



LAKE ERIE



LAKEWIDE  
MANAGEMENT  
PLAN

L A K E E R I E L a M P  
STATUS REPORT

1999



## Preface

In 1993, the governments of Canada and the United States initiated the development of a Lakewide Management Plan (LaMP) for Lake Erie. The goal of the LaMP is to restore and protect the beneficial uses of Lake Erie such as safe beaches, clean drinking water and healthy fish and wildlife populations.

The LaMP is currently in its first stage, problem definition. The four stages that will follow are:

- development of an action agenda;
- selection of remedial and preventative actions;
- implementation of actions; and
- monitoring of results.

We hope that you will find this Status Report informative and that it will provide you with an understanding of the current key issues for the Lake Erie basin. This report has been prepared to provide the reader with the following information:

- general knowledge about the Lake Erie basin;
- how and why the LaMP was initiated;
- the current activities of the LaMP;
- future goals of the LaMP;
- which beneficial uses are impaired, which are not and which ones require further evaluation; and
- a few of the key issues in the basin, which illustrate the complex nature of Lake Erie.

A major focus of the LaMP is ensuring that public interests are solicited and considered at every stage in the plan. For more information on how to become involved in the LaMP, please visit the LaMP website at [www.cciw.ca/glimr/lakes/erie](http://www.cciw.ca/glimr/lakes/erie) or contact one of the LaMP's Public Involvement Coordinators:

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## What is a LaMP?

Lakewide Management Plans (LaMPs) are management strategies being developed and implemented for each of the Great Lakes. It is one of several programs that Canada and the United States are committed to through the Great Lakes Water Quality Agreement (GLWQA).

The GLWQA calls for the LaMP to address persistent *bioaccumulative*<sup>1</sup> toxic pollutants that persist in Lake Erie. The Lake Erie *ecosystem* may not be fully protected or restored until other factors, such as habitat loss and *exotic species*, are addressed. To more effectively address these factors, the Lake Erie LaMP utilizes an *ecosystem approach*. This approach, which crosses government jurisdictions, integrates water quality and natural resource management for the restoration of the environment and the protection of humans, plants and animals. This approach shifts away from the traditional focus on localized pollution management of separate components in isolation, and recognizes that each part of the system affects the other parts.

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This LaMP provides a structure for coordinating the work of environmental and natural resource organizations that historically have not routinely worked together. This effort combines current research, communication and knowledge from public and private sources. By pooling these resources, joint commitments for environmental improvements to Lake Erie are being made.

### Goal of the Lake Erie LaMP:

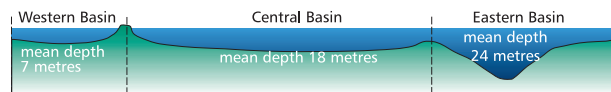
To restore and protect the beneficial uses of Lake Erie, such as safe beaches, clean drinking water and healthy fish and wildlife populations.

## Characteristics of Lake Erie

Lake Erie has several characteristics that make it unique from the other Great Lakes. By volume it is the smallest of the Great Lakes, and next to smallest in surface area. As the shallowest of the Great Lakes,

it warms quickly in the spring and summer and freezes over in the winter.

Lake Erie is naturally divided into three basins. The western basin is very shallow with an average depth of 7.4 metres (24 ft) and a maximum depth of only 19 metres (62 ft). The central basin is quite uniform in depth, with the average depth being 18.3 metres (60 ft) and a maximum depth of 25 metres (82 ft). The eastern basin is the deepest of the three, with an average depth of 25 metres (82 ft) and a maximum depth of 64 metres (210 ft).



Eighty percent of Lake Erie's total inflow of water comes from the upper Great Lakes through the St. Clair River and Lake St. Clair to the Detroit River, which discharges directly to Lake Erie. The remaining twenty percent comes from precipitation and the direct *tributaries* (rivers and streams) in Michigan, Ohio, Pennsylvania, New York and Ontario located within the *Lake Erie basin*. The Niagara River and shipping canals serve as outlets for the lake, which drain into Lake Ontario.

About one-third of the total population of the Great Lakes basin reside within the Lake Erie *watershed*. In total, 11.6 million people live in the watershed, which includes seventeen metropolitan areas, each with more than 50,000 residents. The lake provides drinking water for about eleven million of these inhabitants. The general trend over the past ten years has been a population decline on the US side of the basin and notable growth on the Canadian side in urban areas near the major highway system (SOLEC '96 - Impacts of Changing Land Use, 1997).

Lake Erie is exposed to greater stress due to urbanization and agricultural practices than any of the other Great Lakes. The lake receives chemically enriched runoff and sediment from agricultural lands within the basin. As well, it surpasses all other Great Lakes in the amount of effluent (discharged waste water) it receives from sewage treatment plants (Dolan, 1993).

Lake Erie is the Great Lake most subjected to sediment loading. Long stretches of its shorelines are subject to episodes of active *erosion* by storm waters, particularly during times of high lake levels. The lake also receives sediment via the Detroit River, from Lake St. Clair. Topsoil erosion in the water-

<sup>1</sup> Words highlighted with italics are described in the Glossary

shed contributes sediment to Lake Erie via tributaries, particularly the Maumee River. The total sediment (and dissolved nutrient) load profoundly influences the ecology of the western basin.



Erosion on Lake Erie near Port Burwell

### Effects of Soil Erosion

Approximately ten million tons of soil are eroded annually along Ohio's section of the Lake Erie shoreline.

Some of the effects of this erosion are:

- On average, 1.32 million tons of sediment per year are discharged to Lake Erie from the Maumee River, and this value is higher than any other tributary stream in the Great Lakes basin.
- Approximately 1 million cubic yards of sediment are dredged annually from the Toledo Harbor. The cost of this dredging is over \$3 million. (USACOE).
- Each ton of sediment adds 32 cents to Ohio's water treatment cost.
- Nutrients lost from soil that are eroded in the Ohio part of the Lake Erie basin have an estimated annual value of about \$50 million.



Cladophora on a Stick

## Lake Erie Successes

During the 1960s, Lake Erie was coined the “dead” lake by the press. Government and private actions have resulted in a number of successes in the Lake Erie basin including: reduced loadings of toxic substances, advances in wastewater and sewage treatment, improvements in oxygen levels in the lake and declines in bioaccumulative contaminants in fish tissue and in the eggs of fish-eating birds.

One of the biggest success stories for Lake Erie was the reduction in phosphorus entering the lake. The excessive phosphorus entering the lake during the 1960s caused eutrophic conditions. *Eutrophication* is characterized by high *productivity*. Eutrophication can be a wholly natural phenomenon or it can be accelerated by an increase of nutrient loading to a lake by human activity. In Lake Erie this was exemplified by the rapid growth of certain algal constituents. These algal blooms were so heavy they coloured the water and depleted oxygen in some areas of the lake.

By the late 1960s, Canadian and American regulatory agencies were in agreement that limiting phosphorus *loads* to the lake was key in controlling ex-

cessive algal growth and that a coordinated lakewide approach was necessary to deal with the phosphorus issue. Open lake phosphorus concentrations declined due to the joint efforts. These controls represented an unprecedented success in producing environmental results through binational cooperation.

Concern over the state of Lake Erie led to an increase in research into the causes of environmental degradation. As well, greater public awareness of water quality issues affecting the Great Lakes likely stems from concerns over Lake Erie.

## Great Lakes Water Quality Agreement (GLWQA)



### History of the Great Lakes Water Quality Agreement

- **1909** - Boundary Waters Treaty - Created the International Joint Commission, whose role was to solve disputes over the use of the waters that crossed the international boundaries of the two countries.
- **1972** - First Great Lakes Water Quality Agreement - Addressed overall pollution and water quality deterioration of all five lakes.
- **1978** - Second Great Lakes Water Quality Agreement - Shifted focus from the control of nutrients to include the control of toxic substances.
- **1987** - Amendments to the Great Lakes Water Quality Agreement - Emphasis was shifted to the ecosystem approach to achieve the outlined goals of the GLWQA.

For more information on the GLWQA check out the website available at: [www.cciw.ca/glwqa/intro.html](http://www.cciw.ca/glwqa/intro.html)

It is important for the Lake Erie LaMP and the RAPs, as well as other interest groups around the basin, to work together and keep the lines of communication open in order to reduce duplication of work and avoid future conflicts. Given the past success of Lake Erie RAPs in improving environmental conditions, it is likely that RAPs will be a key part of implementing the LaMP.

As a reflection of the above concerns the governments of Canada and the United States signed the binational treaty, Great Lakes Water Quality Agreement (GLWQA), in 1972. Amendments were made to the Agreement in 1978 and 1987. The 1987 amendment mandated the development and implementation of Lakewide Management Plans (LaMPs) and Remedial Action Plans (RAPs) for each of the Great Lakes.

RAPs were established for localized areas that failed to meet one or more of the 14 beneficial uses (see page 12) outlined in the GLWQA. These areas were designated as *Areas of Concern (AOC)*. The goal of a LaMP is to restore and protect the 14 beneficial uses in open lake waters. The goals of RAPs and LaMPs are similar. Both programs share the following: an assessment record of impairments to beneficial uses, proposed remedial actions, a framework for implementation, and resulting improvements in environmental conditions. RAPs and LaMPs serve as an important step toward virtual elimination of persistent toxic substances and toward restoring and maintaining the chemical, physical and biological integrity of the Great Lakes basin ecosystem.

### Lake Erie AOCs

The IJC has identified 12 specific geographic AOCs in the Lake Erie basin. There are RAP Programs for all 12: Ashtabula River, Black River, Buffalo River, Clinton River, Cuyahoga River, Detroit River, Maumee River, Presque Isle Bay, River Raisin, Rouge River, St. Clair River and Wheatley Harbour.

