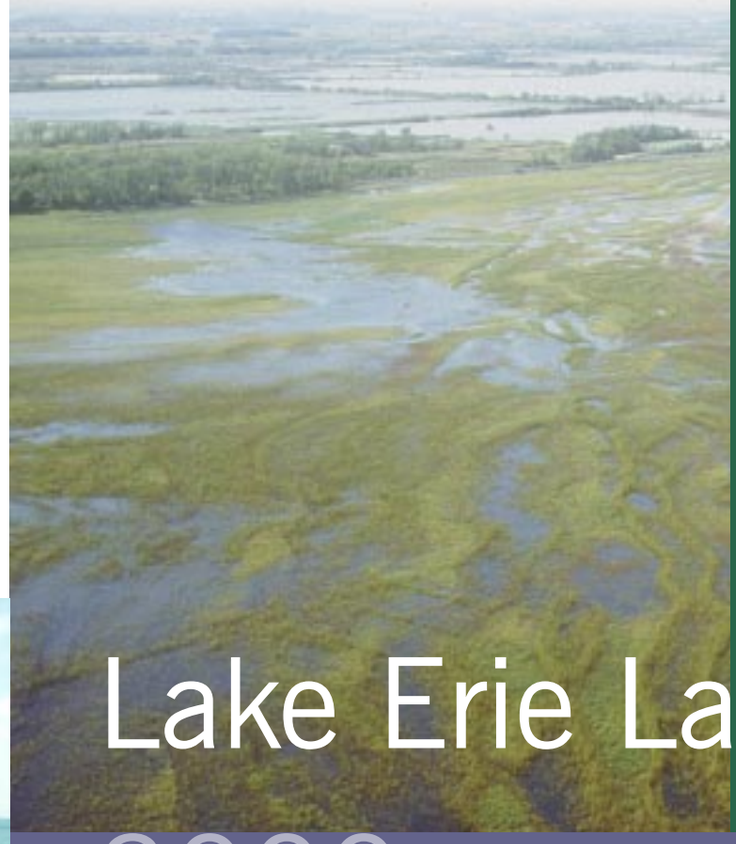
LAKE ERIE

LAKEWIDE
MANAGEMENT
PLAN



# Lake Erie LaMP 2000

# Preface

One of the most significant environmental agreements in the history of the Great Lakes took place with the signing of the Great Lakes Water Quality Agreement of 1978 (GLWQA), between the United States and Canada. This historic agreement committed the U.S. and Canada (the Parties) to address the water quality issues of the Great Lakes in a coordinated, joint fashion. The purpose of the GLWQA is to "restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem."

In the revised GLWQA of 1978, as amended by Protocol signed November 18, 1987, the Parties agreed to develop and implement, in consultation with State and Provincial Governments, Lakewide Management Plans (LaMPs) for lake waters and Remedial Action Plans (RAPs) for Areas of Concern (AOCs). The LaMPs are intended to identify critical pollutants that impair beneficial uses and to develop strategies, recommendations and policy options to restore these beneficial uses. Moreover, the Specific Objectives Supplement to Annex 1 of the GLWQA requires the development of ecosystem objectives for the lakes as the state of knowledge permits. Annex 2 further indicates that the RAPs and LaMPS "shall embody a systematic and comprehensive ecosystem approach to restoring and protecting beneficial uses...they are to serve as an important step toward virtual elimination of persistent toxic substances..."

The Great Lakes Water Quality Agreement specifies that the LaMPs are to be completed in four stages. These stages are: 1) when problem definition has been completed; 2) when the schedule of load reductions has been determined; 3) when remedial measures are selected; and 4) when monitoring indicates that the contribution of the critical pollutants to impairment of beneficial uses has been eliminated. These stage descriptions suggest that the LaMPs are to focus solely on the impact of critical pollutants to the lakes. However, the group of government agencies designing the LaMPs felt it was also an opportunity to address other equally important issues in the lake basins. Therefore, the LaMPs go beyond the requirement of a LaMP for critical pollutants, and use an ecosystem approach, integrating environmental protection and natural resource management.



The LaMP process has proven to be a resource intensive effort and has taken much longer than expected. As a result, the public has had to wait years for a document to review. In the interest of advancing the rehabilitation of the Great Lakes, and getting more information out to the public in a timely manner, the Binational Executive Committee (BEC) passed a resolution in 1999 to accelerate the LaMP effort (BEC, 1999). By accelerate, it was meant that there should be an emphasis on taking action and adopting a streamlined LaMP review and approval process. The LaMPs should treat problem identification, selection of remedial and regulatory measures, and implementation as a concurrent, integrated process rather than a sequential one.

The BEC recommended that a LaMP be produced for each lake by April 2000, with updates every two years thereafter. Furthermore, BEC suggested that the LaMPs be based on the current body of knowledge and state what remedial actions can be implemented now. Consistent with the BEC resolution, LaMP 2000 contains appropriate funded and proposed (non-funded) actions for restoration and protection to bring about actual improvement in the ecosystem. Actions include commitments by the Parties, governments and regulatory programs, as well as suggested voluntary actions that could be taken by non-governmental partners. LaMP 2002 will report on the success of those actions, as well as identify additional actions needed to achieve established goals and ecosystem objectives.

The BEC also endorsed application of the concept of adaptive management to the LaMP process. The LaMPs employ a dynamic process with iterative elements, such as periodic reporting. Adaptive management allows the process to change and build upon lessons learned, successes, new information, and public input. The LaMP will adjust over

time to address the most pertinent issues facing the lake ecosystems.

Some sections of the LaMP 2000 document and the background reports used to produce them have undergone extensive review by the LaMP agencies and the public. Others have not. Some sections are incomplete and identify data gaps and next steps for LaMP 2002. The LaMP 2000 should be viewed as a working document of the dynamic LaMP process. The LaMP 2000 is presented in a loose-leaf format with general tabbed sections that can be inserted into a three-ring binder. This format will allow easy updates, additions of new material and removal of outdated information. The LaMPs for Lake Erie, Lake Michigan and Lake Superior have common chapters, but differ in format and amount of detail. With the help of the many partners and the public, we will be able to take the best qualities from each and design LaMPs for 2002 that are more concise and user-friendly.

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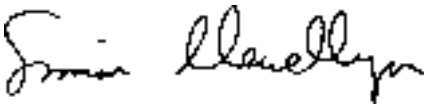

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# Acknowledgements

The Lake Erie LaMP 2000 document was prepared by the Lake Erie LaMP Work Group under the direction of the Lake Erie LaMP Management Committee. Environment Canada and the U.S. Environmental Protection Agency are the federal co-leads for the Lake Erie LaMP. The other agencies playing an active role in the process are:

**Canada**
- Agriculture and Agri-food Canada
- Fisheries and Oceans Canada
- FOCALErie (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

**United States**
- Agency for Toxic Substances and Disease Registry
- 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
- US Fish and Wildlife Service
- US Geological Survey

**Binational**
- Great Lakes Fishery Commission

Many members of the Work Group, Management Committee, technical subcommittees and the Binational Public Forum provided comments and suggestions to improve the document. Dr. Linda Corkum, University of Windsor, prepared Section 11.2 on non-indigenous invasive species. Lauren Lambert, Ora Johannsson and Janet Planck took on the enormous task of synthesizing the beneficial use impairment assessments into Section 4. Karen Rodriguez drafted the Habitat Action Plan (Section 9.3 and Appendix D). Laura Evans worked with Alan Waffle to develop the PCB and Mercury Action Plans in Sections 9.4 and 9.5, respectively, and the related appendices. The Upper Thames River Conservation Authority provided production support on formatting and printing the document, showing utmost patience in dealing with many last minute changes. Julie Letterhos served as the overall editor for the LaMP 2000 document. In keeping with the spirit of binational cooperation, the reader will note the alternation between Canadian and U.S. preferred spelling on a number of occasions.

