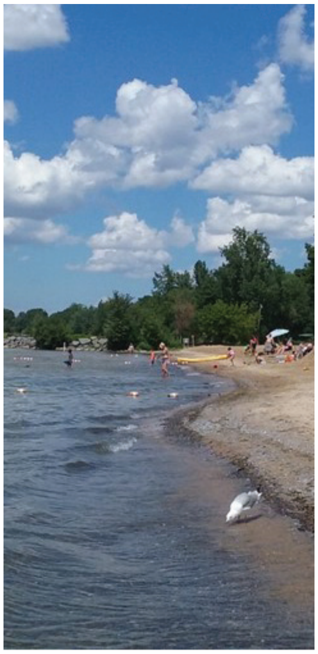

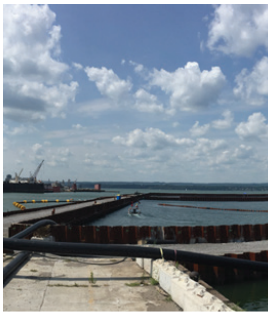

LAKE ONTARIO

LAKEWIDE ACTION AND MANAGEMENT PLAN

2018 - 2022

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The 2018-2022 Lake Ontario Lakewide Action and Management Plan (LAMP) was developed by member agencies of the Lake Ontario Partnership. We gratefully acknowledge the efforts of the core Writing Team, led by Steve Clement (ECCC), Aisha Sexton-Sims (USEPA), Paul Parete (ECCC), and James Lehnen (NYSDEC).

This LAMP reflects the input of many resource management agencies, conservation authorities, scientists, non-governmental organizations, First Nations, Métis, and Tribal Governments committed to restoring and protecting Lake Ontario and its connecting rivers.

We gratefully acknowledge the member organizations of the Lake Ontario Partnership.

Lake Ontario Partnership 2018

- Environment and Climate Change Canada
- Department of Fisheries and Oceans
- Toronto and Region Conservation Authority
- Ontario Ministry of the Environment, Conservation and Parks
- Ontario Ministry of Natural Resources and Forestry
- Quinte Conservation
- Credit Valley Conservation
- U.S. Environmental Protection Agency
- U.S. Fish & Wildlife Service
- U.S. Army Corps of Engineers
- U.S. Geological Survey
- U.S. Forest Service
- U.S. Department of Agriculture - Natural Resources Conservation Service
- National Oceanic & Atmospheric Administration
- New York State Department of Environmental Conservation
- Bureau of Indian Affairs
- Saint Regis Mohawk Tribe

ACRONYMS AND ABBREVIATIONS

AOC	Area of Concern
BCS	Biodiversity Conservation Strategy
BUI	Beneficial Use Impairments
CA	Conservation Authority
CCME	Canadian Council of Ministers of the Environment
CMC	Chemicals of Mutual Concern
CRRA	Community Risk and Resiliency Act
CSMI	Cooperative Science and Monitoring Initiative
CSO	Combined Sewer Overflow
CWS	Canadian Wildlife Service
DDT	Dichlorodiphenyltrichloroethane
DFO	Department of Fisheries and Oceans
ECCC	Environment and Climate Change Canada
EDM	Early Detection and Monitoring
GLAM	Great Lakes St. Lawrence River Adaptive Management
GLFC	Great Lakes Fishery Commission
GLLFAS	Great Lakes Laboratory for Fisheries and Aquatic Sciences
GLMRIS	Great Lakes and Mississippi River Interbasin Study
GLRI	Great Lakes Research Initiative
GLWQA	Great Lakes Water Quality Agreement
HABS	Harmful Algal Blooms
HBCD	Hexabromocyclododecane
IBA	Important Bird Area

IJC	International Joint Commission
LAMP	Lakewide Action and Management Plan
LC-PFCA	Long-Chain Perfluorinated Carboxylic Acids
LOTMP	Lake Ontario Toxics Management Plan
LTBB	Little Traverse Bay Band of Odawa Indians
MECP	Ontario Ministry of Environment, Conservation and Parks
NCC	Nature Conservancy of Canada
NOAA	National Oceanic Atmospheric Administration
NRTMP	Niagara River Toxics Management Plan
NYPA	New York Power Authority
NYSDAM	New York State Department of Agriculture and Markets
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDOS	New York State Department of State
NYSOPRHP	New York State Office of Parks, Recreation, and Historic Preservation
ODWQS	Ontario Drinking Water Standard
MNRF	Ontario Ministry of Natural Resources and Forestry
PAH	Polycyclic Aromatic Hydrocarbons
PAS	Priority Action Site
PBDE	Polybrominated Diphenyl Ethers (Flame Retardants)
PCBS	Polychlorinated Biphenyls
PCDD/F	Dioxin/Furans
PFAS	Per- and poly-fluoroalkyl Substances
PFOA	Perfluorooctanoic Acid

PFOS	Perfluorooctane Sulfonate
POPS	Persistent Organic Pollutants
PGWMN	Provincial Ground Water Monitoring Network
PRISM	Partnership for Regional Invasive Species Management
RAP	Remedial Action Plan
SCCPS	Short-Chain Chlorinated Paraffins
SDWA	Safe Drinking Water Act (U.S.)
SOGL	State of the Great Lakes Report
SRMT	Saint Regis Mohawk Tribe
SRP	Soluble Reactive Phosphorus
SUNY	State University of New York
TEK	Traditional Ecological Knowledge
TNC	The Nature Conservancy
TP	Total Phosphorus
TRCA	Toronto and Region Conservation Authority
USACE	United States Army Corp of Engineers
USCG	United States Coast Guard
USDA-NRCS	United States Department of Agriculture-Natural Resources Conservation Service
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VHS	Viral Hemorrhagic Septicemia

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EXECUTIVE SUMMARY

The Lake Ontario Lakewide Action and Management Plan (LAMP) is a binational ecosystem-based action plan to restore and protect the water quality of Lake Ontario and its connecting river systems, the Niagara and St. Lawrence Rivers. This is the first Lake Ontario LAMP under the 2012 amendment of the Great Lakes Water Quality Agreement (GLWQA). The LAMP was developed by member agencies of the Lake Ontario Partnership which is a collaborative team of natural resource managers led by the governments of the U.S. and Canada, in cooperation and consultation with State and Provincial Governments, Tribal Governments, and watershed management agencies committed to restoring and protecting Lake Ontario, the Niagara River and the St. Lawrence River. In preparing the LAMP, the Lake Ontario Partnership also sought input from scientists, First Nations, Métis, stakeholders, non-governmental organizations and the general public.

Lakewide management is guided by a shared vision of a healthy, prosperous, and sustainable Great Lakes region in which the waters of Lake Ontario are used and enjoyed by present and future generations. Lake Ontario is a valuable resource in many respects, from its significance to Indigenous Peoples, the ecosystem goods and services it provides, to the habitat and species it is home to, including globally significant ecosystems and migratory pathways. Lake Ontario is also home to a variety of natural resources, a regional economy, and a vibrant tourism and recreation industry.

The purpose of the 2018-2022 LAMP is: 1) to summarize the current state of Lake Ontario in relation to the nine General Objectives of the GLWQA and point out key threats; 2) to outline actions that will be taken to address the threats and contribute to the restoration and protection of water quality in Lake Ontario; and 3) to engage all groups and individuals in the Lake Ontario Basin to take action in protecting the water quality in Lake Ontario.

Current State of Lake Ontario

Overall, based on the scientific research, monitoring and reporting completed by over 180 government and non-government Great Lakes scientists and other experts, Lake Ontario is assessed to be in “fair” condition. Chemical contaminants, nutrient and bacterial pollution, loss of habitat and native species, and the spread of non-native invasive species limit the health, productivity, and use of Lake Ontario and its connecting river systems. The state of Lake Ontario is assessed in relation to the nine GLWQA General Objectives as follows:

	GENERAL OBJECTIVE	STATUS
1.	Be a source of safe, high-quality drinking water	GOOD
2.	Allow for unrestricted swimming and other recreational use	FAIR to GOOD
3.	Allow for unrestricted human consumption of the fish and wildlife	FAIR
4.	Be free from pollutants that could harm people, wildlife or organisms	FAIR
5.	Support healthy and productive habitats to sustain our native species	FAIR
6.	Be free from nutrients that promote unsightly algae or toxic blooms	FAIR
7.	Be free from aquatic and terrestrial invasive species	POOR
8.	Be free from the harmful impacts of contaminated groundwater	FAIR
9.	Be free from other substances, materials or conditions that may negatively affect the Great Lakes (Watershed Impacts assessed)	POOR to FAIR

(SOGL, 2017)

LAMP Management Actions

This 2018-2022 LAMP documents 28 actions to address identified threats and priority issues. Actions are grouped under four main issue areas:

1. Nutrient and bacterial-related impacts;
2. Loss of habitat and native species;
3. Aquatic invasive species; and
4. Critical and emerging chemical contaminants.

Over the next five years, these management actions will address key environmental threats using an integrated management approach. This approach recognizes the interactions across Lake Ontario and the need to maintain and enhance ecosystem resilience in view of climate change and other potential new or emerging threats such as plastics and microplastics.

Priority Science and Monitoring Activities

The Lake Ontario Partnership has identified management priorities that require additional scientific study with input from scientists, stakeholders and the public. This information is needed for improved understanding of key issues to better position resources for protection and restoration of Lake Ontario. The priority science and monitoring activities for the 2018-2022 LAMP include: 1) characterize nutrient concentrations and loadings; 2) improve understanding of nearshore nutrient related problems; 3) evaluate aquatic food web status; 4) improve understanding of fish dynamics; 5) characterize LAMP critical and emerging pollutants; and 6) evaluate coastal wetland status.

Collective Action for a Healthy Lake Ontario

There is a role for everyone in implementing the 2018-2022 Lake Ontario LAMP. The LAMP serves as a framework for partnership agencies to coordinate their work and identify where more investment is needed. It also provides opportunities for collaboration with Indigenous Peoples, environmental non-governmental organizations, and the public. The public plays a key role as partners, advocates, and implementers for lakewide protection and management. The 2018-2022 LAMP brings attention to where collective action is needed now to address current threats in Lake Ontario, including:

- Enhancing our understanding of nutrient dynamics;
- Improving the health of aquatic and wetland habitat and native species;
- Controlling aquatic invasive species; and
- Reducing chemical contaminants (legacy and chemicals of emerging concern).

Together, with the guidance of the 2018-2022 LAMP, this collective action can contribute towards reducing threats and support a prosperous and sustainable Lake Ontario for all.

#	Lake Ontario Partnership Actions (2018-2022)	Agencies Involved
	NUTRIENTS AND BACTERIAL RELATED IMPACTS	
1	**Wastewater and Stormwater Management System/Facilities:** • Compliance promotion and enforcement of regulations to control end-of-pipe sources of pollution. • Implement water quality improvement projects, including upgrades/ optimization of wastewater and stormwater facilities and infrastructure. Implement best management practices for the treatment of urban stormwater runoff to the Great Lakes, using green infrastructure and low impact development where feasible.	USDA-NRCS, NYSDEC, MECP, Conservation Authorities, USACE
2	**Nutrient and Bacteria Control:** • Build on existing integrated and systematic efforts within targeted watersheds to improve soil health and reduce the overland runoff of nutrients, sediments, and bacteria to the lake or tributaries. • Where needed and as resources allow, conduct relevant research, source identification/track down, and identify potential actions to address sources. **Watershed:** • Implement site-specific projects within coastal wetlands, beaches, and shorelines that will reduce impacts to the lake from nutrient and bacteria inputs.	USDA-NRCS, NYSDEC, MECP, Conservation Authorities, USACE
3	**Remedial Action Plans:** • Continue to implement remedial actions in the Bay of Quinte, Hamilton Harbour, Toronto and Region and St. Lawrence Areas of Concern to address excess nutrient and bacterial contamination.	ECCC, MECP, MNRF
4	**Watershed Management Planning and Implementation:** • Renew and/or develop integrated watershed management plans and link to coastal and nearshore management and other nutrient reduction/ management actions as required at a community level.	NYSDEC, MECP, Conservation Authorities

#	Lake Ontario Partnership Actions (2018-2022)	Agencies Involved
	SCIENCE, SURVEILLANCE, AND MONITORING	
5	**Nutrients:** • Conduct research and monitoring to better understand nutrient dynamics in Lake Ontario and its watershed including spring and summer open water nutrient and lower food web surveys, and tributary monitoring. • Monitor *Cladophora* growth in nearshore areas and loads of phosphorus to Lake Ontario from tributaries. • Assessment of nearshore waters of Lake Ontario, Niagara and St. Lawrence Rivers under the Nearshore Framework.	ECCC, USEPA, USGS, TRCA, MECP, NOAA, NYSDEC
6	**Agricultural Areas:** • Continue to conduct Environmental Farm Plan risk assessments and edge-of-field monitoring to assess effectiveness of best management practices.	USGS, USDA-NRCS, Conservation Authorities
	OUTREACH AND EDUCATION	
7	**Communication:** • Improve engagement, communication and coordination to build awareness and improve understanding of Lake Ontario & connecting rivers issues	MECP, ECCC,USEPA, NYSDEC, Conservation Authorities
	HABITAT AND SPECIES PROTECTION AND RESTORATION	
8	**Wetlands:** Protect, improve and monitor Lake Ontario coastal and watershed wetlands to support fish and wildlife diversity and habitat through a variety of initiatives including: • Wetland protection through land use policy and land conservation incentives to landowners. • Assess coastal wetland vulnerability to projected climate change impacts and recommend adaptive measures.	USEPA, NYSDEC, USFWS, USGS, USACE, MNRF, ECCC, Conservation Authorities
9	**Stream Connectivity:** Improve access to stream habitat for aquatic life by inventorying and prioritizing key barriers for mitigation. Undertake actions to remove, replace, or retrofit priority barriers (e.g., dams, weirs, road crossings) to allow for fish passage, spawning and migration while excluding invasive species where required.	USFWS, USGS, USEPA, USACE, NYSDEC, SRMT, MNRF, DFO, Conservation Authorities

#	Lake Ontario Partnership Actions (2018-2022)	Agencies Involved
10	**Aquatic Habitat Protection and Restoration:** • Engage stakeholders, public and ENGO's to improve and restore the physical and chemical aspects of aquatic habitat in near shore, shoreline, and upland/riparian areas by: • Promoting beneficial and resilient nature-based shoreline management practices to reduce soil erosion, improve riparian buffers and soften artificially hardened shoreline protection structures. • Supporting the lifecycles of key native, restoration species by protecting and restoring fish spawning and nursery habitat in embayment and nearshore areas. • Encouraging adoption of Low Impact Development techniques and improved stormwater management to reduce the impacts (e.g., sediment and nutrients) of urban development on in-stream and nearshore fish and wildlife habitat. • Planning/implementing programs related to open space conservation and land/forest stewardship, including efforts to increase habitat resiliency in the watershed.	ECCC, MECP, MNRF, Conservation Authorities, NYSDEC, USFWS, USACE, USFS
11	**Species Protection, Restoration and Enhancement:** Continued development, implementation, and evaluation of species protection and restoration plans, including enhancement through stocking, habitat restoration, control of invasive species (e.g., Sea Lamprey), diversification of prey resources, monitoring to measure success, and research to understand recovery processes for the following species: • Lake Trout • Native Coregonids (Bloater and Cisco) • American Eel • Lake Sturgeon • Atlantic Salmon	NYSDEC, USGS, USACE, USFWS, MNRF, DFO, Conservation Authorities
	SCIENCE, SURVEILLANCE, AND MONITORING	
12	**Evaluate Aquatic Food Web Status:** • Evaluate the aquatic food web including primary production, phytoplankton, zooplankton, mysids, *Dreissenid* mussels, and benthos.	MECP, NYSDEC

#	Lake Ontario Partnership Actions (2018-2022)	Agencies Involved
13	**Improve Understanding of Fish Dynamics:** • Improve our understanding of fish ecology and distribution during critical periods and apply new and existing techniques to address key knowledge gaps and inform management decisions.	MNRF, NYSDEC
14	**Coastal Wetland Status:** • Improve engagement, communication and coordination to build awareness and improve understanding of Lake Ontario & connecting rivers issues	MNRF, NYSDEC, ECCC
	INVASIVE SPECIES	
15	**Ballast Water:** • Establish and implement programs and measures that protect the Great Lakes Basin ecosystem from the discharge of aquatic invasive species in ballast water, consistent with commitments made by the Parties through Annex 5 of the GLWQA	Transport Canada, USCG, USEPA
16	**Early Detection and Rapid Response:** • Through the Annex 6 subcommittee, implement an 'early detection and rapid response initiative' with the goal of finding new aquatic and terrestrial invasive species and preventing them from establishing self-sustaining populations. • Implement domestic/regional invasive species management plans	DFO, USFS, USFWS, NYSDEC
17	**Sea Lamprey:** • Control the larval Sea Lamprey population with selective lampricides. Maintain operation and maintenance of existing barriers and the design of new barriers where appropriate.	DFO, USACE, USFWS
18	**Asian Carp:** • Prevent the establishment of invasive carp species.	DFO, USFWS, NYSDEC
	SCIENCE, SURVEILLANCE, AND MONITORING	
19	**Surveillance:** • Maintain and enhance early detection and monitoring of non-native and invasive species (e.g. Asian Carp) through the Annex 6 'early detection and Rapid Response Initiative'.	NYSDEC, USFWS, DFO

#	Lake Ontario Partnership Actions (2018-2022)	Agencies Involved
20	**Monitoring:** • Monitor and evaluate aquatic food web status to help improve understanding of fish dynamics.	USACE, USGS, USFWS, NYSDEC, MNRF
	OUTREACH AND EDUCATION	
21	**Communication:** • Undertake additional aquatic invasive species prevention outreach and education, including discussions with recreational boaters and lake access site signage. • Implement outreach and education programs to minimize the spread of invasive species by recreational boating, fishing equipment, and other recreational activities.	DFO, MNRF, USFWS, NYSDEC
	ADDRESSING POINT SOURCE AND NON-POINT SOURCE CHEMICAL CONTAMINANTS	
22	• Implement and enhance existing programs to control/reduce sources of chemical pollution to air, water and soil/sediment	MECP, USEPA, NYSDEC
23	• Support the development and implementation of the Chemicals of Mutual Concern Binational Strategies	ECCC, USEPA
24	• Identify, understand, and address impacts of critical and emerging pollutants. Where needed and as resources allow, conduct source track down of contamination, and identify potential mitigative actions.	NYSDEC, MECP, USEPA
25	• Pursue site-specific remedial actions where needed to address priority legacy chemical pollutants in sediment, soil, and ground/ surface water.	NYSDEC, NYSDOH, USEPA
26	• Continue to implement Randle Reef contaminated sediment remediation project in Hamilton Harbour, Lake Ontario	ECCC, MECP
27	• Continue to implement contaminated sediment remediation efforts in Port Hope Harbour	NRCan
	SCIENCE, SURVEILLANCE, AND MONITORING	
28	• Implement and enhance binational surveillance and monitoring programs to assess the effectiveness of chemical contaminant reduction efforts and evaluate contaminant trends over time.	ECCC, MECP, USEPA, USGS, NYSDEC

1

1.0 INTRODUCTION

The Lake Ontario Lakewide Action and Management Plan (LAMP) is a binational ecosystem-based strategy to restore and protect the water quality of Lake Ontario and its connecting river systems, the Niagara and St. Lawrence Rivers. This is the first Lake Ontario LAMP under the 2012 amendment to the Great Lakes Water Quality Agreement (GLWQA). It builds upon the work conducted under the pre-2012 LAMPs (Appendix A) and reflects that the best approach to restore the Lake Ontario ecosystem and improve water quality in the two countries is to adopt common objectives, implement cooperative programs, and collaborate to address environmental threats. This LAMP covers the five-year period from 2018 to 2022.

The LAMP was developed by the Lake Ontario Partnership, a collaborative team of natural resource managers led by the governments of the U.S. and Canada, in cooperation and consultation with State and Provincial Governments, Tribal Governments, First Nations, Métis, Municipal Governments, and watershed management agencies. The Lake Ontario Partnership identified the set of priority management actions outlined in this LAMP in consultation with Lake Ontario stakeholders and the public.

The purpose of this 2018-2022 LAMP is to:

1. Summarize the most up-to-date information on the state of Lake Ontario, to raise awareness of water quality issues in the Lake Ontario Basin;
2. Outline actions to address the identified threats and challenges and contribute to the General Objectives of the GLWQA, providing a framework for public agencies to co-ordinate their work; and
3. Engage all individuals and groups interested in Lake Ontario water quality to do their part in protecting the water quality in Lake Ontario.

This LAMP guides the work of natural resource managers, decision-makers, Lake Ontario stakeholders, and the public for the years 2018 to 2022. It is a call to action for anyone interested in the Lake Ontario ecosystem, its water quality, and the actions that will help restore this unique Great Lake.

The Lake Ontario LAMP: A Role for Everyone

Public awareness and appreciation of water quality issues are important aspects of this LAMP. There are many opportunities to get involved in protecting Lake Ontario water quality and ecosystem health. Look for 'Activities that Everyone Can Take' information throughout Chapter 5 and the Lakewide Management Actions in this LAMP. Other activities are described in Chapter 7, Implementing the LAMP. Local watershed organizations also work to improve water quality - contact one near you to volunteer!

The 2018-2022 LAMP is organized as follows:

- **Chapter 1** – the remainder of this chapter provides the background of the GLWQA, the Lake Ontario Partnership, development of the LAMP, and the geographical scope of the Basin;
- **Chapter 2** – describes the importance, value, and uses of Lake Ontario;
- **Chapter 3** – summarizes the most up-to-date knowledge on the status of the Lake Ontario ecosystem;
- **Chapter 4** – gives an overview of four other binational strategies created to address specific water quality or ecosystem concerns that complement and support actions identified in the 2018-2022 LAMP;
- **Chapter 5** – outlines the lakewide actions and management strategies to address the threats to Lake Ontario's ecosystem and connecting river systems identified in Chapter 3;
- **Chapter 6** – gives an overview of science and monitoring priorities relevant to the LAMP; and
- **Chapter 7** – discusses principles that will be used to implement the LAMP, outreach and engagement in implementation, and how members of the public can get involved.

1.1 The Great Lakes Water Quality Agreement

Since 1972, the GLWQA has guided U.S. and Canadian actions that restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes. The 2012 protocol amending the Agreement reaffirms the U.S. and Canada's commitment "to protect, restore, and enhance water quality of the Waters of the Great Lakes and to prevent further pollution and degradation of the Great Lakes Basin Ecosystem" (see https://binational.net/2012/09/05/2012-glwqa-aqegl/).

The Agreement commits Canada and the United States to address 10 priority issues (Table 1). These issues are addressed as 10 annexes in the GLWQA. The Lake Ontario LAMP integrates information and management needs for these issues, with a focus on Lake Ontario-specific management needs to maintain, restore, and protect water quality and ecosystem health.

Table 1: Annexes to address priority issues of the Great Lakes Water Quality Agreement

Annexes
1. Areas of Concern
2. Lakewide Management
3. Chemicals of Mutual Concern
4. Nutrients
5. Discharges from Vessels
6. Aquatic Invasive Species
7. Habitats and Species
8. Groundwater
9. Climate Change Impacts
10. Science

Under the Lakewide Management Annex of the Agreement, Canada and the United States are required to prepare a LAMP every five years, a progress report every three years, and annual updates to the public. Past LAMPs for Lake Ontario can be found at https://www.epa.gov/greatlakes/lake-ontario.

1.2 The Lake Ontario Partnership

The Lake Ontario Partnership is led by Environment and Climate Change Canada (ECCC) and the United States Environmental Protection Agency (USEPA) and consists of representatives of federal, provincial and state agencies, Indigenous Peoples, municipalities, and watershed management agencies (see page i for a list of partnership agencies). These member representatives and agencies focus on restoration, protection, and management of natural resources and environmental health and have the roles, responsibilities, ability and commitment to implement the LAMP. The Lake Ontario Partnership member organizations commit to incorporating, to the extent feasible, LAMP actions in their decisions on programs, funding, and staff resources. While member agencies and organizations operate independently, they are formally linked under the Lake Ontario Partnership to represent a force stronger than the individual parts.

The Lake Ontario Partnership will facilitate the implementation of the LAMP by sharing information, setting priorities, and assisting in coordinating environmental protection and restoration activities. The Partnership uses an ecosystem-based adaptive management approach that recognizes the interaction of human and natural influences on Lake Ontario habitats, species, and physical processes (Figure 1). During the implementation of this LAMP, member agencies of the Lake Ontario Partnership will assess the effectiveness of actions and adjust future actions to achieve the objectives of this plan, as outcomes and ecosystem processes become better understood.

Some of the key programs that support the work of the Partnership include New York State Department of Environmental Conservation's (NYSDEC) Great Lakes Action Agenda (https://www.dec.ny.gov/lands/91881.html), Ontario's Great Lakes Strategy (https://www.ontario.ca/page/ontarios-great-lakes-strategy), USEPA's Great Lakes Restoration Initiative (https://www.epa.gov/great-lakes-funding/great-lakes-restoration-initiative-glri), Canada's Great Lakes Protection Initiative (https://www.canada.ca/en/environment-climate-change/services/great-lakes-protection.html), and the Canada Ontario Great Lakes Agreement. (https://www.ontario.ca/page/canada-ontario-great-lakes-agreement).

Figure 1: An adaptive lakewide management approach for Lake Ontario

1.3 Engagement in the Development of the Lake Ontario LAMP

This LAMP was developed through research, monitoring, and engagement with partnering agencies, academia scientists, non-governmental environmental organizations, Indigenous Peoples, and the general public. The Lake Ontario Partnership informed the general public that the Lake Ontario LAMP was under development and invited public comment in the summer of 2017 via the Great Lakes Information Network (http://www.great-lakes.net/). Lake partners, stakeholders, and the general public were invited to provide input on a draft Lake Ontario LAMP in 2019 via https://binational.net/.

The public plays a critical role as partners, advocates, and implementers for lakewide protection and management. Therefore, the Lake Ontario Partnership established an Outreach and Engagement Subcommittee to enhance opportunities for the public to engage in lakewide management and to foster actions that sustain the health of Lake Ontario. The Subcommittee will work with Lake Ontario Partnership agencies to:

- Report on Lake Ontario management successes, challenges, and next steps;
- Advertise opportunities for public input and participation in Lake Ontario activities on binational.net, the Great Lakes Information Network, and other online venues;
- Promote and encourage restoration and protection initiatives that can be adopted and implemented by individuals, groups, and communities to support the stewardship of Lake Ontario; and
- Develop and implement new outreach and engagement activities.

Benefits of Outreach and Engagement

- Improve people's appreciation and understanding of Lake Ontario
- Share information on issues, threats, management needs, and achievements
- Get more people and groups involved in the restoration and protection of Lake Ontario

1.4 Alignment with Other International Resource Efforts

The Lake Ontario Partnership actively works to ensure that management actions identified in this LAMP complement other international management efforts established under various binational treaties, agreements, and programs; and work within the Lake Ontario ecosystem. These include:

- Water Levels Management: The International Joint Commission provides oversight of water levels and flows in the Great Lakes, including the control structure in the St. Lawrence River (for more information: http://www.ijc.org/en_/Water_Quantity).
- Water Withdrawals Management: The Great Lakes-Saint Lawrence River Basin Sustainable Water Resources Agreement details how eight Great Lakes states and the provinces of Ontario and Quebec manage their water supplies. The Great Lakes-St. Lawrence River Basin Water Resources Compact is a legally binding interstate compact and a means to implement the Governors' commitments (for more information: http://www.glslregionalbody.org/index.aspx and http://www.glslcompactcouncil.org/).
- Fishery Management: The Great Lakes Fishery Commission (GLFC) facilitates cross-border cooperation to improve and preserve the fishery. The Lake Ontario Committee is comprised of senior officials from state and provincial fishery agencies. The Committee is charged with collecting data, producing and interpreting science, and making recommendations. The Committee also develops shared fish community objectives, establishes appropriate stocking levels and harvest targets, sets law enforcement priorities, and formulates management plans (for more information: http://www.glfc.org/lakecom/).
- Water Resource Management: The Great Lakes Commission is a public agency established by the Great Lakes Basin Compact in 1955 to facilitate cross-border cooperation to fulfill their vision for a healthy, vibrant Great Lakes-St. Lawrence River region. The Commission is comprised of senior officials from state and provincial agencies. The Committee is charged with collecting data, producing and interpreting science, and making recommendations regarding integrated water resource management in the Great Lakes (for more information: https://www.glc.org/).

1.5 Geographic Scope of the LAMP: The Lake and its Connecting Rivers

Lake Ontario is the easternmost and last lake in the chain of Great Lakes that straddle the Canada-United States border. Its shoreline is bordered by the Province of Ontario on the Canadian side and New York State on the U.S. side (Figure 2). As directed by the 2012 Agreement, the Lake Ontario LAMP encompasses Lake Ontario and its two connecting rivers, the Niagara and St. Lawrence Rivers, to the international boundary.

The 1987 GLWQA identified nine Areas of Concern (AOCs) within the geographic scope of the Lake Ontario Basin (Figure 2). Annex 1 of the Agreement defines an AOC as a geographic area designated by Canada or the United States where significant impairment of beneficial uses has occurred as a result of human activities at the local level. Impairment of a beneficial use is a reduction in the chemical, physical or biological integrity of the waters of Lake Ontario. Canada and the United States have committed to restoring beneficial uses that have become impaired due to local conditions at Areas of Concern (AOCs), through the development and implementation of Remedial Action Plans (RAPs) for each AOC. More information about Areas of Concern is available at https://binational.net/2014/10/31/status-aocs.

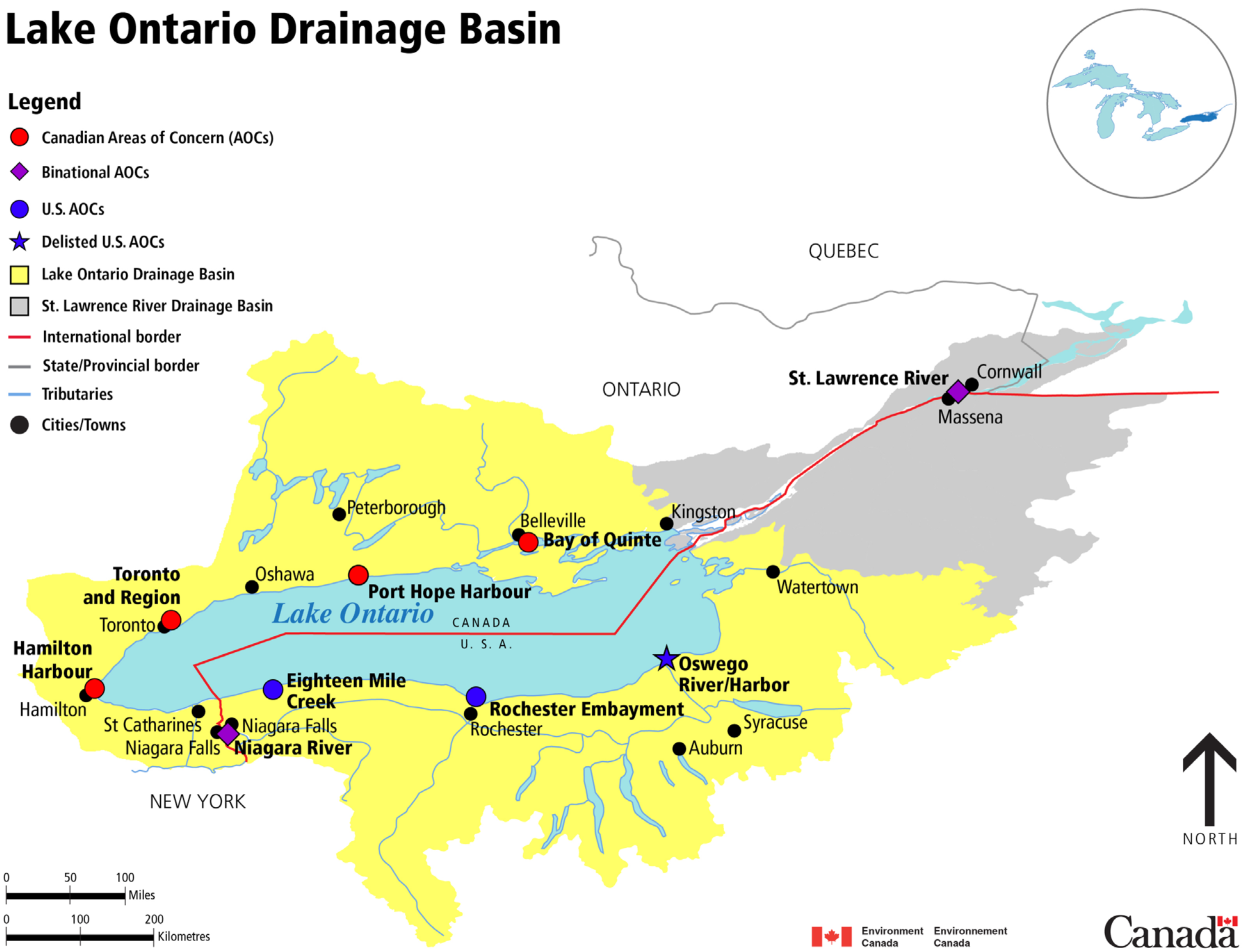

Figure 2: Lake Ontario & St. Lawrence River Drainage Basin with Areas of Concern

(Source: Environment and Climate Change Canada)

2

2.0 INHERENT VALUE, USE, AND ENJOYMENT OF LAKE ONTARIO

Lakewide management is guided by a shared vision of a healthy, prosperous, and sustainable Great Lakes region in which the waters of Lake Ontario are used and enjoyed by present and future generations. The Lake Ontario LAMP derives its vision for lakewide management from the GLWQA.

The Lake Ontario LAMP recognizes the inherent natural, social, spiritual, and economic value of the Lake Ontario Basin ecosystem. This includes the cultural significance of the area to Indigenous Peoples, ecosystem goods and services provided by the Basin, regional economic value, habitats and species, characteristics of global significance, and recreation and tourism opportunities. A healthy watershed supports these uses, value, and enjoyment of Lake Ontario.

The Lake Ontario watershed is currently home to 11 million people (about 9 million Ontarians and 2 million New Yorkers) and has been inhabited and enjoyed for thousands of years by many Indigenous communities. The intense urbanization that has occurred in portions of the Lake Ontario Basin and the exploitation of these ecosystem goods and services, especially over the past 100 years, have significantly contributed to the degradation of the ecosystem within the Lake, connecting rivers and the surrounding watershed (see Chapter 3). Lake Ontario's position downstream of the other Great Lakes also means that its water quality and ecosystem health are impacted by human activities and natural events occurring throughout the Lake Superior, Michigan, Huron, and Erie basins (Figure 3).

Where Water Comes Together With
Other Water
...the places streams flow into rivers.
The open mouths of rivers where they join the sea.
The places where water comes together with other water.
Those places stand out in my mind like holy places.
- Raymond Carver

Lake Ontario is the smallest of the Great Lakes (by surface area), but the 14th largest lake in the world by surface area and 11th largest in volume. It has a surface area of 18,960 km2 (7,340 miles2), an average depth of 86 meters (283 feet) and a maximum depth of 244 meters (802 feet). It is the second-deepest of the Great Lakes and fourh largest in volume at 1,640 km2 (393 miles3) – and when islands are included, the Lake has a shoreline length of 1,146 km (712 miles). Like all the other Great Lakes, Lake Ontario was formed during the retreat of glaciers about 12,500 years ago, taking on its current form about 5,000 years ago.

All of the water from the upper four Great Lakes flows through Lake Ontario, accounting for approximately 80% of inflows into the Lake. The remaining water comes from tributaries (approximately 14%) and precipitation (approximately 6%). Over 90% of the water in Lake Ontario flows through the St. Lawrence River towards the Atlantic Ocean, with about 7% lost to evaporation.

Figure 3: Satellite image of Lake Ontario showing the influence of Lake Erie water entering Lake Ontario via the Niagara River on Lake Ontario’s south shore

(Source: NOAA Coast Watch)

Things Every Resident of the Lake Ontario Basin Should Know

1. Lake Ontario is the 14th largest lake in the world; it is a deep, cold water ecosystem that supports Lake Trout and Whitefish.
2. A critical link in the Lake Ontario food chain is a small freshwater shrimp (*Diporeia*).
3. American Eel lives in Lake Ontario and its tributaries, but spawns in the Atlantic Ocean.
4. There are almost 100 species of native fish in Lake Ontario.
5. It is one of two Great Lakes with water levels that are regulated through dams in Outlet Rivers (the other is Lake Superior).
6. Over 9 million people get their drinking water from Lake Ontario.
7. Only the western portion of the Basin is highly developed; most of the Basin is characterized by rural landscapes.
8. The western part of Lake Ontario is the fastest developing area in the Great Lakes Basin.
9. The open lake is significantly cleaner than it was 20 years ago.
10. Improving the health of Lake Ontario improves the quality of life for people in the Basin.
11. The shoreline of the Upper St. Lawrence River exceeds that of Lake Ontario.

