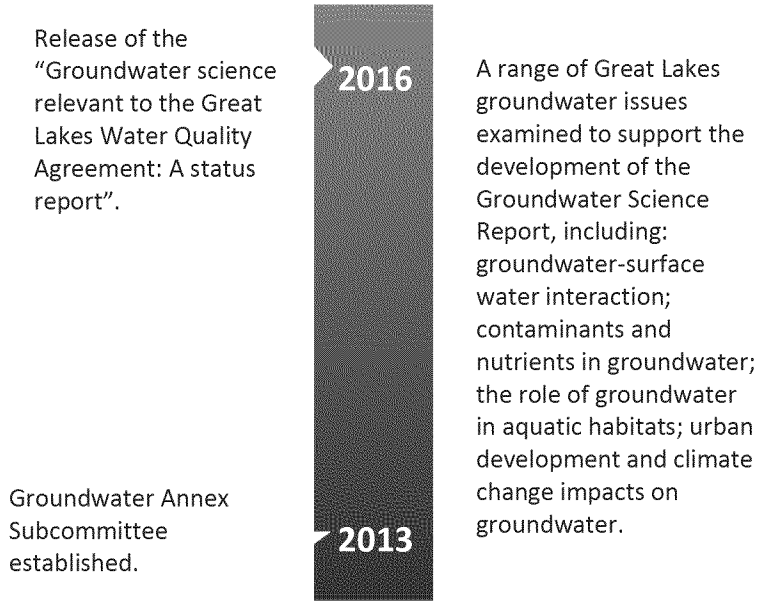
OVERVIEW

Understanding the extent of the impact that groundwater has on the chemical, physical and biological integrity of the Great Lakes is important for the long-term protection of the Great Lakes. Clean groundwater can enhance surface water quality and provide a protective treatment or storage zone; however, contaminated groundwater can act as a long-term source of pollutants and can adversely affect surface water quality. For the first time, the 2012 GLWQA recognizes the interconnection between groundwater and the waters of the Great lakes.

The 2012 GLWQA, commits the United States and Canada to coordinate scientific assessments of groundwater, in order to better understand how groundwater affects surface water quality and quantity, to coordinate groundwater management actions, and to protect and manage groundwater-related stresses affecting the waters of the Great Lakes.

As a first step in this process, the United States and Canada released a report on the relevant and available groundwater science in June, 2016.

PROGRESS TOWARD MEETING GLWQA COMMITMENTS



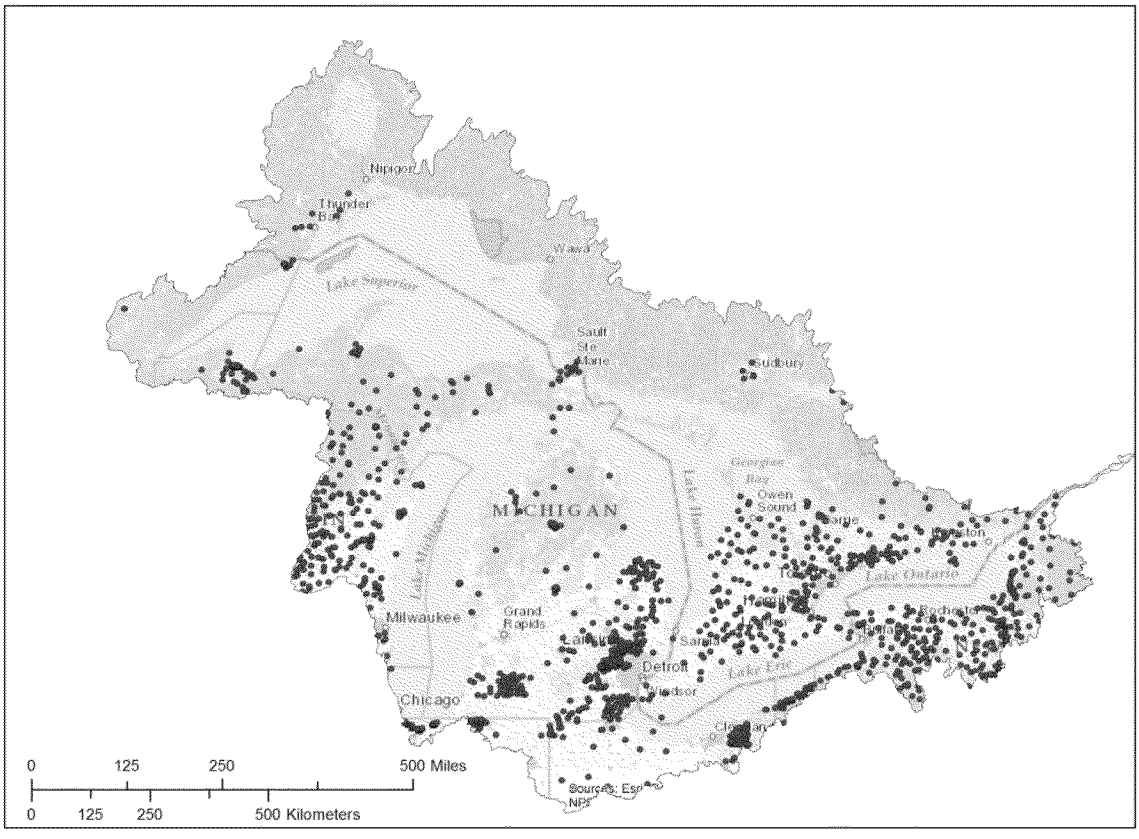


Figure x - Locations of monitoring wells in the Great Lakes basin with publicly available water quality analyses.

The implementation of this Annex is supported by the Groundwater Annex Subcommittee, co-led by the United States Geological Survey and Environment and Climate Canada. Organizations on the subcommittee include:

BINATIONAL ACTIONS TAKEN

By 2015, publish a report on the relevant and available groundwater science

- The Parties led the development of a report entitled, *Groundwater Science Relevant to the Great Lakes Water Quality Agreement: A status report*. The report was finalized and made available on http://binational.net/2015/12/03/groundwater-science/ in June 2016. This report on the relevant and available Great Lakes groundwater science was developed through extensive collaboration among experts in a variety of subject areas from Canadian and United States federal departments, the Province of Ontario, state agencies (Michigan Office of the Great Lakes, Ohio Environmental Protection Agency, Wisconsin Department of Natural Resources), Conservation Authorities, universities, and others. The report takes into account public comments received from

December, 2015 to the end of January, 2016.

- The report provides the current state of science on groundwater and its relation to Great Lakes water quality by examining various issues including: 1) the importance of groundwater-surface water interaction and interconnection; 2) contaminants and excessive nutrients in groundwater; 3) the influence of groundwater in providing aquatic habitats with a focus on Great Lakes nearshore areas, streams, and wetlands; and 4) the influence of urban development and climate change on groundwater quantity and quality. The Report also summarizes priorities for future groundwater science. This report provides a better basis and understanding of the issue of groundwater in the Great Lakes and its influence on the quality of the waters of the Great Lakes; helps assess whether groundwater improves or adversely impacts Great Lakes water quality; and, supports future groundwater science and management actions.