# Table of Contents

# List of Figures



# List of Tables

# Executive Summary

Photo: UTRCA

# Section 1: Executive Summary

## Introduction

One of the most significant environmental agreements in the history of the Great Lakes took place with the signing of the Great Lakes Water Quality Agreement of 1978 (GLWQA), between the United States and Canada. This historic agreement committed the U.S. and Canada (the Parties) to address the water quality issues of the Great Lakes in a coordinated, joint fashion. The purpose of the GLWQA is to "restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem." One of the recommended actions of the GLWQA is the production of Lakewide Management Plans (LaMPs) for the lake waters to identify critical pollutants that impair beneficial uses and to develop recommendations, strategies, and policy options to restore these beneficial uses. LaMPs are also to develop ecosystem objectives for the lakes as the state of knowledge permits. The LaMPs provide a binational structure for addressing environmental and natural resource issues, coordinating research, pooling resources, and making joint commitments to improve the environmental quality of the Great Lakes.

The Lake Erie LaMP process began in 1995 with the publication of the Lake Erie LaMP Concept Paper (U.S. EPA 1995) which provided a framework for building the LaMP. In keeping with the direction of the GLWQA, the framework included an emphasis on public involvement. Throughout the Lake Erie LaMP process and in preparation of LaMP technical reports and documents, the participation and input of the Lake Erie Binational Public Forum has been promoted and encouraged.



Dealing with complex assessments, complicated issues and numerous stakeholders made the LaMP process a resource intensive effort, one that took longer than expected. In the interest of advancing the rehabilitation of the Great Lakes, and getting information to the public in a timely manner, the Binational Executive Committee (BEC) passed a resolution in 1999 to accelerate the effort. Acceleration meant that there should be an emphasis on taking action and adopting a streamlined approach to the LaMP document review and approval process. Steering away from the four-stage process outlined in the GLWQA, BEC recommended a LaMP be prepared every two years based on the current body of knowledge, and state the remedial actions that could be implemented now. The concept of adaptive management will be applied to the LaMP so that it can continue to adjust over time to highlight and address the most pertinent issues in Lake Erie. LaMP 2000 is a working document of the dynamic LaMP process. Some sections and the background reports used to produce them have been extensively reviewed while others have not, but it provides a common baseline against which to measure the progress of Lake Erie beneficial use protection and restoration.

Lake Erie has undergone considerable environmental change over time, being the most highly populated basin of the Great Lakes. The shallow nature of the basin makes it particularly vulnerable to land use changes and loadings. Much of the watershed has been irreversibly changed, and we cannot expect to return to the natural, pristine system of the pre-settlement 1700s. However, protecting the natural lands remaining and restoring the beneficial uses is an achievable goal. For example, the highly polluted conditions of the 1950s to the 1970s were reversed by controlling domestic and industrial discharges to the lake, particularly as related to phosphorus loading. Populations of commercial and sport fish species have been improved by controlling catch rates.

## Ecosystem Change

The introduction of non-indigenous invasive species, particularly the zebra mussel, triggered a tremendous ecological change in the lake. The zebra mussel has altered habitat, the food web dynamic, energy transfer and how nutrients and contaminants are cycled within the lake ecosystem. It is important to continue monitoring and research to better understand the lake system so that appropriate management decisions can be made to protect and restore Lake Erie.

Before ecosystem objectives can be established for Lake Erie, a preferred ***ecosystem alternative*** must first be identified. Ecosystem alternatives are qualitative descriptive statements of desired future conditions in the lake. The ecosystem alternatives are the scenarios that can be achieved through management actions that address contaminant loading, phosphorus management, changes in land use, control of exploitation from fish and wildlife harvesting, and the protection and restoration of natural land (undeveloped natural landscapes or habitat).

Using the results of the Lake Erie Systems Model developed by the ecosystem objectives subcommittee, LaMP 2000 presents four potential ecosystem alternatives. The key driver in the exercise that led to the identification of these four alternatives was the availability of natural land. Therefore, the four alternatives are described primarily in relation to that component. Alternative #1 represents moderate gain in the availability of natural land; alternative #2 represents a high gain; alternative #3 represents a low gain; and alternative #4 represents the status quo. Each alternative can be achieved through a variety of management actions, and social and economic values associated with those management actions must be considered as well. Management actions that affect land use practices and nutrient loading will have the greatest impact on the ecosystem.



A consultation process has been initiated to select a preferred ecosystem alternative. It involves discussions and input from the Lake Erie Binational Public Forum, the interested public, the Work Group and the Management Committee. The preferred alternative is expected to be selected by the end of 2000. Once the preferred ecosystem alternative is selected, specific ecosystem objectives and indicators can be developed. The current state of the lake, as identified by the Lake Erie LaMP problem definition stage, will be compared to the ecosystem objectives to identify further management and research needs.

## Problem Definition

The largest accomplishment of the Lake Erie LaMP to date has been problem definition, specifically determining the status of beneficial use impairments. Only three beneficial use impairments were concluded not to be found in Lake Erie: tainting of fish and wildlife flavor; restrictions on drinking water; and added costs to agriculture and industry. LaMP 2000 synthesizes the results of the beneficial impairment assessments by linking impairment conclusions, causes and trends. The beneficial use impairments are grouped into three broad categories based on the primary areas of public interest for the synthesis. The categories include: human use impairments, impairments due to chemical contaminants, and ecological impairments. Ongoing research, data gaps and potential emerging issues are listed for the impairments in each category. The causes of impairment to date have been identified as: PCBs, mercury, PAHs, lead, chlordane, dioxins, DDE, DDT, mirex, dieldrin, phosphorus, nitrates, *E.coli*, fecal coliform, non-indigenous invasive species, habitat loss, and sediment loading.

Mercury and PCBs have been designated critical pollutants for priority action by the Lake Erie LaMP. A number of chemicals, metals, nutrients, bacteria and suspended solids have been identified as Lake Erie LaMP pollutants of concern. A review of existing databases containing information on these substances was made to determine their utility for calculating loads or tracking ambient environmental concentrations of pollutants (amounts in fish tissue, sediment and the water column). Data available for some of the nutrients may be usable for calculating loads, but for the most part, LaMP 2000 recommends a source track down approach as opposed to a mass balance approach for reducing contaminant loads to

Lake Erie. Once the most seriously contaminated areas and major sources are identified, the Lake Erie LaMP recommends that resources and remedial actions be focused immediately on those areas rather than spent on further attempts to estimate total loads.

The GLWQA requires that LaMPs define the threat to human health posed by critical pollutants, singly or in synergistic or additive combination with another substance. Several of the beneficial use impairments, such as drinking water impairment, fish consumption advisories and recreational water quality use, directly address human health. However, it was decided that the LaMPs had to go beyond the beneficial use impairment assessments to meet the intended purpose of the language in the GLWQA. Therefore, Lake Erie LaMP 2000 describes pathways of exposure, the weight of evidence approach linking environmental exposure to health effects, and suggests a preliminary suite of indicators to measure human health impacts.

## Action Plans for Implementation

One of the primary reasons for accelerating the LaMP process was to support implementation over more planning and document review. LaMP 2000 describes several programs already underway that the Lake Erie LaMP can network with to help restore the lake. These include RAPs, the Great Lakes Fishery Commission, the Great Lakes Binational Toxics Strategy, North American Waterfowl Management Plan, State of the Lakes Ecosystem Conference (SOLEC) and the Lake Erie at the Millenium initiative. The last of these is a binational, coordinated effort to identify the management and research needs of the lake, link them, and obtain the resources to complete the most needed research and monitoring efforts.