2.1 Significance to Tribes, First Nations, and Métis Peoples

It is estimated that Indigenous Peoples have lived in the Lake Ontario Basin for between 7,000 to 11,000 years living in harmony with the land and deriving their material and spiritual needs from the world around them. In earliest times, these cultures were nomadic hunters and gatherers who were drawn to the area by its abundant fish, wildlife, and plant life. Two main groups, the Algonkian-speaking Woodland First Nations (including the Anishinaabe) and the Haudenosaunee, or People of the Longhouse (also known as Iroquois), co-existed in this region. Lake Ontario's name in fact comes from the Mohawk word *ontario*, meaning "Lake of Shining Waters".

Over the centuries, the Indigenous population of the Lake Ontario Basin increased steadily, and Indigenous cultures became more complex.

Temporary, and in some cases permanent, settlements were established near the mouths of major rivers, where families could come together to hunt, fish, trade, and engage in social and spiritual events. By about 1,400 years ago, corn had arrived from more southern regions, and with beans, squash, sunflowers, and tobacco, became an important foundation of Haudenosaunee farming societies. A reliable food supply from agriculture allowed these societies more leisure time to craft decorative and utilitarian objects, some of which were traded with other societies.

Over the next millennium, trade among these early cultures became increasingly important, using routes such as the "Toronto Passage" between Lake Ontario in the south and Lake Simcoe and Georgian Bay in the north. Archaeological evidence from trade goods suggests extensive contact among Indigenous groups in the Lake Ontario Basin and with cultures far outside that region. Examples include copper mined from surface deposits near Lake Superior and marine shell objects from the Gulf of Mexico. Access to Lake Ontario and its tributaries and wetlands was therefore an important consideration in the choice of settlement locations, because it provided fishing and hunting opportunities and efficient travel for trade, diplomatic, and military purposes.

The distribution of Indigenous Peoples in the Lake Ontario Basin shifted over the years, the result of a complex series of events including amalgamation, confederacies, conflict, and associated migration. Today (Figure 4), on the Canadian side, First Nations represent two major ethnicities, the Anishinaabe and the Haudenosaunee. Métis people, who trace their ancestry to European and First Nations roots, have also established communities throughout the Lake Ontario and Niagara River Basins. On the U.S. side, Nations located in New York State are members of the Haudenosaunee or Iroquois Confederacy, the Mohawk, Cayuga, Onondaga, Oneida, Seneca, and Tuscarora, each with its own distinctive language, customs, and governments.

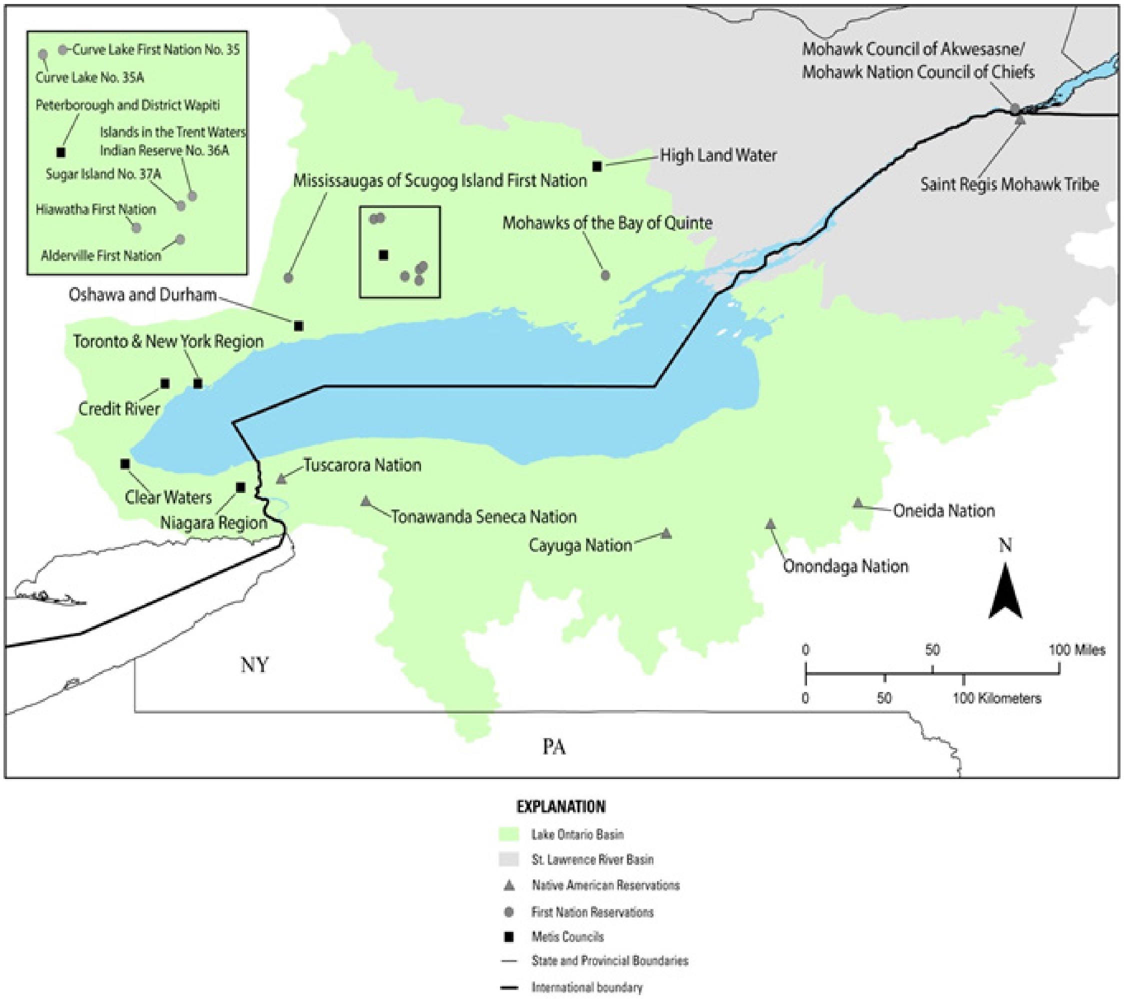

Figure 4: Indigenous communities in the Lake Ontario, Niagara River, and St. Lawrence River Basins. Denotations represent approximate territory centres

(Source: USGS)

Traditional Ecological Knowledge (TEK) is a term that describes the knowledge system of Indigenous People built upon direct observations of the surrounding environment. This Indigenous knowledge is passed down generation to generation and is used to explain their place in complex and interdependent relationships with all of creation. While traditional knowledge is based on historic uses and management of resources, it is important to understand that many of these traditional practices are ongoing and continue within Indigenous communities. TEK demonstrates the strong ties that Indigenous Peoples have with the natural world, and because of this reliance on natural resources it is imperative that the environment remains healthy and safe for continued cultural practices. TEK enhances the understanding and appreciation of Lake Ontario and its connecting river systems and is useful in local, regional, and lakewide management, including the development and implementation of the Lake Ontario LAMP. Because of their strong connection to the Lake as well as TEK, Indigenous People will continue to be engaged in assessing Lake status, identifying priorities for science and action, and in taking action to address Lake issues.

The waters, fish, plants, and wildlife of Lake Ontario and its connecting river systems continue to be culturally important to the First Nations, Tribes, and Métis communities located throughout the Basin. One example that highlights the relationship Indigenous People have with the natural environment is the language and intent of the Ohen:ton Karihwatehkwen, or the Haudenosaunee Thanksgiving Address. The Ohen:ton Karihwatehkwen, otherwise known as the "words before all else," is a Haudenosaunee way of giving thanks instructed by the Creator that is spoken at the opening and closing of any gathering to give thanks for life and all that sustains life. The Thanksgiving Address teaches mutual respect and the responsibility, as well as an understanding, that we as human beings are not separate from the natural world. Central to this reciprocal relationship is the acknowledgement that we are part of the environment as an interconnected system, and that no actions are done in isolation, for everything we do to our environment, we do to ourselves.

2.2 Ecosystem Goods and Services

Lake Ontario and its watershed provide many important ecosystem goods and services which people benefit from when the ecosystem is healthy. Ecosystem goods are vital to sustaining well-being, and to future economic and social development. Examples of some of the important ecosystem goods and services include fresh water, fresh air, fish (commercial and sport), medicinal plants, supporting livestock, and the cultivation and transport of grain, fruits and vegetables, fuels, and timber.

The 2005 Millennium Ecosystem Assessment Program was called for by the United Nations to assess the consequences of ecosystem change for human well-being and the scientific basis for action needed to enhance the conservation and sustainable use of those systems and their contribution to human well-being. The program describes four categories of ecosystem services:

- **Provisioning (supply) services** – Lake Ontario provides drinking water for over 9 million people, a wide range of agricultural products, and a world-class sport fishery that generates millions of dollars annually.
- **Regulating services** – Lake Ontario and its wetlands moderate flooding, erosion, climate, and water quality.
- **Cultural services** – Lake Ontario supports tourism, including ecotourism and recreation. Cultural services also include the non-market values associated with spiritual enrichment, education, aesthetic experiences, and a sense of place for the people who live near the Lake, within the Lake Ontario Basin, and beyond.
- **Supporting services** – Lake Ontario provides the services necessary to produce all other ecosystem services, including photosynthesis, nutrient and gas cycling, soil formation, provisioning of habitat, and support for pollinators.

Historically Lake Ontario species and habitats were used for subsistence practices by Indigenous communities around the Lake Ontario Basin and connecting rivers. Today, revitalization of traditional and cultural practices by Tribal, First Nations, or Métis people include the use of flora and fauna for cultural activities such as medicinal plant harvesting, collection of traditional foods, and targeted locations and species for ceremonial use.

Sandy Pond wetland, eastern Lake Ontario. Lake Ontario's wetlands provide important regulating services to moderate flooding and erosion and improve water quality. They also provide habitat for a wide range of plant and animal species. (Source: US EPA)

2.3 Global Significance

The mild, temperate climate within the Lake Ontario Basin offers warm summers and a long growing season and supports some of the most diverse flora and fauna in Canada and the northeastern United States. There are some areas with remnants of Carolinian forests more typical of southern regions with species like Tulip-Tree, Black Gum, Sycamore, Kentucky Coffee-Tree, and Pawpaw. Many species that Canadian, U.S., provincial, or state agencies categorize as endangered or threatened occur in the Lake Ontario Basin, including Acadian Flycatcher, King Rail, Hooded Warbler, Piping Plover, Spiny Softshell Turtle, Blue Racer (snake), Small-mouthed Salamander, and Lake Sturgeon.

Several ecologically significant features are present. One example is alvars, globally rare, naturally open habitats characterized by thin soils or no soil over limestone or dolostone. Alvars have little capacity to trap and hold water, and experience spring flooding and summer drought. These harsh conditions are inhospitable for many species, so the plants and animals that survive in alvars are often globally rare and in some cases occur in no other habitat in the world. About 50 alvars have been identified in Prince Edward County, along the northeast shore of Lake Ontario, as well as alvars in the eastern basin in the United States.

Lake Ontario is also a globally important resting place for migratory birds. The Great Lakes are a daunting barrier for birds and other migratory species, because of the long stretches of open water they must cross. Birds seek shelter along the shoreline, waiting for favourable wind conditions to carry them across the Lake. Lake Ontario provides significant and globally important stopover areas for more

Alvar habitat, Prince Edward County, Ontario. (Source: MECP) than 100 species of songbirds migrating across the western hemisphere. As they pass through, these birds contribute to seed dispersal and pollination, and consume insect pests that could plague agriculture.

A 2012 Nature Conservancy study[1] has demonstrated that while migrating birds are most abundant in forested areas close to the Lake, they also use isolated patches near agricultural areas and even city parks. Along the northeast shore of Lake Ontario, baymouth sand bars have created wetlands and small, sheltered lagoons, such as those near Presqu'ile Provincial Park and parts of the Bay of Quinte that are particularly important rest areas for migratory birds. At Presqu'ile Provincial Park, 337 wild bird species have been recorded, many of them migratory, and 120 species are known to breed there.

The west end of Lake Ontario, near Hamilton, has been designated as a globally significant Important Bird Area (IBA) in recognition of the tens of thousands of waterfowl that congregate there each spring. The Upper St. Lawrence River/Thousand Islands area is a National Audubon Society-designated Important Bird Area. On the U.S. side, the Braddock Bay and Rochester region includes all or part of three Audubon-designated IBAs. The Braddock Bay

Hamilton Harbour (Source: ECCC)

The Great Lakes St. Lawrence Seaway at Snell Lock, New York. (Source: US DOT) area hosts a remarkable diversity and abundance of birds and is well known for having one of the world's largest spring hawk flights (144,000 counted in 1996), and an important owl migration point. Migrating butterflies also use habitat along the Lake Ontario shoreline to feed, rest, and recover after their long flight across the Lake.

Lake Ontario is also part of an internationally important Seaway, the Great Lakes St. Lawrence Seaway, the longest of its kind in the world. This deep draft navigation system spans 3,700 km (2,340 miles) and allows passage from the Atlantic Ocean into central North America. Connected to a comprehensive road and rail network, the Seaway supports the movement of raw materials and manufactured products into and through the Great Lakes system. Among the cargoes are iron ore for steel production, limestone and cement for construction, and grain for domestic consumption and export.

2.4 Diverse Habitat and Species

Lake Ontario's shoreline supports diverse habitats, from rocky cliffs to dunes and wetlands. Most of the landscape in the Lake Ontario Basin is relatively flat or undulating and rocky outcrops are only found in a few locations, notably the Niagara Escarpment in the west and the Thousand Islands region in the east.

Coastal wetlands occur along most of the Lake's shoreline and near tributary mouths and estuaries. In addition to the Niagara River, the Lake's major tributaries include the Don, Credit, Humber (a Canadian Heritage River), Rouge, Ganaraska, Trent, and Moira Rivers on the Canadian side, and the Salmon, Oswego, Genesee, and Black Rivers and Oak Orchard, Irondequoit, and Sandy Creeks on the U.S. side. Each coastal wetland community is unique in structure and ecological function. Examples include swamps with water-tolerant woody species like Willow and Alder, wet meadows with grasses and sedges, marshes with emergent species

Piping Plover. (Source: NYSDEC)

like cattails and bulrushes, and shallow open waters supporting submerged or floating plants such as Duckweed and Water Lily. While a number of shoreline and inland wetlands have been drained through human activities over the last two centuries, more than 17,800 hectares (44,000 acres) of wetland remain along the Lake Ontario shoreline. Many wetlands are now protected from further drainage or development.

Several embayments offer sheltered habitat for aquatic and riparian species, and protected anchorages for recreational and commercial watercraft. Along the shoreline, coastal beaches, dunes, and sandbars form part of a coastal barrier system. These barrier beaches and dunes are flexible barriers to wave action and storm surges, helping protect critical habitat in the Lake's embayments, wetlands, and estuaries by spreading the impact of wave energy and reducing the risk of structural damage and erosion. At the eastern end of the Lake, referred to as the Eastern Lake Ontario Barrier Complex, is a large complex of coastal dunes and wetlands protected through a network of nature preserves, wildlife management areas, and State parks.

In the Lake's nearshore zone, shallow productive waters provide critical nursery, feeding, and reproductive habitat for waterfowl and many fish species. The open, offshore waters of Lake Ontario are less productive than nearshore waters but consist of a diversity of lower trophic level species (e.g., phytoplankton, zooplankton, pelagic and benthic macroinvertebrate), and prey fish and their predators. Many factors in the Lake's open water zone influence ecosystem function and health, including nutrient dynamics, thermal stratification, productivity, invasive species, and trophic interactions. At least 130 fish species (native & non-native) are known to have occurred in Lake Ontario, although 20 of those are now locally extinct or very rare.

Parks and protected areas are conserving and restoring environmentally important lands across the Lake Ontario Basin, many with a focus on improving the connectivity of terrestrial and aquatic habitats. In upland areas near Lake Ontario, large tracts of forest remain, dominated by Oak, Maple, Beech and Pines. More than 3,500 species of plants and animals inhabit these ecosystems, including Bald Eagle, Great Blue Heron, White Tailed Deer, Beaver, Mink, Otter, Coyote, Porcupine, and Flying Squirrel.

2.5 Natural Resources and the Regional Economy

More than 11 million people live in the Lake Ontario watershed. Most of the urban population (approximately 9 million people) live on the Canadian side, primarily in the large group of urban centres collectively called the Golden Horseshoe, encompassing Toronto, Hamilton, and several smaller cities. On the U.S. side, most of the land use is rural, with the exception of Rochester, Niagara Falls, and Oswego. About 2 million people live in the U.S. portion of the Basin. Outside the Golden Horseshoe and smaller cities, much of the land use in the Basin is rural, open space, or agricultural (Figure 5). Urban areas, roads, and associated infrastructure take up less than 10% of the Basin's land area.

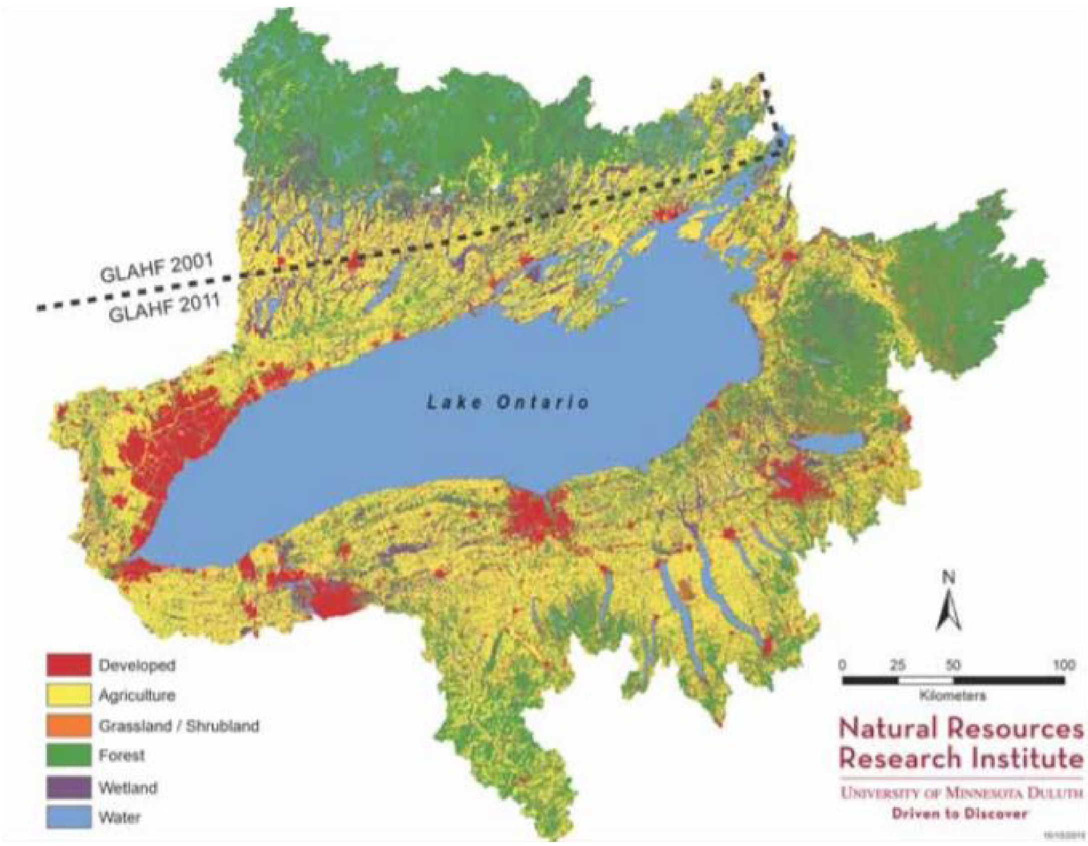

Figure 5: Distribution of land use/land cover across the Lake Ontario Basin

(Source: SOGL, 2017. GLAHF 2001 are an integration of the National Land Cover Dataset (NLCD) and the Ontario Land Cover Compilation v 2.0 data from 2001, whereas GLAPH 2011 incorporate 2011 NLCD and 2012 SOLRIS data (Wang et al., 2015); the GLAPH 2011 dataset does not cover the area north of the demarcation line)

Regional Economy

The Lake Ontario Basin's economy is diverse and includes traditional industries such as agriculture, finance, transportation, shipping and manufacturing, and newer industries such as telecommunications and information technology, pharmaceuticals, environmental technology, and service-oriented private sector companies. Hydroelectric Power generating stations are also prevalent in the Basin, specifically in the St. Lawrence River and Niagara River. Generating stations at Niagara Falls, Ontario and Lewiston, New York produce a quarter of the electricity used in those regions.

The St. Lawrence Seaway plays an important role in the Lake Ontario economy, moving more than 160 million tons of cargo every year to and from the Lake's 13 major ports and generating hundreds of thousands of jobs. In 2010, there were 226,933 U.S. and Canadian jobs associated with the Seaway. Of these, 92,923 people were employed directly in Seaway-related jobs and generated US$14.1 billion (CAD$18.0 billion) in personal income and US$6.4 billion (CAD$8.2 billion) and in direct spending in the regional economy. Cargo handling firms, vessel services, and associated inland transportation generated a further US$33.6 billion (CAD$45.3 billion) in business revenue in the same year, split almost equally between the U.S. and Canada.

Thriving sport fisheries exist for a variety of species in Lake Ontario and its embayments and tributaries, including six trout and salmon species, Walleye, Yellow Perch, and Smallmouth Bass. Offshore angling in the central and western parts of the Lake is largely focused on salmon and trout species, while angling in the eastern areas target Walleye, Smallmouth Bass, and Lake Trout. The sport fisheries generate millions of dollars annually for local, state, and provincial economies (over US$114 million contributed to the New York State economy in 2007; Brown & Connelly, 2009). In 2010, anglers spent greater than 5 million hours and generated CAD$118 million (US$90 million) from fishing in the Canadian waters of Lake Ontario (MNRF, 2015).

Fishing in Lake Ontario. (Source: ECCC)

Lake Ontario has the smallest commercial fishery of all of the Great Lakes, with harvested species including Yellow Perch, Lake Whitefish, Sunfish, and Bullhead.

The mild Lake Ontario climate has made it a preferred growing area for fruits such as apples, cherries, peaches, pears, plums, and grapes. Vineyards are clustered in the Niagara Peninsula, but also occur in Prince Edward County and along the north and south shores of Lake Ontario, and are an important contributor to the regional economy. Agriculture is an important industry throughout the Basin, especially on the U.S. side. Typical crops include corn, wheat, and soybeans, and cash crops such as cabbage, cucumbers, green peas, onions, beans, sweet corn, squash, potatoes, and carrots. Some specialty crops, such as ginseng and hops, are also grown in this region.

2.6 Tourism and Parks

Lake Ontario's natural beauty has been valued by people for thousands of years and continues to be prized today. Millions of people visit the Lake Ontario Basin every year, contributing hundreds of millions of dollars to local economies. Two Canadian national parks, three U.S. national park units, dozens of state and provincial parks, national wildlife sanctuaries, and other protected areas enhance and protect the value of Lake Ontario and its watershed.

In addition to the recreational and wildlife viewing opportunities available in parks and other protected areas, the Lake Ontario Basin offers many other recreational activities. In the summer, sport fishing, swimming, surfing and other water sports, recreational boating, and birdwatching are popular. The Lake's long, beautiful beaches, for example at Sandbanks Provincial Park, Ontario, and Southwick Beach State Park, New York, are particularly popular in the summer months.

Toronto, Ontario. (Source: MECP)

In the winter, the region offers ice yachting and winter rock climbing, in addition to the more traditional pastimes of ice skating, cross-country skiing, ice fishing, and snowshoeing. These opportunities contribute tremendous value to the Basin economy every year, but also enhance the quality of life for millions of Basin residents and visitors.

The Lake Ontario Basin also hosts a diverse and vibrant tourism industry. In the Niagara Peninsula and along the south shore of Lake Ontario in New York, winery tours are popular, while in major cities, music festivals, galleries, museums, dining, shopping, theatres, amusement parks, and major sporting events draw hundreds of thousands of visitors every year. Dozens of agricultural, cultural, and commercial festivals celebrate aspects of the Lake and its varied industries. Examples include fishing tournaments and derbies, Rochester's Lakeside Winter Festival, and Niagara-on-the-Lake's annual Peach Festival. The Niagara region also hosts three annual wine festival events, one for new vintages, one for classic vintages, and one for ice wines. The New York Finger Lakes wineries are also a notable attraction in the Basin.

Oakville, Ontario. (Source: ECCC)

Throughout the Basin, national historic sites and monuments offer opportunities to learn about the region's history and culture. Ecotourism has a growing presence, for instance in the eastern Lake Ontario dune and wetland system in upstate New York and the Niagara Escarpment in southern Ontario, where hiking along the breathtaking Niagara Glen, the southern terminus of the 890 km (553 miles) long Bruce Trail, is especially popular.

The northeastern portion of Lake Ontario and into the St. Lawrence River has rocky shorelines and windswept pines of the Thousand Islands region which support a thriving tourism industry focused on natural beauty and cultural heritage. At the western end of the Lake lies the spectacular Horseshoe Falls and Bridal Veil Falls complex of Niagara Falls, an area that has had an important place in First Nations and Tribal culture for generations and continues to attract millions of visitors every year.

3

3.0 THE STATE OF LAKE ONTARIO

Lake Ontario is in "fair" condition and the trend is "unchanging" in recent years as described in the State of the Great Lakes Technical Report (SOGL 2017). Chemical contaminants, nutrient and bacterial pollution, loss of habitat and native species and the spread of non-native invasive species limit the health, productivity, and use of Lake Ontario and its connecting River Systems.

This chapter summarizes current conditions and ongoing threats to Lake Ontario and its associated waterways. It is organized by each of the nine General Objectives of the 2012 Agreement and Table 2 provides an overview of the status of each objective for Lake Ontario.

The Governments of Canada and the United States, together with their many partners in protecting the Great Lakes, have agreed on a set of nine indicators of ecosystem health. These indicators are in turn supported by 44 sub-indicators, measuring such things as concentrations of contaminants in water and fish tissue, changes in the quality and abundance of wetland habitat, and the introduction and spread of invasive species. This assessment involves more than 180 government and non-government Great Lakes scientists and other experts working to assemble available data to populate the suite of sub-indicators. The Lake Ontario 2018-2022 LAMP will use State of the Great Lakes indicators to track progress toward achieving the General Objectives and the adopted nutrient-related Lake Ecosystem Objectives. The Lake Ontario Partnership may develop more specific Lake Ecosystem Objectives as needed to track progress. Each section in this chapter includes background information, a description of the data collection

Horseshoe Falls, Niagara Falls, Ontario. (Source: ECCC) approach, and science-based indicators that inform status and trends and assess threats.

Over the past 25 years, Canada and the U.S. have made significant progress in restoring and maintaining the Lake Ontario watershed. Positive changes include decreasing contaminant levels in fish such as polychlorinated biphenyls (PCBs). This has resulted in less restrictive advisories on the number and type of fish that can be eaten as contaminants can bioaccumulate in fish and affect other organisms throughout the food chain. The decrease in contaminant levels in fish has contributed to the recovery of fish-eating bird populations such as the Bald Eagle. Beaches are in 'Fair' to 'Good' condition. There are signs of progress in restoring some of our native species as evidenced by increased catches of Lake Sturgeon and their presence at artificial spawning beds, and increased catches of naturally reproduced Lake Trout. Deep Water Sculpin have also made a comeback in Lake Ontario (Weidel et al., 2017).

The health and productivity of Lake Ontario is still limited by other factors. Overall the state of Lake Ontario is graded as 'Fair'. For example, offshore phosphorus concentrations are below the GLWQA target. Declining nutrient levels contribute to reduced overall productivity of the Lake and change the structure of the lower food web, which can impact fish production. In the nearshore waters, despite long-term lakewide nutrient declines, mats of *Cladophora* algae are causing problems in some areas. This can be due to a number of factors: increased water clarity, increased soluble reactive phosphorus (SRP) levels in the nearshore from local point source discharges and increased SRP levels from changes in nutrient cycling with the arrival of the invasive Zebra and Quagga mussels (referred to as *Dreissenid* mussels).

The documented status and trends are based on the State of the Great Lakes (SOGL) 2017 sub-indicator reports produced by ECCC and USEPA. Additional literature reviews and information from scientists and resource managers were also used to inform the discussions in this chapter.

Table 2. Overview of the State of Lake Ontario in Relation to the Nine GLWQA General Objectives

(Source: SOGL 2017)

	GENERAL OBJECTIVE	STATUS
1.	Be a source of safe, high-quality drinking water	GOOD
2.	Allow for unrestricted swimming and other recreational use	FAIR to GOOD
3.	Allow for unrestricted human consumption of the fish and wildlife	FAIR
4.	Be free from pollutants that could harm people, wildlife or organisms	FAIR
5.	Support healthy and productive habitats to sustain our native species	FAIR
6.	Be free from nutrients that promote unsightly algae or toxic blooms	FAIR
7.	Be free from aquatic and terrestrial invasive species	POOR
8.	Be free from the harmful impacts of contaminated groundwater	FAIR
9.	Be free from other substances, materials or conditions that may negatively affect the Great Lakes (Watershed Impacts assessed)	POOR to FAIR

3.1 Drinking Water

GLWQA General Objective: Be a source of safe, high-quality drinking water.

Current Status: Lake Ontario continues to be a safe, high quality source of water for public drinking water systems. (Source: SOGL 2017)

3.1.1 Background

Protecting drinking water and water resources from harmful pollutants is a priority for all levels of government and a shared responsibility involving many partners and communities on both sides of Lake Ontario. Over 9 million New Yorkers and Ontarians get their drinking water from Lake Ontario. Lake Ontario provides drinking water to nearly half of Ontario residents. Of the 12.8 million people who live in the province, 49.2%, or 6.3 million people, draw their drinking water from the Lake. It's by far the most drawn upon source of water to sustain Ontario's growing population.

Municipalities own, or have water supplied to them, through various types of drinking water systems. To protect public health, public drinking water supplies are regulated on the United States side by the New York State Department of Health (NYSDOH) and on the Canadian side by the provincial government through the Ministry of the Environment, Conservation and Parks (MECP). The NYSDOH implements the federal *U.S. Safe Drinking Water Act* (SDWA), within New York State, and the monitoring required by the SDWA.

The MECP has adopted a multi-barrier approach to the protection of drinking water in the Province of Ontario from source to tap. *The Safe Drinking Water Act, 2002* has established stringent standards,

The Great Lakes provide drinking water to 40 million people (Source: ECCC) regular and reliable testing, licensing, operator certification, and inspections requirements.

Ontario's *Clean Water Act, 2006* has created the framework for watershed-based source protection plans to protect sources of municipal drinking water such as Lake Ontario. Vulnerable areas have been delineated around each of the municipal drinking water systems drawing water from Lake Ontario (https://www.gisapplication.lrc.gov.on.ca/SourceWaterProtection/Index.html?site=SourceWaterProtection&viewer=SWPViewer&locale=en-US).

Seven source protection plans (Niagara, Halton-Hamilton, Credit Valley-Toronto and Region-Central Lake Ontario [CTC], Ganaraska Region, Trent, Quinte, and Cataraqui) have policies, written by local stakeholder Committees, to protect these vulnerable areas from activities which are currently taking place in close proximity to the municipal drinking water systems. See http://conservationontario.ca/conservation-authorities/source-water-protection/source-protection-plans-and-resources/ to access these source protection plans.

3.1.2 Threats

Various threats to Lake Ontario as a drinking water source exist that are influenced mainly by land use decisions, human activities, aging infrastructure, and climatic factors. These include:

- Residual sources of legacy contaminants;
- Over-application of commercial fertilizers, manure, road salt, and pesticides that can enter groundwater and surface water;
- Stormwater and wastewater sources, especially during and after extreme storm events;
- Failing septic systems that release bacteria;
- Emerging chemicals of concern such as flame retardants and pharmaceuticals; and
- Chemical spills within the watershed and directly to Lake Ontario.

More information is needed to understand the potential spatial and seasonal occurrence of cyanotoxins in Lake Ontario. The USEPA has provided some emerging information regarding concerns that cyanotoxins found in harmful algal blooms could impact water supplies, as they did in Toledo, Ohio in 2014 (https://www.epa.gov/ground-water-and-drinking-water/managing-cyanotoxins-public-drinking-water-systems). Continued progress toward understanding and addressing these issues will further improve Lake Ontario water quality and its use as a source of drinking water.

3.1.3 How is Drinking Water Monitored?

The MECP and the NYSDOH require municipal drinking water systems to regularly monitor and test their treated water for contaminants. For more information on the Ontario and New York drinking water programs, see: www.ontario.ca/page/drinking-water and www.health.ny.gov/environmental/water/drinking/.

The U.S. SDWA requires that community water suppliers routinely share information about the local water supply, including detailed results of testing for contaminants and health considerations for sensitive populations. More information is available at the NYSDOH website as well as https://www.epa.gov/ccr. USEPA has also developed a mapping tool that can be used to identify drinking water sources and potential threats. The tool is available at: https://www.epa.gov/sourcewaterprotection/dwmaps.

Canadian Drinking Water Guidelines are developed by the Federal-Provincial-Territorial Committee on Drinking Water and have been published by Health Canada since 1968. These drinking water guidelines are designed to protect the health of the most vulnerable members of society, such as children and the elderly. The guidelines set out the basic parameters that every water system should strive to achieve in order to provide the cleanest, safest, and most reliable drinking water possible. More information is available at: https://www.canada.ca/en/health-canada/services/environmental-workplace-health/water-quality/drinking-water/canadian-drinking-water-guidelines.html.

3.1.4 Status and Trends

As a source of water, the status of municipally treated drinking water quality within the Great Lakes Basin is in 'Good' condition with an 'Unchanging' trend for the years 2012 to 2014 (SOGL 2017). Note that the State of the Great Lakes assessment for drinking water was Basin wide (including all Great Lakes) and was not specific to Lake Ontario.

3.1.5 Data Discussion

Ontario's regulated municipal treatment systems provide high quality drinking water to its residents. Drinking water test results for selected parameters met Ontario Drinking Water Standards nearly 100% of the time in recent years. In 2016-17, 99.84% of 517,601 treated drinking water test results from municipal residential drinking water systems met Ontario's drinking water quality standards (ODWQS, 2017).

From 2012 to 2014, over 95% of the total human population within the Great Lakes states received treated drinking water from water supply systems that were in compliance and met health-based drinking water quality standards (SOGL 2017).

3.1.6 Impacted Areas

Although there are no restrictions on the use of Lake Ontario as a source for drinking water systems, some nearshore areas, such as Rochester, Bay of Quinte, and much of the Canadian shores of western Lake Ontario, report occasional "earthy" or "musty" taste and odour problems with finished drinking water. These problems are not atypical of water systems that use surface water as a source of water and are due to naturally occurring substances produced by algae and bacteria in the lake water. Once identified, these can typically be minimized or removed by the water treatment facilities. Some localized areas are also known to experience toxin-producing harmful algal blooms which have the potential to contaminate source waters (see Section 3.6, Nutrients and Algae, for additional information).

3.1.7 Links to Actions that Support this General Objective

Ongoing monitoring and reporting by the state of New York and province of Ontario will maintain the continued achievement of this General Objective. Ontario's locally based Drinking Water Source Protection Program is the most comprehensive assessment of threat to sources of municipal drinking water in Canada. Through this program, municipalities, conservation authorities, landowners and provincial ministries now have regulatory responsibilities to implement the plans created to protect these sources. Ontario has also created a 12-point plan that outlines how Canadian and U.S. partners are working collaboratively to address algal blooms in the Great Lakes and other lakes and rivers. For more information visit https://www.ontario.ca/page/blue-green-algae.

New York State source water protection efforts have been ongoing through the drinking water protection program. *The Clean Water Infrastructure Act, 2017* seeks to enhance these efforts by providing additional investments in open space conservation and land protection for source water areas, wastewater infrastructure, and drinking water infrastructure. The NYSDEC provides funding for most of these programs through its Water Quality Improvement Project Program (http://www.dec.ny.gov/pubs/4774.html). The New York State Environmental Facilities Corporation also provides funding for these programs.

LAMP actions that will continue to protect Lake Ontario as a source of drinking water can be found in Sections 5.1 (Nutrient and Bacterial Related Impacts) and 5.4 (Critical and Emerging Contaminants).

3.2 Beach Health and Safety

GLWQA General Objective: Allow for swimming and other recreational use, unrestricted by environmental quality concerns.

Current Status: Lake Ontario beaches allow for safe swimming and other recreational uses unrestricted from environmental concerns for most of the swimming season. (Source: SOGL 2017)

3.2.1 Background

Beaches are a great place for recreation and relaxation and, if managed properly, provide many ecosystem services. They help create our sense of place, form part of our community personality, drive local economies and provide for a healthy active lifestyle. Beaches are also part of a dynamic ecosystem that can quickly change depending on localized wave energy, wind, currents, rainfall, and inputs of pollutants. Some of the natural factors that can influence beach water quality include:

- Wave height;
- Amount of rainfall;
- Solar radiation;
- Water clarity;
- Water temperature;
- Wind speed and direction;
- Lake water level;
- Shape/contour of coastline;
- Flocks of waterfowl and gulls;
- Presence of algae, especially dense mats of decaying matter; and
- Environmentally-adapted strains of *E. coli* in beach sand.