To check out the progress of the various RAP programs check the website at:

[www.cciw.ca/glimr/raps/intro.html](http://www.cciw.ca/glimr/raps/intro.html)

[www.great-lakes.net/places/aoc/erieaoc.html](http://www.great-lakes.net/places/aoc/erieaoc.html)



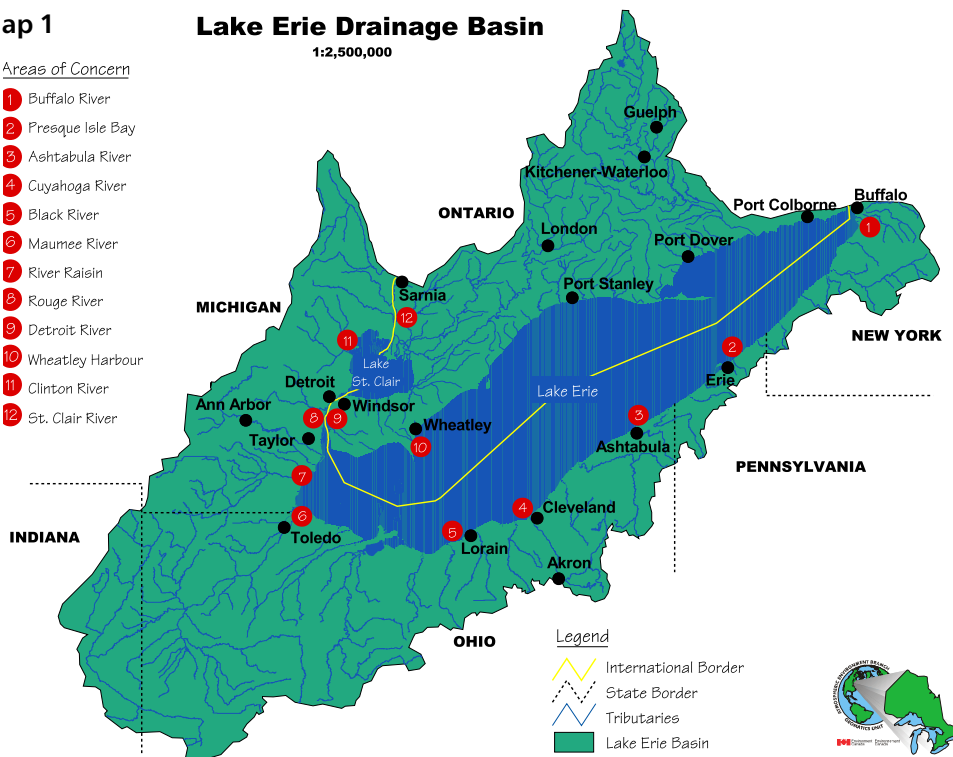
Map 1

Lake Erie Drainage Basin

1:2,500,000

Areas of Concern

- 1 Buffalo River
- 2 Presque Isle Bay
- 3 Ashtabula River
- 4 Cuyahoga River
- 5 Black River
- 6 Maumee River
- 7 River Raisin
- 8 Rouge River
- 9 Detroit River
- 10 Wheatley Harbour
- 11 Clinton River
- 12 St. Clair River



The International Joint Commission (IJC) monitors and assesses progress under the GLWQA and advises the governments of Canada and the United States on matters related to the quality of the boundary waters of the Great Lakes system, including the LaMP and RAP programs.

For Lake Erie the LaMP will be submitted to the IJC for review and comment when the following are complete:

1. problem definition;
2. development of an action agenda;
3. selection of remedial and preventative actions;
4. implementation of action; and
5. monitoring for results.

Furthermore, the Parties report biennially to the IJC on progress made in developing and implementing the LaMP and in restoring beneficial uses. Information from these reports is included in the IJC’s biennial report.

## LaMP Membership

Environment Canada and the United States Environmental Protection Agency are the federal co-leads for the Lake Erie LaMP. The Province of Ontario and the states of Michigan, Pennsylvania, New York and Ohio are active participants in the

program. Other agencies involved in the process include:

### Canada

- Agriculture and Agri-food Canada;
- Department of Fisheries and Oceans;
- FOCALerie (Federation of Ontario Conservation Authorities for Lake Erie);
- Health Canada;
- Ontario Ministry of Agriculture, Food and Rural Affairs;
- Ontario Ministry of the Environment; and
- Ontario Ministry of Natural Resources;

### United States:

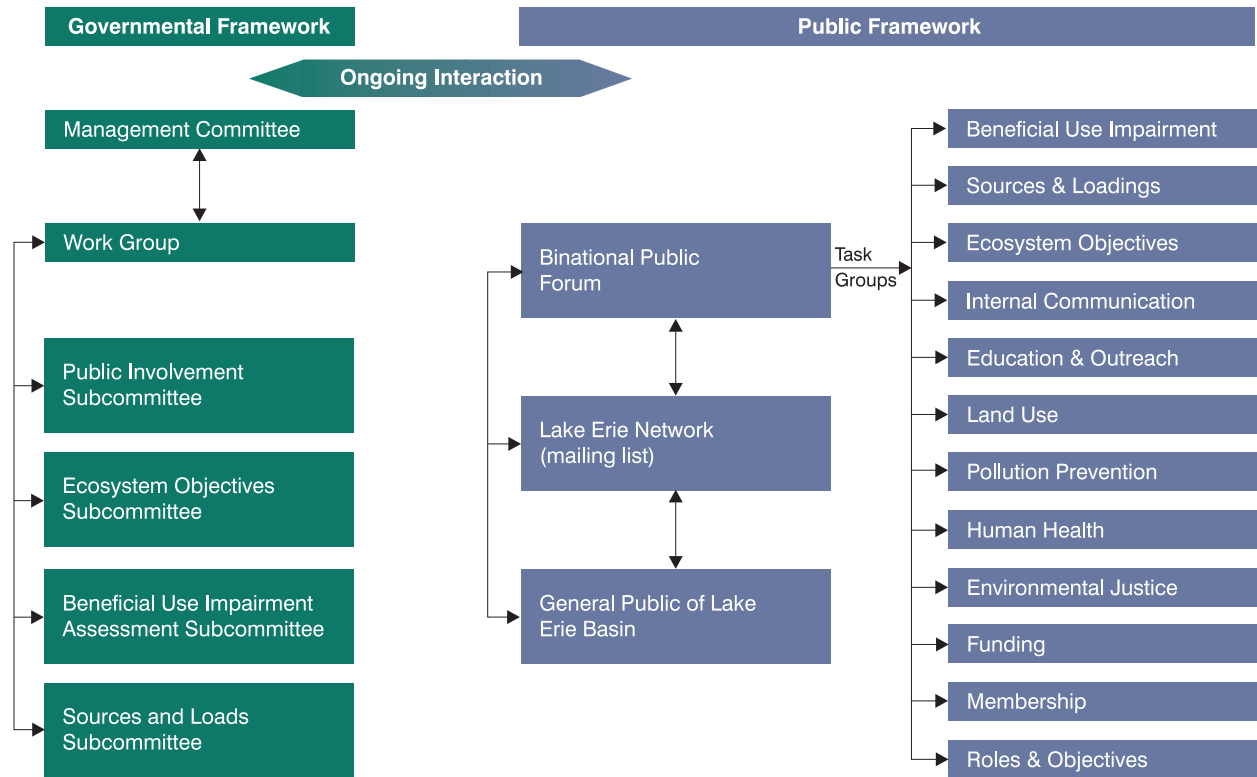
- Michigan Department of Environmental Quality;
- Michigan Department of Natural Resources;
- Natural Resource Conservation Service;
- New York State Department of Environmental Conservation
- Ohio Department of Natural Resources;
- Ohio Environmental Protection Agency;
- Pennsylvania Department of Environmental Protection;
- Seneca Nation of Indians (invited);
- United States Army Corps of Engineers;
- United States Fish and Wildlife Service; and
- United States Geological Survey;

### Binational Observers:

- International Joint Commission;
- Great Lakes Fishery Commission.

# Organizational Structure of the LaMP

In order to effectively carry out all actions required of the Lake Erie LaMP, a tiered organizational structure was implemented:



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- Management Committee:**  
 This committee, made up of senior managers from the federal, state and provincial governments, oversees the development of the Lake Erie LaMP and makes all final decisions. This group has the following responsibilities: assigns and issues charges for the technical Work Group, approves time frames for action, approves recommendations for short-term actions and long-term objectives and provides funding and support for these actions. Members of this group have responsibilities within their jurisdictions for water quality, fish and wildlife, agriculture, *human health* and research.
- Technical Work Group:**  
 This group is comprised of technical representatives from agencies supporting LaMP development within the basin. The group has the following tasks: identifies short-term actions and long-term objectives, establishes time frames and sets priorities for action, ensures implementation of approved actions, identifies environmental and

programmatic indicators to measure success, prepares LaMP documents, coordinates LaMP activities with existing programs and oversees the public participation process. Currently two of the key responsibilities of the Work Group are reporting on LaMP progress and overseeing the activities of four subcommittees: Public Involvement, *Ecosystem Objectives*, Beneficial Uses Impairment Assessment and Sources and Loads. Pages 7-16 describe the activities of the subcommittees.



## Public Involvement Subcommittee

The LaMP has the mandate of ensuring that public opinion is solicited, considered, acknowledged and incorporated where appropriate throughout the process. To oversee and facilitate public input and communication and to incorporate public and stakeholder knowledge into the LaMP process, the Public Involvement Subcommittee of the Work Group was formed. A three-tiered approach is being utilized to effectively facilitate public involvement within the basin.

- **Lake Erie Binational Public Forum:**

This is an established formal body made up of Canadian and American representatives from various geographic locations and interest groups. Initiated in 1995, the Forum meets three times annually, in varying locations throughout the basin. This group represents the most formal level of public participation for the LaMP. The Forum has been divided into different task groups, dealing with pertinent issues including: pollution prevention, sources and loads of pollutants, beneficial use impairments, ecosystem objectives, land use, *environmental justice*, education and outreach and others of a more administrative nature. The Forum has a significant role in the LaMP process,

including: proactive involvement in goal setting and decision making, increasing stakeholder participation, and implementing, facilitating and/or participating in LaMP related activities at a local level where appropriate.

- **Lake Erie Network:**

The level of involvement in this group varies widely. Members of this network indicate their commitment by: requesting LaMP documents, attending meetings or open houses or expressing an interest in becoming involved in the development and implementation of the LaMP. Some members wish to be involved on a continual basis, while for others it is a one time occurrence. This group is provided with information and encouraged to provide comments to the various LaMP groups including the Work Group and Management Committee.

- **General Public:**

This group represents the population that is currently uninvolved in or unaware of the work of the LaMP and therefore still needs to be targeted by the public outreach program of the LaMP. In order to seek this group's input, information is communicated through mass media channels, advertisements or direct mailings. Efforts to target this group will continue.



### Surfers - Check it Out

More information on the LaMP and related activities is available on various websites:

[www.cciw.ca/glimr/lakes/erie](http://www.cciw.ca/glimr/lakes/erie)

(Lake Erie LaMP)

[www.cciw.ca/glimr/intro.html](http://www.cciw.ca/glimr/intro.html)

(Environment Canada - Great Lakes Information Management Resource)

[www.great-lakes.NET/](http://www.great-lakes.NET/)

(USEPA - Great Lakes Information Network)

[www.epa.ohio.gov/lamp/](http://www.epa.ohio.gov/lamp/)

(Ohio EPA)

[www.hc-sc.gc.ca/](http://www.hc-sc.gc.ca/)

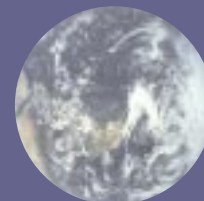
(Health Canada)

[www.ijc.org/](http://www.ijc.org/)

(International Joint Commission)

[www.epa.gov/bns/](http://www.epa.gov/bns/)

(Binational Toxics Strategy)



# Lake Erie Public Forum

The Lake Erie Binational Public Forum is a self-governed, self-directed, self-implementing group of Lake Erie basin citizens focused on the development of the Lake Erie LaMP. The Forum defines their own roles and functions within the LaMP process.

## The Forum has composed a vision statement for the Lake Erie basin:

“The Forum sees the future Lake Erie basin as a place where diverse life forms exist in harmony, social and economic benefits at maximum sustainable levels co-exist, citizens and governments are committed to binational cooperation and a philosophy of *stewardship* ensures a clean, safe environment.”