For Lake Erie LaMP 2000, action plans were developed for habitat protection and restoration, and PCBs and mercury (Lake Erie LaMP critical pollutants) reduction in the Lake Erie ecosystem. Lake Erie LaMP 2000 proposes a process for developing a comprehensive habitat protection and restoration plan. Preliminary screening criteria were created against which to compare existing and proposed habitat projects to the goals and objectives of the Lake Erie LaMP. Additionally, eight different types of projects were determined to be necessary to adequately address habitat restoration in the Lake Erie basin. Thirty-seven existing and 19 proposed habitat projects are presented in this document, and categorized as to type. These projects represent only a preliminary list and a much more complete list will be included in future LaMP documents.

The action plan for mercury describes many ongoing activities being implemented by many of the LaMP agencies to reduce mercury in the environment through education, proper collection and disposal, pollution prevention and implementation and enforcement of regulatory standards and programs. Many of the actions are tied directly to the Great Lakes Binational Toxics Strategy. The mercury action plan also mentions the development of a U.S. EPA Total Maximum Daily Loads Strategy for mercury for Lake Erie. TMDLs are a requirement of the U.S. Clean Water Act and can be used as a tool to contribute to the restoration of beneficial uses of Lake Erie.

For PCBs, the action plan focuses more on cleanup and removal of PCBs from the ecosystem, particularly in regard to remediation of contaminated sediments. Since the production of PCBs have been banned and most jurisdictions no longer permit their discharge, most existing PCBs are due to legacy sources from past production or disposal practices.

## Emerging Issues

In addition to current issues of concern, the Lake Erie LaMP 2000 document presents significant ongoing and emerging issues. The first of these is the problem of non-indigenous invasive species in the lake. They are playing a strong role in influencing the biological populations in the Lake Erie basin, both plant and animal, and both aquatic and terrestrial. Emerging issues include climate change, endocrine disruptors, and the realization that phosphorus management and monitoring must continue while we work to better understand the changing phosphorus cycling in the lake.

## Public Outreach

In addition to reviewing LaMP technical reports, the Lake Erie Binational Public Forum has completed a number of projects and activities that are described in the LaMP 2000 document. Public outreach and involvement is a major component of the LaMP process. In addition to the outreach and input from the Forum, the public involvement subcommittee of the LaMP has implemented several outreach and public education efforts, primarily aimed at making LaMP technical information more public friendly. Both the Binational Public Forum and the Lake Erie LaMP Technical Work Group support websites. They can be found at www.erieforum.org and www.epa.gov/glnpo/lakeerie/ or www.cciw.ca/glimr/lakes/erie/, respectively. All final Lake Erie LaMP background documents, organizational information, general information, etc., are available on the Work Group site.





## LaMP 2002

The next comprehensive LaMP document will not be published until 2002. However, a number of background reports, in depth technical documents, public updates, issue papers, etc. will be developed. Coordinating with the 20 agencies representing two countries, four states, and a province, as well as with the interested public (including the Lake Erie Binational Public Forum), will lead ultimately to a Lake Erie LaMP that all of the partners can commit to implementing.

# Overview



Photo: Ohio EPA

# Section 2: Overview

## 2.1. Introduction to Lake Erie

The physical characteristics of Lake Erie have a direct bearing on how the lake ecosystem reacts to various stressors. 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 cools quickly in the fall. During long, cold winters, a large percentage of Lake Erie is covered with ice, and occasionally it freezes over completely. Conversely, in warmer years, there may be no ice at all. The shallowness of the basin and the warmer temperatures make it the most biologically productive of the Great Lakes.

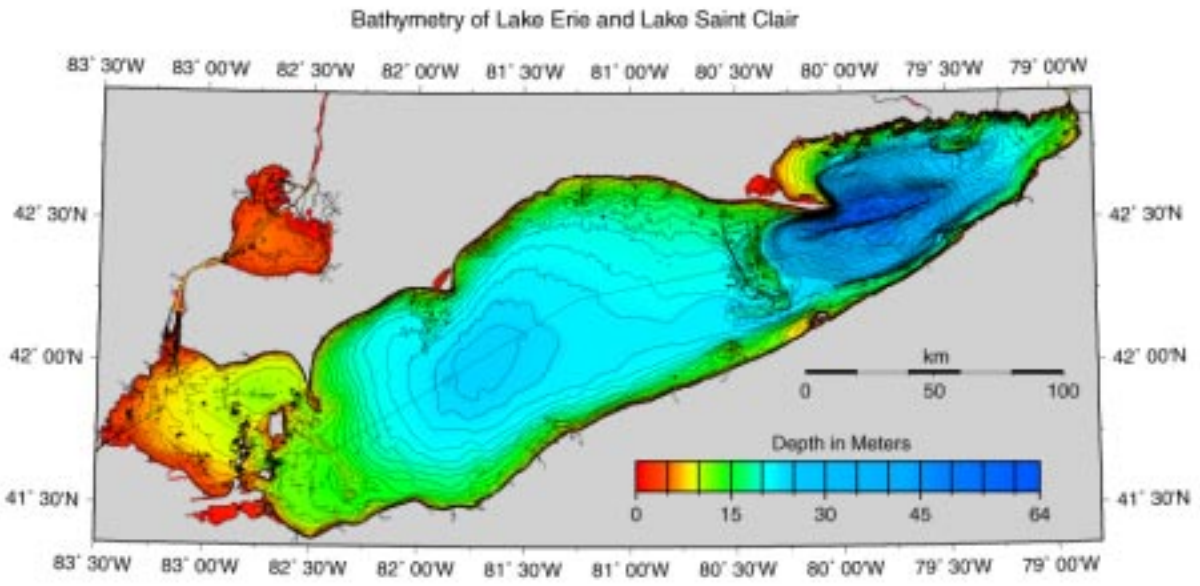
Lake Erie is naturally divided into three basins (Figure 2.1). The western basin is very shallow with an average depth of 7.4 metres (24 ft.) and a maximum depth of only 19 metres (62 ft.). The central basin is quite uniform in depth, with the average depth being 18.3 metres (60 ft.) and a maximum depth 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.). The central and eastern basins thermally stratify every year, but stratification in the shallow western basin is rare and very brief, if it does occur. Stratification impacts the internal dynamics of the lake, physically, biologically and chemically. These physical characteristics cause the lake to function as virtually three separate lakes.

Lake Erie's long narrow orientation parallels the direction of the prevailing southwest winds. Strong southwest winds and strong northeast winds set up extreme seiches, creating a difference in water depth as high as 4.3 metres (14 ft.) between Toledo and Buffalo (Hamblin, 1979). The effect is most spectacular in the western basin where large areas of the lake bottom are exposed when water is sloshed to the northeast, or large areas of shoreline are flooded as water is sloshed to the southwest. Overall current and wave patterns in Lake Erie are complex, highly changeable and often related to wind direction (Bolsenga and Herdendorf, 1993).

Eighty percent of Lake Erie's total inflow of water comes through the Detroit River. Eleven percent is from precipitation. The remaining nine percent comes from the other tributaries flowing directly into the lake from Michigan, Ohio, Pennsylvania, New York and Ontario (Bolsenga and Herdendorf, 1993). The Niagara River is the main outflow from the lake.

About one-third of the total population of the Great Lakes basin resides within the Lake Erie watershed. This amounts to 11.6 million people (10 million U.S. and 1.6 million Canadian), including seventeen metropolitan areas, each with more than 50,000 residents. The lake provides drinking water for 11 million people.