Identifying priorities for science activities and actions for groundwater management, protection, and remediation; and

Coordinating binational groundwater activities under the GLWQA with domestic groundwater programs to assess, protect and manage groundwater impacting the Waters of the Great Lakes.

- Information from the Groundwater Science Report will be used to draft the 2017-2019 Binational Groundwater Priorities for Science and Action, which will be presented for public input at the Great Lakes Public Forum in October, 2016.

- Consultations with other GLWQA Annex Subcommittees is underway to inform these 2017-2019 Binational Priorities; to determine if there needs to be a focus on coordinating specific binational groundwater activities; and to determine the need for surveillance of groundwater quality for priority areas.

- The United States and Canada, supported by a binational group of groundwater scientists, have initiated the development of a State of the Great Lakes Groundwater Indicator. Currently, nitrate and chloride data from groundwater monitoring networks in the Great Lakes basin are being examined to assess the overall environmental status of groundwater quality and help measure progress towards the 2012 GLWQA's Article 3, General Objective (viii), "be free from the harmful impact of contaminated groundwater."

DOMESTIC ACTIONS TAKEN

Identifying groundwater impacts on the chemical, physical and biological integrity of the Waters of the Great Lakes.

- The United States Geological Survey is continuing studies of selected areas of the Great Lakes basin to evaluate the effects of land use and flow path on groundwater quality which, in turn, impact the waters of the Great Lakes as groundwater interacts with surface water.

- The State of Michigan has developed a water withdrawal assessment tool that evaluates the effect of large water withdrawals, including groundwater, on fish habitat in streams. The assessment tool has been used in Michigan for several years and is being evaluated by a few other Great Lakes states for possible implementation. Understanding the effects of groundwater withdrawal on stream habitat is an important consideration under the 2012 GLWQA.

- Researchers at Ohio State University have recently begun a project titled, *Quantifying the effects of surface water-groundwater interaction on dissolved phosphorus loads to Lake Erie*. The results of this research should help clarify the potential for groundwater discharge to streams and lakes adding to already identified surface water sources of phosphorus.

CANADA

Assessing information gaps and science needs related to groundwater to protect the quality of Waters of the Great Lakes.

- In March 2015, the Ontario Geological Survey and Geological Survey of Canada hosted a Groundwater Geoscience Knowledge GAP Analysis session for southern Ontario clients. Session participants identified 30 individual groundwater geoscience knowledge gaps which fell into seven categories including: i) communications, ii) standards and protocols, iii) water quality and geochemistry, iv) surface and groundwater interaction, v) geology and hydrogeology, vi) climate change and vii) data management and dissemination. Further information can be found at www.nrcan.gc.ca (http://geoscan.nrcan.gc.ca/starweb/geoscan/servlet.starweb?path=geoscan/fulle.web&search1=R=297736).

Identifying groundwater impacts on the chemical, physical and biological integrity of the Waters of the Great Lakes.

- The Ontario Geological Survey continues to improve understanding of the data and information needed to assess the impacts of groundwater on the waters of the Great Lakes. A water quality database, created through the Survey's ambient groundwater geochemistry project, is being evaluated for potential use in the development of a groundwater indicator under the guidance of the Science Annex Subcommittee.

- Through the Lake Simcoe / Southeastern Georgian Bay Clean-up Fund, Environment and

Climate Change Canada is currently assessing the role of groundwater as a source of nutrients (phosphorus and reactive nitrogen) to surface waters of Southeastern Georgian Bay and the Nottawasaga River.