## A mission statement has also been developed by the Forum:

“The Lake Erie Forum is a cooperative binational organization of diverse stakeholders whose objective is to restore, protect and utilize Lake Erie waters to achieve maximum sustainable social and economic benefits by promoting:

- ecosystem health, diversity and stewardship;
- recognition and protection of unique environmental areas, such as wetlands, wilderness and open space;
- enhancement and maintenance of public access to the lake and shoreline;
- the protection of indigenous species and their habitats;
- shoreline and lake uses which encourage a healthy economy and environment and are in the public interest; and
- meaningful opportunity for public participation in decisions that affect the lake.”

Forum members have expertise in a diverse range of interests and represent a number of sectors including: agriculture, business and industry, community organizations, education, environmental organizations and interest groups, general public, labour, local government, recreation and tourism, public health and sport and commercial fishing.

## The Forum has three main roles and functions within the LaMP. The Forum shall:

### 1. Play a significant role in the LaMP process with real involvement and proactive initiatives by:

- acting as partners with government and non-government agencies in goal-setting and decision making;
- assisting the technical subcommittees in the drafting of LaMP reports and reviewing Work Group documents before they go to the Management Committee for review;
- providing advice and input to the Work Group and Management Committee in developing and implementing the LaMP; and
- promoting the Forum’s visions and goals for Lake Erie.

### 2. Increase stakeholder participation in the LaMP process by:

- representing a variety of interest groups and geographic areas;
- identifying and involving stakeholders;
- bringing personal experience and talents to the process; and
- taking information from the LaMP back to the community in a form that can be understood by the public.

### 3. Implement, facilitate and/or participate in Forum sponsored LaMP-related activities at the local level where appropriate.

## Ecosystem Objectives Subcommittee

An ecosystem approach was adopted by the Lake Erie LaMP as outlined in the 1987 amendments to the GLWQA. The Ecosystem Objectives Subcommittee was formed to develop the approach for the LaMP. This approach recognizes the dynamic interaction of the land, air and water within the Lake Erie system. Humans and our social, economic, technical and political values are considered to be an integral part of the ecosystem. The ecosystem approach shifts away from the traditional focus on localized pollution management and refocuses our attention on a holistic view of Lake Erie and its basin. Ecosystem objectives to be developed by the subcommittee, in cooperation with the Public Forum, will provide goal statements for which future management actions will be directed.

The public has been involved from the start in developing a set of ecosystem objectives. In 1995, a series of public workshops were held in Canada and the United States as the initial step of gathering the opinions of the various interest groups. At these workshops participants discussed their ideas for the Lake Erie ecosystem and developed lists of statements describing their desired future condition of Lake Erie.

In October 1995 an “experts” workshop was held to consult with the scientific community about what is known and what is hypothesized about the current state of the Lake Erie ecosystem. Participants included representatives of government, non-government organizations, academia and the public. Experts in the following areas included: fisheries and wildlife management, water quality management, aquatic ecology, human health and stewardship. Participants provided expectations of how ecosystem components interact with one another and how the

ecosystem is influenced by both local and regional environmental factors. Over 4,000 statements or expectations about the Lake Erie ecosystem were defined by the end of the workshop. These observations were entered into a database. These included statements of the following nature: “beaches will be swimmable if *fecal coliform* counts are low”, or “the potential for healthy walleye populations exist if the quantity and quality of spawning habitat is high”. This database and the results of the public workshops have been the foundation for the process of developing ecosystem objectives for Lake Erie.

In developing ecosystem objectives the competitive uses within the Lake Erie ecosystem, such as industry, urban growth, agriculture or recreational uses, must be taken into consideration. Because of their conflicting use requirements of the lake, a balance is necessary to develop ecosystem objectives. Each stakeholder group may not fully attain their specific targets to support their activities in the basin. To assist discussions about ecosystem objectives for Lake Erie, a series of qualitative statements about compatible ecosystem conditions, referred to as an “ecosystem scenario,” is being developed. Each ecosystem scenario will describe conditions that could exist for the major ecosystem components, water, land and air, in Lake Erie, given a specific set of assumptions.

For example, based upon a low level of land developments and uses, specific stream and upland habitats may increase and consequently, certain fish and wildlife species have the potential to maintain healthy populations.

A number of ecosystem scenarios will be developed based on alternative, feasible goals for Lake Erie. These will provide a qualitative interpretation of the ecosystem conditions that could result from implementing certain management strategies to achieve the goals.

Four underlying assumptions have been recognized that need to be considered when developing ecosystem scenarios. If these assumptions are not considered, then the ecosystem scenarios and subsequent ecosystem objectives may not be realistic. The four assumptions include, but are not limited to:

1. There are very few components of the Lake Erie ecosystem that can be deliberately controlled through environmental management. Those we can control or influence include: nutrient loadings, fish management through stocking and harvesting, habitat creation or destruction and toxic contaminants.



2. The discharge of toxic substances in toxic amounts shall be prohibited.
3. A commercial and sport fishery will continue to exist on Lake Erie.
4. Zebra mussels and other exotic species are now part of the Lake Erie ecosystem.

As an outcome of the “expert” workshop and the work of the subcommittee a computerized model, referred to as the Lake Erie Model, is being developed. The model, which is not a conventional quantitative model, utilizes a knowledge-based approach which combines narrative statements and numerical data, allowing for uncertainty. As a representation of the Lake Erie ecosystem, this model takes into account the factors that affect the lake and the public’s key values regarding Lake Erie (e.g. swimming, healthy environment). This representation has been taken back to the “expert” workshop participants, to verify that it provides realistic expectations for the Lake Erie ecosystem in order to utilize this information in the model. The model is being developed to enable the subcommittee to explore what Lake Erie could look like under different management strategies. These explorations will result in the production of a set of ecosystem scenarios. These ecosystem scenarios do not represent any kind of pre-judgment or final decisions, but are intended to be understandable options for consideration by agencies, stakeholders and the public.



Eastern Spiny Softshell Turtle

## Beneficial Use Impairment Assessment Subcommittee

The Beneficial Use Impairment Assessment Subcommittee (BUIASC) is charged with conducting an assessment of the 14 beneficial use impairments listed in the Great Lakes Water Quality Agreement. This is an important step towards the identification of actions for restoration and protection of Lake Erie.

The International Joint Commission (IJC) has developed definitions known as listing criteria for each impairment. The 14 impairments are outlined on page 11 and in Table 1 (pages 12-13), with the associated listing criteria outlined in Appendix 1.

Individual assessment reports are being written for each of the 14 potentially impaired uses of Lake Erie and are being released as they are completed. Currently available reports are shown in Table 1 with an asterisk†. Reports on Recreational Water Quality Impairment and Eutrophication or Undesirable *Algae* are expected to be available soon.

The scope of the assessment has been established as the extent of current impairments in the open waters of Lake Erie, *nearshore* areas, embayments, river mouths and the *lake effect zone* of Lake Erie tributaries.

Where known, the causes and/or sources of the impairment are identified. The location of the cause or source of an impairment does not have to fall within the above-mentioned geographic boundaries to be considered within the LaMP evaluation process.

A summary of impairment conclusions to date have been reviewed and accepted by the Lake Erie LaMP Work Group, Management Committee and Public Forum and is provided in Table 1. In Table 1, when an impaired beneficial use is noted in a particular basin, it means that impairment is occurring somewhere in that basin, not necessarily throughout the entire basin referenced. Details about the geographic locations and extent of impairment, where known, can be found in the technical reports (available on request) that support this summary.

The majority of the impairment conclusions to date have been based on listing criteria that refer to existing standards as the benchmark against which im-



pairment is measured. With one exception, the assessments that remain to be completed have few or no existing criteria against which impairment can be evaluated. If any criteria do exist, they are usually in the form of broad objectives that often do not have the level of detail needed to draw impairment conclusions. Consequently, the efforts of the BUIASC have been focused on developing more detailed assessment criteria to complete impairment evaluations.

Due to a lack of concrete assessment criteria, the BUIASC decided to assess, wherever possible, impairment of these “ecological uses” against: (1) out-of-system references, (2) historical conditions, (3) recent concerns, and (4) existing management goals and objectives. The relative weight placed on impairment conclusions related to each of these assessment categories will vary. When there are conflicts between management goals/objectives and our ecological understanding of Lake Erie, these conflicts will be noted and summarized.

With the exception of Added Costs to Agriculture and Industry Assessment, the following assessments utilize the above-mentioned approach. The subcommittee is currently completing the following assessments:

- Degraded Fish Populations - a revised report based on the results of three expert workshops is expected to be available by June 1999, for review by the BUIASC, the Work Group and the Public Forum.
- Loss of Fish Habitat - final draft incorporating review comments by the BUIASC, the Work Group and the Public Forum is expected to be available by March 1999.
- Fish Tumours or Other Deformities - second draft of this report to address review comments from the BUIASC, the Work Group and the Public Forum is underway. The final report is expected to be complete by April 1999.
- Bird or Animal Deformities or Reproductive Problems - a workshop to finalize assessment criteria and set direction for completion of this assessment was held in July 1998. The Work Group endorsed the assessment approach in October 1998. The draft report is underway and is expected to be available for review by May 1999.
- Degradation of *Benthos* - a preliminary draft of this assessment is expected to be available for review by the BUIASC, the Work Group and the Public Forum in June 1999.
- Degraded Wildlife Populations and Loss of Wildlife Habitat - a workshop to consolidate data from all Lake Erie jurisdictions and to set the direction for completion of the assessment report is planned for June 2000.
- Added Costs to Agriculture and Industry - a preliminary draft of this assessment is expected to be available for review by the BUIASC, the Work Group and the Public Forum by July 1999.

Table 1. Summary of Preliminary Beneficial Use Impairment Conclusions, Lake Erie LaMP, July, 1998

Impairment	Causes of Impairment	Impairment Conclusions by Basin	
		West Basin Nearshore	West Basin Open Water
Fish and Wildlife Consumption Restrictions †	Fish- PCBs, mercury, PAHs*, lead, chlordane & dioxins Wildlife- PCBs, chlordane, DDE, DDT & mirex	Impaired for fish; Inconclusive** for wildlife	Impaired for fish; Inconclusive for wildlife
Tainting of Fish and Wildlife Flavour †	None	Not Impaired	
Restrictions on Dredging Activities†	PCBs, heavy metal	Impaired	Not Applicable
Eutrophication or Undesirable Algae	Phosphorus levels	Impaired in Maumee Bay and lake effect zones of the Maumee and Ottawa Rivers in Ohio. Potentially Impaired*** in lake effect zones of the Toussaint, Portage & Sandusky Rivers and Turtle & Muddy Creeks in Ohio.	Not Impaired
Recreational Water Quality Impairment	Exceedances of <i>E. coli</i> and/or fecal coliform guidelines	Impaired	Inconclusive
Restrictions on Drinking Water Consumption / Taste & Odour Problems	None	Not Impaired	Not Applicable
Degradation of Phytoplankton/ Zooplankton Populations †	Zebra and Quagga mussel grazing, species degradation (phytoplankton), high planktivory, species decline, habitat loss/ degradation (zooplankton)	Impaired in lake effect zones of certain tributaries	Not Impaired
Degradation of Aesthetics †	Excessive <i>Cladophora</i> , point/ non-point source stormwater runoff, floating garbage & debris, dead fish, excessive zebra mussels on shoreline areas.	Impaired	Inconclusive

† Technical document available upon request, or on the Internet at: [chagrin.epa.ohio.gov/ohiolamp](http://chagrin.epa.ohio.gov/ohiolamp)

\*PAHs are the basis for a human contact advisory in the Black River, Ohio Area of Concern, but are not the basis for a fish consumption advisory. This advisory was issued by the Ohio Department of Health and means that it is not safe to go into the water in this area.