**Figure 2.1 Bathymetry of Lake Erie Illustrating that the Lake is Comprised of Three Distinct Basins, Primarily Defined by Depth.**




(Map courtesy of the National Geophysics Data Center as prepared by the Great Lakes Environmental Research Laboratory of the U.S. National Oceanic and Atmospheric Administration and the Canadian Hydrographic Service of the Department of Fisheries and Oceans.)



Of all the Great Lakes, Lake Erie is exposed to the greatest stress from urbanization, industrialization and agriculture. Reflecting the fact that the Lake Erie basin supports the largest population, it surpasses all the other Great Lakes in the amount of effluent received from sewage treatment plants (Dolan, 1993). Lake Erie is also the Great Lake most subjected to sediment loading. Intensive agricultural development, particularly in southwest Ontario and northwest Ohio, contributes huge sediment loads to the lake. The Detroit River delivers sediment from the actively eroding shoreline of southeastern Lake Huron and Lake St. Clair. Long stretches of the Lake Erie shoreline experience episodes of active erosion, particularly during storms and periods of high water. The western basin is generally the most turbid region of the lake, and much of its sediment load eventually moves into the central and eastern basins. Suspended sediment can be considered a pollutant in itself, one that has profoundly influenced the ecology of the western basin and the river mouths of most of the Lake Erie tributaries. Most of the lake bottom is covered with fine sediment particles that are easily disturbed when the shallow lake is stirred up by winds.

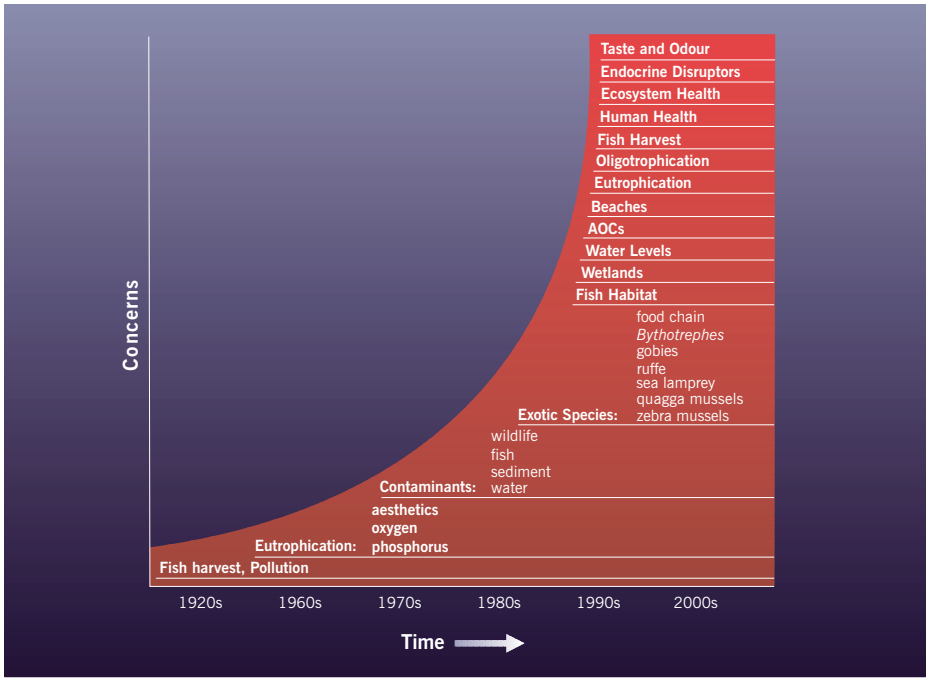
Over the years, as use of the lake and land use around the basin changed, so too did the issues of concern in Lake Erie. The most important issues and the timeframe during which they appeared are illustrated in Figure 2.2. It is interesting to note how some of the issues recur, albeit due to different reasons. Commercial overfishing, pollution and habitat destruction began to take a toll in the late 1800s, and popular commercial fish populations plummeted. Many of the drinking water intakes for the major populated areas were moved far offshore to avoid epidemics of waterborne diseases, such as typhoid, resulting from raw sewage discharge. Nuisance conditions, floating debris, and odors were increasingly common.

Lake Erie was the first of the Great Lakes to demonstrate a serious eutrophication problem. Its shallow nature made it the warmest and most biologically productive of the Great Lakes, but increased nutrient loadings beginning in the1950s made it too productive. Results of this accelerated eutrophication were unhealthy, unattractive and odiferous. Algal blooms caused thick green and blue-green slicks on the water surface; turbidity increased due to more algae and suspended sediment in the water column; and excess *Cladophora*, a long, green, filamentous algae, covered the shoreline in slimy masses and mounded up on

beaches when it died. A result of this increased productivity was oxygen depletion in the bottom waters of the lake as algae died, settled to the bottom and decomposed. The central basin is particularly susceptible to oxygen depletion because summer stratification forms a relatively thin hypolimnion that is isolated from oxygen-rich surface waters. Oxygen is rapidly depleted from this thin layer as a result of decomposition of organic matter. When dissolved oxygen levels reach zero, the waters are considered to be anoxic. In addition to stressing and/or eliminating biological communities, anoxia changes chemical processes on the bottom, regenerating pollutants from the sediments, altering them to forms more readily available for uptake, and recycling these pollutants back into the water column.

Accelerated eutrophication spanned the 1950s to the 1970s, with much of the central basin becoming anoxic. Phosphorus was deemed to be the main culprit. A comprehensive binational phosphorus reduction strategy was implemented to reduce phosphorus discharge from wastewater treatment plants, limit the use of phosphorus-containing detergents in the watershed, and to develop and encourage the use of best management practices to reduce phosphorus runoff from agricultural operations.

### Figure 2.2 Changing Issues in Lake Erie Over Time




Increased industrialization and the formulation of new chemicals to aid in pest control led to concern about contaminants and the accumulation of persistent toxic chemicals in water, sediment, fish and wildlife. The development of extensive pollution control regulations, improvements in treatment technologies, adoption of stringent water quality standards, bans on production and use of certain chemicals, waste minimization and pollution prevention have greatly reduced the direct discharge of contaminants. However, the lingering effects of these historic discharges, such as contaminated sediments and fish consumption advisories, and a greater public awareness of the environment raised further concerns about contaminants in the late 1970s that has continued to the present.

Efforts to restore lake trout, the extirpated top-predator in the cold waters of the eastern basin, were thwarted in the late 1970s and early 1980s by mortality caused by the non-indigenous invasive sea lamprey. Sea lamprey invaded Lake Erie and the upper Great Lakes after the Welland Canal was expanded in the early 1900s (Eshenroder and Burnham-Curtis 1999). Their abundance increased during the 1970s to the point that control efforts were implemented beginning in 1986. With continued control efforts since that time, survival of lake trout has improved enough to allow the establishment of a viable spawning

population (Cornelius et al. 1995).

The introduction of zebra mussels in the late 1980s triggered a tremendous ecological change in the lake. Zebra mussels have changed the habitat in the lake, altering the food web dynamic, energy transfer and how nutrients and contaminants are cycled within the lake ecosystem. Additional non-indigenous invasive species such as the quagga mussel, goby, and several large zooplankton species have further complicated the system.

In the 1990s, changing fish populations fueled a whole new debate on phosphorus loading. Lake Erie had essentially achieved the phosphorus levels established under the Great Lakes Water Quality Agreement as those needed to eliminate the effects of eutrophication. However, the models used to determine the maximum allowable annual phosphorus load did not account for the influence of such a major ecosystem disrupter as the zebra mussel. Eastern basin open water phosphorus concentrations are now even less than the 10 µg/l target value, dramatically reducing the productivity of that basin. Yet, some of the nearshore areas have phosphorus concentrations high enough to support extensive *Cladophora* growth. Attempting to manage the lake system now by simply increasing or decreasing phosphorus loads is no longer workable. Until more is understood about the internal dynamics of phosphorus cycling in the lake, the Lake Erie LaMP has taken the position to continue to support implementation of phosphorus management programs to maintain the phosphorus targets established under the GLWQA.