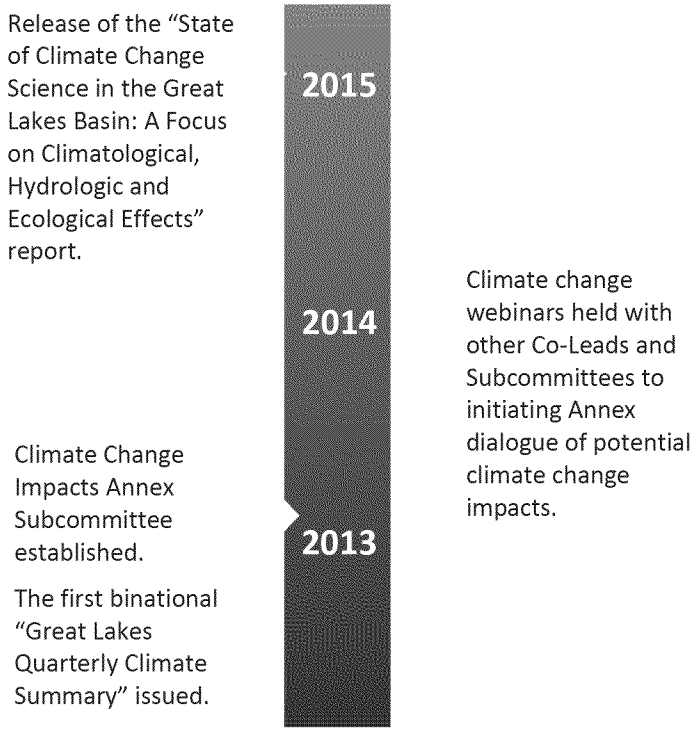
CLIMATE CHANGE IMPACTS ANNEX

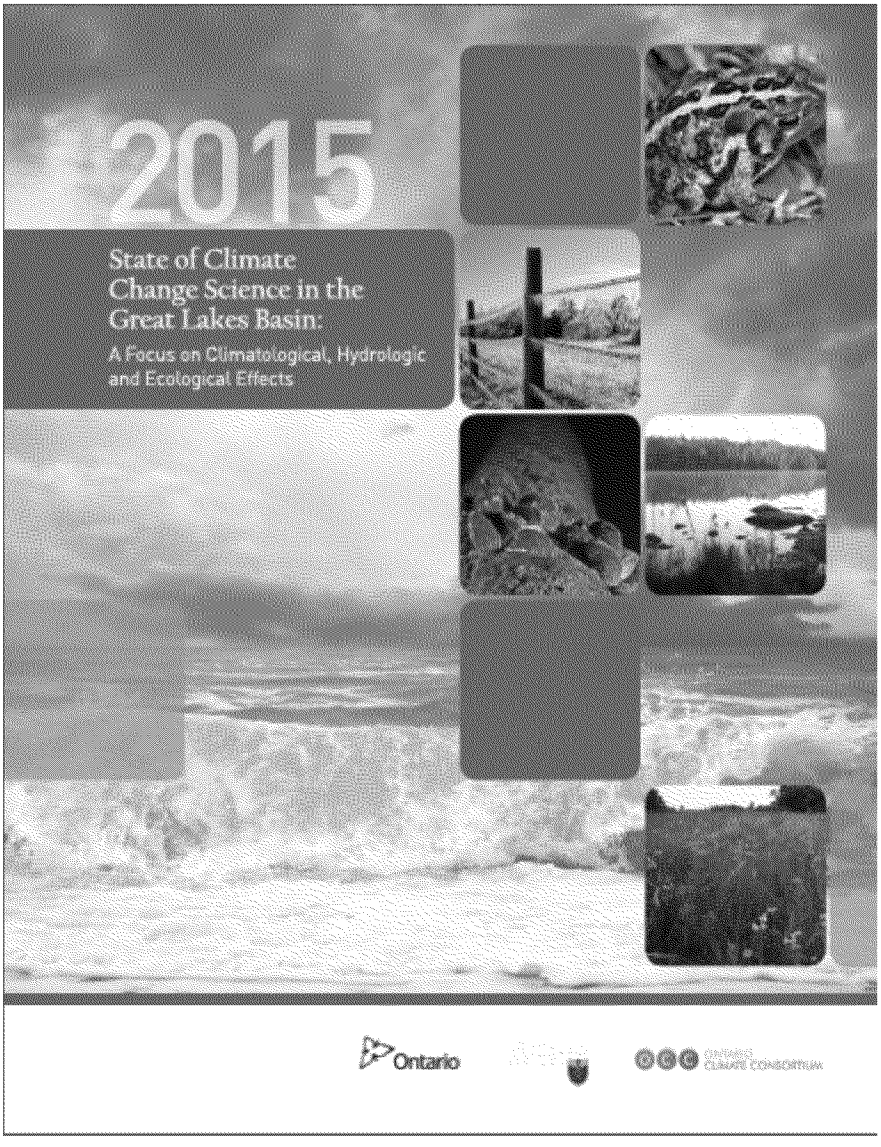
OVERVIEW

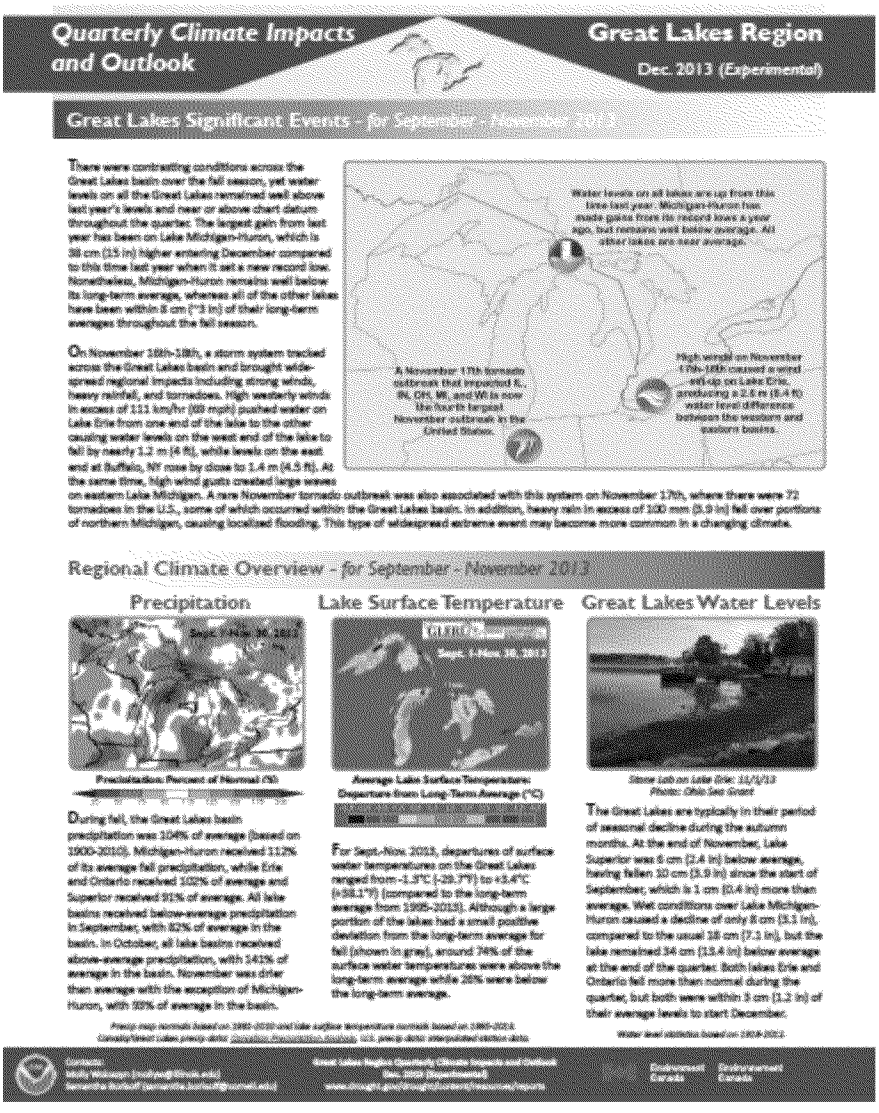
Climate change impacts such as warming temperatures, changing precipitation patterns, decreased ice coverage, and alterations to water levels are being observed across the Great Lakes basin. Climate change impacts physical, chemical and biological processes such as runoff and erosion patterns, nutrient cycling, and wetland development in the Great Lakes. Understanding how climate change affects these processes now and in the future is important to making informed management decisions for the Great Lakes.

Recognizing that climate change has an impact on the quality of waters of the Great Lakes, Canada and the United States incorporated a new Annex in the 2012 GLWQA to address this issue, through which both governments commit to coordinate efforts to identify, quantify, understand, and predict the climate change impacts on the water quality of the Great Lakes and to share information broadly with Great Lakes resource managers to proactively address these impacts.

PROGRESS TOWARD MEETING GLWQA COMMITMENTS




2015
State of Climate Change Science in the Great Lakes Basin:
A Focus on Climatological, Hydrologic and Ecological Effects
Ontario



This Annex's implementation is supported by the Climate Change Impacts Annex Subcommittee, co-led by Environment and Climate Change Canada and the National Oceanic and Atmospheric Administration. Organizations on the subcommittee include: [Confirm following Subcommittee membership with Co-Leads: Environment and Climate Change Canada, Ontario Ministry of Environment and Climate Change, Ontario Ministry of Natural Resources and Forestry, Conservation Ontario, United States National Oceanic and Atmospheric Administration, United States Environmental Protection Agency, United States Geological Survey, Oneida Tribe of Indians of Wisconsin, United States National Park Service, United States Fish and Wildlife Service, United States Army Corps of Engineers]

BINATIONAL ACTIONS TAKEN

Coordinating binational climate change science activities to quantify, understand, and share information that Great Lakes resource managers need to address climate change impacts on Great Lakes water quality.

- In June 2013, Canada and the United States issued the first binational quarterly newsletter focusing on climate impacts and outlooks for the Great Lakes region. The Great Lakes Climate Quarterly newsletters (www.binational.net/category/a9/qcio-btsc) provide a quick and easy-to-understand overview of the latest season's weather and water level conditions, weather and water level-related impacts, and an outlook for the upcoming quarter. These newsletters are produced by Canadian and United States experts for use by managers and practitioners at federal, state, provincial, regional, and local scales as well as stakeholders and the general public.

- A series of webinars were conducted in 2014 to present information on the best available peer-reviewed climate change science in the Great Lakes to GLWQA Annex Subcommittees, as well as other interested parties. Webinars were provided to: 1) enhance broad understanding of climate information; 2) to discuss the type of climate change information required by other Annex Subcommittees to support their activities; and 3) to help focus the work of the Climate Change Impacts Annex Subcommittee in providing tailored climate change information.