**Impairment Conclusions by Basin (continued)**

Central Basin Nearshore	Central Basin Open Waters	East Basin Nearshore	East Basin Open Waters
<b>Impaired</b> for fish; <b>Inconclusive</b> for wildlife	<b>Impaired</b> for fish; <b>Inconclusive</b> for wildlife	<b>Impaired</b> for fish; <b>Impaired</b> for wildlife	<b>Impaired</b> for fish; <b>Inconclusive</b> for wildlife
Not Impaired		Not Impaired	
<b>Impaired</b>	<b>Not Applicable</b>	<b>Impaired</b>	<b>Not Applicable</b>
<b>Potentially Impaired</b> in lake effect zones of Old Woman Creek and the Vermillion, Rocky, Huron, Black, Chagrin and Cuyahoga Rivers in Ohio. Rondeau Bay Ontario. 1998-99 sampling results are expected to provide data for conclusive determination of impairment in the nearshore and river mouths in Ontario.	<b>Not Impaired</b> based on phosphorus and chlorophylla. <b>Inconclusive</b> based on dissolved oxygen levels.	<b>Potentially Impaired</b> 1998-99 sampling results are expected to provide data for conclusive determination of impairment in the nearshore and river mouths.	<b>Not Impaired</b>
<b>Impaired</b>	<b>Inconclusive</b>	<b>Impaired</b>	<b>Inconclusive</b>
<b>Not Impaired</b>	<b>Not Applicable</b>	<b>Not Impaired</b>	<b>Not Applicable</b>
<b>Impaired</b> in lake effect zones of certain tributaries. <b>Unknown</b> in nearshore areas outside lake effect zone (no recent data)	<b>Unknown</b> (no recent data)	<b>Impaired</b>	<b>Impaired</b>
<b>Impaired</b>	No documentation of impairment	<b>Inconclusive</b> for Canadian waters; <b>Impaired</b> for Lake Erie State Park Beach, New York	No documentation of impairment

\*\* Inconclusive - there are little or no data upon which to assess impairment and therefore it is unknown one way or the other whether the impairment is occurring.

\*\*\* Potentially impaired- there are enough data to point to a problem, but not enough data to be absolutely conclusive.

## Sources and Loads Subcommittee

The Sources and Loads Subcommittee was charged with the following, in order to evaluate the sources and loads of pollutants in the basin:

1. Describe the status and trends in concentrations and loads of pollutants that are causing, or have the potential to cause, beneficial use impairments in Lake Erie;
2. Identify the major pollutant sources and the relative contribution of those sources to the beneficial use impairments;
3. Provide a scientific basis for sound management decisions for reducing, removing and eliminating the pollutants from the Lake Erie system; and
4. Identify gaps in the information to identify the sources and loadings, and make recommendations for monitoring to fill in the gaps.



Currently, the following chemicals have been found to cause impairments of beneficial uses in Lake Erie: DDT, PCBs, mercury, lead, dioxins/furans, PAHs, chlordane, Mirex and phosphorus. In addition to

these specific chemicals, *E. coli* and suspended solids have also been found to be pollutants causing impairments of beneficial uses in Lake Erie. These pollutants are the highest priority for analysis, and will be discussed in detail in a technical pollutant report on sources and loads, which is expected to be released for public review in December 1999.

On May 1<sup>st</sup> 1998, the Lake Erie LaMP Management Committee designated two of these chemicals, PCBs and mercury, as critical pollutants for priority action, based on the number of fish advisories caused by these chemicals. As next steps, the Work Group will evaluate and recommend new management options for these chemicals.

The Sources and Loads Subcommittee developed a list of pollutants, designated by a variety of agency programs, as being pollutants of concern throughout the Great Lakes basin (see Table 2). These chemicals include those listed above, as well as those chemicals with the potential to impair beneficial uses in Lake Erie. This expanded list allows the Sources and Loads Subcommittee to begin evaluating information on all chemicals of concern to Lake Erie. By evaluating data on all of these chemicals, strategies to monitor and control problem causing chemicals can eventually be developed.

The subcommittee will also identify potential sources of pollutants from the municipal, industrial and agricultural sectors within the basin. To do this the subcommittee will use generic descriptions of each sector such as the size and location of municipal sewage treatment plants, total emissions from the industrial sector and pesticide and fertilizer use from the agricultural sector. Ambient environmental data such as water and sediment concentrations of pollutants will be evaluated for their utility to track down or identify potential locations of sources. The area chosen for source trackdown was the Lake Erie watershed from the head of the St. Clair River at Point Edward to the outflow of Lake Erie into the Niagara River.

The subcommittee decided to integrate existing electronic data sources using a USEPA product called BASINS (Better Assessment Science Integrating Point and Non-point Sources). This product uses ArcView<sup>®</sup> as its platform and includes tools for “data mining” and performing loading estimates for both *point source* and *non-point source pollution*. BASINS, which was available on a USEPA regional basis, was transformed into a watershed-based product called



LIMS (Lake Erie Information Management System). Information from the US federal databases, containing sources and loadings information or ambient data on a broad geographical basis, for the 53 potential LaMP pollutants was extracted. This new information system allows the subcommittee to evaluate the data’s ability to estimate loadings or identify sources.



**Table 2. Contaminants identified for analysis of sources and loads by the Lake Erie LaMP**  
 (Contaminants indented are degradation products; those shown in italics have been identified as chemicals of concern by the Lake Erie LaMP or have been shown to impair beneficial uses of Lake Erie)

Contaminant(s)	Common source(s)
<b>Organochlorine insecticides and biocides</b> <i>Chlordane</i> <sup>1,3,4,7</sup> <ul style="list-style-type: none"> <li>• <i>Gamma chlordane</i></li> <li>• <i>Alpha chlordane</i></li> <li>• <i>Cis nonachlor</i></li> <li>• <i>Trans nonachlor</i></li> </ul> <i>DDT</i> <sup>1,2,3,4,5,7</sup> <ul style="list-style-type: none"> <li>• <i>DDD</i></li> <li>• <i>DDE</i></li> </ul> <i>Dieldrin</i> <sup>1,3,4,5,7</sup> <i>Toxaphene</i> <sup>2,3,4,5,7</sup> <i>Mirex</i> <sup>2,3,4,5</sup> <ul style="list-style-type: none"> <li>• <i>Photomirex</i></li> </ul> Alpha-hexachlorocyclohexane Beta-hexachlorocyclohexane Delta-hexachlorocyclohexane Hexachlorocyclohexane	Historical use on crops and for termite and fire ant control.  Historical use on crops, microcontaminant in dicofol.  Historical use on crops, termite and moth ant control. Historical use on crops, topical insecticide. Historical use for fire ant control and as flame retardant. Agricultural and topical insecticides.
<b>Industrial organochlorine compounds or byproducts</b> <i>PCB and congeners</i> <sup>1,2,3,4,5,7</sup> <i>Dioxin (2,3,7,8 TCDD)</i> <sup>3,4,5</sup>	Transformers, lubricants and hydraulic fluids. Combustion byproducts and contaminant in pentachlorophenol wood preservative.
<b>Polyaromatic hydrocarbons</b> <sup>3,4,7</sup> <i>Anthracene</i> <i>Chrysene</i> <i>Benz (a) anthracene</i> Dinitropyrene <i>Benzo (a) pyrene</i> <i>Benzo (g,h,i) perylene</i> <i>Benzo (b) fluoranthene</i> Phenanthrene <i>Benzo (k) fluoranthene</i> Fluoranthene	Coal, oil, gas, and coking byproducts, waste incineration, wood and tobacco smoke, forest fires, automotive exhaust, tars and tar products.

Contaminant(s)	Common source(s)
<b>Benzene and phenol compounds</b>	
1,4 Dichlorobenzene <sup>3,4</sup>	Mothballs, household deodorants, other biocides.
Pentachlorobenzene <sup>3,4</sup>	Chemical synthesis.
1,2,3,4 Tetrachlorobenzene <sup>2,4</sup>	
1,2,3,5 Tetrachlorobenzene <sup>3,4</sup>	
Pentachlorophenol <sup>3,4</sup>	Chloroalkali plants, wood preservatives.
Hexachlorobenzene <sup>3,4,7</sup>	By-product of chemical manufacturing, historical wood preservative and fungicide.
3,3 Dichlorobenzidine <sup>3,4</sup>	Plastic manufacturing, glues and adhesives, dyes and pigments for printing inks.
4,4' Methylenebis (2-chloroaniline) <sup>3,4</sup>	Plastics, adhesives.
<b>Trace metals</b>	
Alkyl lead <sup>3,4,5</sup>	Leaded gasolines.
Cadmium <sup>3,4</sup>	Batteries, pigments, metal coatings, plastics, mining, coal burning, metal alloys, rubber, dye, steel production.
Copper <sup>5</sup>	Batteries, pigments, metal coatings, plastics, mining, coal burning, metal alloys, rubber, dye, steel production, plumbing, wiring.
Lead <sup>5</sup>	Batteries, pigments, metal coatings, plastics, mining, coal burning, metal alloys, rubber, dye, steel production, solder.
Zinc <sup>5</sup>	Batteries, pigments, metal coatings, plastics, mining, coal burning, metal alloys, rubber, dye, steel production, roofing.
Mercury <sup>2,3,4,5</sup>	Batteries, air emissions, chloroalkali plants, paints.
Tributyl tin <sup>3,4</sup>	Antifouling paint.
<b>Current-use herbicides<sup>6</sup></b>	
atrazine	Agricultural use on corn and soybeans.
cyanazine	Agricultural use on corn and soybeans.
Alachlor	Agricultural use on corn and soybeans.
metolachlor	Agricultural use on corn and soybeans.
<b>Other contaminants</b>	
Total phosphorus	Fertilizers and sewage.
Nitrate-nitrogen	Fertilizers and sewage.
Fecal coliform bacteria	Sewage and animal waste.
Escherichia coli	Sewage and animal waste.
Suspended sediments	Soil erosion.