Changes in land use, development, and the construction of various shore structures have significantly altered the original habitat available along the Lake Erie shoreline. Many of the wetlands have been drained, filled or altered so they no longer function naturally. Shore structures associated with development or built to protect shore property from high water levels have inhibited the natural flow of beach building materials along the shoreline and, consequently, the natural habitat.



The potential impact of endocrine disruptors on the aquatic community and human health is another issue of concern raised in the 1990s. Weight of evidence suggests that known endocrine disruptor contaminants, such as PCBs, may be impairing Lake Erie populations, both aquatic and human, but it is difficult to make the cause and effect connections.

Issues of concern in Lake Erie will continue to fluctuate over time. Sufficient monitoring, background information and recent research must be available to make the appropriate management decisions and to address new issues before they become catastrophic. Management decisions and actions should take into consideration the potential impact on the overall ecosystem. Using the structure provided by the Lake Erie LaMP process, future remedial and management actions concerning the lake will take into account the expertise, goals and combined resources of the interested public, the private sector, researchers and all the agencies with some jurisdiction over the lake.

## 2.2 LaMP Structure and Process

Under the Great Lakes Water Quality Agreement (GLWQA) of 1978, as amended by Protocol in 1987, the United States and Canada (the Parties) agreed "…to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem." To achieve this goal, the Parties agreed to develop and implement Lakewide Management Plans (LaMP) for each lake, in consultation with State and Provincial Governments. Annex 2 of the GLWQA states that LaMPs shall embody a systematic and comprehensive ecosystem approach. The fourteen beneficial use impairments listed in Annex 2 of the GLWQA (Table 2.1) are the main focus of LaMPs.

## Table 2.1 IJC Listing Criteria for Establishing Impairments of Beneficial Uses (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 byrelevant, 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. |

The GLWQA calls for LaMPs specifically to address persistent bioaccumulative toxic substances, particularly those that are causing or likely to cause beneficial use impairments. Ecosystem objectives specific to each lake are to be established to guide LaMP efforts toward defined endpoints. Based on achieving these ecosystem objectives, the LaMPs will provide a binational structure for addressing environmental and natural resource issues, coordinating research, pooling resources and making joint commitments to improve the environmental quality of the lakes.

In 1993, a temporary binational Implementation Committee was formed, consisting of members of all the state, federal and provincial agencies with jurisdiction over Lake Erie. The charge to this group was to create a framework upon which to build the Lake Erie LaMP. This committee produced the Lake Erie LaMP Concept Paper (U.S. EPA 1995). In addition to addressing critical pollutants, the Implementation Committee felt the integrity of the Lake Erie ecosystem would not be fully protected or restored unless other factors such as habitat loss, nutrient and sediment loading, and non-indigenous invasive species were addressed as well. Therefore, they recommended the scope of the LaMP be broadened to include these other environmental stressors. This decision directed the agencies to embody a stronger overall ecosystem approach in the development of the LaMP. In 1995, binational committees were established to begin actively working on the development of the Lake Erie LaMP. A Status Report was completed in 1999 (U.S. EPA and Environment Canada 1999).

In order to explain clearly the geographic scope of the Lake Erie LaMP, three aspects need to be defined. First, beneficial use impairments were assessed within the waters of Lake Erie, including the open waters, nearshore areas, and river mouth/lake effect areas. Second, the search for the sources or causes of impairments to beneficial uses is being conducted in the lake itself, the Lake Erie watershed, and even beyond the Great Lakes basin. Third, management actions needed to restore and protect Lake Erie may need to be defined and implemented outside of the Lake Erie basin.



Environment Canada and the U.S. Environmental Protection Agency are the federal co-leads for the Lake Erie LaMP. Other agencies involved in the process include:

### Canada

- Agriculture and Agri-food Canada
- Fisheries and Oceans Canada
- FOCALErie (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

### United States

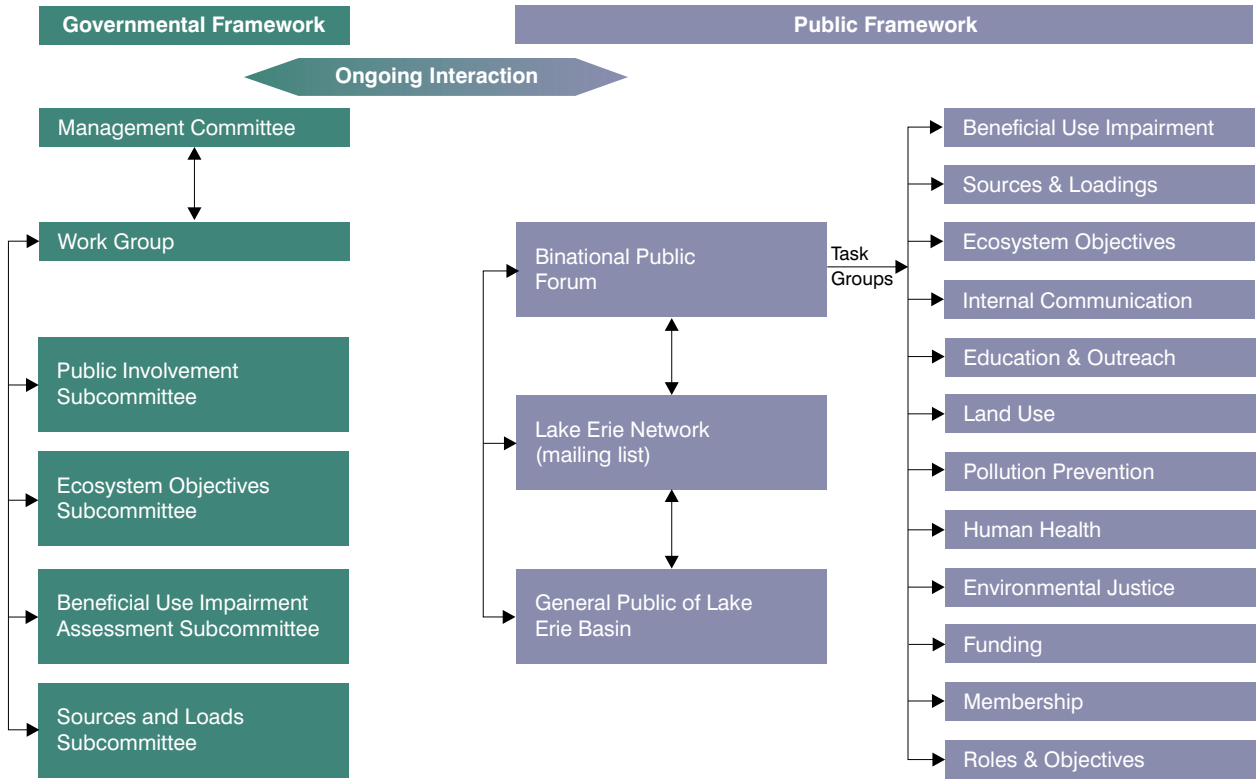
- Agency for Toxic Substances and Disease Registry
- Michigan Department of Environmental Quality
- Michigan Department of Natural Resources
- Natural Resource Conservation Service
- New York State Department of Environmental Conservation
- Ohio Department of Natural Resources
- Ohio Environmental Protection Agency
- Pennsylvania Department of Environmental Protection
- Seneca Nation of Indians (invited)
- US Army Corps of Engineers
- US Fish and Wildlife Service
- US Geological Survey

### Binational Observers

- International Joint Commission
- Great Lakes Fishery Commission

Senior managers from each jurisdiction were invited to participate on the Lake Erie LaMP Management Committee, the group charged with overseeing the development of the Lake Erie LaMP. A number of committees and subcommittees were established to assist the Management Committee in fulfilling its charge. The organizational structure of the Lake Erie LaMP is presented in Figure 2.3. Per the direction of the GLWQA, the Lake Erie Concept Paper proposed significant public involvement be utilized throughout the LaMP process. The Lake Erie Binational Public Forum was created to provide front line coordination and communication with the interested public, and to initiate additional public activities. The Forum has provided substantial input into Section 8 of this document, which describes their purpose and projects. They have also contributed to and reviewed the technical background documents used to prepare this report.