- In December 2015, a "State of Climate Change Science in the Great Lakes Basin: A Focus on Climatological, Hydrologic and Ecological Effects" report was released, which synthesizes the state of climate change impacts in the Great Lakes basin and identifies key knowledge gaps. The Executive Summary and further information is available at [insert binational.net link]. The report, along with a companion database of all the literature reviewed for the report, were developed by the Ontario Climate Consortium, the Ontario Ministry of Natural Resources and Forestry, and McMaster University, with support from Fisheries and Oceans Canada and Environment and Climate Change Canada, and in consultation with the Climate Change Impacts Annex Subcommittee.

Enhancing monitoring of relevant climate and Great Lakes variables to validate model predictions and to understand current climate change impacts.

- A growing ensemble of in situ measurements – including offshore eddy flux towers, buoy-based sensors, and vessel-based platforms – are being deployed through an ongoing binational collaboration known as the Great Lakes Evaporation Network. The Network is helping to reduce uncertainties in the Great Lakes water balance, providing a more robust basis for short- and long-term projections of variations in climate and lake levels, and filling a significant gap in measurements, including evaporation and water temperatures, and related meteorological data. The Network is supported through a consortium of researchers from Environment and Climate Change Canada and the National Oceanic and Atmospheric Administration, the University of Michigan, Northern Michigan University, the University of Colorado, Limno-Tech and the Great Lakes Observing System.

Developing and improving analytical tools to understand and predict climate change impacts.

- Environment and Climate Change Canada, the United States Geological Survey, and the National Oceanic and Atmospheric Administration's National Weather Service and Great Lakes Environmental Research Laboratory, have formed a binational collaboration to assess alternative methods for simulating runoff across large lake basins. The Great Lakes Runoff Inter-comparison Project is a binational collaboration aimed at assessing a variety of models currently used (or that could readily be adapted) to simulate basin-scale runoff to the Great Lakes. The first phase of the Great Lakes Runoff Inter-Comparison Project focused on Lake Michigan and involved the comparison between several very different hydrologic models in their ability to simulate the lake's tributary flows. The second phase of the Great Lakes Runoff Inter-Comparison Project focused on Lake Ontario and compared different hydrologic models in their ability to estimate Lake Ontario's direct incoming runoff. This work has improved the understanding of the differences in various models in simulating total runoff to the lakes and can help lead to improved climate change impact analyses.

DOMESTIC ACTIONS TAKEN

The Government of Canada is committed to addressing climate change by moving toward a pan-Canadian framework for clean growth and climate change, a concrete plan that will allow Canada to meet its international commitments and transition the country into a more resilient, low-carbon economy. Canada is committed to supporting climate change mitigation and adaptation by reducing carbon pollution; putting a price on carbon; and investing in green infrastructure, public transit infrastructure, and energy efficient social infrastructure. Canada will also build on actions already taken by the provinces and territories such as the Province of Ontario's recently released Five-Year Climate Change Action Plan 2016-2020, which includes measures to reduce greenhouse gas emissions in Ontario.

Developing and improving regional scale climate models to predict climate change in the Great Lakes Basin Ecosystem at appropriate temporal and spatial scales.

Linking projected climate change outputs from regional models to chemical, physical, biological models that are specific to the Great Lakes to better understand and predict climate change impacts.

- Environment and Climate Change Canada is supporting the development of coupled atmospheric-land-ocean models for the Great Lakes-St. Lawrence River system that can be integrated with Regional Climate models to evaluate the hydrometeorological impacts of climate change.

- The Ontario Government continues to support the development of high resolution

regional climate projections in support of climate impact assessments on various sectors in Ontario and the Great Lakes basin. In 2015, these regional climate projections were updated with the latest Coupled Model Intercomparison Project Phase 5 data and distributed through the following public climate data portals: http://OntarioCCDP.ca and http://occp.lamps.yorku.ca/.

- A coordinated evaluation of the impacts of climate change on the levels and flows of the St. Lawrence River between 2041-2070 and 1971-1999 is being undertaken through a collaborative of agencies including Fisheries and Oceans Canada, Hydro-Quebec, Direction de l'expertise hydrique of Quebec, OURANOS and Environment and Climate Change Canada. A major focus of this project is improving the analyses of the routing of Ottawa River flows so that Great Lakes and St. Lawrence River models can be linked, resulting in improved climate change impact projections over the entire system.

Enhancing monitoring of relevant climate and Great Lakes variables to validate model predictions and to understand current climate change impacts.

- Environment and Climate Change Canada collects data from a network of approximately 1300 surface weather and climate observing sites across the country. These sites include weather stations owned by Environment and Climate Change Canada, NAV CANADA, National Defence, along with volunteer climate stations. The majority of these sites are automated observing platforms which report year round, 7 days a week, 24 hours a day. Environment and Climate Change Canada in partnership with the Province of Ontario operates 440 active hydrometric gauges in the Canadian portion of the Great Lakes-St. Lawrence River Basin. Environment and Climate Change Canada also supports the operation of three evaporation stations at Stannard Rock on Lake Superior, Long Point on Lake Erie and Simcoe Island on Lake Ontario as part of the Great Lakes Evaporation Network. The information provided through these networks is critical to monitoring and predicting the impacts of climate change on the Great Lakes.

Developing and improving analytical tools to understand and predict climate change impacts.

- Environment and Climate Change Canada's Canadian Precipitation Analysis is an operational near real-time product, available since April 2011 for North America, which leverages a variety of observation and modelling information sources to estimate precipitation accumulation every six hours across Canada. The Canadian Precipitation Analysis is highly regarded due to its unique capability of capturing some of the precipitation features that are specific to the Great Lakes-St. Lawrence River region (including the effects that the lakes have on the precipitation patterns, something that is very difficult to discern with the existing precipitation gauging network). A project was initiated in 2015 to provide the foundation for extending the Canadian Precipitation Analysis back to 1983. This project will help improve hydrological forecasting and land surface estimates (including soil moisture, soil temperature and snow on the ground), leading to improved ecological prediction.

Sharing information that Great Lakes resource managers need to address climate change impacts.

- Ontario is working to establish a climate change modeling collaborative for climate data that will establish a one-window source for climate data, for the purpose of ensuring open access to standardized and wide-ranging Ontario climate information. The modeling collaborative will help both public and private sectors make informed and evidence-based decisions regarding adapting to climate change and increasing resilience.

Developing and improving regional scale climate models to predict climate change in the Great Lakes Basin Ecosystem.

Linking the projected climate change outputs from the regional models to Great Lakes-specific chemical, physical, biological models.

- The National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Lab brought together several different modeling and observational approaches to study climate change in the Great Lakes basin. The modeling activity consisted of further development and application of three atmosphere-lake-land regional climate models: 1) the Coupled Hydrosphere-Atmosphere Research Model (CHARM); 2) the Regional Climate Model version 4 (RegCM4) at the University of Wisconsin; and 3) the Weather Research and Forecasting Model (WRF) at the University of Maryland, as well as the development and testing of a simulation of ice and lower trophic level ecology in the form of a nutrient-phytoplankton-zooplankton-detritus model component.

Enhancing monitoring of relevant climate and Great Lakes variables to validate model predictions and to understand current climate change impacts.