Given the dynamic nature of beach environments and natural influences, it is unlikely that beaches will remain open 100% of time.

Westcott Beach July 2016. (Source: NYSDEC)

3.2.2 Threats

In rural areas where land use is predominately agricultural, and manure is used on fields as a source of nutrients, field drainage systems (such as ditches and tiles) may discharge water directly to shoreline areas of the Lake or into connecting streams and rivers, which then become direct pathways for *E. coli* and other pathogens to enter the Lake and connecting rivers. Pathogens may also migrate through the soil into groundwater where they may then be transported to surface water bodies, including Lake Ontario and tributaries that discharge to the Lake. Rural areas are often not served by centralized wastewater treatment facilities. In these areas, faulty septic systems may also act as pathogen sources to surface and ground water systems.

In urban areas, stormwater runoff from roads, roofs, construction sites, and parking lots can carry various contaminants such as bird or animal fecal matter, trash, contaminated sediment, and road salts to local beaches. In addition, some urban areas around Lake Ontario have sanitary sewer systems that may not have the capacity to meet the demand of increasing populations or have aging combined sanitary and stormwater sewer systems which have not been permitted in Ontario for decades. In both instances the capacity of these systems can be exceeded, especially during heavy rain and snow melt events, and untreated or undertreated waste may discharge directly to the Lake or its tributaries. These discharges may be worsened by climate change, which is anticipated to bring more frequent and intense rain events to the Great Lakes region. Beaches found within protected embayments or next to built seawalls (groynes) and jetties have poorer water circulation and are susceptible to relatively higher levels of *E. coli*.

3.2.3 How is Beach Health Monitored?

Water quality monitoring is conducted by state and county health departments (in New York) and local health units (in Ontario) at select beaches to detect bacteria that indicate the presence of disease-causing microbes (pathogens) from fecal pollution. The New York State Office of Parks, Recreation, and Historic Preservation also requires testing of beach waters within state parks, and closure of beaches when health and safety thresholds are exceeded.

Bacteriological indicator levels and other environmental factors are used to assess the acceptability of water quality for bathing beaches. For the period covered by this SOGL report (2012-2017), in Ontario, the allowable number of *E. coli* colony forming units (cfu) in the water was 100 cfu/100 milliliter (ml), while in

New York it is 235 cfu/100 ml. In New York, a water quality sample that exceeds bacteriological indicator standards prompts a beach closure or advisory and public notification of the exceedance. New York also has criteria for 30-day mean bacteriological results that may be used. Criteria for New York and Ontario can be found at: https://regs.health.ny.gov/volume-title-10/1746432786/section-6-215-water-quality-monitoringwww and https://www.ontario.ca/page/water-management-policies-guidelines-provincial-water-quality-objectives. The NYSDOH historical data for *E. coli* exceedances at Lake Ontario Beaches is available at: http://ny.healthinspections.us/ny_beaches/.

Starting in 2018, all Ontario public health units are required to use the national guideline of ≤200 cfu/100mL geometric mean and/or ≤400 cfu/100mL for a maximum single-sample to inform precautionary messaging for the use of public beaches. The national guideline is based on detailed work of experts on the Federal-Provincial-Territorial Working Group on Recreational Water Quality of the Federal-Provincial-Territorial Committee on Health and the Environment and is endorsed by Health Canada.

The change in threshold will now allow increased access to the benefits of beach activities in a changing climate to enhance physical, social, and mental well-being. The change in threshold for beach monitoring does not reflect worsening water conditions but rather an opportunity to allow greater access to Ontario's beaches and alignment with national guidelines.

Beach health for a given swimming season (Memorial/Victoria Day weekend to Labour Day) is evaluated slightly differently in Ontario and New York. Table 3 provides the beach open and safe rating for Ontario and New York.

Table 3. Ontario and New York State beaches open & safe for swimming

(Source: SOGL 2017)

RATING/TARGET	Percentage of season beaches are open and safe	
	ONTARIO	**NY STATE**
Good	80% or more	90%
Fair	70-79.9%	80-90%
Poor	< 70%	< 80%

3.2.4 Status and Trends

Lake Ontario beaches are in 'Good' condition on the U.S. side, and in 'Fair' condition in Canada, with unchanging conditions in both countries. This is due to differing bacteriological standards in Ontario and New York State (see Section 3.2.3) and may also be due to a higher number of dense urban centers located on the Canadian side of the Lake. Beach water quality has greatly improved around Lake Ontario over the past two decades. There are now 11 Blue Flag beaches on the Canadian shore of Lake Ontario. Blue Flag is an international eco-certification for beaches and marinas that meet a number of water quality, cleanliness and accessibility, ecosystem health and safety standards. For more information see: https://www.blueflag.global/our-programme. Overall, beaches allow for safe swimming and other recreational uses unrestricted from environmental concerns for the majority of the swimming season (SOGL 2017).

3.2.5 Data Discussion

During the swimming seasons from 2011 to 2014, monitored beaches were open and safe for swimming an overall average of 77% of the time in Ontario and 94% of the time in New York (SOGL 2017). In both instances, this reflects a slight improvement from the previous (2008 to 2014) binational assessment where monitored beaches were open and safe for swimming an overall average of 70% of the time in Ontario and 90% of the time in New York (SOGL 2017).

3.2.6 Impacted Areas

Many beaches in the Basin are vulnerable to bacterial contamination based on natural and human-made threats. Human sewage is a major source of bacteria in surface waters, and can come from combined sewer overflows, illegal cross-connections between sanitary and storm sewers, and failing septic systems. Feces from livestock, pets and wildlife (including waterfowl) can also be significant sources of bacteria. Municipalities use *E. coli*, an indicator of bacteria from humans and animals, to measure whether recreational bathing waters are safe for the public.

3.2.7 Links to Actions that Support this General Objective

LAMP actions that address beach health and support this General Objective are discussed in Sections 5.1 Nutrient and Bacterial Related Impacts, and 5.2 Loss of Habitat and Native Species.

3.3 Fish and Wildlife Consumption

GLWQA General Objective: Allow for human consumption of fish and wildlife unrestricted by concerns due to harmful pollutants.

Current Status: Concentrations of harmful pollutants in fish and wildlife have substantially declined, however contaminants such as mercury, PCBs, dioxins, and mirex continue to exceed fish and wildlife consumption criteria designed to protect human health. (Source: SOGL 2017)

3.3.1 Background

Commercial and sport fishing and hunting are popular and economically important activities in and around Lake Ontario. Culturally important subsistence fishing and hunting by Indigenous communities still occurs in the Basin as well. Wildlife use by Indigenous communities may include consumption of flora and/or fauna for traditional foods, medicinal, and/or ceremonial uses.

3.3.2 Threats

Contaminants such as mercury, PCBs, dioxins, and mirex (an organochloride previously used as an insecticide) continue to exceed fish and wildlife consumption criteria designed to protect human health lakewide. Mercury, a naturally occurring metal found in air, water, and soil, has also entered the environment from human activities as it was historically used in a wide range of industrial processes. Inorganic mercury compounds can occur naturally in the environment and are also used in some industrial processes and in the making of other chemicals. Microscopic organisms in water and soil can convert elemental and inorganic mercury into an organic mercury compound, methylmercury, which is toxic and accumulates in the food chain. PCBs are a group of chlorinated organic compounds created in the late 1920s and banned in 1977. Dioxins and furans are unintentional by-products of several industrial processes and in some cases, incomplete combustion. Mirex was also used in the Lake Ontario Basin as a flame retardant in a variety of products. These and other contaminants can persist in the environment and increase in concentration in living organisms over time (bioaccumulation).

To help people enjoy the health benefits derived from eating fish, the NYSDOH and the Province of Ontario issue fish consumption advice so people can make healthy choices about which fish to eat. The advisories include information on which fish species and amounts can be safely consumed, which species should be avoided, and proper cooking techniques to reduce exposure to contaminants. For more details on New York State specific advisories for Lake Ontario and tributary water bodies visit www.health.ny.gov/fish; for Ontario advisory information visit https://www.ontario.ca/page/eating-ontario-fish-2017-18. In addition, the Saint Regis Mohawk Tribe has issued specific advisories for fish and game in Mohawk waters and Mohawk traditional use areas in the St. Lawrence River watershed. For more details on Mohawk advisory information see: www.Srmt-nsn.gov/_uploads/site_files/FishAdvisory_WebFinal.pdf.

New and emerging bioaccumulative contaminants that are not part of routine agency monitoring will continue to pose potential threats to the Great Lakes ecosystem and could trigger new advisories. Continued support of long-term contaminant biomonitoring programs will be key to ensuring that new threats are recognized and addressed early.

3.3.3 How Are Fish and Wildlife Contaminants Monitored?

Canadian and U.S. agencies monitor persistent, bioaccumulative, and toxic compounds in edible portions of fish to determine potential risk to human health through fish consumption. Monitoring in New York State is conducted by the Environmental Monitoring Section of NYSDEC Division of Fish and Wildlife's Bureau of Ecosystem Health. Approximately every three years, Chinook and Coho Salmon and Steelhead tissue samples are collected from the Salmon River Hatchery and analyzed for contaminants. Additional monitoring, including for other fish species, is conducted on an as-needed basis and as enabled by resources. Results from the fish tissue analyses are used by the NYSDOH to issue health advisories for consuming sportfish (see http://www.dec.ny.gov/animals/62194.html).

In Ontario, levels of contaminants in the edible portion of fish from Canadian waters of Lake Ontario are monitored by MECP in partnership with Ontario Ministry of Natural Resources and Forestry (MNRF). For monitoring purposes, Canadian waters of Lake Ontario have been divided into 16 regions ranging from local nearshore areas to open waters. Several nearshore marsh, bay, and harbour areas are also monitored. A variety of fish species are collected from different areas of Lake Ontario every year on a rotating basis. Certain areas such as the Credit River are sampled on an annual basis to understand long-term trends in fish contaminants.

3.3.4 Status and Trends

The status of contaminants in edible portions of fish from Lake Ontario is assessed as 'Fair' and the trend is 'Improving' (SOGL 2017). PCB levels in fish from Lake Ontario have declined substantially over the last four decades to the point where levels are quite similar to other Great Lakes and in fact are recently lower than the other Great Lakes (SOGL 2017). These declining trends combined with the declining levels of mirex and dioxin/furans (PCDD/F) have allowed NYSDOH to relax some of the consumption advisories for Lake Ontario. Although women under 50 and children under 15 should eat none, women over 50 and men over 15 may now consume:

- Up to 4 meals a month of Chinook Salmon, Coho Salmon and Rainbow Trout;
- Up to 4 meals a month of Smaller Brown Trout and Lake Trout; and
- Up to 4 meals a month of Smallmouth Bass from the Niagara River, downstream of Niagara Falls.

This advisory is now the same as the advisory for Lake Ontario (NYSDOH, 2017). (See https://www.health.ny.gov/environmental/outdoors/fish/health_advisories/)

PCB concentrations have decreased in Coho and Chinook Salmon (by 84%), Lake Trout (by 90%), Lake Whitefish (by 44%) and Walleye (by 81%) from Lake Ontario waters since the 1970s. However, concentrations are high enough to trigger fish consumption advisories for the general population. Data shows long-term declines of PCB concentrations in large predator fish but no temporal trend in many bottom-feeding fish (Neff et al. 2014, AEHM, 2016). Mercury concentrations have also declined in Coho Salmon (34%), Lake Trout (70%), and Walleye (45%) as well as other sportfish and are now mostly below the "do not eat" advisory level for women of childbearing age and children (SOGL 2017; MECP, 2017) (Figure 6).

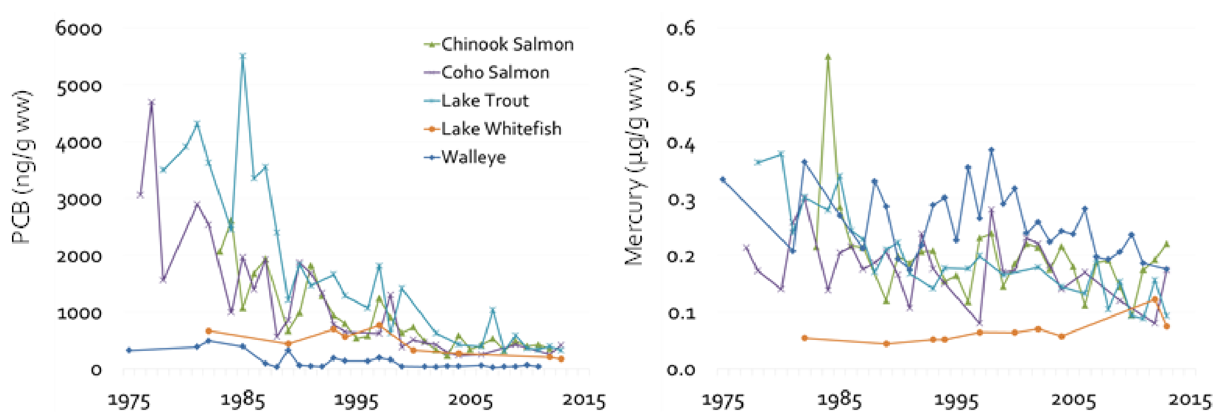

Figure 6: Concentrations of PCB and mercury for fish collected from Ontario waters of Lake Ontario. Measurements for 55-65 cm Chinook and Coho Salmon and Lake Trout, and 45-55 cm Lake Whitefish and Walleye were used

(Source: MECP, 2017)

Monitoring Drives PBDE Reduction

The story of PBDEs (brominated flame retardants, such as polybrominated diphenyl ethers or PBDE) in the Great Lakes is perhaps the best example of how monitoring programs can help recognize potential threats. The discovery of an increasing PBDE trend in Great Lakes Lake Trout and Gulls by Canadian monitoring programs led PBDE manufacturers to withdraw the most problematic PBDE formulations. Within a few years, PBDE concentrations began to decline in animals and plants.

3.3.5 Data Discussion

PCBs, dioxins/furans, and mirex concentrations are declining. Mercury concentrations appear to have generally remained stable (Bhavsar et al., 2010; Li et al., 2014). Any further declines in mercury from the current low levels may vary in the near future considering that a variety of factors may influence mercury accumulation in fish, such as natural sources of mercury, long range atmospheric transport, altered food webs by introduced species affecting feeding patterns and trophic relations, and climate change (Gandhi et al., 2014; Turschak et al., 2014).

3.3.6 Impacted Areas

A summary of area-specific fish consumption advisories is provided in Table 4. Hamilton Harbour PCB concentrations in fish remain among the highest across the Canadian waters of the Great Lakes, despite having declined by 59% to 82% from historical levels (the change was not statistically significant for four species). It should be noted that while this decrease is a positive sign, some species still exhibit recent PCB concentrations above the Ontario consumption advisory benchmark of 105 ng/g (less than 8 meals/month). The results reflect the presence of some ongoing releases to the Lake from historical contamination that is currently being addressed. Work to address releases from historical PCB sources in the Harbour is ongoing, which will in turn address the elevated PCB contamination levels in fish.

Table 4. Chemical contaminant issues limiting human consumption of fish and wildlife in the Lake Ontario Basin

Lake Ontario Regions	Fish Consumption Related Issues
New York State waters of Lake Ontario and its tributaries	• Consumption advisory for Channel Catfish and Carp: do not eat • Consumption advisory for Smallmouth Bass, White Sucker, White Perch, Lake Trout over 25”, Brown Trout over 20”: 1 meal/month • Consumption advisory for Brown Trout less than 20”, Lake Trout less than 25” and all other fish: 4 meals/month • Consumption advisory for women under 50 and children under 15: do not eat any fish • Contaminants of concern: PCBs, dioxin, mirex • For additional advisories that are site specific please visit the www.health.ny.gov/fish website
Hamilton Harbour AOC	• Fish consumption advisory for some species is above the consumption advisory level for PCBs (105 ng/g, or less than 8 meals a month) • Contaminant of concern: PCBs • PCBs levels in fish are generally lower than previous years for most species, but concentrations in fish remain among the highest in all Canadian AOCs

Lake Ontario Regions	Fish Consumption Related Issues
Toronto and Region AOC	• Analysis of trends over time showed substantial declines since the 1970s in contaminant levels in fish from the Toronto Waterfront area, especially for PCBs • Fish consumption advisories for many resident fish found along the Toronto Waterfront are “non-restrictive” (meaning you can eat 8 to 32 meals per month) • Consumption advisories for some migratory fish species as well as Carp and White Sucker are still restrictive • PCB concentrations have declined since the 1970s, but the levels have remained unchanged in the last 25 years
Bay of Quinte AOC	• Fish consumption guidelines due to dioxin and furans levels in fish at the Trent River mouth • Fish consumption guidelines in the Bay have improved and are consistent with guidelines for open waters of Lake Ontario
St. Lawrence River AOC (Cornwall, Massena/ Akwesasne)	• Canada: fish consumption guidelines due to elevated mercury levels in fish from the AOC • Mohawk fish and wildlife consumption advisories due to elevated mercury and PCBs

3.3.7 Links to Actions that Support this General Objective

Actions that address contaminants in fish and wildlife to achieve this General Objective are discussed in Section 5.4 Critical and Emerging Chemical Contaminants. Actions under Nutrient and Bacterial Related Impacts (Section 5.1) and Invasive Species (Section 5.3) may indirectly help to minimize chemical exposure of fish and consumers.

3.4 Chemical Contaminants

GLWQA General Objective: Be free from pollutants in quantities or concentrations that could be harmful to human health, wildlife, or aquatic organisms, through direct exposure or indirect exposure through the food chain.

Current Status: Chemical contaminant concentrations found in air, water, sediment, fish and wildlife have generally decreased since the 1970s, but continue to exceed the most stringent criteria. (Source: SOGL 2017)

3.4.1 Background

Some chemicals have the potential to impact the health of humans and wildlife due to their ability to persist and bioaccumulate in the environment. Government programs have significantly reduced the level of contamination in the Great Lakes, especially of legacy contaminants, but sources of contamination remain in the Lake Ontario watershed.

Chemical contaminants may have both short (acute) and long-term (chronic) negative impacts on the Lake Ontario ecosystem. Short-term effects are typically the result of more concentrated releases of contaminants and are often more readily observable when they occur (e.g., a fish kill associated with a chemical discharge). Chronic effects occur over a longer period and may be more subtle. They are often associated with exposures to lower concentrations of contaminants, making the exact cause of the effect more difficult to identify and manage. Examples of this include the development of a tumor or other deformity on a migratory fish, or impairment to the reproductive capabilities of colonial waterbirds. In other instances, no acute or chronic impacts may necessarily be observed in the exposed organism, but the contaminants may pose potential threats at higher levels of the food chain through bioaccumulation.

Legacy Contaminants

Legacy contaminants are bioaccumulative chemicals that were once widely used and persist in the environment decades after they were banned. They are often a result of industrial and agricultural processes and were often not considered harmful when first used. Legacy contaminants relevant to Lake Ontario include persistent organic pollutants (POPs) such as polychlorinated biphenyls (PCBs); DDT and its derivatives; mercury; and polycyclic aromatic hydrocarbons (PAHs).

Chemicals of Mutual Concern

Under the 2012 GLWQA, Canada and the United States committed to designate certain chemicals found in the Great Lakes as Chemicals of Mutual Concern (CMCs) that are potentially harmful to human health or the environment. To date, eight chemicals (or categories of chemicals) have been designated. These include mercury; PCBs; brominated flame retardants hexabromocyclododecane (HBCD) and polybrominated diphenyl ethers (PBDEs); perfluorinated chemicals perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and long-chain perfluorinated carboxylic acids (LC-PFCAs); and short-chain chlorinated paraffins.

Contaminants of Emerging Concern

Contaminants of emerging concern are substances that had not been detected in the environment in the past, or that were present at concentrations below thresholds thought to be protective of human and ecological health. Some contaminants of emerging concern include pharmaceuticals and hormones, personal care products, microplastics, and other substances commonly used for industrial, commercial and household purposes.

3.4.2 Threats

While levels of chemical contaminants are generally decreasing or stabilizing, atmospheric deposition of contaminants like metals and PAHs continues. Contaminated sediments represent a pollutant sink and potential source of toxic substances by becoming re-suspended in the water or becoming redistributed through water movements. Legacy contaminants persist in Lake Ontario and flame retardants, current-use pesticides, and pharmaceuticals and personal care products (including microbeads) and microplastics may represent emerging issues and future stressors.

The majority of contaminants entering Lake Ontario originate from upstream sources in Lake Erie through the Niagara River (Niagara River Toxics Management Plan, 2012). The concentrations of some of these chemicals already exceed criteria in water entering the Niagara River from Lake Erie, highlighting the importance of upstream sources outside the Lake Ontario Basin. Historical sources of contaminants directly impacting the Niagara River include heavy industry and hazardous waste containment and processing facilities in close proximity to the river. There are some sites which continue to be potential threats via impacts to ground water, discharges and re-suspension of contaminated sediments.

Chloride levels have been increasing in Lake Ontario since the mid-1990s. Increasing urbanization and the associated use of road salt on many roads, parking lots and sidewalks is likely contributing to these increases. Although concentrations in the Lake remain far below those associated with adverse effects on aquatic life, chloride levels are highest at sampling locations in intensely urban areas. Not only is urban stormwater runoff driving increases in Lake Ontario, it is potentially causing periodic adverse effects in urban rivers.

Spills from land-based industry, shipping, and oil transportation infrastructure are a potential source of chemical contaminants. Climate change may also affect the use, release, transport, and fate of chemicals potentially contributing to human and environment impacts (Chang et al., 2012).

3.4.3 How Are Chemical Contaminants Monitored?

ECCC and the USEPA conduct long-term (more than 25 years) Basin wide contaminant surveillance and monitoring programs. Chemical contaminants are monitored in open water, air, sediments, whole fish, and herring gull eggs. These programs are supported by state, provincial, Tribal Governments, First Nations, and academic institutions through other contaminant science and monitoring programs.

Due to the influence that the Niagara River has on Lake Ontario, a water monitoring station was established at the mouth of the Niagara River at Niagara-on-the-Lake to estimate the annual chemical loads and changes in these loads from the river to Lake Ontario. A second station was established at the head of the Niagara River at Fort Erie to estimate the loads of chemicals to the river from Lake Erie. This Upstream/Downstream Program is a key component of the Niagara River Long Term Monitoring Plan and the Niagara River Toxics Management Plan (NRTMP). The overall goal of the NRTMP is to achieve significant reductions of toxic chemical pollutants in the Niagara River (see Section 4.1 for more information).

3.4.4 Status and Trends

The overall status for chemical concentrations found in air, water, sediment, fish, and wildlife in Lake Ontario is 'Fair' (SOGL 2017) (Table 5). Chemical contaminant concentrations have decreased in all categories since the 1970s, and the long-term trends of many legacy contaminants in Lake Ontario are declining or in some instances levelling.

Over the last decade the rate of decline in contaminants has slowed (SOGL 2017). The tissues of some fish and wildlife can contain chemical concentrations at levels that exceed criteria designed to protect human health. New and emerging classes of chemicals make up the remaining contaminant burden measured in Lake Ontario.

Table 5. Summary of status and trends for toxic chemicals sub-indicators

(Source: SOGL 2017)

Feature	Sub-indicator	Status	Trend
Chemical Concentrations	Toxic Chemical Concentration (open lake)	Fair	Unchanging
	Toxic Chemical in Sediment	Fair	Improving
	Toxic Chemical in Great Lakes Whole Fish	Fair	Improving
	Toxic Chemical in Great Lakes Herring Gull Eggs	Fair	Unchanging
	Atmospheric Deposition of Toxic Chemical	Fair	Improving

3.4.5 Data Discussions

Open Water Contaminants

The current status of open water chemical contaminants in Lake Ontario is rated as 'Fair' with an 'Unchanging' trend over time (SOGL 2017). Lake Ontario has one of the highest levels of open water chemical contamination of the Great Lakes due to high population density and high concentration of industrial processes that release into the Lake (also known as point source pollution).

The majority of contaminants entering Lake Ontario originate from upstream sources through the Niagara River (Lake Ontario LAMP, 1998). The Niagara River Upstream-Downstream monitoring program provides valuable information on historical trends of some contaminants entering Lake Ontario from the Niagara River, including PCBs, mirex, DDT and metabolites, and dieldrin, which have shown decreasing trends since the 1980s but continue to exceed the most stringent criteria. Concentrations of mercury attached to suspended solids in the water column have been below the most stringent criteria since 2008.

Concentrations of total polycyclic aromatic hydrocarbons (PAHs) are highest in the lower Great Lakes, with statistically significant increases for total PAHs observed in Lake Ontario (Melymuk et al., 2014). PAHs were found to be contributed to Lake Ontario predominantly through tributary loading.

The most commonly observed in-use pesticides are atrazine, metolachlor and 2,4-D. Concentrations at the monitored locations have not exceeded Canadian Council of Ministers of the Environment (CCME) guidelines, indicating good status, and no temporal trends are observed. Concentrations of these compounds are highest in the lower Great Lakes.

Recent work conducted on PBDEs, and other flame retardants showed higher concentrations in the lower Great Lakes and the spatial patterns were consistent with consumer products as a primary source (Vernier et al., 2014). Dechlorane Plus and HBCD concentrations were highest in Lake Ontario, reflecting manufacturing sources and usage patterns.

Results for perfluorinated compounds are consistent with patterns of consumer point sources, with higher concentrations noted near urban regions (Gewurtz et al., 2013).

Sediment Contaminants

Sediment contaminant concentrations in Lake Ontario are rated in 'Fair' condition with an 'Improving' trend over time (SOGL, 2017). Lake Ontario continues to have higher levels of sediment contamination than the other Great Lakes. Levels of legacy contaminants are the result of historical industrial activities in the Niagara River, some local AOCs and sources in the upstream Great Lakes.

The highest concentrations of mercury in sediments in Lake Ontario are observed in offshore depositional areas characterized by fine-grain sediments (Marvin et al., 2004).

For metals, probable effects level (PEL) guideline exceedances were frequent in Lake Ontario for lead, cadmium and zinc (Lepak et al., 2015).

Studies of sediment core profiles of PBDEs in Lake Ontario suggest that accumulation of these chemicals has recently peaked, or continues to increase (Marvin et al., 2007; Shen et al., 2010). Other flame retardants such as Dechlorane Plus and related compounds Dec604 and Dec602 are found an order of magnitude higher in Lake Ontario in comparison to the other Great Lakes; however, levels have shown a levelling off in recent years (Guo 2015).

Concentrations of PFCs in sediments in Lake Ontario tributaries are highest in urbanized and/or industrialized watersheds. The highest PFC concentrations in open-lake sediments have been found in Lake Ontario. The spatial distribution of PFCs in Lake Ontario is fairly consistent across the Lake, which is primarily due to currents that evenly distribute suspended particles across the major depositional basins (Codling et al., 2014).

Contaminants in Whole Fish

The current status of contaminants in whole fish is assessed as 'Fair' and the levels have 'Improved' over a 15-year period (1999 to 2013) (SOGL, 2017). Levels of contaminants are stable or slowly declining in Lake Trout. Median PCB concentrations in Lake Trout in Lake Ontario continue to decline but are still above the target of 0.1 µg/g GLWQA, 1987 as shown below in Figure 7.

Mercury concentrations in Lake Ontario have been stable or unchanged over the last several years (Zhou et al, 2017). Concentrations of DDT and metabolites in top predator fish have continuously declined with infrequent occurrences of concentrations above target levels in Lake Ontario.

In a national survey of PBDE concentrations in top predator fish from lakes across Canada, average concentrations of Total BDEs (tetra + penta + hexa) were found to be highest in Lake Ontario (Gewurtz et al., 2011). PFOS observed in both the USEPA and ECCC programs show similar patterns and trends and concentrations appear to be declining with statistical significance in Lake Ontario.

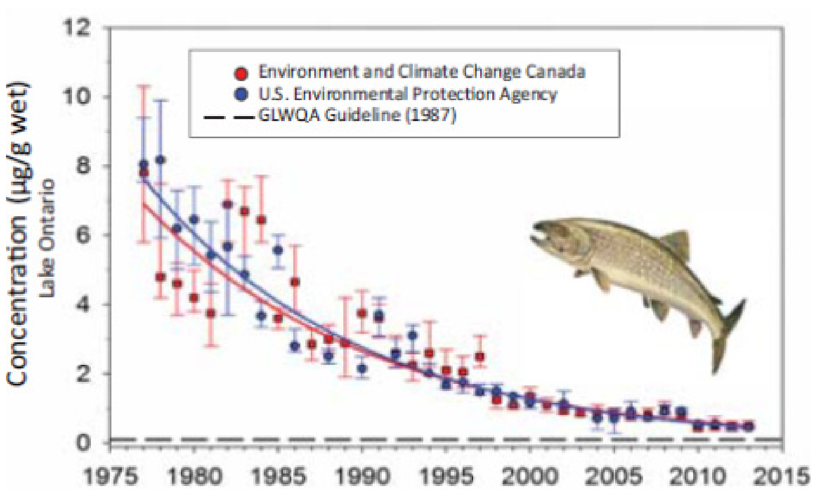

Figure 7: Decline of total PCB concentration for individual and whole-body Lake Trout in Lake Ontario

(Source: SOGL, 2017)

Contaminants in Fish-Eating Birds

Fish eating colonial waterbirds are a good way to track contaminant levels in the Great Lakes. With fish comprising the majority of their diet, tracking contaminant concentrations in Herring Gull eggs helps assess the current chemical concentrations and trends. The current status of toxic contaminants in Herring Gull eggs is assessed as 'Fair' and 'Improving' (1999 to 2013), while the SOGL 2017 assessment is 'Fair' and 'Unchanging'). Long-term trends (1974 to 2013) have shown improvements as noted for Lake Ontario in the SOGL 2017 report, with the last decade showing an unchanging trend. All legacy contaminants have declined significantly since the 1970s. The rates of decline in persistent organic pollutants in Herring Gull eggs were generally lower in later years, and for many colonies, concentrations have stabilized in the last few years (Figure 8). PFCA has increased from 1990 to 2010 in Niagara River colonies. Fully brominated PBDEs (e.g., BDE-209), syn- and anti-Dechlorane Plus, and HBCD have increased from 2006 to 2012 (Letcher et al. 2015).

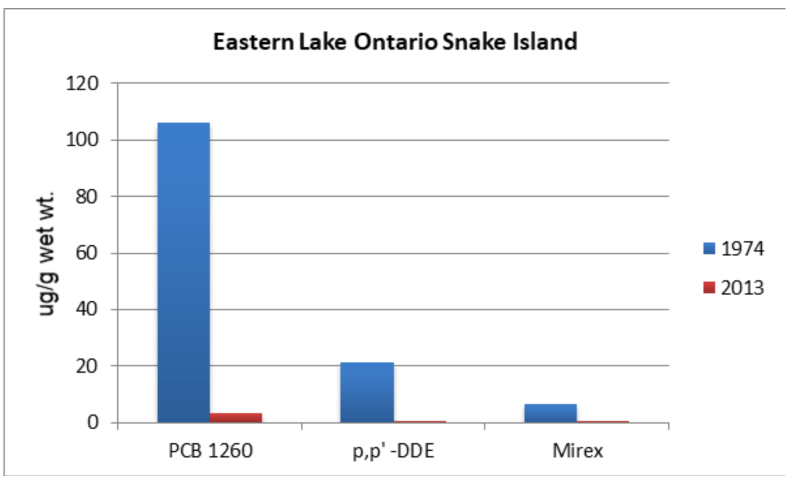

Figure 8: Critical contaminants in Herring Gull eggs

(Source: de Solla et al., 2016)

Lower Contaminants in Fish Eating Birds

Concentrations of Lake Ontario critical pollutants in herring gull eggs, including PCBs, DDT and metabolites, and mirex, declined significantly between 1974 and 2013 reflecting the ongoing success in eliminating the use and releases of these contaminants to the Great Lakes. Gulls from the Snake Island colony in eastern Lake Ontario rely primarily on fish, unlike colonies in urban areas, and provide a good representation of contaminant trends in the open lake aquatic food web (see Figure 8; de Solla et. al., 2016).

Atmospheric Contaminants

The overall Great Lakes assessment of toxic chemicals deposited from the air is 'Fair' and 'Improving' (SOGL, 2017). While levels of toxic chemicals in air are generally low, the large surface area of the Great Lakes allows a significant amount of atmospheric exchange and input of contaminants from the air (Eisenreich & Strachan, 1992). Concentrations of some toxic chemicals are much higher in urban areas and Lake Ontario has elevated inputs from these densely populated areas (SOGL 2017). Long range atmospheric deposition of chemicals of emerging concern, such as flame retardants and other compounds, could be future stressors to Lake Ontario due to the widespread manufacture and use of these products that are persistent in the environment.

3.4.6 Impacted Areas

AOCs continue to be notable areas of concentrated contamination particularly in the sediments and where greatest efforts are required to address legacy contamination to the Basin. AOCs are specific locations around the Great Lakes, on both the Canadian and U.S. sides of the lakes and connecting river systems, which were identified in the GLWQA as being degraded due to human activity at the local level. There are currently four Canadian, two U.S. and two binational AOCs on Lake Ontario and along the Niagara and St. Lawrence Rivers (see Figure 2). Hamilton Harbour, Toronto and Region, Port Hope Harbour, and the Bay of Quinte are Canadian led AOCs. The U.S. led AOCs are Eighteenmile Creek and Rochester Embayment. The St. Lawrence River AOC and the Niagara River AOC are binational, shared by both countries. Appendix D provides details regarding mitigation and management actions in the designated AOCs in the Lake Ontario Basin.

3.4.7 Links to Actions that Support this General Objective

LAMP actions to reduce contaminants and support this General Objective are discussed in Critical and Emerging Chemical Pollutants (Section 5.4). Actions in Nutrient and Bacterial Related Impacts (Section 5.1) could also support this General Objective.

3.5 Habitats and Species

GLWQA General Objective: Support healthy and productive wetlands and other habitats to sustain resilient populations of native species.

Current Status: While the rate of productive wetland degradation has slowed in the last decade through a wide range of habitat restoration projects (including restoration of lost protective barrier beaches and restoration of hundreds of miles of upstream fish passage), more work is needed to sustain resilient populations of native species. (Source: SOGL 2017)

3.5.1 Background

Lake Ontario supports a rich diversity of plants and animals with its great variety of habitats, including coastal dune, marsh, and barrier beach complexes, and cobble beaches and bedrock shores. The shoreline is predominantly rural, with the greater Toronto-Hamilton area and the Rochester metropolitan area as major population centres. Healthy and productive wetlands, tributaries, nearshore, and offshore habitats are essential for strong and resilient native communities of plants, fish, birds, and invertebrate species. These habitats and communities also support important recreational, economic, and ecological activities.

3.5.2 Threats

Critical threats to Lake Ontario's species diversity were identified in the 2011 Lake Ontario Biodiversity Conservation Strategy (BCS) (https://binational.net/wp-content/uploads/2015/02/LakeOntarioBCSen.pdf) including:

- Shoreline development and alterations;
- Loss of aquatic connectivity;
- Loss and alteration of wetlands;
- Pollution;
- Quality of nearshore and offshore waters; and
- Aquatic invasive species.

Some of these threats are discussed in other sections of this report including contaminant threats to habitats and species (Sections 3.2, 3.3, 3.4, and 3.9), Section 3.6 Nutrients and Algae, and Section 3.7 Invasive Species. For example, excessive nutrients can impact water and habitat quality in the Lake's nearshore zone. However, offshore nutrient concentrations are low, and any further reductions may prompt concern about overall fish productivity and questions about the dynamics of nearshore to offshore energy flow. This difference between open lake versus nearshore nutrient concentrations can impact species diversity and productivity.

Shoreline Development & Loss of Habitat Connectivity

Shoreline development and alteration (e.g., hardening, loss of vegetation, changes to land uses) affects the many habitat types that make up Lake Ontario's shores (e.g., dunes, wetlands, cobble shore, tributary mouths). Further up the tributaries, in-stream dams and barriers (such as culverts) have altered the hydrology, sediment transport, and physical habitats (e.g., flow, water temperature) of streams, and prevented fish movement to spawning areas. This negatively impacts native species, including Walleye and Atlantic Salmon. Dams and barriers, however, also stop the spread of invasive species such as the Sea Lamprey, Round Goby, and Viral Hemorrhagic Septicemia Virus.

Loss and Alteration of Coastal Wetlands

Lake Ontario is home to approximately 35,000 hectares (86,000 acres) of coastal wetland habitat (BCS, 2011). Coastal wetlands support high levels of aquatic biodiversity by providing habitat for migratory waterfowl, fish, amphibians, reptiles, and other plant and animal life.

In addition to other factors referenced in the LAMP, close to seven decades of water-level regulation of Lake Ontario and the upper St. Lawrence River has resulted in degradation of coastal wetlands and plant diversity, negatively impacting occurrence of amphibians (e.g., breeding wetland frogs), abundance and distribution of wetland birds, and spawning habitat for fish. The International Joint Commission's Lake Ontario – St. Lawrence River Plan 2014 was initiated in 2017, in part, to improve the quality of coastal wetland ecosystems.