<sup>1</sup>Lake Erie Chemicals of Concern identified by Lake Erie LaMP in 1994

<sup>2</sup>Great Lakes Initiative Bioaccumulative Chemical of Concern (BCC)

<sup>3</sup>Canada-Ontario Agreement (COA) tier 1 or tier 2 contaminant

<sup>4</sup>Binational Toxics Strategy contaminant

<sup>5</sup>Contaminant identified by the IJC or in Remedial Action Plans

<sup>6</sup>USEPA

<sup>7</sup>Canadian Toxic Substance Management Policy - Track 1

## Key Issues Affecting Lake Erie Today

There are a number of key issues that are greatly affecting the Lake Erie ecosystem today, or are cause for concern within the basin. These include, but are not limited to: loss of wetlands, changes in fish populations, presence of exotic species, PCBs, phosphorus and effects of certain chemicals on human health. These issues have been selected because of their significance which ranges from their ability to cause environmental damage, socio-economic impacts or potential health risks, their ability to affect the economy and/or ecology of the basin and/or they have become topics of concern among citizens. These issues have been chosen prior to completion of the Lake Erie LaMP's assessment process and therefore are not based solely on LaMP findings. The future significance of some of these issues to the LaMP is currently unknown, however, based on our current understanding it is assumed that they are of considerable importance and have seriously affected or will affect the Lake Erie ecosystem.

### Loss of Wetlands

Wetlands are defined as land that is saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, hydrophytic (water loving) vegetation and various kinds of biological activity adapted to wet environments (SOLEC '96 - Coastal Wetlands, 1997). They occupy the transitional position between terrestrial and aquatic environments.

Wetlands may be classified as coastal or inland. Coastal wetlands differ from inland wetlands in that they are shaped by large lake processes such as waves, wind tides (seiches) and seasonal and long term fluctuations in waters levels. Water level fluctuations provide the means to rejuvenate wetland plant communities in coastal environments. For inland wetlands the aging process (senescence) dominates and wetlands evolve from open ponds to densely vegetated marshes to dry land over time.

Coastal wetlands may contain many different wetland types including: marshes, swamps, wet meadows and fens, shallow open water, bogs and flats. For Lake Erie, marshes and wooded swamps are the most common.

### Long Point, Ontario

The United Nations Educational, Scientific and Cultural Organization (UNESCO) designated Long Point, Ontario, a Lake Erie wetland, as a World Biosphere Reserve. Long Point was designated as an example of Great Lakes coastal habitat. It provides a unique blend of habitats - long uninterrupted beaches, undisturbed sand dunes, grassy ridges, wet meadows, woodlands, marshes and ponds. The area is attractive to a wide range of interests including: government, commercial, residential, agricultural, recreational and scientific.



Wetlands are ecologically, economically and socially important to the overall health of the Lake Erie ecosystem. They can sustain as much life as a tropical rain forest. Wetlands provide habitat to a diverse number of plants and animals, many of which are not found elsewhere. The Pied-Billed Grebe and Virginia Rail, for example, are completely dependent on wetland habitats. For migratory birds, such as ducks and geese, wetlands are the most important habitat in their migratory cycle as they provide food, resting places and seasonal habitat. The marshes of Lake Erie and Lake St. Clair form the most extensive area of high quality habitat for migratory waterfowl in Ontario south of James Bay. Wetland habitats make a significant contribution to sustaining a productive fishery, preventing damage from erosion and flooding and aiding in the control of point source and non-point source pollution by serving as biological filters. Wetlands also support many recreational activities including hunting, fishing and bird-watching.

Over the years, human activity in the Lake Erie basin has greatly diminished the amount of wetlands. Wetlands have been destroyed or degraded for the purpose of land development, including agriculture,

new harbour facilities and urban expansion, as well as by dredging for commercial and recreational water traffic. The impacts of human activities on wetland losses may be direct or indirect. Infilling or dredging of a wetland results in the loss of the wetland. One consequence is the loss of this habitat for migratory birds. Of equal importance are indirect impacts such as the interruption of water or sediment supply to wetlands by changing landuse and drainage characteristics. The total effect of these actions, which may have occurred some distance away from the impacted wetlands, may be delayed and make it more difficult to establish a cause and effect relationship.

Presently, there are 31 coastal wetland areas on the Canadian side of the Lake Erie basin which cover about 18,885 hectares (ha). On the US side of the basin, 87 coastal wetlands remain with a total coverage of 7,937 ha (SOLEC '96 - Coastal Wetlands, 1997). Prior to urbanization in the basin, one wetland area between Vermillion, Ohio and the mouth of the Detroit River and extending up the valley of the Maumee River covered 122,000 ha. This was part of the Black Swamp, a vast wetland complex which covered an area about 400,000 ha. Only remnants of this wetland remains today. Due to wetland protection laws and because there are fewer areas left which could be filled in, the rate at which wetlands have been filled in has decreased over the last few years. However, total wetland area continues to decrease.

Another concern is the diminishing quality of the remaining wetlands. The remaining wetlands are under tremendous strain. Disruptions in natural ecological processes such as water level variations or the invasion of exotic species (including carp and purple loosestrife) can cause wetlands to lose their resiliency, complexity and connectivity and therefore their ability to support sensitive species. For example, when water levels are not allowed to fluctuate, wetlands can become dominated by a single tolerant plant species, such as the cattail. This loss of plant diversity, through the total loss of wetlands and diminished quality of the remaining wetlands, can cause a chain reaction resulting in a decrease in animal diversity by reducing the variety of food and habitat available.

One response to the disappearance of coastal wetlands has been to *dike* the wetlands that do remain. Diking allows marsh managers to isolate the wetland, to some extent, from stresses such as carp

and excessive wave action, thereby supporting a healthier wetland community. Diked wetlands also include water level control structures so that levels can be managed to optimize development of the vegetation types that support a wide diversity of wetland wildlife, including many waterfowl species.

However, most conventional diking methods prohibit hydrological interchange, which is important to nutrient cycling and *food web* dynamics in the lake, and hamper fish movement in and out of the coastal wetland. For many fish species these are critical spawning, nursery and foraging habitats from which they are presently excluded. New approaches are being investigated to address concerns regarding the utilization of these wetlands as valuable habitats for both fish and wildlife. A pilot project at Metzger Marsh will evaluate these concerns (see sidebox). Diked wetlands and their value as fish and wildlife habitat are currently being assessed by the Beneficial Use Impairment Subcommittee.

#### Metzger Marsh, Ohio

The Metzger Marsh Restoration Project is a cooperative initiative between the Ohio Division of Wildlife, the US Fish and Wildlife Service and other partners. This project has been designed to integrate the benefits of diked wetlands (vegetation establishment and wildlife use) with the benefits of open wetlands (hydrological interchange / fish access). The project consists largely of rebuilding 7,700 feet of coastal wetlands dike. Metzger Marsh previously was a severely degraded wetland consisting of a shallow turbid bay with less than 12.5 ha. of emergent vegetation. Since the restoration of more than 375 ha. of emergent marsh, it is now being heavily utilized by migrating waterfowl and many other species of wetland wildlife. In Spring 1999 the marsh will be open to lake exchange and follow-up monitoring will shed some light on the issue of diking.



## Changes in Fish Populations

The commercial fishery in Lake Erie is the most prosperous of the Great Lakes fisheries. In Canada, Lake Erie represents nearly two-thirds of the total Great Lakes harvest. In 1996, approximately 1288 tonnes (28 million pounds), with a landed value of about \$31 million (CDN), was caught commercially in the Canadian waters of Lake Erie (OMNR, 1997). However, these numbers represent a recent decline in the fishery. There is a very small commercial fishery on the U.S. side of Lake Erie. Lake Erie is also acclaimed for its sport fishery. Fishing for walleye, perch and a number of other species, draws large numbers of sport anglers to the basin each year.

There are three principal environmental conditions in Lake Erie that determine which fish species may dominate, which ones may do well, which are capable of survival and which ones are not capable of survival. These conditions, in order of relative importance, are temperature, *trophic status* and habitat. Human activity in the basin has changed these environmental characteristics. Man has affected the fish community directly through the long term commercial and sport fishery, as well as industrial uses of the lake which cause fish mortality. Indirectly man has had an effect through the accidental or deliberate introduction of exotic species. There were changes to all the above conditions in the lake prior to the 1900s. The trends due to these changes are outlined below.



**Pre-1900** Period of settlement with extensive logging, wetland draining/filling and land clearing. Valuable fisheries for whitefish, walleye,

blue pike and sturgeon; but whitefish, sturgeon and lake trout decline before the end of the century. Considerable change in fish habitat due to dams, agriculture and forestry. Construction of canals provide connections to the Ohio and Hudson Rivers. Gizzard shad from the Ohio River may have colonized Lake Erie. Introduction of carp.



**1900-1930** Highest intensity fishery results in decline of herring to minor status. Walleye increase. Beginning

of eutrophication (due to increased phosphorus loadings to the lake).



**1930-1972** Gross eutrophication of Lake Erie. Changes in the Welland Canal allow lamprey and alewife access to Lake Erie. Smelt arrive (1935) from upstream. Decline of blue pike (later declared extinct), walleye and further decline of whitefish. Boom in yellow perch. Boom and decline of smelt. Colonization by white perch.



**1972-1986** GLWQA leads to reductions in phosphorus loads. Recovery in whitefish and walleye. Recovery in central basin smelt stocks,

followed by decline under *predation* pressure of walleye and trawl fishery. Perch decline from earlier peak to lower plateau. White perch increase in presence of large walleye stock. Spiny water flea (*Bythotrephes*) found in 1984.



**1986-Present** Zebra mussels invade and change food web. Lakewide reduction in yellow perch, reductions in eastern stocks of white

perch, freshwater drum and smelt. *Forage fish* reductions and oscillations forecast effects on predator stocks. Walleye foraging behaviour constrained by water clarity, potentially limiting growth and ultimately production and population fitness.

The questions raised, in light of all these recent changes include: what is the current status of the major species of Lake Erie and do each of the three basins within Lake Erie need to be considered separately, what long term effects will exotic species have on the fish community, where is the fish community going and what will the fish community look like in the future?

Five fish management agencies, provincial and state, share responsibilities for the Lake Erie fisheries and are coordinated by the Lake Erie Committee of the Great Lakes Fishery Commission. All of these agencies are working in support of the LaMP as it relates to the fishery.

## Exotics

Exotics are any species with origins outside of the Lake Erie or Great Lakes basin. Many species present in the Lake Erie basin are exotics that have become prevalent over the years and have not had a major

disruptive impact on the ecosystem. However, there are a few species of exotics that cause significant environmental, socio-economic or public health concerns.

In some cases, the severity and impact of certain exotic species are not widely understood. However, the introduction of exotics is of concern because natural mechanisms to keep their numbers in balance, such as predation, parasites or *pathogens*, may not exist. When population growth is not readily limited by predators, habitat or food supply populations grow at exponential rates and dominate the system, to the detriment of existing species. The domination of the new species will generally stabilize at some point but the ecosystem will have been altered.

There are many ways for exotic species to be introduced into new ecosystems. These include: intentional introductions, airborne particles, water used for food processing, the bait industry and the exotic pet and aquarium trades. In the Great Lakes, however, the most significant way that exotics are introduced is probably through the ballast water on board transoceanic ships, which is pumped in and out of holds of ships as required to provide weight and stability. Organisms can live for periods of time in the ballast hold and when the ballast water is emptied into the lake, the new organism is introduced. There are presently regulations and voluntary guidelines in place to reduce the number of accidental introductions made through this vector, however the success rate of these regulations is not adequate to prevent all potential introductions.