- In 2013, the Lake Superior National Estuarine Research Reserve established a new Sentinel Site located in Pokegama Bay, Lake Superior. With funding support from the National Oceanic and Atmospheric Administration, this Sentinel Site included weather/meteorological station, water quality sonde, surface elevation tables, permanent vegetation transects, geodetic vertical referencing benchmarks, and an acoustic doppler current profiler installation. This site is now recording monthly water quality sampling for nutrients and chlorophyll. The primary goal is to understand sediment movement and how sediment transfer is impacting nearshore marsh environments with increased frequency and intensity of storm events.

- The National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Lab has been exploring the relationships between ice cover, lake thermal structure, and regional climate for over 30 years through development, maintenance, and analysis of historical model simulations and observations of ice cover, surface water temperature, and other variables. Weekly ice cover imaging products produced by the Canadian Ice Service started in 1973. Beginning

in 1989, the United States National Ice Center produced Great Lakes ice cover charts that combined both Canadian and United States agency satellite imagery. These products are available at the Great Lakes Environmental Research Lab through the Coastwatch program (www.coastwatch.glerl.noaa.gov), a nationwide National Oceanic and Atmospheric Administration program within which the Great Lakes Environmental Research Lab functions as the Great Lakes regional node.

- Currently, there is year-round monitoring infrastructure dedicated to understanding off-shore processes that impact Great Lakes ecosystem health. Beginning in Fiscal Year 2015, the National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Lab (with funding support from the National Oceanic and Atmospheric Administration's Coastal Storms Program) is seeking to fill known data gaps (i.e., over-water evaporation and transpiration rates and how those rates effect the overall water budget) through a two-phased approach. First, the team will deploy and manage data from vessel- and buoy-based sensors to improve understanding of over-water meteorology, evaporation, and water temperature in the Great Lakes. Second, the project will also focus on data analysis, system validation, and model assimilation to improve access to and understanding of the acquired data.

Developing and improving analytical tools to understand and predict climate change impacts.

- The National Oceanic and Atmospheric Administration's Office for Coastal Management developed and released the Lake Level Viewer (www.coast.noaa.gov/llv) for the United States portion of the Great Lakes basin in 2014. This tool helps users visualize lake level changes that range from six feet above to six feet below historical long-term average water levels in the Great Lakes, along with potential shoreline and coastal impacts. Communities can use this information to determine what preparations make the most sense in planning for water level change scenarios. Preparations might include zoning restrictions, infrastructure improvements, and habitat conservation. As a result of this work and product delivery, Digital Elevation Models for each lake basin and the associated topographic and bathymetric data are now available on The National Oceanic and Atmospheric Administration's Digital Coast (https://coast.noaa.gov/digitalcoast/).

- The National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Lab developed and released a basin wide Water Level Dashboard in 2014 (www.glerl.noaa.gov/data/dashboard/GLHCD.html). The Dashboard is a dynamic graphical interface for visualizing projected, measured, and reconstructed surface water elevations on the earth's largest lakes. This interface also reflects relationships between hydrology, climate, and water level fluctuations in the Great Lakes.

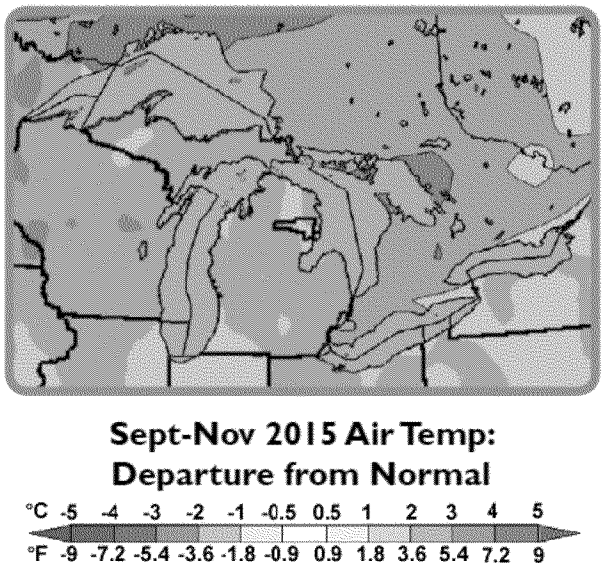
Coordinating binational climate change science activities to quantify, understand, and share information that Great Lakes resource managers need to address climate change impacts.

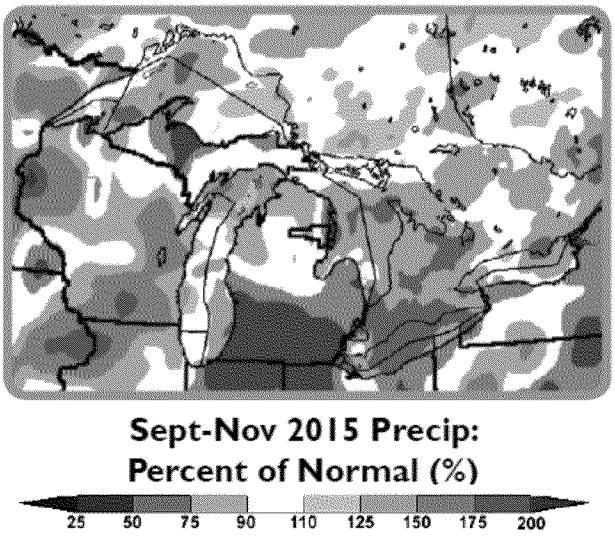
- The National Oceanic and Atmospheric Administration's National Center for Environmental Information produces an annual "State of the Climate" report (www.ncdc.noaa.gov/sotc). This report provides a collection of monthly summaries recapping climate-related occurrences on both a global and national scale.

- The National Park Service released Climate Change Scenario Planning Workshop Summaries for two U.S. National Parks on Lake Superior. The Isle Royale National Park report (https://www.nps.gov/isro/learn/nature/upload/Using-Climate-Change-Scenarios-to-Explore-Management-at-ISRO.pdf) summarized a 2013 workshop and the Apostle Island National Lakeshore report (https://www.nps.gov/apis/learn/nature/upload/APIS-Scenario-Workshop-Report-20160104-FINAL.pdf) summarized a 2014 workshop, which built on the process and results of the earlier session. These two-day workshops were a collaboration between the National Park Service and the Great Lakes Integrated Sciences + Assessments team (http://glisa.umich.edu/) from the University of Michigan. The primary objectives of the sessions were to help National Park Service leadership at local and higher levels make management and planning decisions based on up - to - date climate science and assessments of future uncertainty. The sessions were also designed to (1) assess the effectiveness of using regional - level climate science to craft local scenarios; and (2) provide opportunities for participants to better understand how climate scenarios can be used.

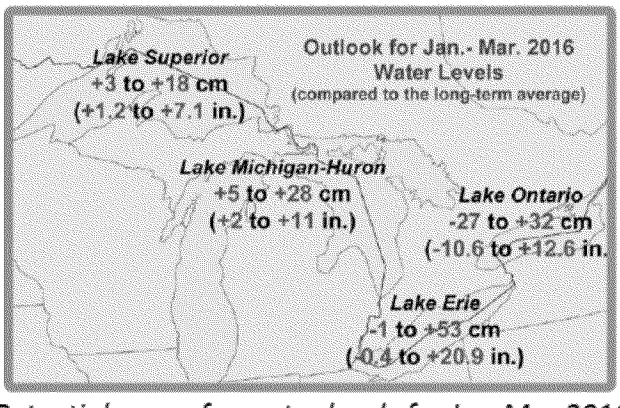
Possible graphics:

Sources: GL Climate Outlook – Fall 2015





Lake Level Outlook



Potential range for water levels for Jan-Mar 2016 compared to the long-term average (1918-2014).