Invasive Species

Invasive species pose several threats to native fish communities including but not limited to: impairing reproduction in some top predators (Alewife impacts vitamin B levels in their predators); decreasing fry survival through predation (Alewife and Round Goby); parasitizing adult fish (Sea Lamprey); replacing and preying upon native food resources (predatory water fleas); and altering energy and nutrient flows through the lower levels of the web (*Dreissenid* mussels). For example, *Dreissenid* mussels have altered phytoplankton species composition, increased water clarity, and have nearly caused localized extinction of the native small crustacean *Diporeia*. For more information on the impacts of invasive species, see section 3.7 of the LAMP.

3.5.3 How is Habitat and Native Species Health Being Monitored?

Habitat and wildlife management agencies monitor a variety of indicators to assess the condition of Lake Ontario coastal wetlands and nearshore, and offshore habitats and species. Wetland plants are collected and identified from points or sampling transects spanning a variety of vegetation zones. An assortment of sampling techniques are used to assess fish community composition including; aerial photos, drones, electrofishing, trap netting, creel surveys and satellite imagery are used to identify and track the extent of wetland communities (SOGL, 2017).

Breeding frog and bird surveys identify calls to monitor the species composition, diversity and abundance at a variety of Lake Ontario wetlands (SOGL, 2017). Wetland fish species diversity and community composition are measured from the overnight catches in fyke nets (SOGL, 2017). The health of nearshore and offshore fish species is monitored through long-term community assessments targeting cold, cool, and warm water species at many life stages. These assessments, using trawls, gillnets, and commercial fishery bycatch reports, provide information such as abundance, size, and age distributions, population distributions, and diets. Lower-trophic level assessments monitor nutrients, primary productivity, algal biomass, and the status of the zooplankton community.

3.5.4 Status and Trends

The overall status of Lake Ontario's habitat and species is 'Fair' (Table 6) and the trend is 'Unchanging,' despite U.S. and Canadian investments in a wide range of habitat restoration projects. These include restoration of lost protective barrier beaches, the restoration of hundreds of miles of upstream fish passage, and a multitude of habitat conservation and restoration efforts. The recent approval of a new U.S.-Canada lake-level regulation plan for Lake Ontario, designed to restore a more natural range of water-level fluctuations, has the potential to improve the quality of more than 24,000 hectares (60,000 acres) of coastal wetlands (SOGL, 2017).

Table 6: Summary of status and trends for habitat and species sub-indicator (Source: SOGL, 2017)

Feature	Sub-Indicator	Status	Trend
Coastal Wetlands	Extent and Composition	Undetermined	Undetermined
	Aquatic Habitat Connectivity	Fair	Improving
	Plants	Fair	Unchanging
	Invertebrates	Fair	Deteriorating
	Amphibians	Poor	Unchanging
	Fish	Fair	Improving
	Birds	Fair	Improving
Nearshore Waters	Fish Eating and Colonial Nesting Waterbirds	Fair	Unchanging
	Lake Sturgeon	Poor	Improving
	Walleye	Good	Unchanging
Open Waters	Benthos	Fair	Unchanging
	Diporeia	Poor	Deteriorating
	Phytoplankton	Good	Unchanging
	Zooplankton	Good	Unchanging
	Prey fish	Poor	Deteriorating
	Lake Trout	Fair	Improving

3.5.5 Data Discussion

Coastal Wetlands

Coastal wetlands provide a critical link between the land and water. They improve water quality in the Lake by filtering sediment and contaminants from runoff and tributary flows, and support biodiversity by providing vital habitat for many species. Currently, the status and trend for coastal wetlands extent and composition are 'Undetermined' due to lack of updated information.

Coastal wetland habitat condition is assessed using biological community indices for several groups of organisms including amphibians, fish, birds and plants. The status of amphibians in Lake Ontario's coastal wetlands is 'Poor' and shows no change over the previous decade. The diversity and abundance of breeding frogs and toads is similar to that observed in Lake Erie and Lake Michigan (SOGL, 2017). Coastal wetland fish communities indicate a range of wetland status from 'Poor' to 'Degraded' to 'Good' (SOGL, 2017) as seen from the distribution of Lake Ontario sampling sites. The index of ecological condition from observations of wetland breeding birds suggests that from 2011 to 2014, Lake Ontario coastal wetlands were, on average, in 'Fair' condition (SOGL, 2017). Wetland habitat for breeding birds appears to have improved significantly over the past decade. Measures of coastal wetland plant communities indicate that the overall status of Lake Ontario's wetlands are 'Fair' and the status is 'Unchanging'. Many of the wetlands surveyed were of moderate to low quality, with very few high-quality plant community scores observed (SOGL, 2017).

Waterbirds

Nine focal species of colonial waterbirds breed in the Lake Ontario watershed: Herring, Ring-Billed and Great Black-Backed Gulls, Caspian and Common Terns, Great Blue Herons, Great Egrets, Black-crowned Night-Herons, and Double-Crested Cormorants. The status of these birds is 'Fair' and 'Unchanging'. Of these species, five remained stable or have shown declines in recent years. Double-Crested Cormorants and Caspian Terns show large increases, while Great Egret populations have expanded since first colonizing Lake Ontario in 1997. As a group, waterbirds represent a link between aquatic and terrestrial habitats, as a large portion of their diets come from fish and other aquatic prey from wetland, nearshore, and open water habitats.

Bald Eagle Recovery in Lake Ontario

The return of the Bald Eagle to the Lake Ontario shoreline demonstrates the progress made to restore the Lake's ecosystem and to reduce bioaccumulative contaminants. Bald Eagles are making an impressive recovery throughout the Great Lakes region and have established at least 12 successful nesting territories along the shoreline of Lake Ontario and the Upper St. Lawrence River, with many additional territories further back in the watershed. To continue their recovery, the conservation of remaining shoreline nesting and foraging habitats is extremely important. Between 2002 and 2008, U.S. and Canadian Bald Eagle experts worked with LAMP partners to identify and prioritize valuable Bald Eagle habitats in the eastern Lake Ontario and Upper St. Lawrence River areas. Twenty-one priority habitat sites were identified in the U.S. and 18 in Canada. Today at least half of these are fully or partially protected through public ownership or conservation easements.

Lake Sturgeon

Multi-agency efforts to monitor and restore remnant Lake Sturgeon populations have been ongoing on the Niagara, Genesee, and St. Lawrence Rivers over the last 15 years. In the lower Niagara River, the U.S. Fish and Wildlife Service has been working with partners to monitor the recovery of Lake Sturgeon. First discovered in 2003, a small, young remnant population in the lower Niagara River was reassessed in 2010. The population was estimated at about 2,800 fish and was increasing faster than expected, likely through successful natural reproduction.

On the St. Lawrence River near Waddington and Massena, New York, the New York Power Authority (NYPA), NYSDEC, USFWS, United States Geological Survey (USGS), and the Saint Regis Mohawk Tribe are working to restore Lake Sturgeon spawning habitats near hydropower and water control projects. Evidence of spawning and reproduction was observed near Waddington in 2008 and 2009 and since then, the habitats have remained stable and clear of sediments. Researchers from NYSDEC and Queens University in Kingston, Ontario are currently studying Lake Sturgeon in the lower Thousand Islands area. Natural populations of Lake Sturgeon spawn in the St. Lawrence (above and below the Moses-Saunders hydro-dam), lower Niagara, Grasse, Trent, and Black Rivers but are likely far below historical levels. Other natural populations are supported through stocking in the Oswegatchie and Raquette Rivers, and Black Lake. A large number of Genesee River stocked female Lake Sturgeon are just now reaching maturity and researchers are eagerly awaiting the first signs of natural reproduction.

Walleye

The status of Walleye in Lake Ontario is ‘Fair’ with an ‘Unchanging’ trend (SOGL, 2017). Rehabilitation efforts occurring at some locations show signs of ‘Improving’ from ‘Fair’ to ‘Good’ status in Lake Ontario (Bowlby & Hoyle, 2017). Local populations of Walleye are self-sustaining in several areas of the Lake. The Bay of Quinte Walleye population is the largest in Lake Ontario. Following a decline in the 1990s, the Walleye population in the Bay of Quinte and the eastern outlet basin has remained relatively stable. Lake Ontario Walleye are currently meeting fisheries management targets identified in the GLFC Fish Community Objectives and Bay of Quinte Management Plan. Recent production of good to strong year classes indicates a maintained or improved population status in the future.

Lake Trout

Fishery management agencies have worked over the last three decades to reestablish naturally reproducing populations of Lake Trout, using the number of mature females as an important measure of this native species ability to sustain its populations (Figure 9). The current status of Lake Trout is 'Fair' and 'Improving' (SOGL, 2017) due to this international effort. Improvements in the status of Lake Trout are attributed to increased survival of stocked fish, effective Sea Lamprey control programs, an increased adult population, and more naturally reproduced fish. Continued progress towards restoration objectives appears likely with the combination of improved status of the adult population, increased availability of healthier prey types, and increased abundance of native prey fish.

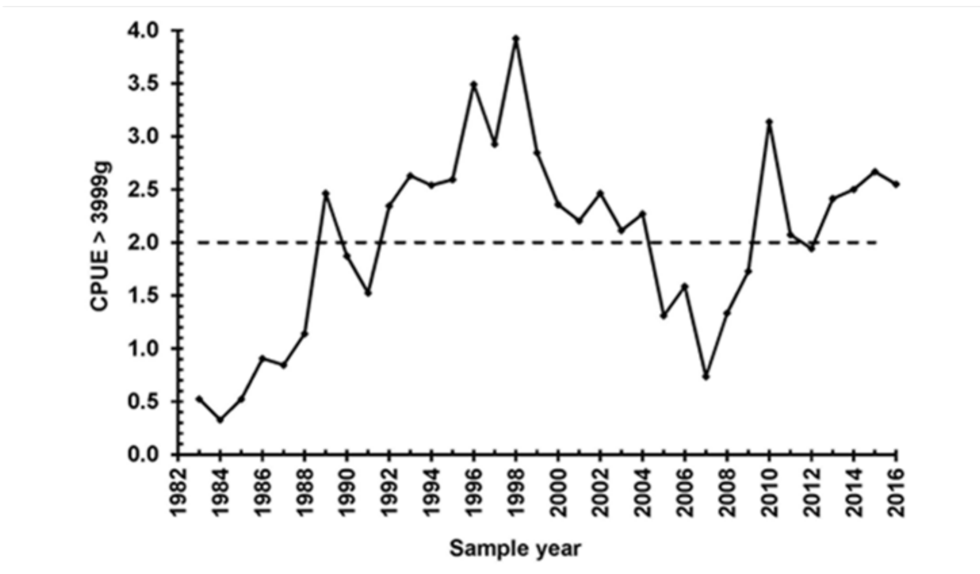

Figure 9: Abundance of mature female Lake Trout caught per unit effort (CPUE) in U.S. waters of Lake Ontario by the USGS and NYSDEC.

(Source: Lantry and Lantry, 2017)

Phytoplankton and Zooplankton

An appropriate balance of phytoplankton and zooplankton is needed for a healthy lake ecosystem. Phytoplankton are the first link in Lake Ontario's food chain and are grazed on by zooplankton and other small animals. Zooplankton are in turn eaten by other species in the Lake, such as small prey fish that are food sources for larger predator fish.

Nutrient levels, status of phytoplankton and zooplankton communities, and lake productivity in open waters of Lake Ontario are generally consistent with low nutrient (oligotrophic) conditions. Indicators of the Lake's offshore benthic community also suggest low nutrient conditions. Spring phosphorus and chlorophyll-a levels (an indicator of phytoplankton abundance) have remained relatively stable over the last decade.

Phytoplankton and zooplankton communities indicate a system in 'Good' condition with an 'Unchanging' trend (SOGL, 2017). Zooplankton biomass declined to low levels in 2004 to 2007 but have shown some recovery since, due in part to changes in species composition (Barbiero et al., 2014; 2015). Certain species have declined (cyclopoid copepods) while others have increased (calanoid copepods). More recently (2010 to 2011), daphnid biomass has improved. These observed zooplankton community shifts in Lake Ontario appear to be influenced primarily from feeding by Alewife and predatory Water Fleas (Barbiero et al., 2014; 2015; Rudstam et al., 2015).

Diporeia

Diporeia (a freshwater shrimp-like crustacean) is a historically important prey item for several native Lake Ontario fishes, including Sculpins, Lake Trout and Lake Whitefish. It plays a critical role in the Lake Ontario offshore food web and nutrient cycling. The population of *Diporeia* declined dramatically through the 1990s following establishment and expansion of *Dreissenid* mussels, and has continued to decline since (Birkett et al., 2015). The last lakewide benthic survey was conducted in 2013 and resulted in the capture of only one individual *Diporeia*. Currently, it is nearly extirpated from Lake Ontario. The status of *Diporeia* is 'Poor' and 'Deteriorating' (SOGL, 2017).

Prey fish

Based on diversity indices and percent native species metrics, Lake Ontario's prey fish community status is 'Poor' with an overall trend assessment of 'Deteriorating' (SOGL, 2017). Until the mid-1950s, native fish including Lake Whitefish, Ciscos (formerly called Lake Herring), and Deepwater Cisco (including Bloater) were an abundant and important food source for large sportfish (e.g., Lake

Trout) in Lake Ontario. Since the decline of these native prey fish, sportfish have fed primarily on Alewife, an invasive species that has led to reproductive impairment or failure from Vitamin B deficiencies in some salmonid species, particularly Lake Trout.

Lake Ontario's prey fish community continues to be dominated by non-native Alewife (96%), which support the majority of the Lake's native and stocked sport fishes (Weidel et al., 2018 and Happel et al., 2017). Balancing predators with prey fish, such as Alewife, is a fundamental aspect of the Lake Ontario Fish Community Objectives established by the Great Lakes Fishery Commission (Stewart et al., 2017). The benthic prey fish community has recently shifted from native Slimy Sculpin, to non-native Round Goby and native Deepwater Sculpin (Weidel et al., 2018). Deepwater Sculpin, once thought extirpated, reappeared in the mid-1990s and have proliferated (Weidel et al., 2017). Today, multiple agencies cooperatively track the population as conservation committees consider reducing the species' elevated conservation status.

After years of international collaboration, a new program to restore native prey fish to Lake Ontario began in 2012 (LO LAMP, 2013). Re-establishing self-sustaining populations of Bloaters in Lake Ontario has been the focus of a binational effort involving the NYSDEC, MNRF, USGS, USFWS, and the GLFC. In November 2012, Bloaters were re-introduced to Lake Ontario with the stocking of 1,200 yearlings near Oswego, New York. Ciscos were stocked into Irondequoit Bay (near Rochester, New York) in December 2012. Re-established populations of Bloaters and enhancing Cisco populations will improve biodiversity in Lake Ontario, provide a quality food source for sportfish, and contribute to a more stable and resilient fish community.

American Eel

American Eel abundance declined precipitously in the last three decades and the species was listed under Ontario's *Endangered Species Act, 2007*. The decline - and in some areas the extirpation - of the American Eel within the Lake Ontario and St. Lawrence River is due to loss of habitat and connectivity mainly through the construction of dams and other structures. You can find more information on the American Eel at https://www.ontario.ca/page/american-eel-recovery-strategy#section-7.

3.5.6 Impacted Areas

Habitat and species-related issues occur throughout regions of Lake Ontario. Dams and barriers are found in tributaries, rivers and streams throughout the Basin. Some larger watersheds such as the Humber River in Western

Toronto have over one hundred in-stream barriers (see MNRF & TRCA, 2005, Humber River Fisheries Management Plan). While dams and barriers hinder the passage of some native species, they may also help limit populations of invasive Sea Lamprey by limiting favourable upstream spawning conditions. Urban areas along Lake Ontario's shorelines (e.g., Greater Toronto Area) are particularly impacted by shoreline alteration such as hardening and lake infilling.

A detailed summary of locations where threats exist to habitats and native species is provided in the 2011 BCS, Tables 2 to 4, and Priority Action Sites are illustrated in Section 4.2. Priority Action Sites were identified as high value watersheds, tributaries, and coastal areas of critical importance to Lake Ontario's biodiversity as determined during the development of the 2011 BCS. Actions identified in Section 5 will be implemented in some of these sites.

3.5.7 Links to Actions that Support this General Objective

Actions that address loss of habitat and native species and contribute to progress towards achieving this General Objective are discussed in Section 5.2, Loss of Habitat and Native Species. Additional actions to address other threats that contribute to loss of habitat and native species are discussed in Nutrient and Bacterial Related Impacts (Section 5.1), Invasive Species (5.3), and Critical and Emerging Chemical Contaminants (5.4).

3.6 Nutrients and Algae

GLWQA General Objective: Be free from nutrients that directly or indirectly enter the water as a result of human activity, in amounts that promote growth of algae and *cyanobacteria* that interfere with aquatic ecosystem health, or human use of the ecosystem.

Current Status: Although Lake Ontario's offshore nutrient concentrations are below GLWQA objectives, excessive nutrient concentrations, among other factors, could be contributing to nuisance algae in some nearshore areas and causing sporadic *cyanobacteria* blooms in some embayments (Source: SOGL 2017).

3.6.1 Background

Nutrients are essential elements of the aquatic ecosystem food chain. However, when present in excessive amounts they can cause significant water quality problems. Conversely, insufficient nutrient levels can decrease food web productivity. Maintaining the proper balance is a challenge. In Lake Ontario's nearshore, with the exception of some localized point-source discharges, the linkage between excess nutrients and blooms of nuisance algae (e.g., *Cladophora*) and harmful algae (e.g., *Cyanobacteria)* are a current area of research. In the offshore, a decline of total phosphorus concentrations below the GLWQA interim substance objective of 10 micrograms per litre (µg/l) for Lake Ontario can limit aquatic food web productivity.

In addition to the interim substance objective for total phosphorus under the GLWQA, Canada and the U.S. adopted Lake Ecosystem Objectives (LEOs) related to algae development for each Great Lake. For Lake Ontario, the relevant LEOs include:

- Minimize the extent of hypoxic zones (areas with low levels of oxygen) in the waters of the Great Lakes associated with excessive phosphorus loading;
- Maintain the levels of algal biomass below the level constituting a nuisance condition;
- Maintain algal species consistent with healthy aquatic ecosystems in the nearshore waters of the Great Lakes;
- 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 Great Lakes; and
- Maintain an oligotrophic (low nutrient) state, relative algal biomass, and algal species consistent with healthy aquatic ecosystems, in the open waters of Lake Ontario.

The re-emergence of *Cladophora* along the nearshore in some areas in Lake Ontario combined with low offshore phosphorus concentrations poses two scientific mysteries: Why are offshore concentrations so low and what is driving the growth of *Cladophora*?

3.6.2 Threats

Nutrients and bacteria enter Lake Ontario, the Niagara River and the St. Lawrence River primarily through "point sources", "non-point sources" and tributaries. Point sources originate from single locations that are relatively easy to identify, such as a wastewater treatment facility discharge. Non-point sources originate from less easily identified sources, such as runoff from urban areas, agricultural fields and operations, failing septic systems, golf courses, or deforested areas. Based on the most recent information, it is estimated that municipal and industrial wastewater discharges combined contribute about 10% of the total phosphorus loading to Lake Ontario, although this concentration may be much higher in some nearshore areas that are close to local point source discharges. Tributaries and other non-point sources such as runoff, account for about 33% of the load and the remaining 57% comes from the Niagara River from upstream sources in Lake Erie (LONTT, 2016). Management actions necessary to address nutrient levels entering the Niagara River from Lake Erie will be considered in the Lake Erie Lakewide Action and Management Plan. Annual variations in the Niagara River phosphorus load can cause these proportions to vary (LONTT, 2016). Specific threats associated with nutrients are discussed below.

Dreissenid **Mussels and** ***Cladophora***

Cladophora is native to Lake Ontario and contributed to the nutrient pathways cycling and food web structures in the lake. *Dreissenid* mussles are invasive organisms that altered the pathways and the structure. *Cladophora*, a filamentous green-algae native to the Great Lakes, has reemerged in the nearshore at nuisance levels reminiscent of the 1960s and 1970s. At that time and since the reemergence in the mid-1990s, *Cladophora* blooms have resulted in shoreline and beach fouling, the clogging of water intakes, reductions in public access, and impacts on property values. The *Cladophora* reemergence is associated with the re-engineered nearshore environment caused by invasive mussels. The *Dreissenid* mussels provided suitable substrate, increased water transparency (which increased the ability of *Cladophora* to survive at much lower depths), convert particulate phosphorus to soluble reactive phosphorus (a form more readily available to *Cladophora*), and retain this phosphorus within the nearshore. *Dreissenid* mussels and *Cladophora* are organisms that alter nutrient pathways cycling and food web structures in the Lake. This process is referred to as the Nearshore Shunt Hypothesis (Hecky et al, 2004). Invasive *Dreissenid* mussels arrived in Lake Ontario in 1989 and the Lake is now dominated by Quagga Mussels (Dreissena bugensis), a close cousin of the Zebra Mussel (Dreissena polymorpha). Both the amount of substrate colonized and density of *Dreissenids* appears to be greater along the north shore in comparison to the south shore. This may be due to the greater availability of suitable hard substrate along the north shore coastal area to which the mussels attach.

Anecdotal reports suggest the incidence of *Cladophora* has increased in Lake Ontario in recent years, particularly along some shoreline segments. Bottom substrate characteristics, water clarity and light levels, seasonal changes in water temperature, and the timing of nutrient pulses can have a significant impact on rates of *Cladophora* production for any given year. Upcoming studies of Lake Ontario's benthic zone may increase understanding of *Dreissenid*-mediated effects.

Harmful Algal Blooms (HABs)

Blooms of *Cyanobacteria*, often referred to as Harmful Algal Blooms (HABs), are triggered by phosphorus and warm temperatures. HABS pose a threat to the Lake ecosystem and human health and have multiple economic impacts including commercial and recreation fishing, municipal and industrial water treatment costs. Managing phosphorus loads to the Lake could have a role to play in deterring HAB formation in certain areas. Looking forward into the future, HABS may increase in frequency with climate change due to an earlier warming of the Lake in the Spring, a longer period of warm temperatures in the Fall and more intense rainfall, which increases runoff from urban and agricultural sources.

Offshore water quality is good with very little cyanobacterial abundance and no reported blooms. However, parts of Lake Ontario, mainly some embayments, have experienced a resurgence of HABs since 2008, negatively impacting ecosystem health as well as municipal drinking water systems and recreational activities. Algal blooms are particularly harmful when they are dominated by *Cyanobacteria* (or "bluegreen" algae) which can produce toxins such as microcystin. The presence of these toxins can pose significant risks to fish, wildlife and human health. If exposed, they can cause gastrointestinal upsets, liver damage, skin rashes, and at elevated levels, can be fatal.

3.6.3 How are Nutrients and Algae Monitored?

Federal, provincial, and state governments as well as other partners (e.g., academia, conservation authorities, municipalities) in both Canada and the United States share in the monitoring of Lake Ontario's ecosystem health. The U.S., Canada Cooperative Science and Monitoring Initiative (CSMI) focuses binational monitoring resources on each of the Great Lakes on a five-year rotating cycle. The 2018 assessment focused on improving the understanding of nutrient loading, transport and cycling in Lake Ontario.

The primary research areas were:

- Amount of phosphorus and nitrogen entering the lake and how these nutrients move through the food web;
- Biological connections between nearshore and offshore areas of the Lake;
- Phytoplankton and zooplankton

population dynamics and use of nutrients in the lower food web;

- Fish population changes, diets and distribution in different areas of the Lake; and
- Transfer of nutrients and energy through the food web of the Lake.

This supports the development of the Lake Ontario Lakewide Action and Management Plan. In order to help determine priorities for science and monitoring in Lake Ontario in 2018, a two-day workshop was held November 15-16, 2016, with the assistance of the International Joint Commission. At this workshop, advice was solicited from participants from over 20 agencies on what the priorities should be and how to address the science priorities. CSMI assessments require collaboration by many organizations. Appendix B describes some of the major monitoring programs that contribute to the state of knowledge on nutrients in Lake Ontario. Section 5.1.5 outlines the actions regarding nutrient and algae science, surveillance and monitoring in Lake Ontario over the next five years.

3.6.4 Status and Trends

Management actions have reduced the amount of phosphorus discharged from sewage treatment plants, and the concentrations of phosphorus in the Great Lakes nearshore zone declined significantly between the 1970s and 1990s.The overall status of nutrients and algae in Lake Ontario is 'Fair' with an 'Unchanging' or 'Deteriorating' trend (SOGL, 2017). The status and trends for the individual sub-indicators used for this overall assessment are provided in Table 7. Nutrient levels are highest in the nearshore waters near the mouths of tributaries that drain urbanized or agricultural areas. In some areas, elevated nutrient levels and environmental conditions result in occasional nuisance algae growth and harmful algal blooms. Section 3.6.5 below, discusses nearshore nutrient conditions in more detail.

Table 7: Summary of status and trends for nutrients and algae sub-indicators

(Source: SOGL, 2017)

Feature	Sub-indicator	Status	Trend
Nutrients and Algae	Nutrients in Lake Ontario (open lake)	Fair	Deteriorating
	Cladophora	Poor	Undetermined
	Harmful Algal Blooms	Fair	Deteriorating
	Water Quality in Tributaries	Fair	Unchanging

3.6.5 Data Discussion

Nutrients in Lake Ontario (Open Lake)

Lake Ontario offshore nutrient concentration data indicate two distinct periods of change. The first measurable change in phosphorus concentrations occurred during the 1970s following implementation of controls on municipal and industrial wastewater discharges from wastewater treatment plants within the lower Great Lakes. This occurred along with the enactment of regulations to reduce the phosphate content in detergents. The second period of decline began in the mid-1990s coinciding with the colonization of *Dreissenid* mussels and subsequent increase in water clarity. Lake Ontario's GLWQA total phosphorus objective of 10 µg/l in the open waters was met by 1991 (Table 8). Spring total phosphorus concentrations have continued to decline since then and are now between 5 to 6 µg/l (Dove & Chapra, 2015).

Low phosphorus levels can reduce the productivity of the lower food webs. Lake Ontario fishery managers are concerned that low offshore nutrient concentrations (less than 10 µg/l) and the resulting reduction in productivity in the lower food web may impact the ability of the Lake to support the fishery (Dove & Chapra, 2015). Reduced productivity could have a negative impact on recreational, commercial and subsistence fishing in Lake Ontario.

Total phosphorus concentrations in the offshore are lower than expected given the degree of annual phosphorus loading delivered by the Niagara River. How nutrients are loaded, circulated, utilized and sequestered in the Lake are not well understood and consequently there is a need to improve our understanding of Lake Ontario's nutrient budget.

Table 8: Lake Ontario nutrient conditions 2015

(TP = total phosphorus; SRP = Soluble Reactive Phosphorus; Source: Makarewicz et al., 2012; Howell et al., 2012)

Lake Ontario Nutrient Conditions

Offshore
- Spring TP below GLWQA 10 ug/l objective since 1991
- Now between 5-6 ug/l

Nearshore (<30 m)
- Lakewide coastal zone decrease in Spring TP similar to offshore.
- Spring TP along the south coast often > 10 ug/l with SRP >19 ug/l .

Nearshore Nutrient Conditions

Lake Ontario nearshore water quality is highly variable and is affected by the size of tributary, non-point and point source discharges, current flow patterns within the nearshore, wind direction, and the distance from shore. Physical processes and phenomena such as north shore upwelling, lake circulation, and the south shore thermal bar can affect local patterns of nutrient concentrations.

In nearshore coastal zones (<30 m depth) spring nutrient loads (total phosphorus (TP) and soluble reactive phosphorus (SRP)) have decreased over the last 2 decades along both the north and south shores of Lake Ontario. Nutrient concentrations are highest closer to the shore (<2 m depth) where TP and SRP can exceed 100 µg/l and 50 µg/l respectively (Makarewicz et al., 2012; Howell et al., 2012). The Canadian nearshore shows a west to east TP gradient with higher levels observed in the more urbanized west end of the lake and decreasing in an easterly direction (Figure 10). The range of TP variability is more pronounced on the New York south shore than the lake's north shore and may reflect the influence of the Niagara River plume, local tributary loading, and the seasonal thermal bar.

It is puzzling that the reemergence of *Cladophora* in some nearshore areas is occurring during a time when phosphorus concentrations have declined to below the GLWQA interim substance objective, the offshore is approaching ultra-oligotrophic (very low nutrient conditions), and nearshore nutrient concentrations are lower than in the past. The results of recent science efforts provide differing conclusions as to whether anthropogenic sources of nutrients are driving localized nuisance growth of *Cladophora*. One conclusion is that *Cladophora* growth appears to be worse under conditions of land-based phosphorus enrichment in some nearshore areas. However, under optimum growth conditions for *Cladophora* (e.g., high mussel density, low light attenuation, large quantity of available hard substrate, calm or protected areas and watershed sources of phosphorus), *Dreissenid* mediated environments also support dense *Cladophora* growth at low ambient phosphorus concentrations. Excluding high, local point source discharges, further research is required to determine the extent to which nuisance growth of *Cladophora* can be managed through increased phosphorus control (Higgins et al., 2012).

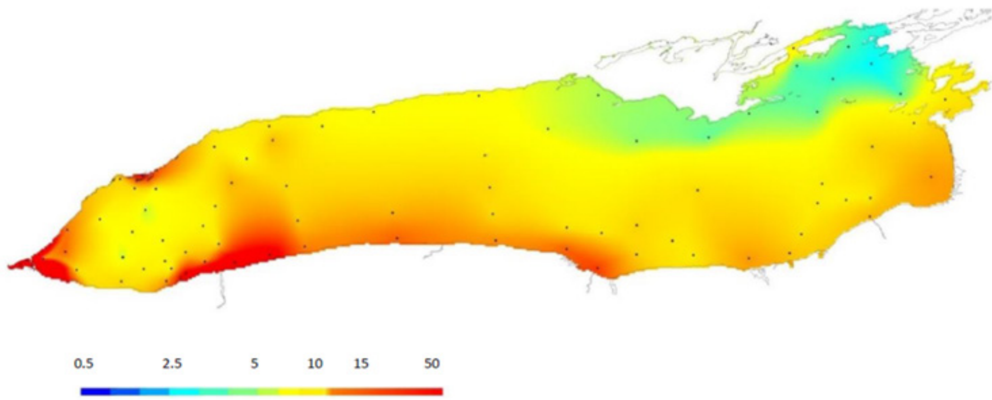

Figure 10: Total phosphorus concentrations (µg/L) in Lake Ontario (Spring 2013)

(Source: Environment and Climate Change Canada)

3.6.6 Impacted Areas

The extent of *Cladophora* coverage appears to be more prevalent along the Canadian nearshore versus U.S. nearshore areas based on satellite mapping. As with *Dreissenids*, this may be due to the greater availability of shallow rocky waters along the north shore relative to the south. In some Canadian and U.S. nearshore areas, *Cladophora* biomass is currently lower than the biomass measured in the 1970s and 1980s at comparable shallow depths (LONTT, 2016). This is the case in Lake Ontario as it is in the upstream Great Lakes. Lakewide, recent *Cladophora* tissue phosphorus concentrations are trending lower than in the past, reflecting a lower phosphorus environment, except in proximity to wastewater treatment effluent discharges where tissue concentrations are at growth stimulating levels (Howell, 2018b). However, currently there is greater areal coverage of *Cladophora* growth from recently increased water clarity in Lake Ontario. Specific locations of reported problems of shoreline fouling by *Cladophora* include St. Catharines, Oakville, Ajax, Newcastle, Presqu'ile and Kingston, Ontario and Rochester, Kendall and Hamlin, New York.

Toxic and nuisance HABs have been reported in several New York embayments (Sodus Bay, Port Bay), and continue to occur in Hamilton Harbour and the Bay of Quinte in Ontario.

3.6.7 Links to Actions that Support this General Objective

LAMP actions that will help manage nutrient and bacterial pollution and support this General Objective are discussed in Chapter 5 under Nutrient and Bacterial Related Impacts (Section 5.1) and Invasive Species (Section 5.3).

3.7 Invasive Species

GLWQA General Objective: Be free from the introduction and spread of aquatic invasive species and free from the introduction and spread of terrestrial invasive species that adversely impact the quality of the waters of the Great Lakes.

Current Status: While the rate of new aquatic invasive species introductions has slowed in the last decade, established species, including viruses, bacteria, algae, invertebrates, fish and plants, continue to expand with significant ecological and economic consequences (SOGL, 2017).

3.7.1 Background

An invasive species is one that is not native and whose introduction causes harm, or is likely to cause harm to the economy, environment, or human health. Lake Ontario has experienced aquatic flora and fauna invasions since at least the time of European settlement. The rate of introductions increased during the 19th and 20th centuries but has slowed in recent decades. Many of these species have enormous impacts on Lake Ontario's ecology and economy (Mills et al.,1993) including decreasing the abundance of native aquatic and plant species, altering nutrient and energy webs, and increasing costs for water treatment, power generation, and industrial facilities. Aquatic invasive species include plants, fish, algae, mollusks, crustaceans, and other invertebrates.

Invasive species enter Lake Ontario through various pathways, including ship ballast water, bait and aquarium releases, as well as being released by the public. Expanded watershed connectivity through shipping channels and canals has sped up the spread of these species. In recent years, the number of invasions has gone down. Scientists are increasingly using science and monitoring networks and digital databases to help track new and potential invaders and pathways, although there are limitations to these approaches. Management of existing invasive species in the Great Lakes continues focus on the control of established populations, reducing their abundance, and, where possible, containing existing populations to limit range expansion. Ongoing outreach and education programs and initiatives are also an important management action that promote awareness of how local and individual efforts can reduce the spread and impacts of invasive species.

3.7.2 Threats

Aquatic Invasive Species

Aquatic invasive species have significantly affected the Lake Ontario ecosystem at all trophic levels. Invasive species have also had substantial economic impacts including losses to recreation, fishing and tourism industries, costs of lakewide research, monitoring and control, and costs of control at power generation facilities and other utilities. While international shipping through the St. Lawrence Seaway has been considered the primary entrance point for new aquatic invasive species, canals, trade in live animals and plants, and recreational boating also provide potential pathways.

Invertebrates

Spiny Water Flea (*Bythotrephes*), Bloody Red Shrimp (*Hemimysis anomala*), and *Dreissenid* mussels (Quagga and Zebra mussels) are three invaders that threaten native species and water quality within Lake Ontario. *Dreissenid* mussels, first detected in Lake Ontario in 1989, are altering the Lake ecosystem by changing nutrient and energy cycling, negatively impacting native species, and promoting harmful algal blooms. By consuming small zooplankton, the Spiny Water Flea changes zooplankton communities and creates competition for food with larval fish that also eat plankton (Yan et al., 2001). Bloody Red Shrimp are also causing declines in zooplankton through a combination of direct predation and competition. Grazing release (dissolved organic carbon released by feeding activity) by Bloody Red Shrimp may also lead to an increase in phytoplankton biomass and contribute to algal blooms in nearshore areas (Koops et al, 2006).

Fishes

Sea Lamprey, a lethal parasitic fish first detected in Lake Ontario in 1863, have significantly affected the ecosystem by harming other fish populations and altering food webs. The invasive Round Goby is found across all five Great Lakes and is abundant in Lake Ontario (first reported in 1998) and some tributaries. Round Goby have since become a food source for some native fish species, providing a potential mechanism for bioaccumulation of chemicals due to their aggressive consumption of *Dreissenid* mussels (Hogan et al., 2007). Round Goby, as well as Alewife and Rainbow Smelt, are also known to prey on small fishes and the eggs of native species such as Lake Trout and Mottled Sculpin, and to compete with other native species for food (Marsden & Jude, 1995).

Grass Carp, Bighead Carp, Silver Carp, and Black Carp are collectively referred to as Asian Carps. These species pose ecological and socio-economic threats to the Great Lakes Basin (Cudmore et al., 2017; Mandrak & Cudmore, 2004; Hayder, 2014). Only one species of Asian Carp, Grass Carp, has been captured in

Lake Ontario (or its tributaries). Seven Grass Carp were captured in Lake Ontario in 2015. A single individual was captured in Jordan Harbour, followed by five more in the area close to the Toronto Islands, and one individual in the Bay of Quinte. No additional Grass Carp were reported to have been captured in Lake Ontario in 2016 or 2017. Grass Carp can change aquatic vegetation density, water quality, and the fish and invertebrate community (Mandrak & Cudmore, 2004). There is no evidence these fish are reproducing in Lake Ontario.

Tench pose a threat to Lake Ontario through competition with native minnow species and may reduce water quality. Tench stir up sediment during feeding, and feed heavily on snails, which may result in algal blooms due to the removal of the algal consumers (Cudmore & Mandrak 2011). Tench are currently spreading from their initial invasion location in the Richelieu River, Quebec. Tench has been identified as an invasive species to monitor, as its rapid range expansion through the St. Lawrence River in the past few years brings it closer to eastern Lake Ontario.