Within the Lake Erie basin a number of exotic species have recently been introduced which are causing concern. The extent of damage done, or that may be done, by these species can be extensive. The following outlines some of the exotics of concern at this time in the Lake Erie basin.

### Dreissenid Mussels (zebra mussels and quagga mussels)

Zebra mussels first entered the western basin of Lake Erie in 1987 and have spread to all five of the Great Lakes. Quagga mussels were found in the eastern basin of Lake Erie in autumn of 1988. It took several years for the populations to expand and the effects were not observed until 1990.

Dreissenids have great potential to spread and colonize new areas due to their high reproductive rate and broad habitat preference. Zebra mussels will

attach to most hard surfaces, including clam shells and are responsible for nearly eliminating native clams from Lake Erie. Quagga mussels can live on softer substrates as well as hard surfaces. On hard substrates they form dense colonies often several shells thick - in a few instances counts of more than a million mussels per square metre have been recorded. The U.S. Fish and Wildlife Service has assessed the potential economic impact of dreissenids, for the Great Lakes region at about \$5 billion (U.S.) over the next ten years. The financial burden is being felt by American and Canadian factories, water suppliers, power plants, ships and fisheries due to colonization by dreissenids of heat exchangers, valves and small diameter piping (Nonindigenous Aquatic Nuisance Prevention and Control Act, 1996).



Zebra Mussels

These mussels have also had an impact on the water quality of Lake Erie. Due to their highly efficient ability to filter suspended particles from the water, water clarity in Lake Erie has increased. While this may sound positive, the drawbacks include the removal of phytoplankton and zooplankton that form the base of the pelagic *food chain*. The net effect of zebra mussels, and their relative the quagga mussel, has been to shift open water food chain dynamics from the upper levels of the water column, where it is useful to walleye and perch, to the bottom sediments where whitefish, burbot, sturgeon and other benthic species feed. The majority of the shift in energy has produced tremendous numbers of ze-

bra mussels instead of fish. These changes in the food supply will greatly affect the fish and wildlife community within the Lake Erie basin.

In summary, several factors have been important in the large and far reaching effects of dreissenid mussels on the Lake Erie ecosystem: their extremely quick reproductive rate, high rate of dispersal, lack of effective competitors or predator and the extensive area of suitable habitat. The dreissenid invasion has had impacts on water quality (including the potential for resuspension of contaminants from sediment), water clarity and the flow of energy through the Lake Erie food web.

### Other Exotic Species of Concern

Other exotics of concern to the integrity of the Lake Erie ecosystem include: round goby, spiny water flea (*Bythotrephes*), Phragmites, sea lamprey, Eurasian watermilfoil, purple loosestrife and others. The impacts of some of these exotics (such as lamprey) are known, however, the impact of more recent invaders is not as well known and is being investigated.

### Polychlorinated Biphenyls (PCBs)

PCBs are synthetic chemical compounds consisting of chlorine, carbon and hydrogen. They are relatively fire-resistant, very stable, do not conduct electricity and have low volatility at normal temperatures, making them very desirable for a wide range of industrial and consumer usages. However, these same properties make them resistant to chemical and biological breakdown through natural processes.

Commercial use of PCBs began in 1929. It was not until 1971 that the manufacturer recognized the problems with the toxicity of the product and voluntarily initiated a program to phase out the usage. Legislation prohibiting the production of PCBs came into effect in 1979, but by this time about 700,000 tons had been produced. Due to their persistent and bioaccumulative nature they are still a concern at certain locations in the Lake Erie basin. Monitoring indicates that PCBs continue to exist in the soils and sediment.

PCBs are a concern because they are soluble in an organic medium and can be stored and concentrated in the fat tissue of organisms. PCBs are passed along at higher and higher concentrations through the food chain, from aquatic plants to plankton (phyto, zoo), fish, fish-eating birds and other animals and eventu-

ally to humans who consume these fish and animals. Most of the fish consumption advisories posted within the basin are due to the presence of PCBs.

Effects can occur at the molecular level (e.g. enzymes, vitamins), the cellular level (e.g. goiters) and physiological level (e.g. liver function). Effects include: deformities in fish-eating birds (including crossed bills, club feet, extra digits and eye and skeletal deformities), reduced reproductive rates in bald eagles and contamination in herring gull eggs and top predator fish eggs.

*Weight of evidence* research indicates that human populations continue to be exposed to PCBs and health consequences may be associated with these exposures. Even though PCBs are declining in the environment, health concerns are still warranted. The main route of human exposure to PCBs is through the ingestion of food. A small amount of exposure is through air (ambient and indoor) and even smaller amounts through drinking water, soil and house dust. People who consume large quantities of locally caught fish, especially in areas where advisories have been issued, are likely to be exposed to higher levels of certain contaminants, including PCBs (Toxic Chemicals Synopsys, 1991).

The concern around PCB and fish consumption stems from people eating more than average amounts of Great Lakes fish and wildlife. Consumption of most Lake Erie fish is acceptable, within the guidelines published by various government agencies. Subpopulations at risk for higher than average exposures include Aboriginal peoples, anglers and hunters and their families, and subsistence groups that consume large amounts of fish and game. Most guidelines also recommend that children and women of child-bearing age limit their intake of certain Great Lakes fish as a precautionary measure. The health effects stated below are not believed to be caused by consuming Great Lakes fish within the government guidelines.



Deformed Cormorant

Possible human health effects (Johnson et al.,1997) include:

1. Reproductive function may be disrupted by exposure to PCBs;
2. Neurobehavioural and developmental deficits occur in newborns and continue through school-age children from in utero exposure to PCBs;
3. Other systemic effects, e.g., self-reported liver disease and diabetes may be associated with elevated serum levels of PCBs; and
4. Increased cancer risks are associated with PCB exposure, for example, liver and breast cancers.

To date the following preliminary beneficial use impairments have been identified in Lake Erie due to PCBs: the majority of fish consumption advisories, wildlife consumption advisories for snapping turtles and waterfowl in New York State, a human contact advisory in the Ottawa River in Ohio, bird or animal deformities or reproduction problems particularly in mink, bald eagles, reptiles and amphibians and restrictions on dredging activities.

Although PCB use has generally been banned or tightly regulated, PCBs still remain in industrial and commercial use in certain circumstances, such as transformers. PCBs previously released into the environment are located in landfills and sediments, and further dispersed in the air and water. Over half of the PCBs manufactured were disposed of - not necessarily destroyed - prior to the enactment of specified regulations. As a result, large amounts of PCBs have been released into the environment. Consequently, pathways exist for PCB exposure and they are still considered a threat to human health and the environment.

## Phosphorus

In Lake Erie, phosphorus is primarily found in two different forms. Soluble phosphorus is dissolved in the water and can be absorbed by phytoplankton. Through photosynthesis it is incorporated into algae, the basis of the aquatic food chain. Phosphorus can also be adsorbed or attached to small soil particles within the water, which in turn slowly settle to the bottom. The phosphorus attached to suspended particles also contributes to high levels of algae growth. The water is generally murky if it contains high phosphorus levels, allowing little light penetration. In this situation, phosphorus particles tend to end up tightly bound in the bottom sediments, and are only useful to leafy rooted plants, which can

directly absorb it. However, if the oxygen disappears from the layer of water just above the sediment (a condition known as *anoxia*), phosphorus can become released from the sediment and again become soluble phosphorus.

Phosphorus is very important in the Lake Erie system because it is the nutrient that controls the amount and type of algae (or phytoplankton) that will grow suspended in the water. Less phosphorus results in smaller quantities of algae. Fewer algae of desirable, edible types result in a loss of food available to other aquatic organisms in the food chain.

As stated earlier in the Lake Erie Successes section of this report, phosphorus became a concern during the 1960s when excessively high levels were present. Steps taken to alleviate the high levels targeted the three main sources: (1) sewage treatment plants were limited to 1mg of phosphorus per litre of treated water released, (2) better agricultural practices were undertaken in the basin to reduce the amount of phosphorus found in the runoff, and (3) the deliberate use of phosphates in detergent and cleaning products was restricted. In the 1978 amendments to the GLWQA, an annual target loading of 11,000 metric tonnes was set, with the confidence that this would alleviate the eutrophic conditions, the excessive algal growth and the associated oxygen depletion in the central basin.

Phosphorus loads and levels have again become a concern in Lake Erie. The issue with phosphorus today is quite different than it was in the 1960s. The current issue relates to the lack of scientific understanding around the utilization of phosphorus presently in the Lake Erie system, and in particular the role that zebra mussels are playing in altering the phosphorus balance. When the annual target load of 11,000 metric tonnes was set in 1978, the Lake Erie system was very different than it is today. Zebra mussels, which have caused major alterations, were not yet present in the lake. The presence of zebra mussels, along with other changes, have created uncertainty about how the Lake Erie food web is working, where food resources are being routed and if they are available to other components of the food chain.

Lake St. Clair is an example of an ecosystem invaded by zebra mussels. If Lake Erie responds in a similar manner, it is expected that over time there will be two significant shifts in the aquatic community: (1) species moving away from the upper water layers



towards the bottom, and (2) an increasing composition of species that prefer rooted vegetation. Such changes are expected in regions adjacent to river mouths and possibly the western basin. Species which can adapt will thrive, as can be seen by smallmouth bass and freshwater drum that are thriving in areas rich in mussels. Other species will decline, as observed in the offshore decline of perch. Despite the 60 percent reduction in phosphorus loading and the mussel invasion, total fish population in the lake has largely been maintained, although species composition has changed. It is difficult to isolate the extent to which the present water quality in Lake Erie is driven by zebra mussels, because many aspects of the water quality are also consistent with reasonable expectations of the phosphorus management strategy agreed to in the GLWQA.

### Dr. Seuss Notes Cleanup of Lake Erie

Dr. Seuss, the author and illustrator of children's tales, in his 1971 book *The Lorax* has the title character commenting on the mythical Humming-Fish:

"So I'm sending them off.  
Oh, their future is dreary.  
They'll walk on their fins and get woefully  
weary.  
In search of some water that isn't so meary.  
I hear things are just as bad in Lake Erie."

In the 1991 reprint of the book (Random House, New York), the last line has been deleted!!

One of the major uncertainties is how the Lake Erie fishery is responding to the changes. The fishery has become very unpredictable, with its composition changing every year. While phosphorus is a major stress, there are additional stresses on the fish community besides phosphorus including: the introduction of exotics including smelt, alewife and white perch, cold weather leading to poor reproduction and fish harvesting activities. Increased water clarity during low phosphorus periods, generally in the summer, has had an impact on the fish community. Fishermen have noted that low *turbidity* in the summer means that fish such as walleye are only found in deep waters, as they are trying to avoid sunlight. These fish tend to move towards the oxygen-reduced, deeper waters of the central basin in order to strike a balance between oxygen levels, temperature, avail-

ability of smaller fish to eat and their need to avoid the bright light.