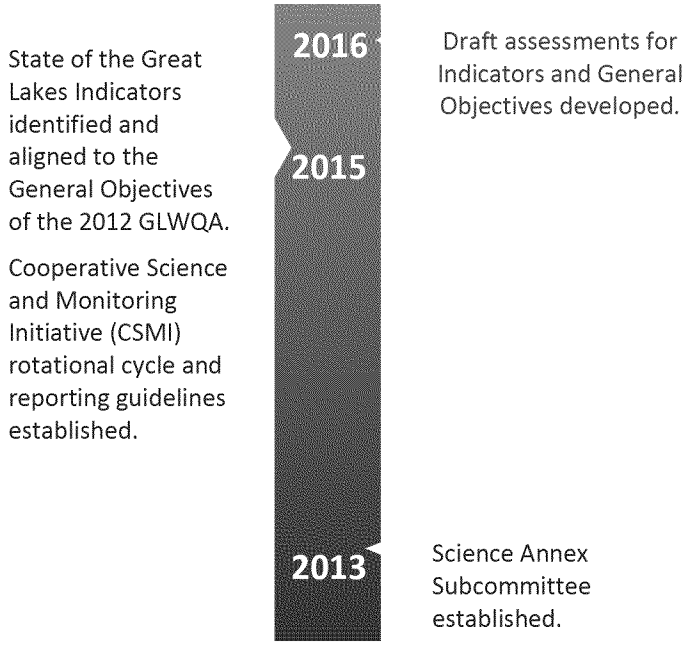
SCIENCE ANNEX

OVERVIEW

Science provides the foundation for management actions and policy decisions in support of meeting the objectives of the Agreement.

The 2012 GLWQA recognizes that the effective implementation of management decisions, policies and programs must be based on the best available science, research and knowledge. Throughout the 2012 GLWQA, specific science-based commitments are captured in relation to various Annexes. The Science Annex of the 2012 GLWQA commits the United States and Canada to enhancing the coordination, integration, synthesis, and assessment of science activities across all Annexes of the Agreement.

PROGRESS TOWARD MEETING GLWQA COMMITMENTS



This Annex's implementation is supported by the Science Annex Subcommittee, co-led by the United States Environmental Protection Agency and Environment and Climate Change Canada. Organizations on the subcommittee include: [Confirm following Subcommittee membership with Co-Leads: Environment and Climate Change Canada, Fisheries and Oceans Canada, Agriculture and Agri-Food Canada, Natural Resources Canada, Ontario Ministry of Environment and Climate Change, Ontario Ministry of Natural Resources and Forestry, Conservation Ontario, United States Environmental Protection Agency, United States National Oceanic and Atmospheric Administration, United States Army Corps of Engineers, United States Geological Survey, Wisconsin Department of Natural Resources]

BINATIONAL ACTIONS TAKEN

Establishing and maintaining comprehensive, science-based ecosystem indicators to assess the state of the Great Lakes, to anticipate emerging threats, and to measure progress in relation to achievement of the Objectives of the Agreement.

In 2016, issue a State of the Great Lakes Report describing basin-wide environmental trends and lake-specific conditions using ecosystem indicators.

- In January of 2015, the United States and Canada confirmed the suite of indicators to be used to assess water quality and the ecosystem conditions of the Great Lakes under the 2012 GLWQA. This suite of indicators builds on the State of the Lakes Ecosystem Reporting by the Parties, which has been ongoing since 1994.

- The indicator suite includes nine indicators, one for each of the General Objectives of the 2012 GLWQA. The nine indicators are supported by 43 sub-indicators [reference Figure].

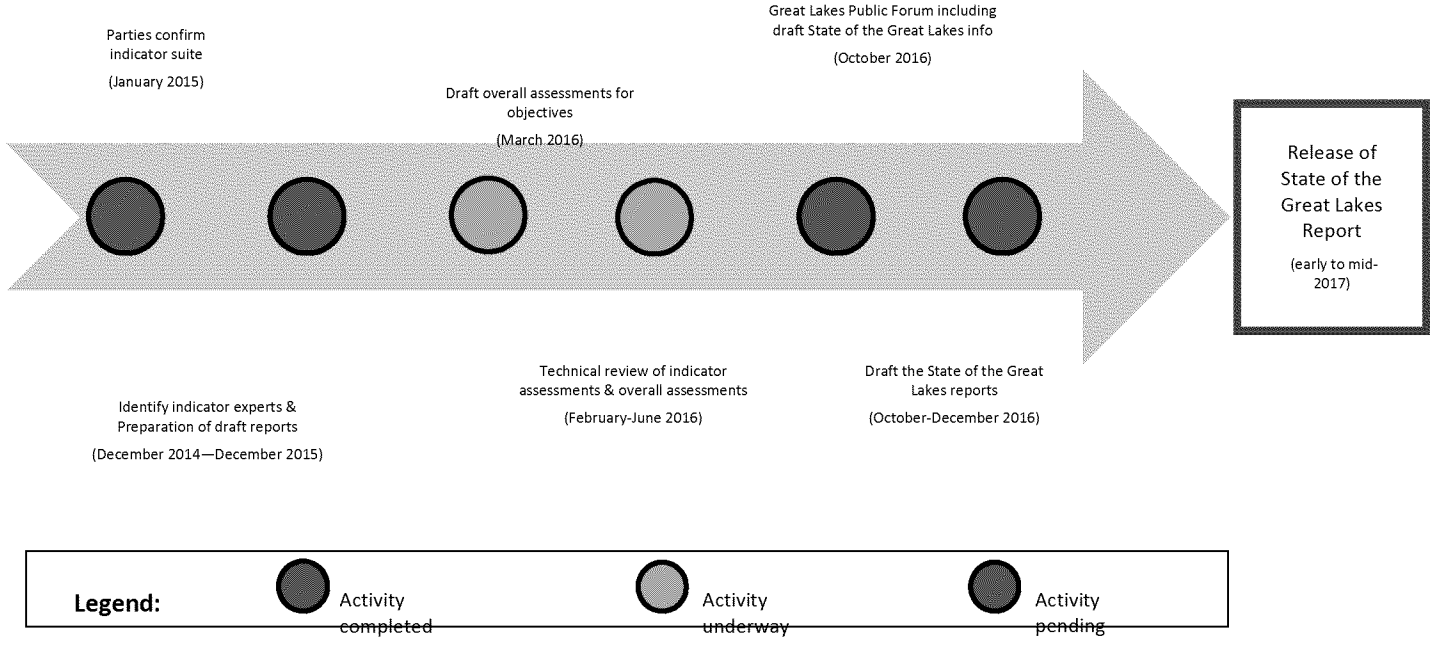
- Over 100 Great Lakes experts representing federal, provincial, state and local governments, as well as academia and non-governmental organizations, have engaged in assembling and assessing relevant data, and reporting against the indicator suite.