Viruses

Viral Hemorrhagic Septicemia (VHS) Virus is an infectious fish disease that causes deaths in several Lake Ontario species, including Freshwater Drum and Round Goby (Lumsden et al., 2007). It can also affect other bait and sport fish within the Basin.

Plants

Several aquatic invasive plants are currently found within the Lake Ontario watershed, including, but not limited to, Water Soldier, Hydrilla, Water Lettuce, Water Hyacinth, Eurasian water-milfoil and Fanwort. Some of these species may have the potential to out-compete native aquatic plant species and therefore alter portions of the Lake Ontario food web, should they find their way to the Lake. The full extent of these plants within the watershed is not known at this time, and it is not known whether the waters of Lake Ontario would provide habitat that is suitable for the survival and spread of these plants.

Terrestrial Invasive Species

The spread of terrestrial invasive species has occurred with increased human movement around the globe, and this trend is likely to continue. Species of concern include the European Common Reed (*Phragmites australis ssp-australis*), Giant Hogweed, and Japanese Knotweed.

3.7.3 How are Invasive Species Monitored?

Established, newly introduced, and potentially invasive species are monitored by state, provincial, and federal agencies, as well as academic institutions through early detection and monitoring (EDM) and detection tracking databases. With this information, these agencies assess the risk of introduction pathways and potentially invasive species and develop Response Plans.

Monitoring and assessing the impacts of invasive species is a significant challenge for management agencies. The sheer size of Lake Ontario and its watershed makes a comprehensive assessment nearly impossible. As a result, estimates of the status and trends of aquatic and terrestrial invasive species are based on limited information, as described below.

Aquatic Invasive Species

Most of the monitoring of aquatic invasive species occurs as a part of routine surveillance programs by environmental protection and natural resource management agencies. Only a few aquatic invasive species have targeted monitoring programs. Adult Sea Lamprey status is measured annually by the Sea Lamprey Program of the Great Lakes Fishery Commission. The population size of invasive *Dreissenid* mussels is estimated on a five-year cycle through a multi-agency sampling effort. Asian Carp surveillance continues in Lake Ontario using Environmental DNA technology. The binational "Early Detection and Rapid Response Initiative" recently established by experts working under Annex 6-Aquatic Invasive Species of the GLWQA, is now monitoring additional locations in the Great Lakes that are potential points of invasion by new aquatic invasive species. More information about the initiative is available at: https://binational.net/2016/10/03/ais-eae/

Terrestrial Invasive Species

Due to the variety of different governmental jurisdictions and the mix of public and private land ownership, there is no single method that assesses the location and spread of terrestrial invasive species in the Lake Ontario watershed. New internet-based technologies, including the Early Detection and Distribution Mapping System (EDDMapS) (http://www.eddmaps.org/) and iMap Invasives (https://www.imapinvasives.org/) allow land managers and private citizens to voluntarily share information. These systems provide some spatial data that helps track the spread of invasive species, including Emerald Ash Borer, European Buckthorn, Garlic Mustard, Phragmites and Purple Loosestrife. The USDA Forest Service and Michigan State University maintain the Emerald Ash Borer Information Network website, which includes monthly updates on the confirmed locations for this species in the U.S. and Canada: http://www.emeraldashborer.info/about-eab.php

3.7.4 Status and Trends

The status of invasive species in Lake Ontario is 'Poor' and the trend is 'Deteriorating' due to interbasin spread of these invasive species (Table 9). While the rate of new introductions has slowed in the last decade, established species, including viruses, bacteria, algae, invertebrates, fish, and plants, continue to expand with significant ecological and economic consequences. Notable species include Alewife, Sea Lamprey, Round Goby, Rainbow Smelt, Bloody Red Shrimp, *Dreissenid* mussels, Spiny Waterflea, Water Chestnut, Phragmites and the Viral Hemorrhagic Septicemia Virus. The 2012 GLWQA commits the U.S. and Canada to cooperate on reducing and managing the spread of invasive species. Agencies recognize that prevention efforts are the most effective management tool, supported by rapid response to early detections.

Table 9: Summary of status and trends for invasive species sub-indicators

(Source: SOGL, 2017)

Feature	Sub-indicator	Status	Trend
Invasive Species	Impacts of Aquatic Invasive Species	Poor	Deteriorating
	Dreissenid Mussels	Poor	Deteriorating
	Sea Lamprey	Good	Unchanging
	Terrestrial Invasive Species	Poor	Deteriorating

3.7.5 Data Discussion

Aquatic Invasive Species

The status of *Dreissenid* mussels is 'Poor' and 'Deteriorating'. Although densities in shallow waters appear to be declining, they remain high, while densities in deep waters continue to increase. The abundance of adult Sea Lamprey and wounding rates (Figure 11) caused by adults are currently near or below Great Lakes Fisheries Commission targets. Lamprey control efforts are ongoing.

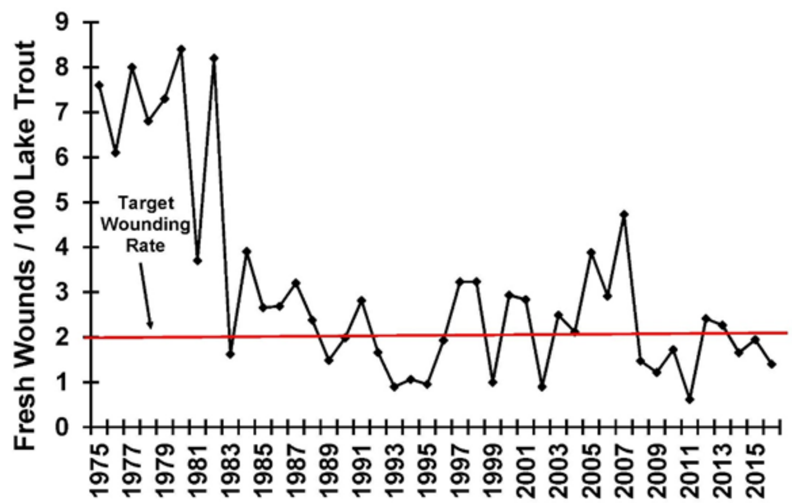

Figure 11: Sea Lamprey Lake Trout wounding rates

(Source: NYSDEC, 2017)

The Ontario MNRF and NYSDEC are taking lakewide actions to prevent the spread of VHS. This includes restriction on movement and sale of commercial bait within the management zone and VHS testing of stocked fish (MNRF, 2011).

Sea Lamprey Harm Reduction

Sea Lamprey pose a significant threat to the viability of Lake Ontario Trout and Salmon populations. Binational efforts led by the Great Lakes Fishery Commission to control Lamprey through chemical and physical methods has successfully reduced their populations. This has kept the number of wounds on Lake Trout below the target level through much of the last decade (Figure 11) minimizing their impact on Lake Trout and other fish populations.

Terrestrial Invasive Species
The state of terrestrial invasive species negatively affecting the waters of Lake Ontario is ‘Poor’ and ‘Deteriorating’. Several species continue to expand. For example, European Common Reed (*Phragmites australis ssp-australis*) is in aggressive competition with native vegetation and its spread is swiftly reducing species diversity and wildlife habitat (Bains et al., 2009). Giant Hogweed is of significant concern as it can cause photodermatitis and burning of the skin if a person comes in contact with the plant. Japanese Knotweed can aggressively dominate riparian areas and provide less soil retention than native woody vegetation, creating a higher erosion risk (see www.nyis.info for more information).

3.7.6 Links to Actions that Support this General Objective

In 2013, the Great Lakes St. Lawrence Governors and Premiers released the first list of 16 “least wanted” aquatic invasive species that present a serious threat to the Great Lakes-St. Lawrence River Basin. Since then, the region’s eight states and two provinces have taken more than 40 actions to prohibit or restrict these high-risk species, including the Asian Carp. On May 4, 2018, the Governors and Premiers announced five additions to the list of “least wanted” aquatic invasive species; Tench, Marbled Crayfish, New Zealand Mud Snail, European Frogbit, and Yellow Floating Heart. More information can be found at (http://www.gsgp.org/projects/aquatic-invasive-species/).

LAMP actions that support this General Objective are discussed in Section 5.3 Invasive Species. Terrestrial species are covered in Loss of Habitat and Native Species (Section 5.2).

3.8 Groundwater

GLWQA General Objective: Be free from the harmful impact of contaminated groundwater.

Current Status: There is no evidence of significant impacts of contaminated groundwater to Lake Ontario. Known contaminated groundwater sites are actively managed and monitored through environmental programs. (Source: SOGL 2017)

3.8.1 Background

Groundwater is linked with surface water and other parts of the water cycle. Groundwater influences water quality and the availability, amount, and function of habitats for aquatic life within streams, inland lakes, coastal wetlands, and nearshore waters (Grannemann et al., 2000). Lake Ontario cannot be protected without protecting the groundwater resources in the Great Lakes Basin (IJC, 2010).

3.8.2 Threats

The significance of contaminated groundwater discharges on the Great Lakes Basin is unknown. However, many sources of groundwater contamination exist, and groundwater is a major source of water for surface water bodies (Grannemann & Van Stemvoort, 2015). In the southern portion (U.S. side) of the Lake Ontario watershed, water does not easily pass through glacial deposits (clay, silt, sand, gravel, rock versus other substrates) and spends more time in shallow groundwater, making it more vulnerable to contamination from human activities. Shallow groundwater is more likely to be impacted by nutrients and pesticides from agricultural activity. Development in urban areas reduces the amount of water that cycles into groundwater, and there is considerable evidence that urbanization radically alters the entire urban water cycle (Custodio, 1997; Lerner, 2002). Chloride contamination from salts is likely to occur wherever road density is greatest. It is estimated that 20% of septic systems cause excessive nutrient leaching into groundwater due to poor design, poor maintenance, and inappropriate site conditions (CCA, 2009; IJC, 2011).

3.8.3 How is Groundwater Monitored?

In Canada, groundwater quality is monitored and reported by the Environmental Monitoring and Reporting Branch of the MECP in partnership with the Ontario conservation authorities. The Provincial Groundwater Monitoring Network (PGMN) is a partnership program with all 36 conservation authorities and 10 municipalities (in areas not covered by conservation authorities). The network was established in 2000 and was designed to collect and manage ambient (baseline) groundwater level and quality information from key aquifers across Ontario.

Currently, the PGMN consists of 484 active groundwater monitoring wells located across the province. Of these, there are 182 active monitoring wells within the Lake Ontario watershed. These wells are sampled annually and the samples analyzed for a suite of chemical parameters including metals, general chemistry, and major ions. The information and data collected from the PGMN is being used by the MECP, conservation authorities, and municipalities responsible for implementing groundwater management programs. Data is posted on the MECP's website at: https://www.ontario.ca/data/provincial-groundwater-monitoring-network.

In addition, the Ontario Geological Survey has conducted the Ambient Groundwater Geochemistry Project which provides a comprehensive analytical characterization of the chemical state of groundwater across all of southern Ontario resulting in coverage of an area of approximately 96,000 km^2. The data include detailed inorganic chemistry for almost 2,300 water samples. Parameters tested include dissolved gases, major ions, trace elements, isotopes of water, and field measurements of alkalinity, temperature, pH, redox potential, and electrical conductivity. The project data is available at https://www.mndm.gov.on.ca/en/mines-and-minerals/applications/ogsearth/ambient-groundwater-geochemistry.

Groundwater quality in New York is assessed through an ongoing Ambient Groundwater Monitoring Program between the NYSDEC Division of Water and the USGS (http://www.dec.ny.gov/lands/36064.html). The objectives of the program are to assess and report on the quality of the State's groundwater, identify long-term groundwater quality trends, characterize naturally occurring or background conditions, and establish an initial statewide comprehensive groundwater quality baseline for future comparison. The program is designed so that all major drainage basins in the State are monitored once every five years. 2018 will mark completion of the third full sampling rotation.

In each study year, NYSDEC and USGS sample approximately 60 wells, divided among the basins being studied. The final selection of wells includes an equal split of public and private wells, an equal split of bedrock and overburden aquifer wells, and an overall equal geographic distribution of wells. Sampling and analysis of groundwater includes field and physical parameters, bacteria, nutrients, inorganic and organic contaminants, dissolved gasses and radiochemicals. Data reports are developed by the USGS for each major basin and are available online at USGS's New York Ambient Groundwater Quality Monitoring webpage (https://ny.water.usgs.gov/projects/305b/). Monitoring data collected under this program is available from the USGS through their National Water Information System (https://waterdata.usgs.gov/nwis).

Groundwater in New York is also monitored by designated parties on a routine basis as part of long-term operation and maintenance programs at waste disposal areas (landfills), hazardous waste sites, or other facilities where the potential for groundwater contamination may exist. In addition, groundwater is monitored on an as-needed basis in support of NYSDEC site-specific investigative and remedial program activities.

3.8.4 Status and Trends

The overall status of groundwater quality, based on current knowledge and data in the Great Lakes Basin, is assessed as 'Fair'. For Lake Ontario, groundwater is assessed as 'Fair' with the trend being 'Undetermined' (SOGL, 2017). The full extent of groundwater contamination in the Basin and the overall status of this General Objective will need to be examined further. Currently the Lake Ontario Basin has sufficient, distributed data and thus no caveats to note on the whole basin assessment for this Lake (SOGL, 2017). Trend analysis was not part of this initial assessment (2016 to 2017) and is anticipated to be a component of future assessments (SOGL, 2017).

3.8.5 Data Discussion

Ontario's groundwater monitoring network rarely found levels of contaminants above Ontario drinking water quality standards. Of the 258 wells that were assessed in the Lake Ontario Basin, the groundwater quality was poor in 74 (29%), fair in 78 (30%), and good in 106 (41%) wells. Groundwater quality is generally in good condition throughout the agricultural areas within the watersheds of southern Ontario. In the west, above the Niagara Escarpment, and in the east along the St. Lawrence River, a thick Paleozoic sequence supports carbonate aquifers capable of supplying high yields of normally good quality water. In central southern Ontario (near the Greater Toronto Area) and at various locations above the Niagara Escarpment, glacial deposits of Quaternary age form complex aquifer systems that locally provide excellent yields of high quality water (Chu et al., 2016).

Conservation Ontario has recently produced a report card that summarizes all the groundwater results from the Provincial Ground Water Monitoring Network: http://conservationontario.ca/policy-priorities/science-and-information-management/watershed-reporting/.

3.8.6 Links to Actions that Support this General Objective

LAMP actions that support this General Objective are discussed in Critical and Emerging Chemical Contaminants (Section 5.4).

3.9 Other Substances, Materials and Conditions

GLWQA General Objective: Be free from other substances, materials or conditions that may negatively impact the chemical, physical or biological integrity of the waters of the Great Lakes.

Current Status: Most threats to Lake Ontario are being addressed through ongoing environmental programs. Plastic litter and microplastics are a recent concern in freshwater environments including Lake Ontario, yet sources, transport, and fate remain unclear (SOGL, 2017).

Other issues of public concern may impact ecosystem health in the Lake Ontario Basin and obstruct progress to achieve this General Objective. Understanding these threats will help inform the public and guide management decisions and priority actions.

3.9.1 Microplastics

Microplastics are non-biodegradable organic polymers such as polyethylene, polypropylene, and polystyrene, that are generally less than 5 millimeters (0.2 inches) in size. They include fibers from clothing and rope, plastic particles from the breakdown of bags, packaging and containers, and plastic beads from personal care products.

A recent study of plastic pollution in 29 tributaries of the Great Lakes found that 98% of the plastics collected were microplastics; 71% of these were microfibers (Baldwin et al. 2016). A study focused on the open waters of the Great Lakes found high levels of microplastics in Lake Ontario, which is attributed to the fact that the Lake Ontario Basin is highly populated (Eriksen et al., 2013).

The impacts of microplastics on Great Lakes water quality and ecosystem health are not fully understood. Further research is required to determine the risk to fisheries and aquatic wildlife populations.

Plastic pollution has the potential to affect fish and wildlife populations in three different ways: 1) complications due to ingestion; 2) leakage of plastic additives; and 3) exposure to persistent organic pollutants associated with the surface of the plastics (Anderson et al., 2016). A recent review of the effects of exposure to microplastics on fish and aquatic invertebrates by Purdue University (Foley et al., 2018) reported that feeding, growth, reproduction, and survival of freshwater biota in the presence of microplastics was highly variable across taxa. They noted that animals that serve as prey to larger predators (e.g., zooplankton) may be particularly susceptible to negative impacts of exposure to microplastic pollution, with potential for ramifications throughout the food web.

In addition to the potential for physical or toxicological effects on organisms, microplastics introduce hard substrate into aquatic ecosystems, which can subsequently alter pelagic and bacterial communities (Anderson et al., 2016).

The U.S. government signed into law the Microbeads-Free Waters Act on December 28, 2015 under the U.S. Federal Food, Drug and Cosmetic Act. Under this legislation, the manufacture of personal care products containing plastic microbeads was banned after July 1, 2017, and the sale of these products banned as of July 1, 2018. This new law also applies to both cosmetics and non-prescription drugs, including toothpastes.

In June 2017, the Canadian government published the Microbeads in Toiletries Regulations which will help reduce the quantity of plastic microbeads entering Canadian freshwater and marine ecosystems by prohibiting the manufacture, import, and sale of toiletries used to exfoliate or cleanse that contain plastic microbeads, including non-prescription drugs and natural health products. A prohibition on the manufacture, import and sale of toiletries that contain plastic microbeads occurred in 2018.

These bans on the use of microbeads in personal care products are an important first step in reducing the flow of microplastics into the Great Lakes. However, numerous other sources of microplastics remain, including: urban runoff (containing polystyrene, plastic bags, bottles, wrappers, cigarette butts, and tire particles); fishing gear and discarded debris from boats; plastic shavings and dust from factory floors; wastewater treatment facility effluent (synthetic fibers from clothing and textiles, fragments of larger debris); combined sewer overflows; and atmospherically-deposited synthetic fibers.

NOAA's Great Lakes Marine Debris Action Plan establishes a comprehensive framework for strategic action to ensure that the Great Lakes, its coasts, people and wildlife are free from the impacts of marine debris https://marinedebris.noaa.gov/great-lakes-land-based-marine-debris-action-plan.

The Province of Ontario's proposed Made-in-Ontario Environment Plan outlines the province's plan to protect the environment, commits to several actions to reduce plastic waste and pollution, including:

- Work with other provinces, territories and the federal government to develop a plastics strategy to reduce plastic waste and limit microplastics that can end up in our lakes and rivers;
- Seek federal commitment to implement national standards that address recyclability and labelling for plastic products and packaging to reduce the cost of recycling in Ontario;
- Work to ensure the Great Lakes and other inland waters are included in national and international agreements, charters and strategies that deal with plastic waste in the environment; and
- Review and update Ontario's Great Lakes Strategy to continue to protect fish, parks, beaches, coastal wetlands and water by reducing plastic litter entering waterways.

3.9.2 Botulism

According to the U.S. Geological Survey, botulism outbreaks are causing extensive mortality of fish and fish-eating birds in the Great Lakes (see https://www.sciencebase.gov/catalog/item/539773f8e4b0f7580bc0b420). Botulism results from ingestion of neurotoxins produced by the bacterium *Clostridium botulinum*, which leads to paralysis and death. Periodic outbreaks of type E botulism have occurred in the Great Lakes since at least the 1960s, but outbreaks have become more common and widespread since 1999, particularly in Lakes Michigan, Erie, and Ontario. Botulism has been responsible for over 80,000 bird deaths on the Great Lakes since 1999. Spores of the botulinum bacterium are naturally widely distributed in the environment, but toxin production occurs only when suitable environmental conditions allow spore germination and growth. Scientists suspect the conditions needed to promote toxin production are related to local soil and water conditions, as well as presence of invasive species such as *Dreissenid* mussels and Round Gobies, but these links have not yet been proven.

3.9.3 Watershed Impacts

Expanding populations, urban development, and agriculture land use practices can cause land-based pressures on the Great Lakes ecosystem, especially in areas with large population centers. Urban and agricultural lands are a function of our society and important to those in the Lake Ontario Basin because they help support people and the economy. Impacts on water quality from urban and agricultural areas make the Great Lakes more vulnerable to impairments or threats. One of the threats to water quality in Lake Ontario due to land-based pressures listed above is chloride contamination from road salts. Some recent research has shown that chloride levels in groundwater and surface water in the Great Lakes region are exceeding the severe threat level (acute toxicity) for aquatic life as defined by the CCME. Public awareness, managed usage of road salts, and adequate equipment can reduce threats posed by chloride (road salts). Chlorides are also a concern due to the way they change the dynamics of delivery of other pollutants to the lake during winter and spring seasons. Chloride-rich water is denser and sinks to the bottom of the lake (lakebed), resulting in the deposit of other contaminants from urban runoff onto the lakebed, particularly near the mouths of tributaries.

Research has shown that an increase in forest cover improves water quality. Forest cover within a riparian zone (land along a lake, river or stream) plays a key role in stabilizing soil and can help reduce the amount of runoff from the land and reduce nutrient loadings and other non-point source pollutants. However, with half of the Great Lakes Basin currently in agricultural or developed land use, and with much less forest cover in the more southern parts of the Great Lakes Basin, there is still a significant risk on water quality from land-based pressures.

In the Lake Ontario Basin, there is a moderate level of forest cover in riparian zones which suggests there is a moderate risk to water quality and ecosystem integrity. Similarly, most watersheds in the Lake Ontario Basin have moderate forest cover, which has declined from 2002 to 2011 on the Canadian side of the Basin. These data suggest there is a potential for water quality problems and risks to ecological integrity due to loss of forest cover, particularly in Canada where losses have been larger, while the U.S. has remained unchanged.

In New York State, a Great Lakes Riparian Restoration Opportunity Assessment was completed by the New York Natural Heritage Program. This assessment identifies priority areas to restore riparian conditions based on an analysis of ecosystem health and ecosystem stress indicators (more information on this tool can be found at http://nynhp.org/treesfortribsgl).

3.10 Climate Change and Adaptation

Climate information is not assessed in the same manner as other indicators in this LAMP. Impacts from changing climate trends include warming air and water temperatures, changing precipitation patterns, decreased ice coverage, and water level fluctuations. These climate trend-related impacts interact with one another; alter the physical, chemical, and biological processes in the lake and surrounding watershed; and pose challenges to management agencies as they work to achieve many of the Agreement's General Objectives (Figure 12).

For example, the Lake Ontario ecosystem has experienced both high and low water levels and neither condition can be assessed as 'Good' or 'Poor'. However, prolonged periods of high or low water levels may cause stress to the ecosystem. Data collected over the past 30 to 40 years in the Great Lakes Basin show increases in the amount of precipitation and summer surface water temperature, and a reduction in ice cover. Lake levels have also generally decreased, although there has been a recent rebound in water levels in the past few years. It is not yet possible to say with any certainty if changes in water levels are expected to increase or decrease over time, however, it is expected that water levels will continue to become more variable and extreme (e.g., higher highs and lower lows).

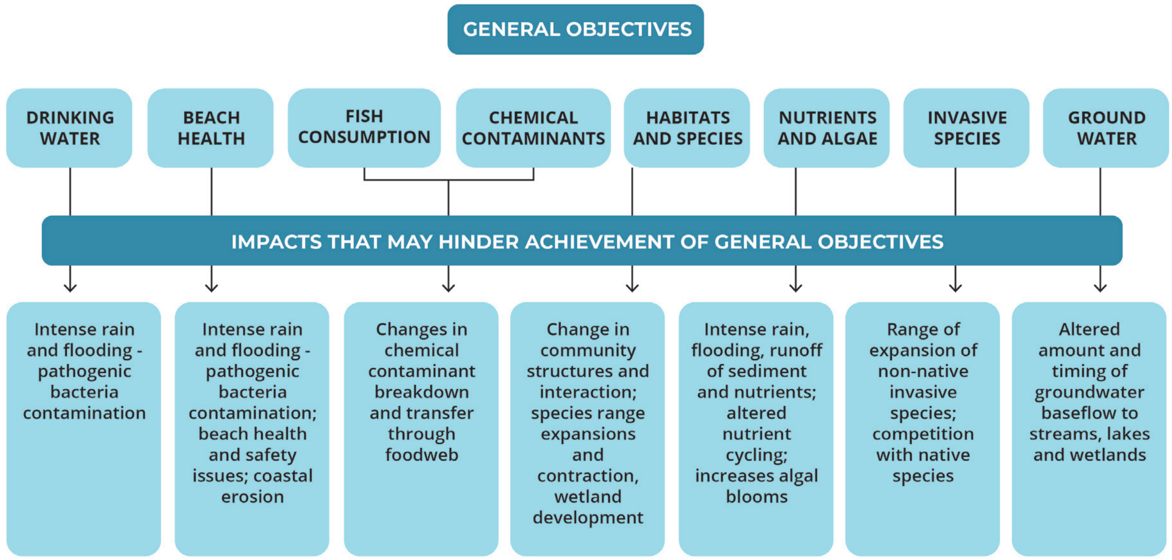

Figure 12: Potential climate trend impacts, and challenges to achieving the General Objectives of the 2012 GLWQA

National Oceanic and Atmospheric Administration (NOAA) Great Lakes Integrated Science and Assessment Team has documented changing climate patterns in the Lake Ontario Basin (see http://glisa.umich.edu/division/ny09). When comparing Basin wide data between the 30-year periods of 1951-1980 against 1981-2010, the top 1% of storms occurring during these times show an increase in intensity by 5.1%. The amount of precipitation falling during these storms has increased by 24.5% and the number of storm days has increased by 23.6 days per year. Total annual precipitation in the Great Lakes region increased by 10.7 cm (~13%) between 1955 and 2004, with the majority of change occurring during the summer and winter (Andresen et al., 2012; Hodgkins et al., 2007); All seasons have warmed, but winter and spring had the greatest warming and showing an increase in average temperature of 1.4°C (2.6°F) and 1.6°C (2.8°F) respectively. Ice cover has shown a declining trend. Between 1973 and 2010, the extent of ice cover on Lake Ontario has decreased by 88%.

These changes can affect the health of the Lake Ontario Basin including impacts to spawning and other habitats for fish species, the amount and quality of coastal wetlands, and changes in forest composition. Shifts in climate trends can also lead to the northward migration of invasive species and alter habitat in a way that favours some invaders over native species. Other outcomes that could result from a shift in climate trends includes an extended growing season, increases in runoff and nutrient loads, and changes to contaminant cycling, which could lead to increased frequency and presence of HABs, and can decrease water quality.

Climatic conditions are a restrictive factor for many aquatic species, forcing them to migrate northwards to cooler temperatures, and as such, many invasions occur during short favourable periods (e.g., during heat waves, when the lake temperature is warm). Continued warming with climate change may extend the frequency, range, or duration of these events and allow invasive species to persist or develop larger populations (Walther et. al., 2009). Warmer temperatures are also expected to favour establishment and spread of aquatic invasive species over the success of native fish species (Melles et. al., 2015). Round Goby, for example, are predicted to gain more suitable habitat with continued warming in the Great Lakes (Collingsworth et. al., 2017). Furthermore, increases in more extreme climate events such as flooding are likely to result in the escape and spread of previously confined aquatic species (Walther et. al., 2009).

The following observed and projected Great Lakes climate trends are taken from State of Climate Change Science in the Great Lakes Basin (McDermid et al., 2015) and other cited sources.

Temperature

- Projected 1.5 to 7°C increase in air temperature by the 2080s in the Great Lakes Basin; and
- Projected increase in the number of frost-free days (Davidson-Arnott, 2016).

Precipitation

- Total annual precipitation in the Great Lakes region increased by 10.7 cm (~13%) between 1955 and 2004, with the majority of change occurring during the summer and winter (Andresen et al., 2012; Hodgkins et al., 2007);
- Projected 20% increase in annual precipitation across the Great Lakes Basin by 2080s, with greater variability in winter precipitation;
- Projected decrease in snowfall, with accompanying decrease in duration and depth of snow cover; and
- Changes in frequency and magnitude of extreme weather events with increased flooding and intensity of storms while at the same time increased risk of drought and drier periods in between (Winkler et al., 2012).

Ice Cover

- Average ice coverage for the Great Lakes Basin has decreased by more than 50% over the last two decades (Wang et al., 2012);

- Projected annual average ice cover, thickness, and duration (across all Great Lakes) could fall to near zero by 2050s (Hayhoe et al., 2010; Music et al., 2015); and
- Reduction of lake ice cover resulting in an early onset of stratification and longer surface water temperature warming period (Austin and Colman 2008; Franks Taylor et al., 2010).

Projected Seasonal Changes

- Models that forecast climate-related impacts on the Great Lakes suggest a downward shift in water level range with less inter-annual fluctuation (Abdel-Fattah and Krantzberg 2014; Bartolai et al., 2015);
- Changes in precipitation and ice cover lead to a change in the seasonal lake level cycle with somewhat lower levels at the end of the summer and higher levels in the winter (MacKay and Seglenicks 2013);
- Shorter, warmer winters and longer and hotter summers;
- Fluctuations around lower mean water levels; and
- Increases in the direction and strength of wind and water currents.

Biological Impacts

The first documented evidence of biological change associated with recent climatic warming in the Great Lakes shows a reorganization of the open water diatom community within the past 30–50 years to one characterized by elevated abundances of several species in the Cyclotella genus and closely related genera, coinciding with rising atmospheric and water temperatures (Reavie et al., 2016). The Cyclotella increases are believed to be a result of new physical regimes in the lakes such as changing stratification depths and longer ice-free periods, and may have important implications to the Great Lakes food web.

4

4.0 BINATIONAL STRATEGIES

Many of the issues and threats to Lake Ontario discussed in Chapter 3 are complex and addressing them requires collaboration and partnerships on both sides of the Lake. Under the 2012 GLWQA, the Lake Ontario Partnership has been given the role to develop and implement Lake-specific binational strategies to address current and future potential threats to water quality.

Chapter 4 describes four existing Binational Strategies that help address the environmental stressors negatively impacting Lake Ontario's water quality. The LAMP actions outlined in Chapter 5 have been designed to complement the work that has already and is currently being done through these binational strategies.

4.1 The Niagara River Toxics Management Plan

On February 4, 1987, ECCC, USEPA, MECP, and NYSDEC signed the Niagara River Declaration of Intent (DOI), committing the agencies to achieve significant reductions of toxic contaminants in the Niagara River. A key target of the DOI was to reduce loadings of persistent toxic chemicals of concern into the Niagara River by 50% by 1996. The DOI, combined with a detailed annual work plan, formed the Niagara River Toxics Management Plan (NRTMP). The work plan served as the primary mechanism for maintaining agency accountability to the NRTMP and, while a formal governance structure for the NRTMP was established, actions in support of work plan were incorporated into existing agency programs, and included source track down and reduction, water quality monitoring, sediment quality monitoring, biomonitoring, information management, and public information and involvement. After some time, and as progress under the NRTMP continued, the work plan component moved from an annual update to an as-needed approach.

Contaminants Addressed under the Niagara River Toxics Management Plan

The specific toxic chemical pollutants were not defined in the DOI, but were later developed by the Four Parties, and include the following 18 contaminants. The 10 toxics in bold text subsequently became the focus of reduction efforts because they were deemed to have significant sources along the Niagara River.

- Arsenic
- **Benz(a)anthracene**
- **Benzo(a)pyrene**
- **Benzo(b) fluoranthene**
- **Benzo(k) fluoranthene**
- Chlordane
- Chrysene
- Dieldrin,
- DDT
- **Dioxin**
- **Hexachlorobenzene**
- Lead
- **Mercury**
- **Mirex/Photomirex**
- Octochlorostyrene
- **PCBs (Polychlorinated biphenyls),**
- **Tetrachloroethylene Toxaphene**

Through hazardous waste site remediation efforts and bans that were placed on the use of some toxic chemicals, the NRTMP was successful in achieving the original goal of reducing loadings of targeted toxics by at least 50% by 1996. And, in 1996, the Four Parties re-affirmed their commitment to the NRTMP in a "Letter of Support (LOS)" that stated

"The Four Parties commit to reduce toxic chemical concentrations in the Niagara River by reducing inputs from sources along the River. The purpose is to achieve ambient water quality that will protect human and aquatic life and wildlife and, while doing so, improve and protect water quality in Lake Ontario as well."

Recognizing the difficulties of accurately tracking continued contaminant load reductions over a long period of time, the LOS included two reporting metrics for evaluating progress under the NRTMP: maintenance of downward trends in concentrations of chemicals that exceed water quality criteria or that are associated with Niagara River sources; and, achievement of downstream concentrations that are statistically equivalent to those upstream.

The work of the NRTMP continues through ongoing collaboration between the Four Parties, including source trackdown, monitoring and, where needed, remedial action. Monitoring programs generally show that concentrations of priority toxics in water, sediment and biota continue to decline. However, despite the continuing efforts of the Four Parties, concentrations of some chemicals in the Niagara River still exceed the strictest agency criteria for water quality, and downward concentration trends for some contaminants are leveling off. The monitoring data also show that the concentrations of some contaminants already exceed criteria when water enters the Niagara River from Lake Erie, highlighting the importance of identifying and addressing upstream sources.

With renewed binational focus on the Great Lakes under the Canada-Ontario Agreement, U.S. Great Lakes Restoration Initiative, and the 2012 amendment to the GLWQA, representatives from the Four Parties are identifying options for the future of the NRTMP and ways it can continue to play a role in reducing contaminant inputs to the Niagara River and, subsequently, Lake Ontario. It is recognized that changes in policies, programs, and governance that have occurred over the past 30 years in both Canada and the U.S. will need to be taken into consideration during this process.

4.2 The Lake Ontario Binational Biodiversity Conservation Strategy

Previous Lake Ontario LAMPs have provided a framework to assess, restore, protect, and monitor the ecosystem health of the Lake. It was within this framework that in 2006, the Lake Ontario Partnership initiated a process to create a biodiversity conservation strategy for Lake Ontario that was binational in scope, and tasked Nature Conservancy of Canada (NCC) and The Nature Conservancy in the U.S. (TNC) to coordinate with partner agencies and organizations to develop this strategy.

The Binational Biodiversity Conservation Strategy (BCS) was prepared through the participation and input of 150 experts from over 50 agencies, universities, and organizations. The project scope was

"to develop bi-national strategies for conserving and restoring the biological diversity of Lake Ontario, including its coastal habitats, pelagic and benthic zones, tributaries, and connecting channels."

The final report, *The Beautiful Lake, A Binational Biodiversity Conservation Strategy for Lake Ontario*, completed in 2009, includes detailed summaries and maps of key components of Lake Ontario's biodiversity, such as coastal wetlands, forests, and tributaries. The full report can be downloaded here: https://www.conservationgateway.org/ConservationByGeography/

NorthAmerica/wholesystems/greatlakes/Pages/lakeontario.aspx.

The BCS identified broad categories of recommended actions, not all of which were necessarily implementable on a binational, lakewide scale. To determine which components of the BCS should be formally incorporated into the Lake Ontario LAMP, a binational effort was initiated and, in 2011, *Implementing a Lake Ontario LAMP Biodiversity Conservation Strategy* ("BCS Implementation Plan") was released (https://binational.net/wp-content/uploads/2015/02/LakeOntarioBCSen.pdf).

The BCS Implementation Plan recommended five high-level categories for action to help focus coordination and management activities (see Appendix C). A significant achievement of the BCS was the identification of 28 Priority Action Sites (PASs) (Figure 13). PASs are high value watersheds, tributaries, and coastal areas of critical importance to Lake Ontario's biodiversity. The PASs were the focus areas for the recommendations made within the BCS Implementation Plan. The BCS, including the PASs, continue to serve as a primary resource for the Lake Ontario Partnership in their efforts to plan and implement actions (including many of those identified in Chapter 5) to improve the ecosystem health of the Lake and its watershed.