**Figure 2.3 Organizational Structure of the Lake Erie LaMP**




Although the Lake Erie LaMP team has produced a number of background documents, none of the staged reports as outlined in Annex 2 of the GLWQA have been completed. In an effort to accelerate the entire Great Lakes LaMP process, the Binational Executive Committee (BEC) issued a resolution in July 1999 that recommended a change from the four stage LaMP process, described in the GLWQA, to production of a biennial document on LaMP status (Table 2.2). This would allow planning and implementation to occur simultaneously rather than sequentially, and put more emphasis on implementation than on document production and review. Since all of the LaMPs are at different levels of development, the new biennial reporting approach will apply somewhat differently to each of the lakes but, in all cases, restoration and protection activities will be highlighted. Having comparable documents for all of the lakes will also help to set priorities and identify the issues that may need to be addressed on a Great Lakes basinwide scale.

**Table 2.2 Binational Executive Committee Consensus Position on the Role of LaMPs in the Great Lakes Restoration Process**

The development and implementation of Lakewide Management Plans (LaMPs) are an essential element of the process to restore and maintain the chemical, physical, and biological integrity of the Great Lakes ecosystem. Through the LaMP process, the Parties, with extensive stakeholder involvement, have been defining the problems, finding solutions, and implementing actions on the Great Lakes for almost a decade. The process has taken much longer and has been more resource-intensive than expected.

In the interest of advancing the rehabilitation of the Great Lakes, the Binational Executive Committee calls on the Parties, States, Provinces, Tribes, First Nations, municipal governments, and the involved public to significantly accelerate the LaMP process. By accelerate, we mean an emphasis on taking action and a streamlined LaMP review and approval process. Each LaMP should include appropriate actions for restoration and protection to bring about actual improvement in the Great Lakes ecosystem. Actions should include commitments by the governments, parties and regulatory programs, as well as suggested and voluntary actions that could be taken by non-governmental partners. BEC endorses the April 2000 date for the publication of "LaMP 2000," with updates every two years.

BEC is committed to ensuring a timely review process and will be vigilant in its oversight.

The BEC respects and supports the role of each Lake Management Committee in determining the actions that can be achieved under each LaMP. BEC expects each Management Committee to reach consensus on those implementation and future actions. Where differences cannot be resolved, BEC is committed to facilitating a decision. BEC recognizes the Four-Party Agreement for Lake Ontario and the uniqueness of the agreed upon binational workplan.

The LaMPs should treat problem identification, selection of remedial and regulatory measures, and implementation as a concurrent, integrated process rather than a sequential one. The LaMPs should embody an ecosystem approach, recognizing the interconnectedness of critical pollutants and the ecosystem. BEC endorses application of the concept of adaptive management to the LaMP process. By that, we adapt an iterative process with periodic refining of the LaMPs which build upon the lessons, successes, information, and public input generated pursuant to previous versions. LaMPs will adjust over time to address the most pertinent issues facing the Lake ecosystems. Each LaMP should be based on the current body of knowledge and should clearly state what we can do based on current data and information. The LaMPs should identify gaps that still exist with respect to research and information and actions to close those gaps.

*Adopted by BEC on July 22, 1999.*

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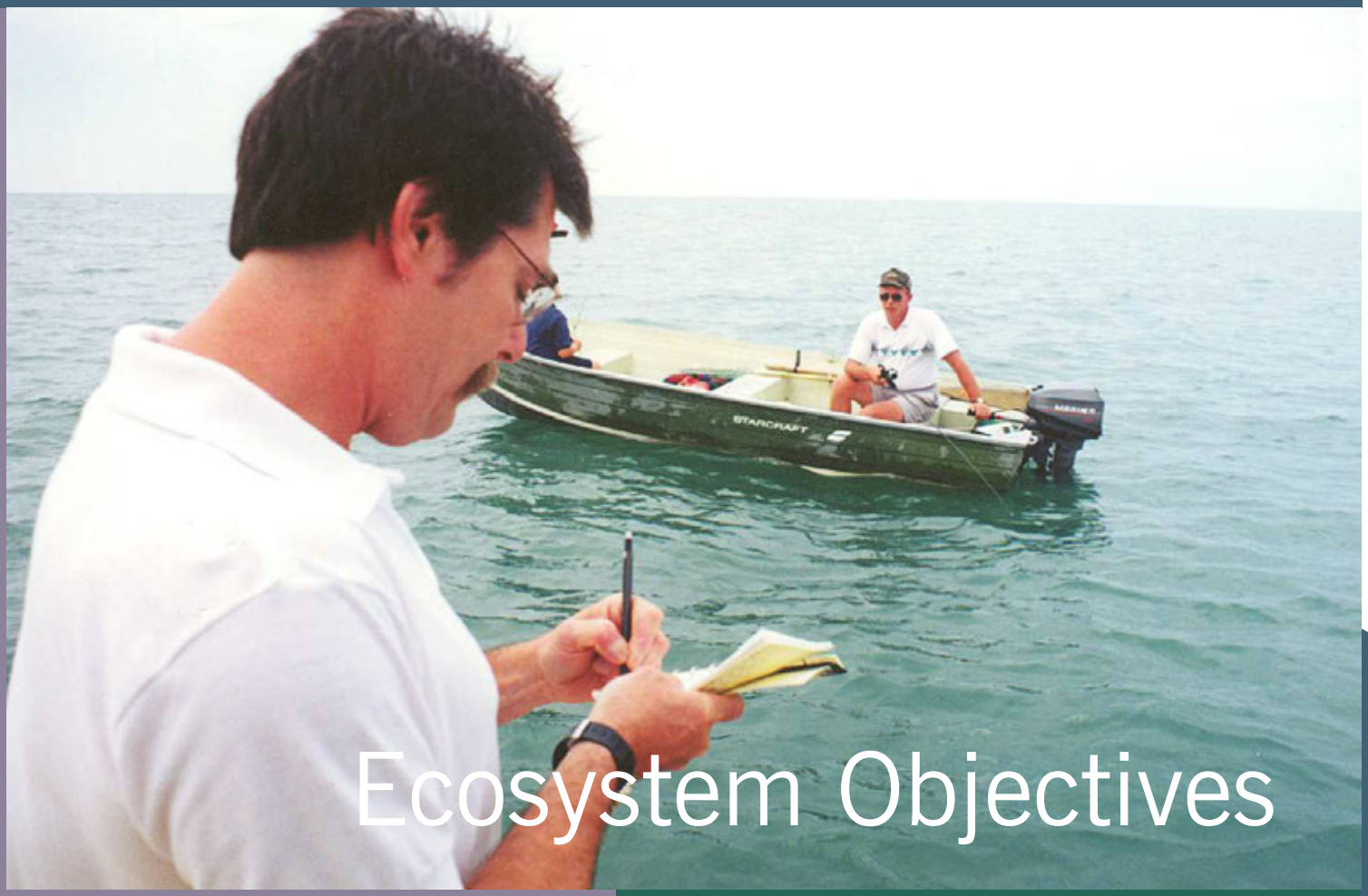


# Ecosystem Objectives

Photo: John Cooper

# Section 3: Ecosystem Objectives

## 3.1 Introduction

The Lake Erie LaMP has adopted a generalized ecosystem approach, as outlined in the 1987 amendments to the Great Lakes Water Quality Agreement (GLWQA). This approach recognizes that all components of the ecosystem are interdependent, including the water, biota, surrounding watershed and atmosphere. Humans are considered an integral part of the system.