- In 2016, draft assessments for the indicators were developed and reviewed by subject matter experts. These draft assessment will be presented at the Great Lakes Public Forum in October, 2016 for public comment. A final State of the Great Lakes report, describing basin-wide and lake-specific environmental trends and conditions using the ecosystem indicators, is targeted for release in 2017 [reference Figure].

Indicators & Sub-Indicators for Assessing the State of the Great Lakes

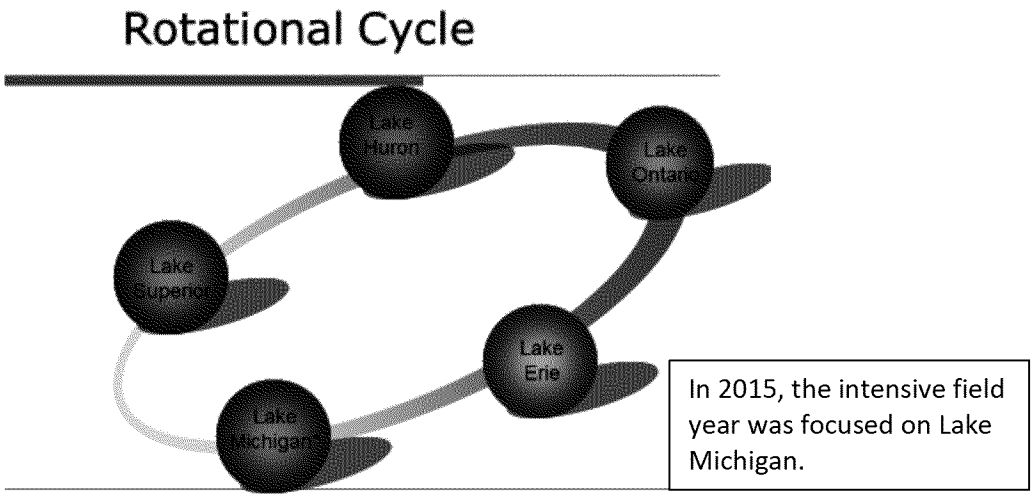
1. Drinking Water
2. Beaches
3. Fish Consumption
4. Toxic Chemicals
   - Toxic Chemical Concentrations (open water)
   - Toxic Chemicals In Great Lakes Whole Fish
   - Toxic Chemicals In Great Lakes Herring Gull Eggs
   - Toxic Chemicals in Sediment
   - Atmospheric Deposition of Toxic Chemicals
   - Water Quality in Tributaries
5. Habitat & Species
   - Coastal Wetland Invertebrates
   - Coastal Wetland Fish
   - Coastal Wetland Plants
   - Coastal Wetland Amphibians
   - Coastal Wetland Birds
   - Coastal Wetlands: Extent and Composition
   - Aquatic Habitat Connectivity
   - Fish Eating and Colonial Nesting Waterbirds
   - Phytoplankton (open water)
   - Zooplankton (open water)
   - Benthos (open water)
   - Diporeia (open water)
   - Preyfish (open water)
   - Lake Trout
   - Walleye
   - Lake Sturgeon
6. Nutrients & Algae
   - Nutrients in Lakes (open water)
   - Harmful Algal Blooms
   - Cladophora
7. Invasive Species
   - Aquatic Invasive Species
   - Sea Lamprey
   - Dreissenid Mussels
   - Terrestrial Invasive Species
8. Groundwater
9. Watershed & Climate Impacts
   - Water Levels
   - Surface Water Temperature
   - Ice Cover
   - Precipitation Events
   - Baseflow due to Groundwater
   - Watershed Stressors
   - Forest Cover
   - Land Cover
   - Tributary Flashiness
   - Hardened Shorelines
   - Human Populations

State of the Great Lakes Report timeline



Implementing a cooperative science and monitoring initiative for each of the Great Lakes on a five-year rotational basis.

- The Cooperative Science and Monitoring Initiative (CSMI) was developed under the 1987 GLWQA in order to binationally coordinate science to provide information to support Great Lakes decision-making. Monitoring and research activities in the Great Lakes basin are coordinated with an emphasis on enhanced monitoring and research field activities on one of the Great Lakes per year, on a five year rotating cycle [reference figure].

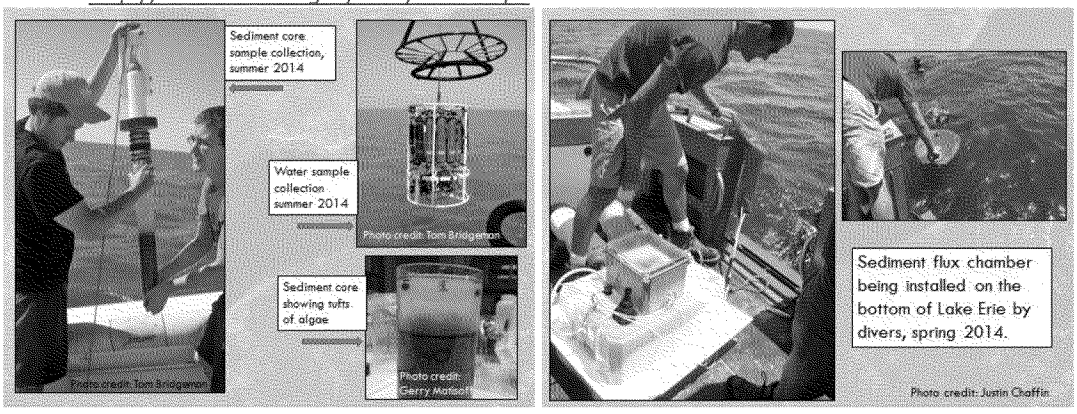


- The United States and Canada established and are implementing the following multi-step CSMI process for each Great Lake: 1) identification of science and monitoring needs; 2) planning; 3) coordinated monitoring (field year); 4) laboratory analysis; 5) data analysis and reporting; and, 6) final report and communicating out.

- Examples of lake-specific cooperative science include:
  - An assessment in Lake Ontario, in 2013, of the lower food web and the implementation of projects across federal and state agencies addressing nutrient loadings and the nearshore-to-offshore movement of nutrients;
  - An assessment in Lake Erie, in 2014, of Dreissenid mussel populations, nutrient loadings from rivers and western basin sediments and development of a phosphorus mass balance model for the western and central basin;
  - Undertaking projects in Lake Michigan, in 2015, to address nutrient and contaminant loads to the lake, to address contaminants in the lake, and to investigate the movement of nutrients and energy from nearshore to offshore supporting fisheries; and
  - An assessment in Lake Superior, in 2016, of chemical emission reduction actions and an evaluation of the health of the lower food web and important fish communities.

[Possible images to use of Lake Guardian and Limnos. Ensure have rights to use of all images.]
Source: *https://www.ec.gc.ca/grandslacs-greatlakes/default.asp?lang=En&n=F9A91157-1&printfullpage=true*

[Develop similar CSMI image]
Source: http://lakeerie.ohio.gov/GLRI/CSMI.aspx



Facilitating information management and sharing to improve knowledge, accessibility and exchange of relevant Great Lakes information.