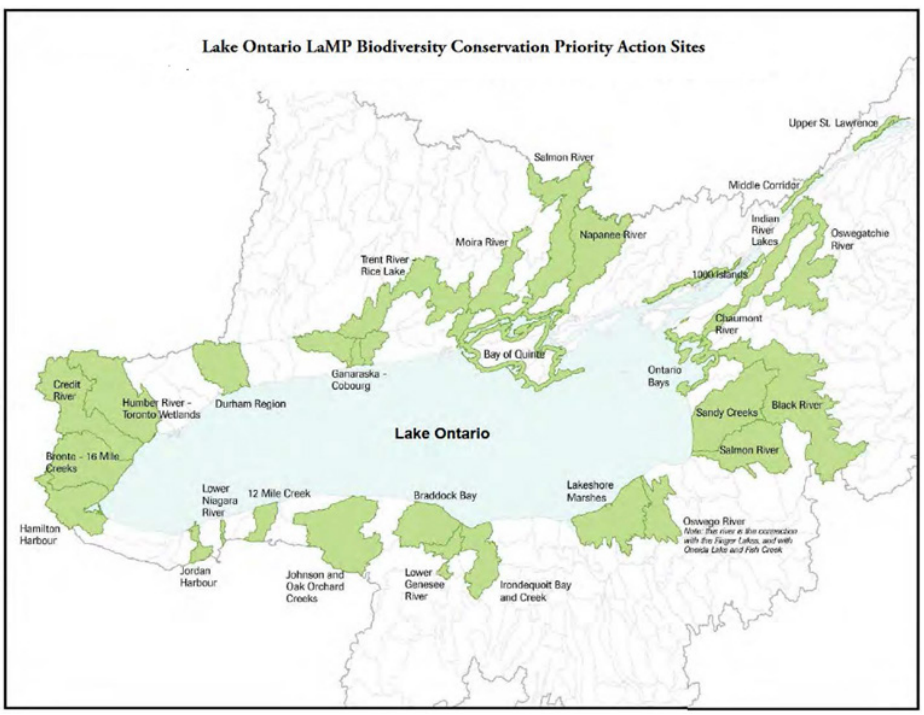

Figure 13: Map of identified Priority Action Sites in Lake Ontario

(Source: Lake Ontario LAMP Work Group and Technical Team, 2011)

4.3 The Nearshore Framework

The shallow nearshore waters of the Great Lakes are highly productive environments. Most species of Great Lakes fish use nearshore waters as important spawning or nursery habitat for one or more life stages. As a result, the nearshore area hosts the highest diversity of fish species. The GLWQA recognizes that nearshore waters must be restored and protected because urban and rural communities rely on the nearshore for safe drinking water; recreational activities such as swimming, fishing and boating; and water withdrawals for industry and power generation. The nearshore is the hydrological and ecological link between watersheds and the open waters. A sustainable and prosperous Great Lakes economy is dependent upon a healthy nearshore ecosystem.

In acknowledgment of the importance of the nearshore, the 2012 GLWQA committed Canada and the United States to develop a Nearshore Framework to improve our understanding of the nearshore ecosystem; identify causes of impairment and threats to the nearshore; and identify nearshore protection, restoration, and prevention activities. Enhanced nearshore mapping and assessment conducted under the Nearshore Framework will increase our understanding of the value of diverse and healthy nearshore habitats for biota and ecosystem functioning. The Lake Ontario Partnership can use this information during development of the LAMPs to better refine and guide best management practices and actions to protect, restore, and enhance specific nearshore habitat types, and to clearly communicate the importance of protecting Great Lakes nearshore habitats to the public. The Parties will include enhanced nearshore assessment data and maps in all future LAMPs beginning with the Lake Erie LAMP.

In Canada, a comprehensive nearshore assessment of all the lakes and connecting rivers is being completed by 2022 under Canada's Great Lakes Protection Initiative. Lake Ontario's nearshore assessment including the Niagara and St. Lawrence Rivers is underway and will be completed in 2019. In the United States, the National Coastal Condition Assessment (NCCA) was completed on the Great Lakes in 2015 and is scheduled to be repeated with enhancements in 2020.

4.4 Chemicals of Mutual Concern

Annex 3, Chemicals of Mutual Concern (CMC), of the 2012 GLWQA commits Canada and the U.S. to prepare and issue binational strategies to reduce the release and impact of chemicals which have been designated as CMC under the Agreement. These are prepared in cooperation and consultation with state and provincial governments, Tribal Governments, First Nations, Métis, municipal governments, watershed management agencies, other local public agencies, and the public. These strategies may include research, monitoring, and surveillance actions, as well as pollution prevention and other control mechanisms and actions. Both countries also commit to monitoring and reporting on progress towards implementing these strategies.

The first group of CMC has been identified through a binationally agreed upon multi-stakeholder process. The first set of CMC under the Agreement include:

- Hexabromocyclododecane (HBCD);
- Long-Chain Perfluorinated carboxylic acids (LC-PFCAs);
- Mercury;
- Perfluorooctanoic acid (PFOA);
- Perfluorooctane sulfonate (PFOS);
- Polybrominated Diphenyl Ethers (PBDEs);
- Polychlorinated Biphenyls (PCBs); and
- Short-Chain Chlorinated Paraffins (SCCPs).

The binational strategies for PCBs and HBCD have been finalized and are available on binational.net. The remaining strategies are currently being drafted and are expected to be finalized by the end of 2019.

Canada and the U.S. continue to recognize the need to manage CMC by implementing measures to reduce or eliminate their releases into the environment, including, as appropriate, measures to achieve virtual elimination and zero discharge. Both countries also recognize that a lifecycle management approach is important for addressing CMC. This means that the environmental impacts at all stages of a chemical's lifecycle – from import or manufacture, through use, re-use, and disposal – are recognized and managed appropriately.

5

5.0 LAKEWIDE MANAGEMENT ACTIONS

The Lake Ontario Partnership agencies have developed an ecosystem-based strategy to improve the water quality of Lake Ontario and the Niagara and St. Lawrence River systems. Government agencies, Indigenous Peoples, stakeholders, and the public all have an important role in identifying threats and implementing priority management actions for the Lake Ontario Basin over the next five years. The Lake Ontario Partnership agencies will work with these various groups to address key environmental threats through the implementation of management actions between the years of 2018 to 2022. The approach will include continuing engagement and relationship building with Indigenous communities to collaborate in restoring, protecting and conserving Lake Ontario and its connecting river systems.

Investigating ecosystem health. (Source: TRCA)

This Chapter outlines the 2018-2022 LAMP management actions. The actions address the threats identified in Chapter 3, complement the binational strategies outlined in Chapter 4, and contribute towards achieving the nine GLWQA General Objectives. As many of the threats discussed in Chapter 3 cross multiple General Objectives, the actions under this 2018-2022 LAMP are grouped by four specific issue areas:

1. Nutrient and bacterial related impacts;
2. Loss of habitat and native species;
3. Invasive species; and
4. Critical and emerging chemical contaminants.

For each issue area, the background, priority issues, progress to date, science priorities, and continued actions needed to address challenges are discussed.

The identified management actions build on the many achievements already realized from ongoing science, monitoring, and binational and domestic initiatives. The actions focus on cooperation, collaborative implementation, and reporting under the Lake Ontario LAMP. Linkages between the General Objectives, binational strategies and actions area summarized in Appendix E. Table 10 shows the connections between threats, impacts, General Objectives and the Lake Ontario LAMP issue areas. The management actions will be implemented to the extent feasible, given available resources and domestic policy considerations by the various agencies with corresponding mandates.

Table 10: Connections between threats and Lake Ontario LAMP issue areas

Stressor	Threat	Impact/Potential Impact	LO LAMP 2018-2022 Issue Area	GLWQA General Objective
Rural non-point source pollution (e.g., agricultural run-off, drainage tiles, faulty septic systems)	Harmful Algae Blooms (HABs), increased *E.coli* levels	Drinking water source contamination; poor beach health and beach closures; decreased ecosystem health	Nutrient and Bacterial Related Impacts (5.1)	GO#1 (drinking water), GO#2 (beach health and safety), GO#5 (habitat and species), GO#6 (nutrients and algae)
Urban non-point source pollution (e.g., stormwater run-off and overflow)	Harmful Algae Blooms (HABs), increased *E.coli* levels, increased chloride levels in water	Drinking water source contamination; poor beach health and beach closures; decreased ecosystem health; groundwater contamination	Nutrient and Bacterial Related Impacts (5.1)	GO#1 (drinking water), GO#2 (beach health and safety), GO#5 (habitat and species), GO#6 (nutrients and algae); GO#8 (groundwater)
Point and non-point source pollution, current and historic (e.g., WWTP, industrial, manufacturing, agriculture activities)	Emerging chemicals of concern (e.g., pharmaceuticals) Chemicals of Mutual Concern Legacy contaminants (Mercury, PCBs, dioxans, mirex, etc.) Harmful Algae Blooms (HABs), increased *E.coli* levels, increased chloride levels in water	Drinking water source contamination; bioaccumulation in wildlife affecting human health and habitats; groundwater contamination; poor beach health and beach closures; decreased ecosystem health	Critical and Emerging Chemical Contaminants (5.4) Nutrient and Bacterial Related Impacts (5.1)	GO#1 (drinking water), GO#2 (beach health and safety), GO#3 (fish and wildlife consumption), GO#4 (chemical contaminants); GO#5 (habitat and species); GO#8 (groundwater)

Stressor	Threat	Impact/Potential Impact	LO LAMP 2018-2022 Issue Area	GLWQA General Objective
Shoreline development and alteration	Negative impact on coastal habitat	Impact on native species, decreased ecosystem health	Loss of Habitat and Native Species (5.2)	GO#5 (habitat and species)
Barriers and dams	Loss of habitat connectivity	Impact on native species, decreased ecosystem health	Loss of Habitat and Native Species (5.2)	GO#5 (habitat and species)
Lake Ontario water level management	Loss and alteration of wetlands	Loss of native species and habitat	Loss of Habitat and Native Species (5.2)	GO#5 (habitat and species)
Various (e.g., shipping, pet trade, boating)	Invasive species – e.g., *Dreissenid* mussels, prey fish, etc.	Impact on native species, reduced ecosystem health, altering nutrient pathways, harmful algae blooms	Invasive Species (5.3)	GO#1 (drinking water); GO#2 (beach health and safety); GO#5 (habitats and species); GO#6 (nutrients and algae), GO#7 (invasive species)
Various - industrial, manufacturing, shipping and transportation	Chemical spills	Drinking water contamination, health of ecosystem	Critical and Emerging Chemical Contaminants (5.4)	GO#1 (drinking water), GO#4 (chemical contaminants); GO#5 (habitat and species)
Climate change	Increased stormwater run-off from increased storm frequency and severity; changes in water levels and precipitation; increase spread of invasive species	Contamination of drinking water, wildlife and habitats; impact on native species and habitats	Nutrient and Bacterial Related Impacts (5.1); Loss of Habitat and Native Species (5.2); Invasive Species (5.3); Critical and Emerging Chemical Contaminants (5.4)	All nine general objectives

5.1 Nutrient and Bacterial Related Impacts

5.1.1 Background

As discussed in Sections 3.2 and 3.6, most areas of Lake Ontario are not impacted by bacterial pollution or excessive nutrients (phosphorus and nitrogen) that can lead to nuisance or harmful algal blooms and can make beaches unsafe. However, localized nutrient and bacterial pollution is an ongoing issue that exists in some nearshore coastal areas and embayments.

Localized nutrient and bacterial pollution is limiting the full achievement of the following General Objectives:

- #2: Allow for swimming and other recreational use, unrestricted by environmental quality concerns;
- #5: Support healthy and productive wetlands and other habitats to sustain resilient populations of native species; and
- #6: Be free from nutrients that directly or indirectly enter the water as a result of human activity, in amounts that promote growth of algae and *Cyanobacteria* that interfere with aquatic ecosystem health, or human use of the ecosystem.

More information on the status and threats of bacterial pollution or excessive nutrients can be found in Sections 3.2 (Beach Health and Safety) and 3.6 (Nutrients and Algae).

5.1.2 Priority Issues

Below are priority areas for the management, reduction, and prevention of nutrient and bacterial-related impacts to Lake Ontario.

Point Source Pollution

The efforts of multiple levels of government to protect water quality by regulating end-of-pipe point discharges from outfalls have been generally successful. With this in mind, it is recognized that there are still point source discharges occuring at some locations in the Basin. Industrial and municipal wastewater facilities must have approval to establish, use, and operate facilities and there are site-specific effluent limits and monitoring and reporting requirements for operation. Such end-of-pipe controls are part of addressing nutrient enrichment-related issues. High density confined animal feeding operations can generate large amounts of animal waste and excess nutrients if not properly managed. Discharges from some concentrated animal feeding operations (CAFOs) are treated as point sources under Canadian and U.S. regulatory programs.

Opportunities exist, particularly along

Lake Ontario's western shore, to further optimize the performance of wastewater treatment plants, and to reduce the volume and frequency of bypasses and overflows. Optimization techniques would improve the management of phosphorus levels in continuous effluent discharges. During heavy storm events or snowmelt, the volume of runoff, domestic sewage, and industrial wastewater can go above the capacity of combined sewer systems resulting in combined sewer overflows. When this occurs, untreated or minimally treated stormwater and wastewater discharge directly to nearby streams, rivers, and lakes with potential negative impacts to water quality.

Non-Point Source Pollution – Urban Areas

Diffuse pollution occurs when contaminants leach into surface waters and groundwater as a result of rainfall or snowmelt moving over and through the ground. Residential, urban, and shoreline development can disrupt natural water flows, transport nutrients from lawn fertilizers, cause sediment pollution from land clearing and development or construction activities and create high volumes of runoff from impervious surfaces. This is particularly noted along Lake Ontario's western shore that is undergoing extensive urban development (i.e. Greater Toronto Area through to Niagara). It is common that rural residents in single-family homes depend upon on-site septic systems to treat household sewage. Failing septic systems can contribute phosphorus and bacteria to waterways.

Non-Point Source Pollution - Agricultural

Commercial fertilizers and animal manure can be a threat to water quality if they are over-applied, applied too close to a watercourse, applied on frozen ground, or applied just before a heavy rain. Row-cropping has generally moved toward larger fields, and some fence rows have been removed allowing for easier machinery operation. In many cases, cropping occurs immediately beside water courses with little or no vegetation remaining adjacent to the water (riparian vegetation).

While annual row cropping can result in bare fields in the non-growing season, recent extension efforts and government programs have promoted the use of cover crops to reduce runoff in the non-growing season. Extensive tiling can compound non-point source pollution problems. Tile drainage systems, while reducing sediment losses from farm fields compared to untiled fields, can result in a shift in production to annual row crops and away from forage and pasture production which can result in bare fields during the non-growing season. The shift away from permanent cover crops such as forages can have negative consequences on water quality. In some instances, tiling systems effectively become unregulated point sources that can discharge directly into water bodies, bringing sediment, nutrients, bacteria and other pollutants.

5.1.3 Progress Made to Date

The GLWQA 2012 includes commitments to review nutrient loadings and water quality targets for each of the Great Lakes, recognizing the resurgence of nearshore nutrient problems. Great Lakes nutrient issues are being examined by the GLWQA's Nutrients Annex Subcommittee. Article 4 and the Nutrients Annex of the 2012 GLWQA commits the Parties to implement programs to reduce phosphorus loadings from municipal sources (including urban drainage), industrial sources, agriculture, and forestry. The GLWQA 2012 revisions also formalized the Cooperative Science and Monitoring Initiative (CSMI) process placing it under the GLWQA's Annex 10 Science Subcommittee.

To date, GLWQA Nutrients Annex nutrient target reconsideration activities have focused on Lake Erie, but attention will be shifting to other lakes including Lake Ontario in coming years. While Lake Ontario's nutrient issues are distinctly different than Lake Erie's, which has large in-basin agricultural nutrient sources, more than half of Lake Ontario's total nutrient load are received from Lake Erie via the Niagara River. Management actions to reduce nutrient loads to Lake Erie will have an impact on the load of nutrients to Lake Ontario via the Niagara River. The Niagara River plume, with its significant impact on Lake Ontario's south shore and the nutrient load from the rapidly growing urban areas and tributaries along the western shore, pose distinctly different challenges than those found in Lake Erie. Although there is broad agreement that in-basin nutrient loads are responsible for large scale Lake Erie water quality problems, no such agreement currently exists for Lake Ontario.

Many domestic initiatives and programs are in place to address nutrient and bacterial pollution, including priority watershed identification and monitoring, incentive and grant programs for local landowners to undertake best management practices, regulatory measures, and upgrades to municipal wastewater treatment plants. The United States Forest Service (USFS) forest management program is guided by law, regulation, and agency policy to ensure that National Forests are managed in an ecologically sustainable manner (https://www.fs.fed.us/forestmanagement/aboutus/index.shtml). The USDA has developed an agroforestry strategic framework which combines agriculture and forestry technologies to create land-use systems that are healthier and more sustainable (https://www.usda.gov/topics/forestry). NYSDEC protects stormwater quality by issuing stormwater permits which require stormwater pollution prevention plans for discharges from construction activities including road building (http://www.dec.ny.gov/chemical/43133.html#Permit).

Voluntary farm assistance programs support farms of all sizes to engage in agricultural pollution prevention practices. Programs are implemented in New York by the Nonpoint Source Program (http://www.dec.ny.gov/chemical/94150.html) and through the USDA Natural Resources Conservation Service (NRCS) (https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/) and Farm Service Agency (https://www.fsa.usda.gov/about-fsa/index).

The Canada-Ontario Environmental Farm Plan (http://www.omafra.gov.on.ca) is an example of a risk assessment approach being implemented in Ontario to help farmers understand their greatest environmental risks in their operations. Similarly, New York's Agricultural Environmental Management (AEM) is a voluntary, incentive-based program that helps farmers make common-sense, cost-effective, and science-based decisions to help meet business objectives while protecting and conserving the State's natural resources (https://www.nys-soilandwater.org/aem/index.html).

5.1.4 Science and Monitoring Priorities

Science and Monitoring Priorities for Nutrient and Bacterial-Related Impacts

1. Characterize nutrient concentrations and loadings
2. Improve the understanding of nearshore nutrient-related problems

In order to help determine priorities for science and monitoring in Lake Ontario in 2018, a two-day workshop was held November 15-16, 2016, with the assistance of the International Joint Commission. At this workshop, advice was solicited from participants from over 20 agencies and academic institutions, on what the priorities should be and how to address the science priorities. The identified LAMP science priorities are summarized in Chapter 6, Table 16.

Many of these were the focus for the Lake Ontario 2018 CSMI field activities completed in 2018. The Lake Ontario Partnership, in close coordination with the GLWQA Annex 10 Science Subcommittee, will coordinate the planning and implementation of selected Lake Ontario science priorities. Chapter 6 provides details regarding all science and monitoring priorities for Lake Ontario.

Routine stream and open water monitoring and edge-of-field monitoring is conducted by federal, provincial, municipal, and state agencies. This monitoring allows agencies to report on nutrient trends and assess effectiveness of agricultural best management practices, streambank and riparian restoration, and stormwater management practices.

Anecdotal reports as well as more recent research (Howell, 2018a, 2018b; Kuczynski et al., 2016) suggest the incidence of Lake Ontario nuisance *Cladophora* has increased in recent years, particularly along some shoreline segments. Excessive nearshore nutrient concentrations, *Dreissenid* mussel impacts, and increased water clarity are suspected to be the major factors driving the apparent increase in *Cladophora* growth. However, the high degree of year-to-year variability, coupled with the lack of long-term quantitative information on *Cladophora* trends, presents a challenge to managers seeking to identify specific objectives for any future integration of localized, regional and/or Basin wide nutrient reduction initiatives. Lake Ontario is currently well below the GLWQA open water nutrient concentration target, which was first met more than two decades ago. Fishery managers are concerned that low offshore nutrient concentrations may limit the ability of the lake to support desirable fisheries (LONTT, 2016). Scientists are currently working to better understand the dynamics of nutrient flow in the Lake Ontario system to better inform future management decisions.

5.1.5 Actions 2018-2022

Over the next five years, the Lake Ontario Partnership will encourage and support nutrient management efforts and work with scientists and Great Lakes experts to understand and reduce the impacts of nutrients in the waters of Lake Ontario. This will be achieved by a combination of binational and domestic programs and other measures. Table 11 provides a summary of nutrient-related monitoring and management actions identified by the Lake Ontario Partnership, the agencies that will lead project implementation, and associated focus areas in the Biodiversity Conservation Strategy. Actions were selected based on an understanding of nutrient sources, geographic scope of the issue and localized impacts, and opportunities for remediation, monitoring, and management actions.

A key focus of actions will be to enhance understanding of nutrient dynamics and cycling, in order to identify specific objectives for Lake Ontario Basin nutrient management initiatives. An important issue for establishing nutrient objectives includes phosphorus cycling integrated over the offshore and nearshore of *Dreissenid* mussel-infested areas affected by large watershed loading inputs.

The Lake Ontario Partnership will undertake project tracking and reporting on the status and achievements of nutrient monitoring and management actions. Not all of the member agencies of the Lake Ontario Partnership are responsible for monitoring, surveillance, and implementation. Actions will be undertaken to the extent feasible, by agencies with the relevant mandates.

Table 11: Lake Ontario Partnership actions for nutrients and bacterial related impacts

#	Lake Ontario Partnership Actions (2018-2022)	Agencies Involved	BCS Programmatic Focus Areas (see Appendix C for details)
	POINT SOURCE AND NON-POINT SOURCE POLLUTION		
1	**Wastewater and Stormwater Management System/Facilities:** • Compliance promotion and enforcement of regulations to control end-of pipe sources of pollution. • Implement water quality improvement projects, including upgrades/optimization of wastewater and stormwater facilities and infrastructure. Implement best management practices for the treatment of urban stormwater runoff to the Great Lakes, using green infrastructure and low impact development where feasible	USDA-NRCS, NYSDEC, MECP, Conservation Authorities	PFA 5

#	Lake Ontario Partnership Actions (2018-2022)	Agencies Involved	BCS Programmatic Focus Areas (see Appendix C for details)
2	**Nutrient and Bacteria Control:** • Build on existing integrated and systematic efforts within targeted watersheds to improve soil health and reduce the overland runoff of nutrients, sediments, and bacteria to the Lake or tributaries. • Where needed and as resources allow, conduct relevant research, source identification/track down, and identify potential actions to address sources. **Watershed:** • Implement site-specific projects within coastal wetlands, beaches, and shorelines that will reduce impacts to the lake from nutrient and bacteria inputs.	USDA-NRCS, NYSDEC, MECP, Conservation Authorities, USACE	PFA 5
3	**Remedial Action Plans:** • Continue to implement remedial actions in the Bay of Quinte, Hamilton Harbour, Toronto and Region and St. Lawrence Areas of Concern to address excess nutrient and bacterial contamination.	ECCC, MECP, MNRF	
4	**Watershed Management Planning and Implementation:** • Renew and/or develop integrated watershed management plans and link to coastal and nearshore management and other nutrient reduction/management actions as required at a community level.	NYSDEC, MECP, Conservation Authorities	PFA 5

#	Lake Ontario Partnership Actions (2018-2022)	Agencies Involved	BCS Programmatic Focus Areas (see Appendix C for details)
SCIENCE, SURVEILLANCE, AND MONITORING			
5	**Nutrients:** • Conduct research and monitoring to better understand nutrient dynamics in Lake Ontario and its watershed including spring and summer open water nutrient and lower food web surveys, and tributary monitoring. • Monitor *Cladophora* growth in nearshore areas and loads of phosphorus to Lake Ontario from tributaries. • Assessment of nearshore waters of Lake Ontario, Niagara and St. Lawrence Rivers under the Nearshore Framework.	ECCC, USEPA, USGS, TRCA, MECP, NOAA, NYSDEC	
6	**Agricultural Areas:** • Continue to conduct Environmental Farm Plan risk assessments and edge-of-field monitoring to assess effectiveness of best management practices.	USGS, USDA-NRCS Conservation Authorities	PFA 5
OUTREACH AND EDUCATION			
7	**Communication:** • Improve engagement, communication and coordination to build awareness and improve understanding of Lake Ontario & connecting rivers issues	MECP, ECCC,USEPA, NYSDEC, Conservation Authorities	PFA 1 PFA 3 PFA 4

Actions that everyone can take to prevent nutrients and bacteria from entering groundwater, streams, wetlands and Lake Ontario

- Choose phosphate-free detergents, soaps, and cleaners and use appropriate amounts
- Avoid using lawn fertilizers that contain phosphorus
- Properly dispose of pet waste
- Use natural processes to manage stormwater
- runoff and increase permeable surfaces – e.g., plant a rain garden with native plants, shrubs, and trees so that water soaks into the ground
- Inspect and pump out your septic system regularly
- Use improved septic technologies, including converting septic systems to municipal or communal sewage systems
- Keep cattle out of streams
- Integrate agricultural best management practices such as: grassed swales, shelter belts, filter and/or buffer strips to control and reduce stormwater runoff and trap nutrient and sediment runoff

5.2 Loss of Habitat and Native Species

5.2.1 Background

The main factors contributing to the loss of biological diversity are habitat alteration, destruction and fragmentation on land, in tributaries, and along the shores of Lake Ontario. This includes unsustainable shoreline development and alterations, water level management, and dams and barriers in streams and tributaries. Other threats include non-point source pollution, non-native invasive species, and climate change. These factors may prevent the achievement of the following General Objective:

- #5: Support healthy and productive wetlands and other habitats to sustain resilient populations of native species.

Actions that restore and protect habitat and species will also indirectly benefit other General Objectives:

- #6: Be free from nutrients that directly or indirectly enter the water as a result of human activity, in amounts that promote growth of algae and *Cyanobacteria* that interfere with aquatic ecosystem health, or human use of the ecosystem.

The 2011 BCS Implementation Plan (see Section 4.2) identifies key threats to biodiversity and priority action sites to guide binational action. Many threats and actions to address them are covered in other sections of this chapter, including Nutrient and Bacterial Related Impacts (5.1), Invasive Species (5.3), and Critical and Emerging Chemical Contaminants (5.4). More information on the status and trends of the loss of habitat and native species specifically can be found in section 3.5.

5.2.2 Priority Issues

Partner agencies are working together to achieve healthy and productive wetlands and other shoreline habitats to sustain resilient populations of native species. Below are two priority areas for the restoration and protection of habitat and species.

Shoreline Development and Alterations

Approximately 30% of Lake Ontario's shoreline is in a heavily or moderately hardened condition (SOGL, 2017). In many urban areas, shoreline development and alteration disrupt natural coastal and nearshore processes (i.e. pollution filtration and sediment transport), disrupt flow and water circulation patterns, alter or eliminate connections with coastal wetlands and dunes, and contribute to loss of wetland habitat. Shoreline hardening, removal of riparian vegetation, and lake substrate material can also reduce the quality of habitat for nearshore dwelling fish, waterbirds, and other aquatic dependent animals.

Loss of Aquatic Habitat Connectivity

Dams and a variety of barriers slow or block movement of migratory fishes between Lake Ontario and tributaries used for spawning, and nursery or overwintering habitat (e.g., Atlantic Salmon, Walleye, American Eel; BCS; SOGL, 2017). In addition to damming, culverts at road stream crossings can also obstruct the passage of fish through tributaries.

Barriers such as dams do, however, play a beneficial role in that they help prevent Sea Lamprey (a serious threat to Lake Ontario's native fishes including Lake Trout), from accessing thousands of miles of additional spawning habitat. In-stream barriers also prevent the spread of other invasive species including Round Goby, which present a threat to native fishes (see Sections 3.7 and 5.3).

5.2.3 Progress Made to Date

Since 2011, agencies and partners in both Canada and the U.S. have completed or initiated a great amount of work that directly or indirectly supports the BCS and the Implementation Plan. Under the 2011 BCS, more than 100 aquatic habitat restoration projects have been completed by agencies, environmental non-governmental organizations, stakeholders, and local municipalities between 2011 and 2015. These have included, but are not limited to, riparian tree planting, stream bank stabilization and restoration, installation of in-water fish habitat features (e.g., coarse aggregate and natural woody debris), and monitoring of restoration success. Table 12 provides a sample of Canadian and U.S. funding programs that conserve, protect, and restore habitat and native species and a selection of these programs are described further below.

Table 12: Examples of Canadian and United States funding programs that support restoration of Lake Ontario aquatic habitat and native species

United States	Canada
• Great Lakes Restoration Initiative • Great Lakes Sediment and Nutrient Reduction Program • North American Wetlands Conservation Act Grants • New York State Great Lakes Protection Fund • New York State Wildlife Grants • Sustain Our Great Lakes program grants	• EcoAction Community Funding • Great Lakes Protection Initiative • The Aboriginal Fund for Species at Risk • The Community Interaction Program • The Environmental Damages Fund • The Habitat Stewardship Program • The Pathway to Canada Target 1 Challenge (Canada's Nature Fund) • Recreational Fisheries Conservation Partnerships Program (RFCPP) • Ontario Great Lakes Guardian Community Fund • Ontario Land Stewardship and Habitat Restoration Program • Provincial funding to implement MNRF priorities under the Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health and Ontario's Great Lakes Strategy

Native Species

State, provincial, and federal agencies have developed strategies to work towards restoration of fish species including Lake Trout, Bloater, Lake Sturgeon, Atlantic Salmon, and American Eel. These agencies have also taken efforts to restore species to specific areas of historical importance including Walleye in Hamilton Harbour and Cisco in Irondequoit and Sodus Bays. Several agencies and academic institutions have collaborated on actions such as habitat evaluation and improvement, stocking, Sea Lamprey control, and assessment, which have resulted in improved status for each of these species.

The Return of Piping Plovers

For the first time since the early 1980s, Piping Plovers have been observed nesting on the beaches of Lake Ontario. The endangered Great Lakes Piping Plover population has risen from 12 pairs in 1990 to 75 pairs in 2016 with most nesting in Michigan. In order for the population to fully recover, it needs to expand to other locations in the Great Lakes. Protecting the pairs that have recently returned can help reach historic population levels and contribute to the recovery of the species through enhancement and restoration of natural shorelines. With ever-growing demands on beaches, there are significantly fewer places for plovers to nest, rest, and feed, and plovers are particularly susceptible to human disturbance. Sites where plovers are nesting need to be managed in a way to reduce disturbances.

Habitat Connectivity

In the summer of 2016, the Saint Regis Mohawk Tribe (SRMT) oversaw the removal of the Hogansburg Dam, a 281-foot dam near the mouth of the St. Regis River, a tributary to the St. Lawrence River. This project marked the first removal of a federally licensed dam by a U.S. Tribe, as well as the first removal of a hydropower dam in New York State. The removal opened 441 kilometers of river and stream (274 miles) migration routes to upstream spawning and nursery habitat, benefiting Walleye, Muskellunge, Atlantic Salmon, Lake Sturgeon, American Eel, and others.

SRMT also rescued nearshore native freshwater mussels in the area above the dam that would have died following the de-watering associated with the dam removal. Surveys found 11 native mussel species present within the project area, four of which are considered New York

Rescued St. Regis River native mussels being relocated upstream in advance of the removal of the Hogansburg Dam. (Source: SRMT Environment Division

State Species of Greatest Conservation Need (NYS SGCN). In total, 66,539 mussels were relocated, including 6,550 which were assumed to be NYS SGCN. Preventing mussel mortality was important in this river system since the population has not been impacted by invasive mussel species, and because the mussels have an important ecological function that contributes to water quality.

The North Atlantic Aquatic Connectivity Collaborative developed protocols for assessing road stream crossings for the Northeast. NYSDEC, USFWS, and partners are working collaboratively to assess crossings and engage additional partners. The data from the assessments are populated into a database that is publicly available, to help inform local flood mitigation and habitat restoration projects. For more information, go to www.streamcontinuity.org. In addition, the Great Lakes Fishery Commission has developed a Sea Lamprey control map to help inform where barriers are needed to prevent Sea Lamprey introductions (see http://data.glfc.org/).

Coastal Wetlands

Multiple efforts are ongoing in the assessment and improvement of Lake Ontario's coastal wetland health. IJC's Lake Ontario – St. Lawrence River Plan 2014 (http://www.ijc.org/en_/plan2014/home) was implemented to allow more natural water level changes, which are expected to increase diversity in wetlands. Coastal wetland creation and restoration along the Toronto waterfront has resulted in additional wetland habitat for a variety of birds and native fish species. For example, at Tommy Thompson Park TRCA has created or enhanced 24.5 ha of coastal wetlands since 2004. One of the tools for creating shallow water habitat, offshore berms, is gaining in popularity due to its success in creating wetlands and riparian areas. At Braddock Bay Wildlife Management Area near Rochester, New York, a lost barrier beach was restored protecting a 138 ha (340 acre) highly diverse wetland that was in danger of eroding. Submerged aquatic vegetation is expected to increase on the protected side of the barrier island due to the expected increase in water quality.

Since 2011, over $5 million has been invested in coastal wetland restoration, and additional work is underway. Recently, two important coastal wetland restoration and monitoring projects have been undertaken in Priority Action Areas on the southeast and northwest shorelines of Lake Ontario. Together, these coastal wetland restoration projects on opposite shores of the Lake have demonstrated the collaborative work being accomplished by government agencies and stakeholders through the Lake Ontario Partnership.

In Ontario, Rattray Marsh, one of the last remaining coastal wetlands along the western end of Lake Ontario, provides habitat for multiple species at risk and species of conservation concern. MNRF, Credit Valley Conservation Authority, and ECCC are collaborating to restore Rattray Marsh. With a total investment to date of CAD$1.7 million (US$1.4 million), wetland soil has been restored through dredging deposited sediments and contaminated soils, and barriers have been installed to control invasive fish species. Additional work will help to conserve, rehabilitate, and monitor biodiversity and habitat in the marsh and other coastal wetlands at the western end of Lake Ontario.

In New York State, the 27 km (17-mile) long eastern Lake Ontario dunes and wetlands system is the largest freshwater dunes system in the eastern Great Lakes. With grants totaling over US$1 million (CAD$1.3 million) from the Great Lakes Restoration Initiative (GLRI), the Nature Conservancy (TNC) has partnered with Ducks Unlimited and NYSDEC to restore wetlands, control invasive plant species, and improve natural flows in this priority area.

Through the Great Lakes Protection Initiative (2017-2022), the Government of Canada is taking action to improve the health and resilience of coastal wetlands. Environment and Climate Change Canada and partners will assess wetland vulnerability to projected climate change effects to better understand the degree to which coastal wetlands are susceptible to, and unable to cope with, climate-related impacts. Study findings will be shared, and stakeholders and rights holders engaged to identify and prioritize tools and approaches (adaptive measures) to enhance wetland resilience. To learn about the Great Lakes Protection Initiative visit: https://www.canada.ca/en/environment-climate-change/services/great-lakes-protection.html.

Other actions are being taken to reduce shoreline hardening. The New York

State Community Risk and Resiliency Act (CRRA), 2014 seeks to develop Natural Resiliency Measures guidance that will provide information to contractors and landowners on feasible natural and/or nature-based alternatives to traditional hard structures.

5.2.4 Science and Monitoring Priorities

Science and Monitoring Priorities for Loss of Habitat and Native Species

1. Evaluate aquatic food web status
2. Improve understanding of fish dynamics
3. Coastal wetland status

In order to help determine priorities for science and monitoring in Lake Ontario in 2018, a two-day workshop was held November 15-16, 2016, with the assistance of the International Joint Commission. At this workshop, advice was solicited from participants from over 20 agencies on what the priorities should be and how to address the science priorities. The identified LAMP science priorities are summarized in chapter 6, Table 16. Many of these were the focus for the Lake Ontario 2018 CSMI field activities completed in 2018. The Lake Ontario Partnership, in close coordination with the GLWQA Annex 10 Science Subcommittee, coordinated the planning and implementation of selected Lake Ontario science priorities. Chapter 6 provides details regarding all science and monitoring priorities for Lake Ontario.

Several agencies, academic institutions, and not-for profit organizations continue to assess and report on aquatic habitat and the status of native species. These include:

- Long-term fish community monitoring including bottom trawl, acoustic, and gill net surveys (USGS, NYSDEC, MNRF); and
- Binational monitoring of wetland composition, extent and health to report on trends through time and assess changes due to an updated water level regulation plan and recent restoration projects (USEPA, NYSDEC, State University of New York (SUNY) Brockport, ECCC/CWS, conservation authorities).

5.2.5 Actions 2018-2022

Actions developed to address threats

and improve the state of aquatic habitat and species in the Lake Ontario Basin are outlined in Table 13. Between 2018 and 2022, agencies will implement these actions in partnership with a broad group of non-governmental organizations, stakeholders, local municipalities, and members of the public, whose participation is critical for success. The table also includes focus areas from the Biodiversity Conservation Strategy associated with each action.