The need to recognize this interdependence is underlined by observations from the recent ecological history of Lake Erie. The eutrophic conditions of the 1950s to1970s were caused by high phosphorus loading (Burns, 1976; Chapra, 1977) and remediated by phosphorus reduction programs designed to meet target concentrations. During the 1960s and 1970s, the fish community of Lake Erie was extremely degraded (Hartman, 1972). Under conditions of reduced phosphorus loading and international cooperation in fisheries management, there was a recovery in the walleye fishery (Hatch *et al.*,1987; Knight, 1997). Subsequently, Makarewicz and Bertram (1991) showed that the structure of the food web was reflecting the influence of both bottom-up (nutrient reduction) and top-down (predation) structuring (McQueen *et al.,* 1986; Munawar *et al.,* 1999).

The Great Lakes Water Quality Agreement calls for the development of ecosystem objectives and indicators for all of the Great Lakes. For Lake Erie, the level of change in the ecosystem has been extensive, and in many cases appears irreversible (Burns 1985). We cannot return to the pre-settlement conditions of the pre-1700s, but we can work toward achieving a healthier, more diverse and less contaminated ecosystem. Therefore, the Lake Erie LaMP will first identify *ecosystem alternatives* for Lake Erie before developing ecosystem objectives. *Ecosystem alternatives are **qualitative** descriptive statements of desired future conditions* for the Lake Erie basin, including nearshore and offshore waters, tributaries, flora and fauna. Ecosystem alternatives must reflect society's environmental, social and economic values and are therefore being developed with input from the public.



The approach for Lake Erie is to examine the effects on the state of the system that may be achieved through management actions, or levers, that address: 1) reduction of contaminants loading; 2) phosphorus management; 3) changes in land use; 4) control of exploitation by sport and commercial fisheries, hunting and trapping; and 5) creation and restoration of natural landscapes. These are the five major *management levers* with which we can alter the condition of the ecosystem.

Once the preferred ecosystem alternative is selected, ecosystem objectives must be developed taking into account the competitive uses within the Lake Erie ecosystem, such as industry, urban growth, agricultural or recreational uses. Finally, indicators must be developed. Ecosystem indicators have been identified (SOLEC, 1998) as measurable features that provide managerially and scientifically useful evidence of environmental and ecosystem quality, or reliable evidence of trends in quality. It is desirable to link closely to the SOLEC indicator exercise where possible. However, the definition of indicators must be broadened for the Lake Erie LaMP ecosystem objectives effort to: *Indicators are measurable features which identify the current state of the ecosystem relative to the desired state of the ecosystem.*

### 3.2 Ecosystem Alternative Development Process

The Lake Erie LaMP Ecosystem Objectives Subcommittee (EOSC) was charged with the task of developing ecosystem objectives for Lake Erie. The EOSC is a binational group of about 15 individuals with expertise in limnology, water quality, and fisheries and wildlife management. Three members of the Lake Erie Binational Public Forum have worked closely with the committee throughout the exercise. Again, the first step in the process was to identify ecosystem alternatives. The committee began the exercise by holding four public workshops around the basin to gain ideas on the desired state of the Lake Erie ecosystem. This was followed by an expert workshop where published information and expert opinion was solicited concerning key relationships in the ecosystem.

A conceptual model of three ecosystem alternatives was developed for initial discussion. Several other attempts at developing a model that could be used for Lake Erie were made. As a result, a fuzzy cognitive map (FCM) approach was adopted to model ecosystem alternatives for Lake Erie. A FCM model is one way to analyze a complex system by representing the most important components of that system as nodes of a network. Individual nodes are connected to many other nodes. A change at one node will affect all connected nodes, and then all the nodes connected to those nodes, generating a ripple effect. Taking an FCM approach required more data and, therefore, a second expert workshop was held. The results of the second workshop led to the development of an FCM model for the lake dubbed the Lake Erie Systems Model. The model will be used as a tool to help understand how various components of the ecosystem interact, but it is not a panacea to predict future conditions.

Three major categories of actions and reactions are used to explain the output of the Lake Erie Systems Model: 1) management levers; 2) ecosystem health response; and 3) beneficial use to humans. Management levers are a variety of human actions that affect the ecosystem. Ecosystem health response describes the condition of individual biotic and habitat components and the reaction to the management levers. Beneficial use refers to those human uses defined in the GLWQA that are affected by the management levers. By randomly and simultaneously moving all management levers in different directions and monitoring responses of all non-lever variables, a large set of different potential outcomes in the ecosystem can be generated. These outcomes can then be grouped into a form that can be recognized and described using a statistical clustering procedure. Groups that are considered to be significantly different from each other constitute *ecosystem alternatives*. A detailed description of how the model was developed and how it processes data can be found in the ecosystem objectives subcommittee's report, Colavecchia *et al.* (in prep.).



The model generated various ecosystem alternatives. These alternatives do not include social, economic or political values because they are not part of the ecosystem. Rather, the values are what will be used to determine the ecosystem alternative that we choose. These issues will be incorporated into the decision-making process described in section 3.4, and also as we proceed with identifying specific ecosystem objectives.

### 3.3 Draft Ecosystem Alternatives

Protection of natural, undeveloped land in the Lake Erie basin is the most effective way to return Lake Erie to a more pristine state. Of the management levers examined in the model, those that affect the availability of natural, undisturbed land cause the largest response across the greatest number of variables. Therefore, the availability of natural lands is the key driver of the ecosystem clusters. Nutrient levels are the second most important influence but do not have the impact that natural land (habitat) has on the ecosystem. In other words, phosphorus can be strictly managed, but unless natural land or habitat is protected and restored, only marginal response will be seen by many components of the ecosystem. Therefore, the ecosystem alternatives derived from the model will be described based on their gain in natural land compared to the status quo conditions of the 1990s. Therefore, of the management levers, land use practices and phosphorus (or nutrient) management will have the most impact on improving Lake Erie.

From the clustering exercise, seven distinct groups (ecosystem alternatives) emerged. Three groups represented highly degraded environmental conditions relative to present (1990), while four represented existing or improved environmental conditions. Only the latter four groups are considered viable ecosystem alternatives for a future state of Lake Erie. Ecosystem alternative #4 (ECA#4) represents the status quo, or existing conditions. ECA#1 represents a moderate gain in natural lands from the status quo. ECA#2 represents a high gain in natural lands, and ECA#3 represents low gain of natural land.

A more detailed description of the impact on ecosystem health and human uses associated with each ECA based on the management actions implemented is presented in Table 3.1. These alternative states, or ecosystem alternatives, are pictures of what the Lake Erie environment could be depending on how and to what extent the human population is willing to adjust future land use needs. Many combinations of management actions are possible to achieve each ecosystem alternative. Each of the ecosystem alternatives presented serve to only broadly group the management actions that could be implemented to obtain them. The ecosystem objectives that will subsequently be developed under the preferred ecosystem alternative will contain more specific language to guide management actions.