- Data and information management and sharing efforts to support implementation of relevant 2012 GLWQA commitments are being examined. An initial examination was undertaken to understand the data and information management and sharing needs across all of the Annexes of the GLWQA. Based on this information and discussions at the Great Lakes Executive Committee meetings, the Science Annex Subcommittee will be examining existing Great Lakes-related distributed data and information access systems and platforms and their application to a specific pilot project on a priority area such as the Lake Erie phosphorus and/or nearshore issue.

Identifying science priorities, taking into account recommendations of the International Joint Commission.

Undertaking a review of available scientific information to inform management actions and policy development.

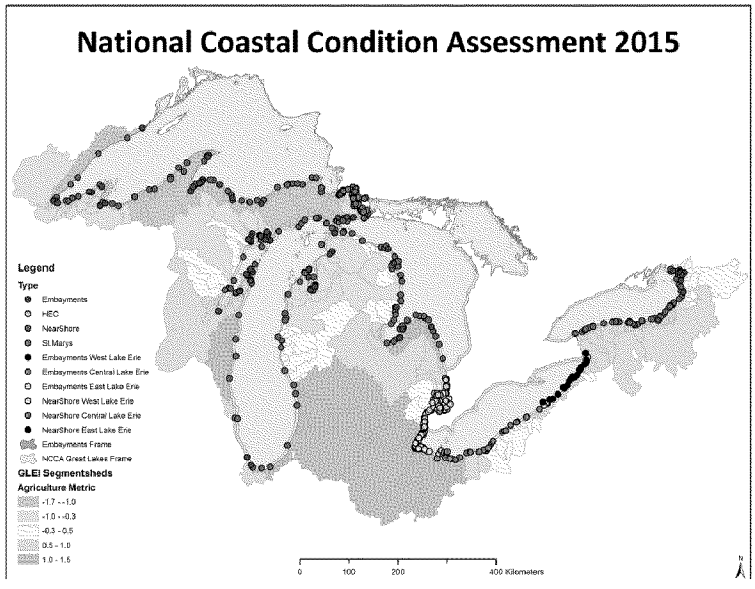
- The Science Annex Subcommittee coordinated and assisted in the development of the 2014-2016 binational priorities for science amongst the other Annexes. As called for in Article 5 of the 2012 GLWQA, these priorities, along with the priorities for action, were posted on binational.net (www.binational.net/2014/03/20/psa-pasa-2014) in March 2014.

- In support of the development of nutrient objectives for controlling nuisance *Cladophora* in the Great Lakes, Canada and the United States held a binational workshop on January 28-26, 2016 to determine the state of knowledge of *Cladophora* from the perspectives of the entire Great Lakes basin, individual lakes, and areas within each lake where *Cladophora* is perceived to be a significant local problem. The findings of the workshop will help guide a strategy for proposing nutrient reduction targets that will control *Cladophora*.

DOMESTIC ACTIONS TAKEN

- Between 2013 and 2016, the United States Environmental Protection Agency's Great Lakes National Program Office used Great Lakes Restoration Initiative (GLRI) funding to maintain and enhance its Long-Term Great Lakes Monitoring Programs. These programs include the Open Lake Water Quality Surveys, the Integrated Atmospheric and Deposition Network, and the Great Lakes Fish Monitoring and Surveillance Program.

- Between 2013 and 2016, GLRI funding helped supplement the Environmental Protection Agency's implementation of its Great Lakes National Coastal Condition Assessment. The assessment is undertaken every five years to determine the condition of the nation's coastal waters as well as to evaluate the importance of key stressors such as nutrients and pathogens. The Great Lakes assessment included monitoring 100 sites per Great Lake, including the connecting channels (Huron-Erie Corridor and St. Marys River).



- In support of the Nutrient and Lakewide Management Annexes, and with the support of GLRI funding, the Environmental Protection Agency and the United States Geological Survey assessed and better understand the impacts of agriculture and agricultural practices, climate change, and land use change on the timing and magnitude of delivery of nutrients and sediments to the Great Lakes.

- In 2015, the United States National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Laboratory partnered with the University of Michigan's Cooperative

Institute for Limnology and Ecosystems Research and used GLRI funding to sample eight sites throughout the western basin of Lake Erie and four sites in Lake Huron's Saginaw Bay. The sampling was done to assess the impact of land use on algal bloom development. Measurements of bloom toxicity have proven invaluable to regional stakeholders and the Nutrients Annex Task Team.

- In an effort to build broader research partnerships, the Environmental Protection Agency's Great Lakes National Program Office has made the 180-foot R/V Lake Guardian available to researchers to provide sampling access to the open waters of the Great Lakes.

- With the support of GLRI funding, an initial coastal wetland classification assessment was completed that will be used by the Habitat and Species Annex Subcommittee to prioritize coastal wetland work.

CANADA

- The Government of Canada is committed to Open Science and Open Data, which includes performing science in a more open and collaborative manner, and maximizing accessibility to federal publications and data. Through the Action Plan on Open Government, Canada is pledging to expand its open government activities to broaden access to data and information, ensure transparency and accountability, and strengthen citizen engagement in the activities of government and in the democratic process. Data collected by Environment and Climate Change Canada in the Great Lakes to support the implementation of the 2012 GLWQA, is being prepared for release on GoCs Open Data Portal and datasets are being piloted through the process to validate and ensure future sustainability and openness of the approach.

- The Freshwater Quality Monitoring and Surveillance Program (FWQMS) of Environment and Climate Change Canada conducts water quality surveys of nutrients and contaminants in water, sediment and aquatic biota in the open lakes, tributaries, Areas of Concerns and in the connecting channels. This long-term monitoring program monitors legacy compounds (such as PCBs, PAHs and organochlorine pesticides), and more recently, also includes monitoring of emerging compounds (such as organosiloxanes, brominated and organophosphate flame retardants and Bisphenol A).

- In 2014, Environment and Climate Change Canada collaborated in a joint study with the Ontario Ministry of the Environment and Climate Change to measure changes in herbicide concentrations in Ontario urban streams (with five of the ten urban streams selected flowing into Lake Ontario) following a cosmetic pesticides ban in 2009. Findings indicate that concentrations in the majority of the study streams decreased significantly following the cosmetic pesticides ban, decreasing from 16% to 92%, depending on the stream and herbicide.

- As part of Great Lakes Nutrient Initiative, Environment and Climate Change Canada supported the development and implementation of binational phosphorous load targets in Lake Erie

by conducting intensive open lake, nearshore and tributary monitoring; and modelling and research on nuisance and harmful algal blooms.

- Environment and Climate Change Canada is also conducting nutrient loading research in Georgian Bay to identify adverse impacts such as the generation of harmful algal blooms and hypoxia in some nearshore regions.

- In March 2013, a Canadian workshop was organized to support identifying possible science priorities that Canada could put forward for first three years under the 2012 GLWQA, pursuant to the development of the binational priorities for science called for in Article 5 of the 2012 GLWQA.

- Within Environment and Climate Change Canada, two Great Lakes Science Days have been held in an effort to share information on priorities, progress and emerging issues, and also to encourage continued collaboration between Great Lakes scientists, researchers and program teams within the department.