Much of the above discussion has focused on the fishery in the open waters of the lake. It is also important to consider other aspects of the lake when investigating the changes due to the zebra mussel invasion and changing nutrient regimes. In some nearshore environments and tributaries there continues to be concern over too much phosphorus. An overabundance of *Cladophora* continues to foul beaches in some areas and many tributaries remain nutrient enriched. On the other hand, increased water clarity has increased other uses of the lake including the creation of a vibrant scuba diving industry as well as benefiting other recreational uses such as swimming and other water sports.



Algae on a Beach

Given the understanding that the Lake Erie ecosystem is complex, the following key questions need to be answered: is there enough information available to determine the pros and cons or risks and trade-offs of future management options and actions? It is this uncertainty and lack of understanding that led the Management Committee to draw together a group of "experts", knowledgeable on both phosphorus dynamics and the ecology of Lake Erie. The "experts" are attempting to determine how the system is presently working and how it may work in the future.

### Human Health

Human health impacts in the Lake Erie basin are of obvious interest to the citizens living there. For this reason, it is necessary to clearly identify which human health issues fall within the *scope of the LaMP*.

The GLWQA requires the LaMP to assess whether 14 beneficial use impairments are occurring in Lake Erie. The LaMP addresses human health issues that

are related to these beneficial uses. Seven of these beneficial uses target human health, either directly or indirectly. They are:

- Restrictions on fish and wildlife consumption;
- Tainting of fish and wildlife flavor;
- Restrictions on drinking water consumption, or taste and odour problems;
- Beach closings;
- Fish tumors or other deformities;
- Bird or animal deformities or reproductive problems; and
- Degradation of aesthetics

The concerns about long-term effects of low-level exposures to environmental contaminants in humans highlights the importance of the well-documented adverse effects already seen in other parts of the ecosystem. Health Canada used a weight of evidence approach to assess the human health effects from exposure to environmental contaminants. Although most of these studies focus on the Great Lakes basin they do not specifically address Lake Erie.

Human health effects resulting from exposure to environmental contaminants are well documented. These effects are not exclusive to Lake Erie, or even the Great Lakes basin, but can be seen globally. Reproductive studies have shown that chemical contaminants (including PCBs) may cause adverse fetal and neonatal effects such as low birth weight and reduced gestational age. Developmental, behavioral and neurological effects, (e.g. early developmental deficits in motor function of newborns and infants), are among the more consistent findings.

Exposure to drinking water chlorination by-products, such as trihalomethanes, through long-term consumption of chlorinated surface water is associated with an increased risk of bladder cancer and is suggestive of an increased risk of colon cancer (Reidel et al., 1997).

In Lake Erie certain microorganisms are measured, and serve as general indicators of recreational water quality. These microorganisms may cause illness and consequently bodily contacts should be avoided. For example, elevated levels of *E. coli* (or fecal coliform bacteria) are indicative of fecal contamination and the possible presence of enteric (intestinal) pathogens. *E. coli* and/or fecal coliforms are monitored on a regular basis by various health agencies around the basin and are included in the scope of the LaMP. Elevated levels of these microorganisms usually re-

sult in beach closings. However, there are many other microorganisms which are not monitored on a regular basis. These include pathogens of a bacterial nature (e.g. *Staphylococcus*, *Pseudomonas*), or a viral nature (e.g. Hepatitis A, Norwalk virus) or other types (e.g. *Cryptosporidium*, *Giardia*).

In order to meet the GLWQA requirements and Lake Erie basin human health concerns the Lake Erie LaMP is in the process of compiling and assessing relevant human health studies and databases, specific to Lake Erie. At the same time, human health agencies at the federal, provincial, state and local levels are being contacted and recruited to the Lake Erie LaMP process in order to help develop a plan for human health issues in the LaMP.

### Human Health Websites

For more information check out these web pages:

Health Canada:

[www.hc-sc.gc.ca](http://www.hc-sc.gc.ca)

HC Great Lakes Health Effects Program:

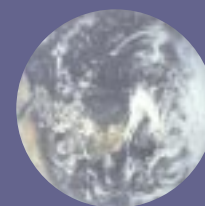
[www.hc-sc.gc.ca/ehp/ehd/bch/bioregional/glhhep.htm](http://www.hc-sc.gc.ca/ehp/ehd/bch/bioregional/glhhep.htm)

U.S. EPA Great Lakes Human Health Page:

[www.epa.gov/glnpo/health.html](http://www.epa.gov/glnpo/health.html)

ATSDR Great Lakes Human Health Effects Research Program:

[atsdr1.atsdr.cdc.gov:8080/grtlakes.html](http://atsdr1.atsdr.cdc.gov:8080/grtlakes.html)



## Next Steps

By the year 2000 the LaMP intends to:

- Develop and adopt ecosystem objectives to target specific goals; included in this exercise is continued support to the development of the Lake Erie Model (see page 10), as well as validation of the model by the scientific community and through public consultation;
- Complete the beneficial use impairment assessments and, to the extent possible, determine the causes of those impairments;
- Obtain additional information regarding jurisdictional databases on pollutant sources and loadings and use this information to recommend options;
- Identify additional Lake Erie critical pollutants including potential sources and preliminary load calculations;
- Continue to support research investigating Lake Erie food web issues and changes. This includes, but is not limited to, nutrient and contaminant cycling in the lake, changes to the structure, function and composition of the Lake Erie web, phosphorus loads and zebra mussels.
- Determine which human health issues are appropriate for the Lake Erie LaMP to address, recruit the appropriate personnel and develop a targeted plan to address the issues.
- Expand and implement the public involvement strategy; and
- Complete a cumulative Problem Definition document.

The members and agencies of the Lake Erie LaMP will be developing and implementing action plans focused on restoring beneficial uses and achieving ecosystem objectives over the next three to five years. The LaMP process will continue to identify emerging issues of concern and determine appropriate actions. These actions will require a coordinated binational response across agencies and jurisdictions.



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*Summary from Federal Wildlife Laws Handbook "NONINDIGENOUS AQUATIC NUISANCE PREVENTION AND CONTROL ACT OF 1990"* 16 U.S.C. 4701-4751, November 29, 1990, as amended 1991, 1992 and 1996. Overview.

Ontario Ministry of Natural Resources, Fish and Wildlife Branch. *Lake Erie Fisheries Report 1996*. Queen's Printer for Ontario: 1-55p. March 24, 1997.

Reidel, D., N. Tremblay and E. Tompkins. (ed) *State of Knowledge Report on Environmental Contaminants and Human Health in the Great Lakes Basin*. Great Lakes Health Effect Program, Environmental Health Division, Health Canada. 1997

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*Preventing and Controlling Soil Erosion and Sedimentation*. Great Lakes Commission. April, 1994.

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## Glossary

### algae:

Simple rootless plants, collectively called phytoplankton, that grow in sunlit waters in relative proportion to the amounts of light and nutrients available. They are food for fish and small aquatic animals. (Glossary of Great Lakes Ecosystem Management Terms - Excerpted from the 1992 EPA Report to Congress on the Great Lakes Ecosystem)

### anoxia:

Absence of oxygen necessary for sustaining most life. In aquatic ecosystems, this refers to the absence of dissolved oxygen in water. (*The Great Lakes - An Atlas and Resource Book*), generally through the decomposition of organic matter.

### Area of Concern (AOC):

A geographic area that fails to meet the General or Specific Objective of the GLWQA where such failure has caused or is likely to cause impairment of beneficial use or of the area's ability to support aquatic life. (Annex 2 - GLWQA)

### benthos:

Organisms living on the bottom of bodies of water (Demayo and Watt 1993). (The State of Canada's Environment Infobase Website)

### bioaccumulative:

General term describing a process by which chemical substances are ingested and retained by organisms, either from the environment directly or through consumption of food containing the chemicals (Government of Canada 1991). (The State of Canada's Environment Infobase Website)

**Cladophora:**

A submerged filamentous green algae, which very few animals feed on directly, which has a very unpleasant odour associated with it. (*Natural Ecosystems* - W.B. Clapman, Jr.)

**coliform bacteria:**

Group of bacteria predominantly inhabiting the intestinal tracts of humans and other warm-blooded animals, but also occasionally found elsewhere (Demayo and Watt 1993). The total coliform group is commonly used as an indicator of the sanitary quality of water, because ingestion of these bacteria in drinking water can result in diseases such as cholera. (The State of Canada's Environment Infobase Website)

**DDT (dichlorodiphenyltrichloroethane):**

An insecticide which was commonly used after World War II and is now banned in the US and Canada. DDT and its metabolites are toxic pollutants with long-term persistence in soil and water. They concentrate in the fat of wildlife and humans and may disrupt the human body's chemical system of hormones and enzymes. DDT caused eggshell thinning in a number of fish-eating birds and is associated with the mortality of embryos and sterility in wildlife, especially birds. DDT still enters the Great Lakes, probably from a number of sources including airborne transport from other countries, leakage from dumps, and the illegal use of old stocks. (Minnesota Sea Grant Glossary Website)

**dike:**

A structure, usually made of earth/rock, built to control water levels. (Webster's Dictionary)

**dredging:**

A process used to clean, deepen or widen an area by removing sand or mud, especially from a body of water. (Webster's Dictionary)

**E. coli:**

See coliform bacteria.

**ecosystem:**

A biotic community and its abiotic environment, considered together as a unit. Ecosystems are characterized by a flow of energy that leads to trophic structure and material cycling. (*State of the Great Lakes 1997*)

**ecosystem approach:**

A comprehensive and holistic approach to understanding and anticipating ecological change, assessing the full range of consequences, and developing appropriate responses. It recognizes the complexity of ecosystems and the interconnections among component parts. Among other things, the ecosystem approach recognizes that humans are an integral part of ecosystems and that human social and economic systems constantly interact with other physical and biological parts of the system. Within the context of sustainability, all interactions must be considered in an integrated fashion. (The State of Canada's Environment Infobase Website)

**ecosystem objectives:**

A statement of goals for the future desired state of an ecosystem, including the waters, watersheds, flora and fauna and the people living within the basin. (LaMP Progress Report - Draft - May 1997)

**Environmental Justice:**

The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including racial, ethnic, or socioeconomic groups, should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies. (USEPA)

**erosion:**

The wearing away and transportation of soils, rocks and dissolved minerals from the land surface or along shorelines by rainfall, running water or wave or current action. (*The Great Lakes - An Atlas and Resource Book*)

**eutrophication:**

The process of fertilization that causes high productivity and biomass in an aquatic ecosystem. Eutrophication can be a natural process or it can be a cultural process accelerated by an increase of nutrient loading to a lake by human activity. (*State of the Great Lakes 1997*)

**exotic species:**

Species not native to an ecosystem and have been either intentionally introduced or have inadvertently infiltrated the system. (*The Great Lakes - An Atlas and Resource Book*)

**fecal coliform:**

See coliform bacteria.