Table 13: Lake Ontario Partnership actions for loss of habitat and native species

#	Lake Ontario Partnership Actions (2018-2022)	Agencies Involved	BCS Programmatic Focus Areas (see Appendix C for details)
	HABITAT AND SPECIES PROTECTION AND RESTORATION		
8	**Wetlands:** Protect, improve and monitor Lake Ontario coastal and watershed wetlands to support fish and wildlife diversity and habitat through a variety of initiatives including: • Wetland protection through land use policy and land conservation incentives to landowners. • Assess coastal wetland vulnerability to projected climate change impacts and recommend adaptive measures.	USEPA, NYSDEC, USFWS, USGS, USACE, MNRF, ECCC, Conservation Authorities	PFA 1 PFA 3 PFA 4 PFA 5
9	**Stream Connectivity:** Improve access to stream habitat for aquatic life by inventorying and prioritizing key barriers for mitigation. Undertake actions to remove, replace, or retrofit priority barriers (e.g., dams, weirs, road crossings) to allow for fish passage, spawning and migration while excluding invasive species where required.	USFWS, USGS, USEPA, USACE, NYSDEC, SRMT, MNRF, DFO, Conservation Authorities	PFA 1 PFA 2 PFA 3 PFA 4

#	Lake Ontario Partnership Actions (2018-2022)	Agencies Involved	BCS Programmatic Focus Areas (see Appendix C for details)
10	**Aquatic Habitat Protection and Restoration:** • Engage stakeholders, public and ENGO's to improve and restore the physical and chemical aspects of aquatic habitat in near shore, shoreline, and upland/riparian areas by: • Promoting beneficial and resilient nature-based shoreline management practices to reduce soil erosion, improve riparian buffers and soften artificially hardened shoreline protection structures. • Supporting the lifecycles of key native, restoration species by protecting and restoring fish spawning and nursery habitat in embayment and nearshore areas. • Encouraging adoption of Low Impact Development techniques and improved stormwater management to reduce the impacts (e.g., sediment and nutrients) of urban development on in-stream and nearshore fish and wildlife habitat. • Planning/implementing programs related to open space conservation and land/forest stewardship, including efforts to increase habitat resiliency in the watershed.	ECCC, MECP, MNRF, Conservation Authorities, NYSDEC, USFWS, USACE, USFS	PFA 1 PFA 4 PFA 5

#	Lake Ontario Partnership Actions (2018-2022)	Agencies Involved	BCS Programmatic Focus Areas (see Appendix C for details)
11	**Species Protection, Restoration and Enhancement:** Continued development, implementation, and evaluation of species protection and restoration plans, including enhancement through stocking, habitat restoration, control of invasive species (e.g., Sea Lamprey), diversification of prey resources, monitoring to measure success, and research to understand recovery processes for the following species: • Lake Trout • Native Coregonids (Bloater and Cisco) • American Eel • Lake Sturgeon • Atlantic Salmon	NYSDEC, USGS, USACE, USFWS, MNRF, DFO, Conservation Authorities	PFA 2 PFA 4
	SCIENCE, SURVEILLANCE, AND MONITORING		
12	**Evaluate Aquatic Food Web Status:** • Evaluate the aquatic food web including primary production, phytoplankton, zooplankton, mysids, *Dreissenid* mussels, and benthos.	MECP, NYSDEC	PFA 2 PFA 4
13	**Improve Understanding of Fish Dynamics:** • Improve our understanding of fish ecology and distribution during critical periods and apply new and existing techniques to address key knowledge gaps and inform management decisions.	MNRF, NYSDEC	PFA 4

#	Lake Ontario Partnership Actions (2018-2022)	Agencies Involved	BCS Programmatic Focus Areas (see Appendix C for details)
	Coastal Wetland Status:		
14	• Improve engagement, communication and coordination to build awareness and improve understanding of Lake Ontario & connecting rivers issues	MNRF, NYSDEC, ECCC	PFA 1 PFA 3

These actions have been designed to work with and complement existing legislation, strategies, and actions. Protection and conservation actions are enabled by federal, state, provincial, and municipal policy and or legislation. Management actions are supported through a diverse combination of core agency programs, binational entities or agreements, and project funding initiatives targeting stakeholder involvement. Important examples of binational groups seeking to improve Lake Ontario habitats and species include the Great Lakes-St. Lawrence River Adaptive Management (GLAM) Committee, which works to evaluate the regulation of water levels and flows, and the Great Lakes Fishery Commission's Lake Ontario Committee, which leads efforts to work toward achievement of Fish Community Objectives. Stakeholder-focused project funding initiatives, which actively target species and habitat improvement, include the Ontario's Great Lakes Guardian Fund and the Sustain Our Great Lakes funding initiative.

Lake Ontario Partnership actions will be carried out, led or contributed to by partner agencies that have a mandate to complete the identified work, to the extent possible. The agencies in Table 13 involved in the implementation of each projects is not exhaustive, and many projects rely on the involvement of additional agencies, stakeholders, and entities not listed.

The Lake Ontario Partnership will undertake project tracking and reporting on the status and achievements of actions to protect and restore habitat and species. Not all of the member agencies of the Lake Ontario Partnership are responsible for monitoring, surveillance, and implementation.

Actions that everyone can take to reduce the loss of habitat and native species in and around Lake Ontario

- Learn how to identify aquatic invasive species and how to prevent their spread
- Plant native trees and shrubs on your property
- Keep natural vegetation along the coast and streams
- Take advantage of land conservation incentives that promote protection of habitat features
- Follow Ontario and New York freshwater fishing regulations
- Actively practice soil erosion control, riparian buffer planting, and shoreline softening measures
- Support and/or volunteer with local conservation authorities, stewardship councils, and non-government environmental associations for shoreline clean up, habitat restoration, and restoring dune beach habitats

5.3 Invasive Species

5.3.1 Background

The introduction, establishment, and spread of invasive species are significant threats to Lake Ontario water quality and biodiversity. As discussed in Section 3.7, introduced or established aquatic invasive species of concern in the Lake Ontario Basin include but are not limited to Alewife, Sea Lamprey, Round Goby, Rainbow Smelt, Bloody Red Shrimp, Tench, *Dreissenid* mussels, Spiny Waterflea, European Common Reed (*Phragmites australis ssp.australis*), Water Soldier, Hydrilla, Water Lettuce, Water Hyacinth, Fanwort, and the Viral Hemorrhagic Septicemia Virus. The full extent of invasive species within the watershed is not known at this time, and it is not known whether or not the waters of Lake Ontario would provide habitat that is suitable for the survival and spread

Sea Lamprey. (Source: DFO)

of these invasive plant species.

Although there has only been one new aquatic invasive species introduced through ballast water to the Great Lakes Basin since 2006, the impacts from previous invaders continue as they spread through the Great Lakes ecosystem. *Dreissenid* mussels have a negative impact on Lake Ontario through alteration of the food web and change in nutrient levels, water clarity, and algal biomass. The ecological link between mussels, decomposing nuisance algae, and Round Goby is also speculated to enhance the transfer of botulinum toxin through the food web, resulting in Type E botulism-related deaths of loons, waterfowl, shorebirds, and fish, some of which are species at risk.

Aquatic invasive species are undermining efforts to restore and protect ecosystem health, water quality, and the full achievement of the following General Objectives:

- #4: Be free from pollutants in quantities or concentrations that could be harmful to human health, wildlife, or aquatic organisms, through direct exposure or indirect exposure through the food chain;
- #5: Support healthy and productive wetlands and other habitats to sustain resilient populations of native species; and
- #6: Be free from nutrients that directly or indirectly enter the water as a result of human activity, in amounts that promote growth of algae and *Cyanobacteria* that interfere with aquatic ecosystem health, or human use of the ecosystem.

More information on the status and threats of aquatic invasive species can be found in Section 3.7.

5.3.2 Priority Issues

The most effective approach to preventing the introduction and spread of new invasive species is to manage the pathways through which invasive species enter and spread. Below are four priority areas for the management, reduction, and prevention of invasive species.

Canals and Waterways

The construction of canals and waterways to connect waterbodies has provided a way for aquatic invasive species to travel to areas that were not previously accessible. Sea Lamprey, for instance, moved into the upper Great Lakes from the St. Lawrence River and through Lake Ontario, following the building of the Welland Canal and New York Barge Canals. The threat of Asian Carps advancing through the Chicago Area Waterways System has led to extensive research into barriers to prevent the movement of invasive fishes through canals and waterways. Research into both physical and non-physical barriers to fish movement has led to a variety of options that may help to restrict the movement of aquatic invasive species between the Great Lakes and Mississippi River drainage (USACE, 2014). While the Great Lakes and Mississippi River Interbasin Study (GLMRIS) highlights techniques specifically designed for use in preventing movement of invasive species between the Great Lakes and the Mississippi River, the equipment and strategies could be adapted for other canals and waterways in the Great Lakes Basin.

Shipping

Ballast water is used by vessels to help maintain stability and safe operating conditions for the vessel. When there is little weight from cargo on the vessel ballast water is pumped in to add weight and stability. The ballast is emptied when cargo is loaded onto the ship, to maintain the proper vessel draft. This enables the spread of aquatic species from one body of water to another when organisms collected in the ballast water are pumped out in a different waterbody. This was the mechanism by which *Dreissenid* mussels and the Round Goby were introduced into the Great Lakes system.

Canada's Ballast Water Control and Management Regulations (2011) entered into force on September 8, 2017. The future regulations will require that all ships in international traffic meet a standard with regards to ballast water and sediment management, in order to control the transfer of aquatic invasive species. In 2012, the United States Coast Guard (USCG) issued a rule establishing mandatory numeric concentration-based ballast water discharge limits. This rule sets the standard for the allowable concentration of living organisms in a ship's ballast water discharged into U.S. waters. It also requires all ocean-going vessels, including No Ballast on Board (NOBO) vessels, to meet ballast water management (BWM) requirements.

Recreational Activities

Recreational watersports, boating, and sport fishing can result in the transfer of aquatic invasive species to new waterbodies. Aquatic invasive species can be attached to hulls, gear, ropes, trailers, or even accidentally or intentionally introduced for recreational opportunities (for example sport fish or bait fish). It is important to raise awareness among individuals involved in these activities about the risks involved with the improper use and release of baitfish, the transport of invasive species on boats and gear, and the risks associated with intentionally releasing fish into new waterbodies. The use of cleaning and/or disinfecting stations, and providing details on the disinfection process to recreational users in areas where no station is available, is important to help limit unintentional transfer of aquatic invasive species through recreational activities.

Trade

Invasive aquatic plants and animals have been documented in both the live trade of aquarium and pond plants and animals, as well as the food trade. Intentional release into natural ecosystems, and unintentional release (through flooding or other escape), provide ways for these invasive species to be introduced into natural environments. While many species are tropical and would not survive the winter in the Great Lakes, there are species, such as Goldfish, Koi (Common Carp), Red-eared Slider Turtle, and plants such as Parrot's Feather and Water Soldier that can survive our climate. By working with industry representatives and providing information to aquarium and pond owners, intentional introductions can be avoided.

5.3.3 Progress Made to Date

One of the challenges to evaluating the success or progress of aquatic invasive species programs is determining what a successful result means – for example, is it limiting expansion, maintaining low levels, or total absence of a species?

The application of Federal *Aquatic Invasive Species Regulations* in Canada in 2015 and the United States *National Invasive Species Act,1996* (re-authorizing the *Nonindigenous Aquatic Nuisance Prevention and Control Act,1990*), has improved the authority of federal departments and agencies in the fight to prevent the entry and establishment of aquatic invasive species in Canadian and American waters. The Canadian Food Inspection Agency regulates the import, sale, and movement of plants coming into Canada, as well as transport within Canada. In the United States, the *Lacey Act, 1900* regulates the import or transport of species that are determined to be injurious to humans or the welfare of the environment. These regulations will help to control the import of aquatic invasive species, possibly destined for the food trade or the aquarium and water garden trades.

In New York State, a regulation was adopted in July 2014 that prohibits or regulates the possession, transport, importation, sale, purchase, and introduction of select invasive species. The purpose of this regulation is to help control invasive species by reducing the introduction of new and spread of existing populations. This regulation became effective March 10, 2015 (http://www.dec.ny.gov/animals/99141.html). New York State, under its Environmental

Conservation Law, has also formed and funded Partnerships for Regional Invasive Species Management (PRISMs) in their efforts to address invasive species (http://www.dec.ny.gov/animals/47433.html).

In Ontario, the *Invasive Species Act, 2015* along with its first suite of regulations came into force in November of 2016. The *Act* is intended to prevent, detect, respond to, and manage invasive species in the province. It provides the province with the ability to regulate invasive species banning certain activities such as their sale, possession, transportation, release, and importation. The *Act* also enables the province to ban certain activities which may spread invasive species such as recreational boating, or the movement of firewood. As of January 1, 2018, there were 16 aquatic invasive species regulated under the *Invasive Species Act, 2015* which make up those species listed as Least Wanted by the Great Lakes Governors and Premiers.

Canada's Ballast Water Control and Management Regulations (2011) have helped to limit the movement of aquatic invasive species. The Ballast Water Management Convention (2017) will require that all ships in international traffic meet a standard with regards to ballast water and sediment management, in order to control the transfer of aquatic invasive species.

In the United States, Congress enacted the *Nonindigenous Aquatic Nuisance Prevention and Control Act (NANPCA), 1990* to allow the U.S. Coast Guard to issue regulations to prevent the introduction and spread of aquatic invasive species into the Great Lakes through the ballast water of vessels. The NANPCA, 1990 requires all ships entering the Great Lakes to meet a standard regarding ballast water exchange, allowing individual states to more stringently regulate ballast water discharges and thereby prevent the introduction of further aquatic invasive species. Since enactment of NANPCA, regulations have been expanded to all ocean-going vessels including NOBOBs.

Continued development, implementation, and expansion of aquatic invasive species early detection surveillance and response programs by multiple Canadian and U.S. agencies will help to limit the spread and impacts of these invasive species. Some of these agencies include: the Conference of Great Lakes St. Lawrence Governors and Premiers (http://www.gsgp.org/projects/aquatic-invasive-species/), the Great Lakes Phragmites Collaborative (https://www.greatlakesphragmites.net/), and the Great Lakes Hydrilla Collaborative (http://hydrillacollaborative.com/).

5.3.4 Science and Monitoring Priorities

Science and Monitoring Priorities for Invasive Species

1. Evaluate the aquatic food web status
2. Improve understanding of fish dynamics

In order to help determine priorities for science and monitoring in Lake Ontario in 2018, a two-day workshop was held November 15-16, 2016, with the assistance of the International Joint Commission. At this workshop, advice was solicited from participants from over 20 agencies on what the priorities should be and how to address the science priorities. The identified LAMP science priorities are summarized in chapter 6, Table 16. Many of these were the focus for the Lake Ontario 2018 CSMI field activities completed in 2018. The Lake Ontario Partnership, in close coordination with the GLWQA Annex 10 Science Subcommittee, will coordinate the planning and implementation of selected Lake Ontario science priorities. Chapter 6 provides details regarding all science and monitoring priorities for Lake Ontario.

Research into the threats posed to the Great Lakes Basin by Asian Carps has been prioritized for several years. Entry through the Chicago Area Waterway System represents the highest threat; however, introduction through other means can occur. Fisheries and Oceans Canada, the MNRF, and the Toronto and Region Conservation Authority (TRCA) are conducting early detection surveillance on all areas identified as suitable for Asian Carp feeding and spawning including the Canadian waters of Lake Ontario. This early detection surveillance, along with fish community survey sampling, has resulted in the capture of Grass Carp in Lake Ontario waters. Research into new sampling techniques, gears, and targeted sampling will continue to be developed. In the United States, the *Water Resources Reform and Development Act, 2014* gave direction to the USFWS to lead a multiagency effort to slow the spread of Asian Carp in the Upper Mississippi River and Ohio River basin, in coordination with the U.S. Army Corps of Engineers, the National Park Service, and the U.S. Geological Survey.

Other long-term monitoring programs will continue to sample and identify changes in native and invasive species populations. Fisheries and Oceans Canada's Great Lakes Laboratory for

Fisheries and Aquatic Sciences (GLLFAS) has an ecology laboratory conducting routine sampling of the zooplankton community in Lake Ontario waters. Sampling in Hamilton Harbour, the Bay of Quinte, and the Toronto Harbour over the past five years has helped to identify zooplankton species composition, abundance and biomass in the sampled areas. GLLFAS will continue to monitor zooplankton communities in Lake Ontario. The USFWS Early Detection Monitoring program has sampled benthic macroinvertebrates, plants, and larval and adult fish to determine species composition and abundance throughout Lake Ontario, including Rochester/ Irondequoit Bay, the lower Niagara River and Oswego Harbor. USFWS will continue to monitor benthic macroinvertebrates, plants, and fish communities in Lake Ontario. In addition, the USFWS has participated in annual lower trophic level monitoring, including zooplankton, phytoplankton and nutrients, since the mid-1990s. This multi-agency effort provides a comprehensive long-term data set.

5.3.5 Actions 2018-2022

Through Annex 6 – Aquatic Invasive Species of the GLWQA, Canada and the U.S. commit to continue to develop and implement strategies to prevent the introduction of aquatic invasive species, limit and control the spread of existing aquatic invasive species, and when possible, eradicate existing aquatic invasive species in the Great Lakes Basin.

While the rate of new species entering the Great Lakes has reduced, the impacts and spread of existing aquatic invasive species continues to be a priority for management actions. Task teams of Annex 6 – Aquatic Invasive Species are currently focusing on early detection, pathways risk assessment, and management, response, and species risk assessment. Existing early detection surveillance programs, such as Fisheries and Oceans Canada's Asian Carp Program and the USFWS Early Detection Monitoring Program, will continue in the Great Lakes Basin. Table 14 provides a summary of Lake Ontario Partnership actions for aquatic invasive species, including agencies involved in implementation, and associated Biodiversity Conservation Strategy focus areas.

The Lake Ontario Partnership will undertake project tracking and reporting on the status and achievements of invasive species actions. Not all of the member agencies of the Lake Ontario Partnership are responsible for monitoring, surveillance, and implementation. Actions will be undertaken to the extent feasible, by agencies with the relevant mandates.

Table 14: Lake Ontario Partnership actions for aquatic invasive species

#	Lake Ontario Partnership Actions (2018-2022)	Agencies Involved	BCS Programmatic Focus Areas (see Appendix C for details)
	Ballast Water:		
15	• Establish and implement programs and measures that protect the Great Lakes Basin ecosystem from the discharge of aquatic invasive species in ballast water, consistent with commitments made by the Parties through Annex 5 of the GLWQA	Transport Canada, USCG, USEPA	PFA 2
	Early Detection and Rapid Response:		
16	• Through the Annex 6 subcommittee, implement an 'early detection and rapid response initiative' with the goal of finding new aquatic and terrestrial invasive species and preventing them from establishing self-sustaining populations. • Implement domestic/regional invasive species management plans	DFO, USFS, USFWS, NYSDEC	PFA 2 PFA 4
	Sea Lamprey:		
17	• Control the larval Sea Lamprey population with selective lampricides. Maintain operation and maintenance of existing barriers and the design of new barriers where appropriate.	DFO, USACE, USFWS	PFA 2

#	Lake Ontario Partnership Actions (2018-2022)	Agencies Involved	BCS Programmatic Focus Areas (see Appendix C for details)
18	**Asian Carp:** • Prevent the establishment of invasive carp species.	DFO, USFWS, NYSDEC	PFA 2
	SCIENCE, SURVEILLANCE, AND MONITORING		
19	**Surveillance:** • Maintain and enhance early detection and monitoring of non-native and invasive species (e.g. Asian Carp) through the Annex 6 'early detection and Rapid Response Initiative'.	NYSDEC, USFWS, DFO	PFA 4 PFA 5
20	**Monitoring:** • Monitor and evaluate aquatic food web status to help improve understanding of fish dynamics.	USACE, USGS, USFWS, NYSDEC, MNRF	PFA 3 PFA 5
	OUTREACH AND EDUCATION		
21	**Communication:** • Undertake additional aquatic invasive species prevention outreach and education, including discussions with recreational boaters and lake access site signage. • Implement outreach and education programs to minimize the spread of invasive species by recreational boating, fishing equipment, and other recreational activities.	DFO, MNRF, USFWS, NYSDEC	PFA 2 PFA 3 PFA 4

Actions that everyone can take to reduce the threat of aquatic invasive species in Lake Ontario

- Clean, drain and dry your boat before using it on a different body of water
- Do not release aquarium fish and plants, live bait, or other exotic animals into the wild
- Learn how to identify and report invasive species – this helps with early detection and removal. There are many online resources such as www.invadingspecies.com
- If you think you have discovered an aquatic invasive species, report it to the Invading Species Hotline at 1-800-563-7711 or online at www.EDDMapS.org/Ontario. Field experts will verify the report and notify managers responsible for dealing with invasive species

5.4 Critical and Emerging Chemical Contaminants

5.4.1 Background

Lake Ontario is no longer subjected to the significant chemical contaminant loadings that were common from the onset of industrialization through the 1970s. However, environmentally significant concentrations of some contaminants remain, to varying degrees, both within the water column of the Lake, and attached to suspended and lake bed sediments.

Environmental concentrations of some compounds are an ongoing problem and may limit the full achievement of the following General Objectives in the waters of Lake Ontario:

- #3: Allow for human consumption of fish and wildlife unrestricted by concerns due to harmful pollutants;
- #4: Be free from pollutants in quantities or concentrations that could be harmful to human health, wildlife or aquatic organisms through direct exposure or indirect exposure through the food chain; and
- #8: Be free from harmful impact of contaminated groundwater.

More information on the status and threats of chemical contaminants can be found in Section 3.4 (Chemical Contaminants).

5.4.2 Priority Issues

Nearly all older and regulated or banned chemicals (legacy contaminants) have decreased in Lake Ontario over the past 40 years. Non-legacy compounds, such as brominated flame retardants (PBDEs), have declined in recent years, although some replacements for these compounds are increasing in the environment. Although declines are being seen, concentrations of some compounds, like PCBs and PBDEs, still exceed environmental quality guidelines or objectives. Actions identified in this Lake Ontario LAMP continue to target the following legacy pollutants for action as threats to water quality and the ecological health of the lake: mercury, dieldrin/aldrin, PCBs, mirex, dioxins/furans, and DDT and its metabolites.

Monitoring in Lake Ontario. (Source: MECP)

PCBs and other chemicals can be carried by air currents from within and outside the Lake Ontario Basin to the Great Lakes, and atmospheric deposition will therefore continue to be a source of these contaminants. Substantially lower rates of contaminant loadings also still occur through direct discharges (e.g., industrial or municipal wastewater), indirect discharges (e.g., runoff/stormwater), resuspension of contaminated sediments, and from being transported through groundwater from contaminated land-based sites (e.g., landfills, disposal areas, etc.). The Niagara River area currently and historically included various sources of contaminants impacting the river. These sources include heavy industry and hazardous waste containment and processing facilities in close proximity to the river. These contaminants are, in some instances, available to aquatic organisms and have the potential to bioaccumulate through the food chain, ultimately posing risks to top aquatic and terrestrial predators, including humans.

Environmental monitoring and research programs are investigating the presence, trends, and potential environmental impacts of a range of new chemicals of interest such flame retardants, pharmaceuticals, hormones, antibiotics, personal care products, plastics, and other materials found in the Great Lakes. Annex 3 – Chemicals of Mutual Concern of the GLWQA provides binational direction on dealing with these chemicals of interest.

5.4.3 Progress Made to Date

Numerous environmental programs have been established over the past several decades to control the release of municipal and industrial chemicals into the environment and remediate contaminated sites. As a result, concentrations of most monitored toxic chemicals in the Great Lakes have declined substantially over the past 40 years. Further reductions in chemical contaminants will be achieved by a combination of in-basin and out-of-basin programs.

As noted in Section 4.1, Niagara River loadings of 10 targeted toxics in the NRTMP have been reduced (since 1996) by at least 50%, and the work of the NRTMP continues through ongoing collaboration between the Four Parties, including source trackdown, monitoring and, where needed, remedial action.

Under Annex 3 – Chemicals of Mutual Concern of the GLWQA, the first set of CMCs have been designated and binational strategies are being drafted to reduce the release and impact of each (see Section 4.4). The binational strategies for PCBs and Hexabromocyclododecane (HBCD) have been finalized and are available on www.binational.net. The remaining strategies are being drafted and are expected to be finalized by the end of 2019.

5.4.4 Science and Monitoring Priorities

Science and Monitoring Priorities for Chemical Contaminant Impacts

1. Characterize Lake Ontario LAMP critical and emerging pollutants

In order to help determine priorities for science and monitoring in Lake Ontario in 2018, a two-day workshop was held November 15-16, 2016, with the assistance of the International Joint Commission. At this workshop, advice was solicited from participants from over 20 agencies on what the priorities should be and how to address the science priorities. The identified LAMP science priorities are summarized in chapter 6, Table 16. Many of these were the focus for the Lake Ontario 2018 CSMI field activities completed in 2018. The Lake Ontario Partnership, in close coordination with the GLWQA Annex 10 Science

Subcommittee, will coordinate the planning and implementation of selected Lake Ontario science priorities. Chapter 6 provides details regarding all science and monitoring priorities for Lake Ontario.

The critical pollutants targeted for action have been selected based on the potential risks they present to fish and wildlife, as well as humans. Lake Ontario Partnership agency resources have been, and are anticipated to continue to be, made available to monitor these contaminants (in water, sediment, air, plants, fish, and wildlife) in order to inform management decisions and, where necessary, direct remedial efforts. Continued monitoring of sentinel species like colonial waterbirds and Lake Trout is also recommended by water quality managers to support long-term chemical contaminant assessments for the Lake Ontario Basin. Ongoing monitoring in the Niagara River, as part of the Upstream/Downstream Program, is a key component of the Niagara River Long Term Monitoring Plan. This monitoring is an important component of the NRTMP. The overall goal of the NRTMP is to achieve significant reductions of toxic chemical pollutants in the Niagara River that impact Lake Ontario. (see Section 4.1 for more information on the NRTMP).

Regulatory frameworks for managing emerging contaminants, including applicable standards, thresholds, or criteria against which concentrations in environmental media (water, sediment, tissue) can be compared, do not exist in all jurisdictions within the Lake Ontario watershed. This prevents the Lake Ontario Partnership from addressing many emerging contaminants in the same manner as the legacy contaminants. However, monitoring for these emerging contaminants will continue as resources allow, in order to increase our understanding of the extent to which they exist in Lake Ontario and their potential impacts.

5.4.5 Actions 2018-2022

The 2012 Agreement reaffirms the commitment to restore water quality and ecosystem health in Great Lakes AOCs. Article 4 of the 2012 Agreement commits the Parties to implement programs for pollution abatement, control, and prevention for industrial sources, contaminated sediments, and radioactive materials. Article 6 commits the Parties to notification and response under the Canada-United States Joint Inland Pollution Contingency Plan to advise each other of threats of a pollution incident, or planned activities that could lead to a pollution incident. Federal, provincial, and state agencies continue to work with local stakeholders to implement Remedial Action Plans across the Lake Ontario Basin.

Table 15 provides a summary of Lake Ontario Partnership actions to address chemical contaminants for the LAMP 2018-2022, including associated focus areas of the Biodiversity Conservation Strategy. The Lake Ontario Partnership will undertake project tracking and reporting on the status and achievements of chemical contaminants actions. Not all of the member agencies of the Lake Ontario Partnership are responsible for monitoring, surveillance, and implementation. Actions will be undertaken to the extent feasible, by agencies with the relevant mandates.

Other actions that will continue support the reduction of chemical contaminants in Lake Ontario include:

- Continue to implement regulations to control end-of pipe sources of pollution;
- Continue national and international efforts to reduce atmospheric inputs of chemical contaminants;
- Pursue site specific remediation to address contaminated sediments;
- Pursue site specific remediation to address contaminated groundwater;
- Assess effectiveness of actions through surveillance and monitoring;
- Other actions described in the LAMP to address nonpoint sources of nutrients (e.g., Section 5.1, Nutrient and Bacterial Related Impacts); and
- Implement activities identified in GLWQA binational strategies for Chemicals of Mutual Concern, as appropriate.

Table 15: Lake Ontario Partnership actions for critical and emerging chemical contaminants

#	Lake Ontario Partnership Actions (2018-2022)	Agencies Involved	BCS Programmatic Focus Areas (see Appendix C for details)
ADDRESSING POINT SOURCE AND NON-POINT SOURCE CHEMICAL CONTAMINANTS			
22	• Implement and enhance existing programs to control/reduce sources of chemical pollution to air, water and soil/sediment	MECP, USEPA, NYSDEC	
23	• Support the development and implementation of the Chemicals of Mutual Concern Binational Strategies	ECCC, USEPA	PFA 5
24	• Identify, understand, and address impacts of critical and emerging pollutants. Where needed and as resources allow, conduct source track down of contamination, and identify potential mitigative actions.	NYSDEC, MECP, USEPA	PFA 5
25	• Pursue site-specific remedial actions where needed to address priority legacy chemical pollutants in sediment, soil, and ground/ surface water.	NYSDEC, NYSDOH, USEPA	
26	• Continue to implement Randle Reef contaminated sediment remediation project in Hamilton Harbour, Lake Ontario	ECCC, MECP	
27	• Continue to implement contaminated sediment remediation efforts in Port Hope Harbour	NRCan	

#	Lake Ontario Partnership Actions (2018-2022)	Agencies Involved	BCS Programmatic Focus Areas (see Appendix C for details)
	SCIENCE, SURVEILLANCE, AND MONITORING		
28	• Implement and enhance binational surveillance and monitoring programs to assess the effectiveness of chemical contaminant reduction efforts and evaluate contaminant trends over time.	ECCC, MECP, USEPA, USGS, NYSDEC	

Actions that everyone can take to prevent chemicals from entering the Lake Ontario ecosystem

- Take household hazardous materials to hazardous waste collection depots
- Don't burn garbage in barrels, open pits, or outdoor fireplaces, to prevent the release of toxic compounds like dioxins, mercury and lead
- Properly dispose of unused or expired medication through take-back programs at your pharmacy
- Consider using driveway sealants which minimize the release of toxic substances that run off into the ecosystem during rainstorms
- Use natural pest-control methods that are non-toxic to the environment
- Choose eco-friendly household cleaning and personal care products

6

6.0 SCIENCE AND MONITORING PRIORITIES

6.1 Great Lakes Cooperative Science and Monitoring Initiative

Lake Ontario, and the Niagara and St. Lawrence Rivers are highly dynamic, responding to a large number of chemical, biological, and physical factors. Far from balanced and stable, these ecosystems can experience abrupt changes that have a cascading effect on ecosystem and water quality changes that are difficult to fully understand. For example, the arrival of the exotic *Dreissenid* mussels in the late 1980s and early 1990s greatly transformed the Great Lakes ecosystem as we knew it. Invasive mussel impacts on aquatic food web nutrient cycling remains poorly understood despite intensive research efforts highlighting the complex nature of these ecosystem changes.

The U.S. Canada Cooperative Science and Monitoring Initiative (CSMI) helps to address this and other management questions by focusing binational monitoring resources on each of the Great Lakes on a five-year rotating cycle. This supports the development of LAMPs as well as water quality and natural resource management strategies and assessments. Lake Ontario's first CSMI year was 2003 which had a focus on the lower aquatic food web in the open lake. The scope of CSMI 2008 was expanded to also include nearshore nutrient related issues and expanded fishery assessments. CSMI 2013 saw the inclusion of coastal wetlands status as part of the reporting process. Lake Ontario CSMI 2018 is focusing on the priorities summarized in Table 16.

The steady expansion of Lake Ontario CSMI activities since the first 2003 year reflects the strengthening binational government and academic partnerships that favour collaborative efforts, leveraging of resources, and increased communication on critical science issues. The Great Lakes Fishery Commission's (GLFC's) Lake Ontario Committee, the Great Lakes Research Consortium, and the Great Lakes Wetland Consortium are important science partners.

For more information regarding CSMI see the fact sheets at the following link: http://seagrant.sunysb.edu/articles/t/cooperative-science-and-monitoring-initiative-for-lake-ontario-resources?q=csmi.

6.2 Lake Ontario Science and Monitoring Priorities

In order to help determine priorities for science and monitoring in Lake Ontario in 2018, a two-day workshop was held November 15-16, 2016, with the assistance of the International Joint Commission. At this workshop, advice was solicited from participants from over 20 agencies on what the priorities should be and how to address them. These broad LAMP priorities considered recommendations developed by the GLWQA Annex 4-Nutrients Lake Ontario Nutrient Target Task Team and by the GLFC's Lake Ontario Committee. The identified LAMP science priorities are summarized in Table 16. These priorities were the focus of the Lake Ontario 2018 CSMI field activities in 2018. Due to the complexity of the issues, many of the science activities are multi-year in nature and will continue for the duration of this LAMP.

Table 16: Lake Ontario LAMP science priorities

Science Priority	Issue Area	Activities
1. Characterize nutrient concentrations & loadings	Nutrient and Bacterial Related Impacts	Characterize nutrient concentrations in nearshore and in open waters with a focus on nutrient loadings from tributaries, point and non-point sources as well as inputs from the Niagara River. This will support development and use of hydrodynamic/ecological models to improve understanding of nutrient cycling and transport in the nearshore and offshore, as well as the nature of food web issues, *Cladophora* growth and phosphorus sources and sinks.

Science Priority		Issue Area	Activities
2.	Improve understanding of nearshore nutrient-related problems	Nutrient and Bacterial Related Impacts	Characterize the degree and extent of nearshore nutrient-related impairments to help understand triggers of HAB, blue-green algal blooms and develop a standardized binational methodology to monitor *Cladophora*. This supports the continuation of nearshore monitoring efforts in order to maintain long term nearshore and tributary water quality data set to inform focused water quality improvement efforts in areas of relatively higher need and to track success of management and conservation activities
3.	Evaluate aquatic food web status	Loss of Habitat and Native Species Invasive Species	Evaluate primary production, phytoplankton, zooplankton, mysids, *Dreissenid* mussels & benthos, in order to better understand the status of the Lake's food web. Support is needed to repeat long-term open lake water quality and zooplankton assessments. For *Dreissenid* mussels, assessing overall changes in distribution, a better understanding of *Dreissenid* growth and reproductive rates in deeper, colder waters is needed in order to fully understand the impacts this benthic species is having on the Lake Ontario aquatic food web.

Science Priority		Issue Area	Activities
4.	Improve understanding of fish dynamics	Loss of Habitat and Native Species	Spatial Assessment & Monitoring will focus on how prey fish are distributed spatially within Lake Ontario and their habitat use. A better understanding of spatial and vertical prey fish distribution will assist with interpretation of existing prey fish surveys and support native fish restoration and Improve understanding of prey fish ecology, abundance and distribution during critical periods. expand use of existing techniques and technologies (acoustic telemetry, angler surveys, etc.) to address predator/prey fish knowledge gaps.
5.	Characterize critical and emerging pollutants	Critical and Emerging Chemical Pollutants	Collection of Water, fish tissue, biota and sediment samples will help characterize critical and emerging chemical pollutants and assist in the identification of sources including industrial wastewater inputs and atmospheric deposition. This will largely meet key LAMP information needs to inform policy and actions such as binational strategies for CMCs.
6.	Coastal wetland status	Loss of Habitat and Native Species	Evaluate the extent, composition, and condition of coastal wetlands as well as substrate in Lake Ontario wetlands will inform the need to be better characterized. This is important as coastal wetlands support healthy fish/wildlife habitat and healthy fish populations as well as take up excessive nutrients in the nearshore.

7

7.0 IMPLEMENTING THE LAMP

Achieving the General Objectives of the Agreement is a challenging task and one that will require the collective action by many partners throughout the Lake Ontario Basin.

The health of Lake Ontario (including the St. Lawrence River and Niagara River), and the condition of its watershed are interconnected. A host of factors – chemical contaminants, urbanization, shoreline development, sediment-bound nutrient loading, non-native invasive species, and degraded or fragmented habitat – interact with a changing climate to produce complex changes. The actions documented in the 2018-2022 LAMP will address key environmental threats using an integrated management approach that recognizes the interactions across Lake Ontario, including humans, and the need to maintain and enhance ecosystem resilience in view of climate change.

7.1 Principles for Implementation

Lake Ontario Partnership organizations commit to incorporating, to the extent feasible, LAMP actions in their decisions on programs and resources. In implementing the LAMP, the Lake Ontario Partnership organizations will be guided by the principles and approaches outlined in the GLWQA, including:

- **Accountability** – the effectiveness of actions will be evaluated by individual partner agencies, and progress will be reported through LAMP Annual Reports and the next LAMP;
- **Adaptive management** – the effectiveness of actions will be assessed, and future actions will be adjusted, as outcomes and ecosystem processes become better understood and as new threats are identified;
- **Coordination** – actions will be coordinated across jurisdictions and stakeholder agencies, where possible;
- **Prevention** – anticipating and preventing pollution and other threats to the quality of the waters of the Great Lakes to reduce overall risks to the environment and human health;

- **Public engagement** – incorporating public opinion and advice, as appropriate, and providing information and opportunities for the public to participate in activities that contribute to the achievement of the objectives of the GLWQA;
- **Science-based management** – implementing management decisions, policies, and programs that are based on best available science, research and knowledge, as well as traditional ecological knowledge, when available; and
- **Ecosystem approach** – taking management actions that integrate the interacting components of air, land, water, and living organisms, including humans.

The implementation of projects will remain one of the highest priorities of the individual organizations that make up the Lake Ontario Partnership. Partnering agencies will take action, to the extent feasible, given budget constraints and domestic policy considerations. Internal agency work planning and reporting will help track commitment progress and provide an accountability mechanism for the results of each individual organization. Internal Lake Ontario Partnership committee work plans will track implementation to support coordination between organizations and in the engagement of others, as well as to support lakewide reporting on LAMP implementation.

7.2 Engagement, Outreach, and Education

Everyone has a role to play in protecting, restoring, and conserving Lake Ontario. Engagement, collaboration, and active participation of all levels of government, watershed management agencies, and the public are the cornerstone of current and future actions. Collective action is essential for the successful implementation of this LAMP and for the achievement of the General Objectives of the GLWQA. The challenges and threats to Lake Ontario need to be more widely recognized, as do opportunities for everyone to play a role in finding solutions that ensure a healthy watershed and lake ecosystem now and into the future.

Engagement, education, and involvement will support and move the public from the role of observer to active participant. Local communities, groups, and individuals are among the most effective champions to achieve environmental sustainability in their own backyards and communities. Member agencies of the Partnership will pursue binational and domestic outreach and engagement activities to consult on challenges, priorities, and strategies and to encourage and support active community-based environmental action.