**food chain:**

A food relationship in an ecosystem in which energy and nutrients are transferred through a series of organisms by each stage feeding on the preceding one and providing food for the succeeding stage (adapted from Demayo and Watt 1993). Each stage of a food chain is known as a trophic level. The first trophic level consists of the green plants that can undertake photosynthesis, thereby obtaining their energy from the sun. Members of a chain are interdependent so that a disturbance to one species can disrupt the entire hierarchy. (The State of Canada's Environment Infobase Website)

**food web:**

The complex feeding network occurring within and between food chains in an ecosystem, whereby members of one food chain may belong to one or more other food chains. (The State of Canada's Environment Infobase Website)

**forage fish:**

Fish that eat plankton as a mainstay of their diet and are consumed by other fish higher in the food chain. (*State of the Great Lakes 1997*)

**human health:**

The state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. (World Health Organization)

**lake effect zone:**

The area within the tributary where the water of the lake and the tributary are mixed. (LaMP Progress Report - Draft - May 1997)

**Lake Erie basin:**

Land area that delivers runoff water, sediment and dissolved substances to Lake Erie and its tributaries. (*State of the Great Lakes 1997*)

**loads:**

Total mass of contaminants to a water body or to the land surface over a specified time (e.g., tonnes per year of phosphorus) (adapted from *Upper Great Lakes Connecting Channels Study*, Management Committee 1988). (The State of Canada's Environment Infobase Website)

**nearshore:**

This definition is somewhat ambiguous and different people define it in different ways. On land, the nearshore zone is that area which is affected by the lake - waves, wind, ice, currents, temperature and the rising and falling of lake levels. In water, the nearshore zone consists of areas with water warm enough to support a community of warm water fish and other associated organisms. (*State of the Lakes Ecosystem Conference 1996 Background Paper: Integration Paper 1997*)

**non-point source pollution:**

Sources of pollution in which wastes are not released at one specific identifiable point but from a number of spread out points that are difficult to identify and control, such as surface runoff from precipitation or atmospheric deposits. (*State of the Great Lakes 1997*)

**PAHs (polynuclear aromatic hydrocarbons):**

A class of organic compounds formed through incomplete combustion and that have cancer-producing properties. (*State of the Great Lakes 1997*)

**pathogens:**

Disease causing agents such as bacteria, viruses or parasites. (*The Great Lakes - An Atlas and Resource Book*)

**phytoplankton:**

Collective noun for organisms that drift around in water because they are not capable of swimming against currents in the water (Arms 1990). (The State of Canada's Environment Infobase Website)

**point source pollution:**

A source of pollution that is distinct and identifiable (Environment Canada et al. 1988). Includes smokestacks and outfall pipes from industrial plants and municipal sewage treatment plants. (The State of Canada's Environment Infobase Website)

**predation:**

The act of one animal or bird preying upon another. (Webster's Dictionary)

**productivity:**

The conversion of sunlight and nutrients into plant material through photosynthesis, and the subsequent conversion of this plant material into animal material. (*The Great Lakes - An Atlas and Resource Book*)

**scope of the LaMP:**

Includes the chemical, physical and biological influences on the Lake Erie ecosystem, as well as management practices. The scope of environmental stressors to be addressed by the Lake Erie LaMP will be determined by three methods: language in the GLWQA, other known stressors and a full assessment of the 14 beneficial use impairments. (LaMP Progress Report - Draft - May 1997)

**stewardship:**

Management of natural resources that conserves them for future generations, usually used to distinguish from short-term, utilitarian management objectives (Meffe et al. 1994). (The State of Canada's Environment Infobase Website)

**tributary:**

A river or stream flowing into a larger body of water including other rivers, streams or lakes. (Webster's Dictionary)

**trophic status:**

A measure of the biological productivity in a body of water. Aquatic ecosystems are characterized as oligotrophic (low productivity), mesotrophic (medium productivity) or eutrophic (high productivity). (*The Great Lakes - An Atlas and Resource Book*)

**turbidity:**

Refers to waters that are cloudy or murky as a result of suspended sediment. Water may become turbid as a result of soil erosion, from injections of effluents containing particulate matter or through the churning up of bottom sediments (e.g., via boat traffic in a body of water or by dredging activities). (The State of Canada's Environment Infobase Website)

**watershed:**

Land area that delivers runoff water, sediment and dissolved substances to a major lake or river and its tributaries. (*State of the Great Lakes 1997*)

**weight of evidence approach:**

This approach considers all high-quality scientific data on adverse health effects, derived from studies on a range of wildlife species, from toxicological research on laboratory animals and epidemiological studies. (Health Canada's *State of Knowledge Report*)

**zooplankton:**

Collective noun for organisms that drift around in water because they are not capable of swimming against currents in the water (Arms 1990). (The State of Canada's Environment Infobase Website).

## Appendix 1 - IJC Listing Criteria for Establishing Impairment (IJC, 1989)

Beneficial Use Impairment	IJC Listing Criteria
Restrictions on Fish and Wildlife Consumption	When contaminant levels in fish or wildlife populations exceed current standards, objectives or guidelines, or public health advisories are in effect for human consumption of fish and wildlife.
Tainting of Fish and Wildlife Flavor	When ambient water quality standards, objectives, or guidelines for the anthropogenic substance(s) known to cause tainting are being exceeded or survey results have identified tainting of fish and wildlife flavor.
Degraded Fish and Wildlife Populations	When fish or wildlife management programs have identified degraded fish or wildlife populations. In addition, this use will be considered impaired when relevant, field-validated, fish and wildlife bioassays with appropriate quality assurance/quality controls confirm significant toxicity from water column or sediment contaminants.
Fish Tumors and Other Deformities	When the incidence rates of fish tumors or other deformities exceed rates at unimpacted control sites or when survey data confirm the presence of neoplastic or preneoplastic liver tumors in bullheads or suckers.
Bird or Animal Deformities or Reproductive Problems	When wildlife survey data confirm the presence of deformities (e.g. cross-bill syndrome) or other reproductive problems (e.g. egg-shell thinning) in sentinel wildlife species.
Degradation of Benthos	When the benthic macroinvertebrate community structure significantly diverges from unimpacted control sites of comparable physical and chemical characteristics. In addition, this use will be considered impaired when toxicity (as defined by relevant, field-validated bioassays with appropriate quality assurance/quality controls) of sediment associated contaminants at a site is significantly higher than controls.
Restrictions on Dredging Activities	When contaminants in sediments exceed standards, criteria, or guidelines such that there are restrictions on dredging or disposal activities.
Eutrophication or Undesirable Algae	When there are persistent water quality problems (e.g. dissolved oxygen depletion of bottom waters, nuisance algal blooms or accumulation, decreased water clarity, etc.) attributed to cultural eutrophication.
Restrictions on Drinking Water Consumption or Taste and Odor Problems	When treated drinking water supplies are impacted to the extent that: 1) densities of disease-causing organisms or concentrations of hazardous or toxic chemicals or radioactive substances exceed human health standards, objectives or guidelines; 2) taste and odor problems are present; or 3) treatment needed to make raw water suitable for drinking is beyond the standard treatment used in comparable portions of the Great Lakes which are not degraded (i.e. settling, coagulation, disinfection).
Recreational Water Quality Impairment	When waters, which are commonly used for total-body contact or partial-body contact recreation, exceed standards, objectives, or guidelines for such use.
Degradation of Aesthetics	When any substance in water produces a persistent objectionable deposit, unnatural color or turbidity, or unnatural odor (e.g. oil slick, surface scum).
Added Costs to Agriculture or Industry	When there are additional costs required to treat the water prior to use for agricultural purposes (i.e. including, but not limited to, livestock watering, irrigation and crop-spraying) or industrial purposes (i.e. intended for commercial or industrial applications and noncontact food processing).
Degradation of Phyto/ Zooplankton Populations	When phytoplankton or zooplankton community structure significantly diverges from unimpacted control sites of comparable physical and chemical characteristics. In addition, this use will be considered impaired when relevant, field-validated, phytoplankton or zooplankton bioassays (e.g. Ceriodaphnia; algal fractionation bioassays) with appropriate quality assurance/quality controls confirm toxicity in ambient waters.
Loss of Fish and Wildlife Habitat	When fish or wildlife management goals have not been met as a result of loss of fish or wildlife habitat due to a perturbation in the physical, chemical or biological integrity of the boundary waters, including wetlands.



## Appendix 2 - List of Agencies Who Participated in the Development of the Lake Erie LaMP Status Report

The following Lake Erie LaMP agency partners have participated in the development and concur with the publication of this document:

### Canadian Agencies

- Agriculture and Agri-Food Canada
- Canadian Department of Fisheries and Oceans
- Environment Canada
- Federation of Conservation Authorities of Lake Erie
- Health Canada
- Ontario Ministry of Agriculture, Food and Rural Affairs
- Ontario Ministry of the Environment
- Ontario Ministry of Natural Resources

### U.S. Agencies

- Natural Resources Conservation Service/U.S. Department of Agriculture
- New York State Department of Environmental Conservation
- Ohio Department of Natural Resources
- Ohio Environmental Protection Agency
- Pennsylvania Department of Environmental Protection
- U.S. Environmental Protection Agency
- U.S. Fish and Wildlife Service
- U.S. Geological Survey

### Michigan Department of Environmental Quality concurs with the following reservation:

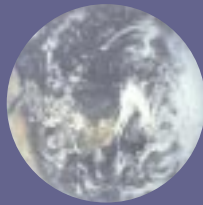
The State of Michigan is generally supportive of this document, but has reservations, particularly in regard to the sections concerning phosphorus control and fisheries. The State of Michigan will continue to aggressively pursue regulatory and voluntary programs to control point and nonpoint sources of pollution. These actions will improve environmental quality, protect and restore habitat, as well as decrease the loads of phosphorus to Lake Erie. The State feels these actions are warranted for the protection of human health and the environment.

**Website addresses listed in glossary:**

The State of Canada's Environment Infobase Website  
[www1.ec.gc.ca/cgi-bin/foliocgi.exe/soerengp/query=\\*/doc/{t9301}?](http://www1.ec.gc.ca/cgi-bin/foliocgi.exe/soerengp/query=*/doc/{t9301}?)

Glossary of Great Lakes Ecosystem Management Terms  
[www.epa.gov/glnpo/ecopage/docs/glossary.html](http://www.epa.gov/glnpo/ecopage/docs/glossary.html)

Minnesota Sea Grant - Glossary of the Great Lakes  
[www.d.umn.edu/seagr/gls.html](http://www.d.umn.edu/seagr/gls.html)

**Photo Credits**

Profile of Lake Erie

**Environment Canada**

Erosion on Lake Erie near Port Burwell

**Environment Canada**

Cladophora on a Stick

**Environment Canada**

Map of Lake Erie with Areas of Concern

**Environment Canada**

Water Sampling

**Environment Canada**

Point Source Water Pollution

**Upper Thames River Conservation Authority**

Long Point, Ontario

**Michelle Fletcher, Upper Thames River Conservation Authority**

Metzger Marsh, Ohio

**Ohio Department of Natural Resources**

Zebra Mussels

**Upper Thames River Conservation Authority**

Deformed Cormorant

**Environment Canada**

Algae on a Beach

**Dr. John Gannon, US Fish & Wildlife Service**

The Maumee River in downtown Toledo

**Michael Saletra**