7.3 How Can the Public Become More Involved?

The public can get involved by:

- Keeping informed, through access to Annual Reports at https://binational.net/;
- Reviewing and providing input on the development of Lakewide Action and Management Plans;
- Attending one of the meetings or summits hosted by the multi-agency domestic initiatives;
- Learning about all the Great Lakes issues and events on http://www.great-lakes.net/, through the New York State Great Lakes Clearinghouse at http://seagrant.sunysb.edu/articles/t/new-york-s-great-lakes-home, and through the Great Lakes Regional Calendar at https://www.glc.org/greatlakescalendar/; and
- Participating in projects run by local watershed organizations to improve water quality and habitat of Lake Ontario.

The Lake Ontario community can also get involved through outreach and engagement activities that cross the Canada-U.S. border. The Great Lakes Public Forum (GLPF) takes place every three years during which Canada and the U.S. review the state of the Great Lakes, highlight ongoing work, discuss binational priorities for science and action, and receive public input.

There are also many initiatives within Canada and the U.S. that engage all levels of government, watershed management agencies, environmental organizations, community groups, and the public. New York State engages regional stakeholders in collaborative activities to achieve goals

Great Lakes Public Forum, 2016

in New York's Lake Ontario Basin through its Great Lakes Action Agenda. More information is available at http://www.dec.ny.gov/lands/91881.html. The Province of Ontario engages regional stakeholders in collaborative activities to achieve goals in the Lake Ontario Basin through its Great Lakes Strategy. More information is available at https://www.ontario.ca/page/ontarios-great-lakes-strategy.

7.4 Collective Action for a Healthy Lake Ontario

The 2018-2022 LAMP brings attention to priority action areas for the 2018 to 2022 time period to address current threats in Lake Ontario:

- **Supporting nutrient reduction efforts and enhancing our understanding of nutrient dynamics** – to better reduce the negative impacts of nutrients and bacteria, through programs focused on point-source and non-point source pollution, watershed planning, studying nearshore nutrient-related problems, monitoring, and increased awareness and engagement;
- **Improving the health of aquatic and wetland habitat and native species** – improving the state of aquatic habitat and species in Lake Ontario by increasing stream connectivity, protecting and restoring native species, controlling invasive species, and increasing our understanding of food web status, fish dynamics, and coastal wetland status;
- **Controlling aquatic invasive species** – decreasing the ecological and economic threats and impacts of invasive species by preventing their introduction, limiting their spread, and eradicating where possible, through early detection and response, entry point programs, species-specific interventions, monitoring and surveillance, and outreach and education; and
- **Reducing chemical contaminants** – addressing legacy contaminants and chemicals of emerging concern, by supporting existing programs that control or reduce contaminant sources, studying emerging pollutants, site-specific remedial action where appropriate, and characterizing critical and emerging pollutants.

The 28 actions documented in the 2018-2022 LAMP are not isolated activities – they support, complement, and enhance existing initiatives including the binational strategies described in Chapter 4, actions underway by federal, provincial, municipal, conservation authorities and Tribal agencies, and programs carried out by environmental non-governmental organizations. The public plays a key role as partners, advocates, and implementers for lakewide protection and management. There is a role for everyone in implementing the 2018-2022 Lake Ontario LAMP.

Together, with the guidance of the 2018-2022 LAMP, this collective action will help advance the achievement of the nine GLWQA General Objectives in Lake Ontario, reducing existing threats and supporting clean water, healthy habitats and native species, and a prosperous and sustainable Lake Ontario for all.

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APPENDIX A: PRE-GLWQA 2012 LAKEWIDE OBJECTIVES FOR LAKE ONTARIO

Work first began on Lake Ontario ecosystem goals, objectives, and indicators as part of the Lake Ontario Toxics Management Plan (LOTMP) in the late 1980s. U.S. and Canadian monitoring experts brought together by the LOTMP developed ecosystem goals and objectives for the Lake. The previous LAMP adopted these goals and objectives, to provide a vision for the future of Lake Ontario and describe the role that human society should play. Specifically, these goals and objectives stated that:

- The Lake Ontario ecosystem should be maintained and, as necessary, restored or enhanced to support self-reproducing and diverse biological communities;
- The presence of contaminants shall not limit uses of fish, wildlife, and waters of the Lake Ontario Basin by humans, and shall not cause adverse health effects in plants and animals; and
- We, as a society, shall recognize our capacity to cause great changes in the ecosystem and we shall conduct our activities with responsible stewardship for the Lake Ontario Basin.

The previous LAMP also adopted the LOTMP's five ecosystem objectives that describe the conditions necessary to achieve LAMP ecosystem goals:

- Aquatic Communities – the waters of Lake Ontario shall support diverse and healthy reproducing and self-sustaining communities in dynamic equilibrium, with an emphasis on native species;
- Wildlife – the continuation of a healthy, diverse, and self-sustaining wildlife community that utilizes the lake habitat and/or food shall be ensured by attaining and sustaining the waters, coastal wetlands, and upland habitats of the Lake Ontario Basin in sufficient quantity and quality;
- Human Health – the waters, plants, and animals of Lake Ontario shall be free from contaminants and organisms resulting from human activities at levels that affect human health or aesthetic factors, such as tainting, odour, and turbidity;
- Habitat – Lake Ontario offshore and nearshore zones, surrounding tributary, wetland, and upland habitats shall be of sufficient quality and quantity to support ecosystem objectives for the health, productivity, and distribution of plants and animals in and adjacent to Lake Ontario; and
- Stewardship – Human activities and decisions shall embrace environmental ethics and a commitment to responsible stewardship.

APPENDIX B: NUTRIENT MONITORING PROGRAMS IN U.S. AND CANADA

Agency	Program	Description
ECCC and partners	Great Lakes Surveillance Program	Ship-based spring and summer cruises conducted on Lakes Superior, Huron, Erie, and Ontario approximately every 2 years. Monitored parameters include nutrients, major ions, metals, organic contaminants and compounds of new and emerging concern.
USEPA	Great Lakes Monitoring Program	Ship-based spring and summer cruises conducted on all Great Lakes to sample water, aquatic life, sediments, and air. Data gathered shows trends in water quality and aquatic life.
ECCC, USEPA, USGS	Great Lakes Connecting Channels Project	Project monitors water quality in the Niagara and St. Lawrence Rivers. Provides information about the concentrations and loadings of nutrients in the major inflows and the outflow of Lake Ontario.
USEPA	National Coastal Condition Assessment	Statistical survey of the condition of Great Lakes coastal waters. Water quality, sediment quality, benthic community condition, and fish tissue contaminants are evaluated.
USEPA and partners	Great Lakes Coastal Wetland Monitoring Program	Basin wide, collaborative approach allows for major coastal wetlands throughout the entire Great Lakes to be sampled on a rotating basis over five years using a comprehensive, standardized procedure. Samples coastal wetlands yearly for bird, amphibian, fish, macroinvertebrate, and vegetation communities, as well as water chemistry. Includes collaboration of federal agencies, states, and academic partners on both the U.S. and Canadian sides of the Great Lakes.

Agency	Program	Description
NYSDEC, MNRF, USGS, USFWS, Cornell	New York Lake Ontario Biomonitoring Program	Long-term monitoring of water quality nutrients, chlorophyll and zooplankton.
ECCC, MECP, NYSDEC, TRCA, USGS	Various	Long-term water monitoring and science programs that provide information on nearshore and tributary water quality condition and identification of threats.
USGS and partners (academia)	Edge-of-Field / Soil Health Assessment	Technical support to soil quality assessment activities associated with Edge-of-Field (EoF) monitoring programs established in the Great Lakes Watershed and link the soil quality assessments to edge-of-field water monitoring data. The focus of this project is to establish a) standardized, in-field soil health monitoring protocols for EoF sites, b) to create a robust baseline dataset of soil health at EoF sites, and c) to connect field-scale soil health parameters with the water quality leaving these fields.

APPENDIX C: PROGRAMMATIC FOCUS AREAS AND EXAMPLE ACTIONS OF THE LAKE ONTARIO LAMP BIODIVERSITY CONSERVATION STRATEGY

Programmatic Focus Areas (PFA) and Example Actions
PFA 1. CONSERVE CRITICAL LANDS AND WATERS **Includes land securement in priority areas, aided by targeted conservation funding, watershed planning, and management of public and private lands for the benefit of biodiversity.**

- Evaluate the status of integrated watershed planning/plans and their implementation throughout the Basin
- Promote links among local plans with government, academic or private efforts having similar biodiversity conservation goals
- Create strategies and incentives to advance planning and implementation where critical assistance is required
- Develop inventories and identify repositories of integrated planning efforts among the lake's watersheds that support the LAMP's biodiversity conservation goals and objectives

Programmatic Focus Areas (PFA) and Example Actions
PFA 2. REDUCE THE IMPACT OF AQUATIC INVASIVE SPECIES
Aquatic invasive species have changed various components of the native aquatic food web in fundamental ways. Actions are geared to reduce the introduction and spread of invasive species on a Basin wide scale.

- Identify options to help prevent the spread of aquatic invasive species between Lake Ontario and other watersheds (e.g., permanent barriers, cargo transfer stations, small watercraft lifts and cleaning stations) without interrupting the transport of goods or recreation
- Review existing inventories of species involved in live trades and apply risk assessment procedures to identify those which pose the highest risk of ecosystem damage
- Consider approaches to prevent introductions via the boating pathway by finding support for boat washing stations and inspection stations on major transportation routes and water access points
- Inventory all boat landings and major water access points that may provide pathways for AIS to enter to Lake Ontario and identify those with the highest probability of new invasions
- Consider the feasibility of developing a Basin wide rapid response framework to coordinate interjurisdictional response to early detection of AIS plants for high risk areas, such as the Welland Canal, New York Oswego/Erie Canal, and Hamilton Harbour

Programmatic Focus Areas (PFA) and Example Actions

PFA 3. RESTORE CONNECTIONS AND NATURAL HYDROLOGY

Dams, artificial lake level controls and shoreline development have directly and indirectly impacted biodiversity. Aquatic invasive species complicate the issue as physical barriers can help stop their spread. Decisions about fish passage or dam removal need to be based on local conditions and needs.

- Monitor and assess key Lake Ontario and Upper St. Lawrence environmental indicators to support adaptive management in response to water level regulation
- Identify opportunities to better connect coastal wetlands to the Lake through culvert modifications or other options
- Update inventories of abandoned and unused dams that could be mitigated to provide upstream passage for Lake Ontario fish and develop a proposed removal strategy for each candidate dam
- Periodically update the current database and map of barriers to lake-to-tributary connectivity

PFA 4. RESTORE NATIVE FISH COMMUNITIES AND NATIVE FISH SPECIES

The native fish community of Lake Ontario has been highly altered by over-fishing, damming of tributaries, pollution of nearshore waters, and the impacts of invasive species.

- •Evaluate the progress towards restoring native prey fish, Atlantic Salmon, American Eel, Lake Trout and Lake Sturgeon
- Inventory and monitor the effectiveness of native fish stocking/re-introduction
- Develop options to better engage a broad and diverse spectrum of stakeholders in restoration of native species
- Conserve watersheds, embayments, and coastal wetlands of particular importance to supporting the lifecycles of native fish species

Programmatic Focus Areas (PFA) and Example Actions
PFA 5. RESTORE THE QUALITY OF NEARSHORE WATERS
Non-point source pollution from urban, suburban, and agricultural sources can lead to algal blooms that alter water chemistry, decrease oxygen levels, and can alter species composition in the littoral zone.

- Promote beneficial shoreline management practices that seek to balance economic and biodiversity benefits
- Promote soil erosion control, riparian buffer planting and conservation actions along streams, coastal zones and wetlands
- Promote concepts and methods of low impact development through outreach to developers

APPENDIX D: LAKE ONTARIO AREAS OF CONCERN REMEDIAL ACTIONS

Areas of Concern (AOCs) are specific locations around the Great Lakes, on both the Canadian and U.S. sides of the lakes and connecting river systems, which were identified in the Great Lakes Water Quality Agreement as being severely degraded by human activities at the local level to the point that beneficial uses were impaired. There are currently 4 Canadian, 2 U.S. and 2 Binational AOCs on Lake Ontario and along the Niagara and St. Lawrence Rivers. Hamilton Harbour, Toronto and Region, Port Hope Harbour, and the Bay of Quinte are Canadian led AOCs. The U.S. led AOCs are Eighteenmile Creek and Rochester Embayment. The St. Lawrence River and Niagara River AOCs are binational, shared by both countries.

Following the 1987 protocol to the GLWQA, U.S. and Canadian agencies independently developed RAPs for the U.S. domestic and Canadian sides of the Niagara and St. Lawrence River AOCs. At the St. Lawrence River AOC, a Joint Goal Statement was produced shortly following the development of the respective RAP documents to recognize the shared and unique commitments of the U.S. and Canadian partners, develop a more complete understanding of the environmental conditions in the area, and realize an ecosystem-based approach to restoration through continued cooperation amongst the partners.

Working with community members, indigenous communities, and local governments Canada and U.S. are implementing Remedial Action Plans (RAPs) to restore the beneficial use impairments identified in each AOC. Beneficial use impairments (BUIs) can include restrictions on fish and wildlife consumption, degraded fish and wildlife populations and loss of habitat, degraded benthic populations, bird or animal deformities or reproduction problems, restrictions on dredging activities, degradation of aesthetics, beach closings, and excessive nutrients (eutrophication). More information about Beneficial Use Impairments can be found here: https://www.epa.gov/great-lakes-aocs/beneficial-use-impairments-great-lakes-aocs.

Significant progress has been made to date. In the Canadian Lake Ontario and river system AOCs, 22 beneficial use impairments underwent a status change to “not impaired”, leaving 30 still impaired. In the U.S. AOCs, there have been nine impaired beneficial uses restored, leaving 37 impairments (Progress Report of the Parties, 2016). These remaining impairments are a priority of the federal, provincial, and state governments under the 2012 GLWQA.

Cleaning up these AOCs benefits the broader Lake Ontario and Niagara and St. Lawrence River ecosystems. This will result in better water quality, open beaches, and fewer fish consumption restrictions. Many of these AOCs contain critical coastal wetlands, which are used by lake fish species for spawning and nursery habitat, and provide homes and migratory pathways for birds which are species at risk. When AOCs are removed from the list of degraded areas, environmental monitoring and reporting continue to ensure the environmental improvements achieved through the AOC process are sustained.

Priority Actions for Areas of Concern

Priority actions for the eight AOCs for the period between 2018 and 2022 are discussed below for each AOC. The LAMP will support efforts to address these priority action areas which will be implemented under each respective Remedial Action Plan.

Canadian Niagara River Area of Concern

The Niagara River was designated a binational AOC because historic industrial activities and urban development severely degraded water quality and ecosystem health. On the Canadian side, extensive progress has been made through the clean-up of contaminated sediment, the creation of fish and wildlife habitat, and the reduction of chemicals and nutrients entering watercourses that flow into the Niagara River.

Three of the original eight beneficial use impairments have been re-designated to “not impaired” status, including Eutrophication/Undesirable Algae. Two potential additional BUIs that were undergoing further assessment, including Degradation of Phyto/ Zooplanton Populations, have now been designated as ‘not impaired’..

The Canadian Niagara River Remedial Action Plan continues to address the remaining five beneficial use impairments on the Canadian side of the AOC. Actions are underway to create coastal wetland and shoreline habitats and to mitigate elevated levels of bacteria affecting local beaches.. These efforts seek to restore the degradation of fish and wildlife populations, loss of fish and wildlife habitat, and beach closings BUIs. Post-project monitoring and evaluations of the success of these remedial actions are anticipated to continue after 2019.

Hamilton Harbour Area of Concern

Hamilton Harbour was designated as an AOC because water quality and environmental health were severely degraded due to intensive long-term industrial and urban development around its shores. These activities resulted in 8 of the 14 GLWQA beneficial uses deemed as 'impaired', and four others requiring further assessment.

Water quality and ecosystem health have improved in Hamilton Harbour. Today four of six managed colonial waterbird species have reached their restoration target population levels. The fish community responded positively to actions improving water quality, habitat, and reducing invasive species, but are still faced with the challenge of low oxygen levels in some parts of the bay. A stocking program has successfully reintroduced Walleye to the Harbour to restore the balance of native top predators. Sport fish PCB concentrations have declined by 59% to 82% from historical levels, however some species have demonstrated no significant trends and consumption restrictions remain among the highest of all Great Lake AOCs. The presence of current and historical sources of PCBs continues to be addressed by the RAP and the Ministry of Environment, Conservation and Parks in order to address some of the beneficial use impairments. Phosphorus levels have decreased substantially since the 1980s in the Harbour as seen through the long-term monitoring. Historically loaded phosphorus from the sediments may slow the response of the system to implementation actions, but its exact impact is not known at this time.

Cootes Paradise Marsh has seen some improvements in aquatic plant growth as a result of a planting program and exclusion of carp through a barrier. In 2017, historically high water levels negatively impacted the marsh and allowed for carp to re-enter, which together with other impacts from the flooding caused significant issues for aquatic vegetation and conditions in the marsh. Work to address loadings of nutrients in the watershed, as well as improvements to the Dundas Wastewater Treatment Plant and other conditions affecting the marsh, will improve the conditions in Cootes Paradise Marsh.

The following major projects for restoring the Hamilton Harbour AOC are underway:

- Randle Reef Sediment Remediation Project – the first stage of Randle Reef project has been completed with the construction of the 6.2 ha (15 acres) double steel-walled Engineered Containment Facility which will safely manage 695,000 m^3 (25 million ft^3) of coal tar (polycyclic aromatic hydrocarbons, PAHs) and heavy metal contaminated sediment. The second stage, dredging of the contaminated sediment and placing into the contaminant facility, started in 2018 and is underway.

- Wastewater Treatment Plant Upgrades – Halton's Skyway Wastewater Treatment Plant completed tertiary treatment upgrades in 2016 and performance of the plant is better than anticipated with effluent phosphorus levels below RAP targets. Hamilton's Woodward Wastewater Treatment Plant tertiary treatment upgrades are underway and scheduled for completion in 2022. In 2016, Hamilton's real-time control of its Combined Sewer Overflow system reduced the number of untreated sewage overflows. The Dundas Wastewater Treatment Plant improvements are under review by the City of Hamilton which includes treatment-level recommendations and RAP targets.

Toronto and Region Area of Concern

Within Reach: 2015 Toronto and Region Remedial Action Plan Progress report highlights the accomplishments in the AOC from 2007 to 2015 (full report is available at www.TorontoRAP.ca). Four of the 11 original BUIs have been re-designated to 'not impaired', including: degradation of benthos, restrictions on dredging activities, fish tumors or other deformities, and bird or animal deformities or reproductive problems. Scientific studies are underway to assess the remaining seven BUIs.

Progress to date includes:

- Levels of contaminants in fish continue to decline and there are no longer restrictions on consumption for many resident fish. Temporal trend analysis has shown that levels of both PCB and mercury in fish from the Toronto waterfront have declined, in some cases by over 90%;
- Implementation of the Toronto Waterfront Aquatic Habitat Strategy has created and restored habitats increasing the diversity of fish and wildlife species in the Toronto and Region AOC, including 17 ha (42 acres) of wetlands at Tommy Thompson Park and Humber Marshes.
- Eight of Toronto's 11 waterfront beaches are now Blue Flag beaches due to substantial reductions in *E. coli* loadings and beach closings;
- The aesthetics of Toronto watercourses and the waterfront are primarily considered 'Excellent' or 'Good'; and
- Phosphorus levels along the waterfront now meet the target set for the

Remedial Action Plan. However, continued work on critical wet weather flow infrastructure projects is needed.

Two pivotal projects to delist Toronto as an AOC are currently underway:

- Don River and Central Waterfront Combined Sewer Overflow (CSO) Project – key to delisting Toronto as an AOC is the Don River and Central Waterfront CSO Project, which is part of Toronto's CAD$2.8 billion (US$2.3 billion) Capital Plan to implement the Wet Weather Flow Master Plan projects over the next ten years. The project will address wet weather flow controls and sanitary servicing needs in one complete system through integrated underground tunnels and storage shafts that capture, store, and transport stormwater and combined sewer overflows to a new high-rate treatment facility. The result will be the virtual elimination of CSO discharges.
- Don River Mouth Naturalization Project – on June 28, 2017, the Canadian Prime Minister, Ontario Premier, and Toronto Mayor announced CAD$1.185 billion (US$960 million) in funding for Waterfront Toronto and the Don River Mouth Naturalization Project. The project will create 29 ha (72 acres) of naturalized area in a new river valley, which includes 14 ha (35 acres) of aquatic habitat, plus an additional 16 ha (40 acres) of new parkland – all of which will strengthen biodiversity and help clean our water.

Port Hope Area of Concern

Port Hope was designated an AOC because of a legacy of contamination from the operation and waste management practices of Eldorado Mining and Refining between 1933 and 1953. This produced an estimated 85,000 to 95,000 m^3 (3-3.4 million ft^3) of sediment containing low-level radioactive material within the turning basin and west slip of the Port Hope Harbour.

Delisting the Port Hope AOC requires that the low-level radioactive waste contaminated sediment be removed from Port Hope Harbour. Through Canada's Port Hope Area Initiative, work began in early 2016 on the construction of the long-term, low-level radioactive waste management facility to receive these sediments as well as historic, low-level radioactive waste from other locations in the Municipality of Port Hope. The facility, an engineered above-ground mound, is designed to isolate the waste and has already started receiving waste from various locations across the Municipality. The preparation for the removal of sediments is underway.

Bay of Quinte Area of Concern

The Bay of Quinte was identified as an Area of Concern due to excessive nutrients, persistent toxic contamination, bacterial contamination, and the loss of fish and wildlife habitat. In 1987, when the Bay was identified as an AOC in the GLWQA, 10 of the 14 beneficial uses were considered to be impaired, and one required further assessment to determine its status.

The efforts of multiple agencies and partners have realized substantial gains in the restoration of the impaired beneficial uses, including:

- Phosphorus inputs to the bay from sewage treatment plants have been reduced by 96% since 1965;
- The fish and wildlife habitat and populations are now restored and provide some of the best fishing experiences in Ontario;
- Fish consumption restrictions are steadily decreasing, and beaches are consistently open for swimming.
- Since 2017, six BUIs have had a status change to “not impaired”; and
- Currently, there are five BUIs of which one is expected to be re-designated to ‘not impaired’ status in 2019.

The remaining restoration actions focus on reducing phosphorus inputs from land use and stormwater to decrease the amount of algal biomass in the bay, and developing a long-term phosphorus reduction strategy.

St. Lawrence (Cornwall) Area of Concern

Contamination of fish and sediment by heavy metals and toxic organics, fish habitat loss and degraded populations, eutrophication, and bacterial contamination were the factors behind identifying the St. Lawrence River (Cornwall) as an AOC. Although identified as a binational AOC, New York State is delivering a separate Remedial Action Plan for the Massena area.

Significant progress has been made on environmental improvements since the mid-1980s on the Ontario side of the AOC. Since initially being classified as an AOC, five BUIs have been re-designated as ‘not impaired’. Additionally, two BUIs that required further assessment also underwent a status change to ‘not impaired’. There are currently seven BUIs that are either impaired or require further assessment. The re-designation process occurs individually on a BUI-by-BUI basis, and includes a public review period. Additional actions are required prior to re-designating the eutrophication or undesirable algae and the loss of fish and wildlife habitat BUIs. It is anticipated that these plans for actions will be completed by 2021. The restrictions on fish consumption BUI will undergo additional assessment, based on the results from the Guide to Eating Ontario Fish reports that were published by MECP. Although the mercury content in fish is decreasing, the fish consumption advisories in the AOC are still above those at reference sites.

The focus remains on completing all actions and steps for delisting the AOC. Given the significant progress that has been made to date, the local community has also begun to talk about post-delisting. This includes approaches for managing the St. Lawrence River in the Lake Ontario LAMP context while also maintaining the local community momentum and interest in protecting and enhancing the river over the longer term.

St. Lawrence River Area of Concern at Massena/Akwesasne

Centuries of agricultural and industrial development have had significant and dramatic impacts on the environmental integrity of the AOC. The expansion of the logging industry cleared large tracts of land and fostered regional growth of dairy farms. In 1897, the decision by the St. Lawrence Power Company to dig a canal from the Grasse River to the St. Lawrence River and establish a hydroelectric dam attracted larger industries to the area, such as the Aluminum Company of America (ALCOA). Development along the St. Lawrence River culminated in 1959 with the completion of the St. Lawrence Seaway and Moses-Saunders Power projects. These developments have contributed to the loss of fish and wildlife habitat, sediment contamination, and impacts to native fish and wildlife species. Legacy contamination at both the former ALCOA and former General Motors sites are currently being addressed through the federal Superfund program.

Recent studies conducted by Saint Regis Mohawk Tribe (SRMT), including investigations of the health and population status of furbearers, turtles, freshwater mussels, Lake Sturgeon and avian species, have provided a greater understanding of many of the AOC's BUI's. Results from these and other studies are being used in development of a Fish and Wildlife Habitat and Population Strategy. Once developed this strategy will identify actions needed to reach and fulfill desired endpoints and delisting criteria as well as lay out the foundation for long-term maintenance and monitoring plan.

NYSDEC, in cooperation with SRMT, is currently conducting assessments of submerged aquatic vegetation and emergent vegetation throughout the AOC. Additionally, an assessment of wetland habitat throughout the AOC is planned for the 2019 field season. Data gathered from this effort will be used to target habitat restoration opportunities in the St. Lawrence, Raquette, St. Regis, and Grasse Rivers.

NYSDEC Fish & Wildlife Staff, in cooperation with SRMT, have also been collecting and caging mussels in the lower Grasse River in order to preserve native mussel populations in the river following expected sediment dredging and capping associated with the former ALCOA Superfund remediation. SRMT is leading the mussel propagation and restoration effort targeting Species of Greatest Conservation Need (SGCN). Mussels removed from the proposed dredging and capping areas and mussels propagated in-situ will be re-seeded along the lower Grasse River following the completion of the habitat restoration in the Superfund area.

Following the endorsement of the Remedial Advisory Committee (RAC) in August 2016, NYSDEC, in coordination with the Saint Regis Mohawk Tribe, proposed a set of administrative changes for the U.S. domestic portion of the St. Lawrence River AOC to USEPA GLNPO in December 2018. These changes included: formally changing the official name of the AOC to the St. Lawrence River AOC at Massena/Akwesasne, adopting an updated AOC map that depicts the extent of Akwesasne territory and identifies traditional use areas within the AOC, modifying BUI criteria to address restoration of impaired beneficial and cultural (Mohawk) uses, and naming the Saint Regis Mohawk Tribe as co-coordinators for implementing the Remedial Action Plan (RAP). USEPA GLNPO concurred with the proposed administrative changes in March 2019. Currently, NYSDEC and the Saint Regis Mohawk Tribe are developing a formal agreement that delineates their respective roles and responsibilities as co-coordinators. This is expected to be finalized in the fall of 2019.

De-listing of the St. Lawrence River at Massena AOC is contingent on the remediation and restoration of the Grasse River. In-river work planned for 2019 is expected to take four to five years to complete.

Eighteenmile Creek Area of Concern

Historic municipal and industrial discharges that occurred along the developed section of Eighteenmile Creek within the city of Lockport have had significant impacts to the environment. Most significantly, these discharges have led to the contamination of sediments in the creek by PCBs and heavy metals. The health of the benthos has been impaired by the contamination of creek sediment, and fish consumption has been restricted by the presence of PCBs in the flesh of various game fish. Contaminant sources have been identified and are currently being remediated through the federal Superfund program. The Eighteenmile Creek AOC and upstream source areas were added to the Superfund National Priorities List in 2012.

The USEPA plans to address the site in three phases. Phase 1, which is largely complete, included demolishing the former Flintkote plant site and cleanup at nine residential properties on Water Street in the city of Lockport, New York. Remedial activities in Phase 2 will include complete excavation of creek sediments, and a combination of excavation and capping at adjacent upland industrial properties within the Creek Corridor, which is the 4,000-foot segment of Eighteenmile Creek from the New York State Barge Canal to Harwood Street. Phase 3 involves a Remedial Investigation (RI) of 8 reaches leading to the creek mouth at Lake Ontario, which is expected to be complete by the end of 2019. A feasibility study is scheduled to follow in 2020.

The Eighteenmile Creek AOC currently has five Beneficial Use Impairments (BUIs). Recently, completed work to assess specific BUI's include: a study of benthic macroinvertebrates communities and sediment toxicity within the AOC and a reference site, and a detailed sediment survey of Olcott Harbor to assess potential restrictions on dredging activities. Ongoing projects planned in the AOC include a mink study to assess contamination effects on wildlife populations and reproduction, and a fish tissue analysis to reevaluate restrictions on fish and wildlife consumption. Ultimately, it is anticipated that these projects, along with the completion of Superfund remediation, will lead to the de-listing of the Eighteenmile Creek AOC between 2026 and 2030.

Rochester Embayment Area of Concern

Work continues in restoring the Rochester Embayment AOC. The last remaining management action, the restoration of Braddock Bay, which includes the construction of a barrier beach to protect one of New York's most valuable wetlands, was completed in September 2018. NYSDEC and the Monroe County Department of Public Health are moving forward with removing four beneficial use impairments: tainting of fish and wildlife flavour, restrictions on dredging activities, eutrophication or undesirable algae, and beach closings. Continued habitat monitoring and documentation of ecosystem recovery to support beneficial use impairment removals will be an ongoing priority. The Rochester Embayment AOC is currently on track for de-listing in 2021 to 2022.

U.S. Niagara River Area of Concern

Priority LAMP actions for the binational Niagara River AOC include:

- Analyzing contaminants in edible fish in coordination with the U.S. Geological Survey and the New York State Department of Health to support the update of consumption advisories as appropriate;
- Supporting coastal wetland habitat restoration projects in the upper river (above Niagara Falls) to improve fish spawning/nursery habitat and aquatic ecosystem productivity;
- Assessing the health of fish and wildlife populations along the River; and,
- Supporting a joint U.S.-Canadian pursuit of a "Ramsar designation" for the Niagara River as a wetland of international importance, which would highlight and celebrate environmental achievements.

In New York, NYSDEC and the New York State Office of Parks, Recreation and Historic Preservation are currently supporting design and implementation of five habitat restoration projects around Grand Island that focus on restoration of coastal wetland. A working group is in the process of selecting additional projects that, together with several already completed projects, will fully address the "loss of fish and wildlife habitat" BUI.

The remaining priority is to address contaminated sediment. NYSDEC, EPA, USGS, and USACE have been collaborating to develop a sediment evaluation strategy for the Niagara River AOC. Based on the results of a June 2016 tributary sediment screening assessment, NYSDEC has requested the addition of six tributaries to the AOC as source areas: Lackawanna Ship Canal, Two Mile Creek, Rattlesnake Creek, Tonawanda Creek, Little Niagara River, and Bergholtz Creek. Additionally, USEPA and USACE conducted sediment sampling in the Black Rock Canal, and parts of Smoke, Scajaquada, and Cayuga creeks in 2017. During 2018, the two agencies will conduct sampling in the main stem of the upper Niagara River, with additional sampling in tributaries to follow in 2019. Remediation of contaminated sediment will occur as resources allow. NYSDEC has submitted a proposal to the USEPA under the *Great Lakes Legacy Act (GLLA), 2002* for a feasibility study and remedial design to address sediment in the Black Rock Canal and Lower Scajaquada Creek that is contaminated with PCBs and PAHs, particularly near the mouth of Scajaquada Creek.

APPENDIX E: LINKAGES BETWEEN GENERAL OBJECTIVES, THREATS, BINATIONAL STRATEGIES AND ACTIONS

(Note: actions column below is a summary of the actions outlined in Chapter 5)

General Objective	Threats	Binational Strategies	Actions
#1: Be a source of safe, high-quality drinking water	Nutrient and Bacterial Related Impacts Critical and Emerging Chemical Pollutants	The Niagara River Toxics Management Plan Chemicals of Mutual Concern	• Continue to implement regulations to control end-of pipe sources of pollution • Continue national and international efforts to reduce atmospheric inputs of chemical contaminants • Pursue site specific remediation to address contaminated sediments • Maintain, and where possible, optimize support for infrastructure improvement programs for wastewater treatment plants and stormwater management facilities • Continue/enhance integrated, systematic, and targeted nutrient reduction efforts in priority watersheds
#2: Allow for unrestricted swimming and other recreational use	Nutrient and Bacterial Related Impacts		• Assemble, synthesize, and report on nutrient and bacterial pollution and beach health • Improve engagement, communication, and coordination to build awareness and improve understanding • Maintain, and where possible, optimize support for infrastructure improvement programs for wastewater treatment plants and stormwater management facilities • Where needed and resources allow, conduct relevant research source identification/track down and potential actions to address the source
#3: Allow for unrestricted human consumption of the fish and wildlife	Critical and Emerging Chemical Pollutants	The Niagara River Toxics Management Plan Chemicals of Mutual Concern	• Continue to implement regulations to control end-of pipe sources of pollution • Continue national and international efforts to reduce atmospheric inputs of chemical contaminants • Pursue site specific remediation to address contaminated sediments and ongoing and locally controllable sources • Maintain, and where possible, optimize support for infrastructure improvement programs for wastewater treatment plants and stormwater management facilities
#4: Be free from pollutants that could harm people, wildlife or organisms	Critical and Emerging Chemical Pollutants	The Niagara River Toxics Management Plan Chemicals of Mutual Concern	• Continue to implement regulations to control end-of pipe sources of pollution • Continue national and international efforts to reduce atmospheric inputs of chemical contaminants • Pursue site specific remediation to address contaminated sediments and ongoing and locally controllable sources • Where needed and as resources allow, conduct source track down of contamination, and identify potential mitigative actions

General Objective	Threats	Binational Strategies	Actions
#5: Support healthy and productive habitats to sustain our native species	Nutrient and Bacterial Related Impacts Loss of Habitat & Native Species Invasive Species	The Lake Ontario Binational Biodiversity Conservation Strategy The Nearshore Framework	• Nearshore reef and shoal spawning habitat rehabilitation • Aquatic habitat assessments and rehabilitation • Watershed restoration and protection of native species and restoration planning efforts • Shoreline management planning and actions that address regional stressors and threats • Monitor, map, and report on coastal wetland condition • Detect and respond to new invasive species introductions • Reduce the impacts of invasive species, including Phragmites • Maintain, and where possible, optimize support for infrastructure improvement programs for wastewater treatment plants and stormwater management facilities • Use green infrastructure and low impact development • Continue/enhance integrated, systematic, and targeted nutrient reduction efforts in priority watersheds • Develop, renew, and revise integrated watershed management plans • Conduct research and monitoring to better understand nutrient dynamics in Lake Ontario and its watershed • Assemble, synthesize, and report on nutrient and bacterial pollution and beach health • Improve engagement, communication, and coordination to build awareness and improve understanding • Stop the establishment of Bighead and Silver Asian Carp • Minimize the spread of invasive species by recreational boating, fishing equipment, and other recreational activities

General Objective	Threats	Binational Strategies	Actions
#6: Be free from nutrients that promote unsightly algae or toxic blooms	Nutrient and Bacterial Related Impacts Loss of Habitat & Native Species Invasive Species		• Shoreline management planning and actions that address regional stressors and threats • Monitor, map, and report on coastal wetland condition • Reduce the impacts of invasive species, including Phragmites • Minimize the spread of invasive species by recreational boating, fishing equipment, and other recreational activities • Maintain, and where possible, optimize support for infrastructure improvement programs for wastewater treatment plants and stormwater management facilities • Use green infrastructure and low impact development • Continue/enhance integrated, systematic, and targeted nutrient reduction efforts in priority watersheds • Develop, renew, and revise integrated watershed management plans • Conduct research and monitoring to better understand nutrient dynamics in Lake Ontario and its watershed • Assemble, synthesize, and report on nutrient and bacterial pollution and beach health • Improve engagement, communication, and coordination to build awareness and improve understanding
#7: Be free from aquatic and terrestrial invasive species	Invasive Species	The Lake Ontario Binational Biodiversity Conservation Strategy	• Prevent introductions from ballast water • Detect and respond to new invasive species introductions • Minimize the spread of invasive species by recreational boating, fishing equipment, and other recreational activities
#8: Be free from the harmful impacts of contaminated groundwater	Critical and Emerging Chemical Pollutants	The Niagara River Toxics Management Plan Chemicals of Mutual Concern	• Pursue site specific remediation to address contaminated groundwater • Pursue site specific remediation to address contaminated sediments • Assess effectiveness of actions through surveillance and monitoring

General Objective	Threats	Binational Strategies	Actions
#9: Be free from other substances, materials or conditions that may negatively affect the Great Lakes	Critical and Emerging Chemical Pollutants Invasive Species Loss of Habitat & Native Species	The Niagara River Toxics Management Plan Chemicals of Mutual Concern The Nearshore Framework	• Continue to implement regulations to control end-of pipe sources of pollution • Continue national and international efforts to reduce atmospheric inputs of chemical contaminants