The Lake Erie Systems Model assumes that toxic contaminants will be managed according to the GLWQA principles of zero discharge and virtual elimination. There is already a strong focus on rehabilitating those areas of Lake Erie that are adversely affected by persistent toxic chemicals, such as the AOCs. As such, levels of contaminants should be declining, not present at varying levels, and not controlling other ecosystem components. Ecosystem objectives for Lake Erie will not be proposed that allow toxic substances to exist in toxic amounts to the detriment of human health or wildlife. Therefore, all four ECAs begin with the assumption that loading of contaminants into the Lake Erie ecosystem has been reduced to zero, and describe a contaminant free ecosystem. However, a representation of the processes of contaminants has been incorporated into the model to ensure that the implications can be considered in forecasts for the future. If zero discharge is not achieved, contaminant levels in the ecosystem (hence, negative impacts on the ecosystem) would be expected to be the highest under ECA#4 (status quo), reduced under ECA#2 and ECA#3, and lowest under ECA#1.



Table 3.1 illustrates the results of the model for each ECA. For management levers, the more symbols, the less environmental stress is occurring. For the response to ecosystem health and human uses, a *Consumer's Report* format is used to show differences in responses. A full circle has the highest potential for improving ecosystem health or human use; an open circle the least.

**Table 3.1 Response of Various Lake Erie Ecosystem Components Under the Four Ecosystem Alternative (ECA) States as Derived from the Lake Erie Systems Model**

| CATEGORY | Ecosystem COMPONENT | ECA#1 | ECA#2 | ECA#3 | ECA#4 |
|---|---|---|---|---|---|
| **Management Levers** | Phosphorus loading | 🚹🚹🚹🚹 | 🚹🚹🚹 | 🚹🚹🚹 | 🚹🚹 |
| | Changes in land use | 🚹🚹🚹 | 🚹🚹🚹🚹 | 🚹🚹 | 🚹🚹 |
| | Harvest - fishing, hunting, trapping | 🚹🚹 | 🚹🚹 | 🚹🚹 | 🚹🚹 |
| | Restoration of natural landscapes | 🚹🚹 | 🚹🚹🚹 | 🚹🚹 | 🚹🚹 |
| **Ecosystem Health** | Environment/Habitat | ● | ● | ◔ | ◔ |
| | Plankton | ○ | ○ | ○ | ◔ |
| | Aquatic Plants | ● | ● | ◑ | ◔ |
| | Benthos (Cold-Water) | ○ | ○ | ○ | ○ |
| | Benthos (Cool-Water) [a] | ◔ | ◔ | ◔ | ◑ |
| | Amphibians | ● | ● | ◔ | ◑ |
| | Reptiles | ◑ | ● | ◔ | ◔ |
| | Fish | ◑ | ● | ◔ | ◔ |
| | Birds | ◑ | ● | ○ | ◔ |
| | Mammals | ● | ● | ◔ | ◑ |
| **Beneficial Use to Humans** | Natural environments | ● | ● | ◔ | ◑ |
| | Less *Cladophora* on beach | ◑ | ◑ | ◑ | ◔ |
| | Water transparency nearshore | ● | ◑ | ◑ | ◔ |
| | Swimmability (Bacteria) | ● | ◑ | ◑ | ◔ |
| | Absence of consumption advisories | ● | ◑ | ◑ | ◔ |
| | Absence of need to dredge | ● | ● | ◑ | ◔ |
| | Drinking water/taste and odor | ● | ◑ | ◑ | ◔ |

[a] Benthos is showing degradation compared to the status quo due to the suppression of organisms like *Diporeia* and *Mysis* by Dreissenid mussels.



## 3.4 Decision-making process for selecting an ecosystem alternative

As noted at the end of section 3.1, there are three steps involved in setting a direction for the Lake Erie ecosystem: 1) a preferred ecosystem alternative must be selected; 2) ecosystem objectives must be developed that describe in narrative form more details to set the stage for the actions needed to achieve the preferred alternative; and 3) indicators must be developed to measure progress in achieving the desired ecosystem alternative. The process described below addresses primarily the selection of an ecosystem alternative.

***Who* will evaluate the ecosystem alternatives?**

- Members of the LaMP Work Group, who have already eliminated three of seven ecosystem alternatives from consideration. The work group will consider the opinions of the interested public along with agency personnel, and will make recommendations to be considered by the LaMP Management Committee.
- Members of the Lake Erie Binational Public Forum, who will consider the four remaining alternatives at two of their meetings, and whose opinions and recommendations will be considered by the Work Group and Management Committee.
- Interested members of the public at large who choose to attend open meetings at which the ecosystem alternatives will be presented and discussed.

- Agency personnel who will provide comments to their Work Group member.
- The LaMP Management Committee, who will make the final approval.

The input that is expected includes:

- Comments, concerns, and suggestions provided by the public representatives and agency staff concerning the relative advantages and disadvantages of particular ECAs. Some of this information will elaborate upon or complement the presented descriptions of the ecological, beneficial use, social, and economic implications of the ECAs. However**,** participants in the consultation process may **also** provide information or their interpretation of the effects of the ECA that contribute to a more complete understanding of the implications.
- Polling-type data on the preferences of representatives of the public for the different ECAs. This information will not only indicate the extent to which agreement on the objectives is possible or exists, but also the reasons for differing views on the ECAs. Differences of opinion could arise due to differing understandings of the environmental and social implications of the ECAs; they can also occur because of fundamental differences in values among participants. Documentation of these reasons is critical. For the Public Forum, effective communication of this information is crucial to its stated role of "promoting the Forum's vision and goals for Lake Erie".

***What* information will be used by the process and what product is anticipated?**

Information provided to evaluators will include the four ecosystem alternatives described in section 3.3. Each ECA describes, in very general terms, both a direction for the Lake to go (what types of changes to make, if any) and how far to go.

The final product of the process is to be:

- A preferred future state for the Lake Erie ecosystem, which will correspond to one of the ECAs, or perhaps a combination, and;
- The preferred state will be described in terms of the general policy levers that are likely to be necessary to achieve it, and a qualitative summary of the resulting ecosystem health, effects on beneficial uses, and social and economic costs and benefits (broadly construed).



Detailed, quantitative information on the impacts and characteristics of the chosen alternative will not be included. This is because the policies and management measures required to achieve them cannot be specified exactly, and tools for projecting ecological, economic, and social effects are unavailable within the time frame required.

Consequently, the selected alternative should *not* be viewed as a firm and unswerving commitment to a precise target for the future state of the system. As more information becomes available about what actions are required and their likely effects, it is anticipated that adjustments may be made. Rather, the alternatives represent a set of guiding principles; they are a policy commitment that management actions should be constructed and evaluated considering the Lake Erie LaMP's commitment to moving the Lake in the direction implied by the alternatives.

***When and where* will consultation on the ecosystem alternatives take place?**

The following sequence of events will occur:

*May 2000: Submission of draft materials on ECAs for evaluation at the June 2000 Binational Public Forum meeting.*

*June 2000 Binational Public Forum meeting: Initial assessment of ecosystem alternatives.*

*July 31, 2000: Materials on ecosystem alternatives to be finalized and subsequently distributed to the Forum and interested public.*

*September-October 2000: Public meetings (approximately four in each country).*

*September-November 2000: Forum members consult as individuals with their constituencies and other members of the public.* Forum members will have two tasks: to communicate information about the ecosystem objectives' process and ECAs, and to gather information on how their groups and other members of the public view the alternatives.

*November 2000 Public Forum meeting: Final assessment of ECAs.* Final polling of the Forum's views of the ECAs. The Forum would also discuss the phrasing of the ecosystem objectives that would be implied by the Forum member recommendation of a preferred ecosystem alternative.

*December 2000: Work Group and Management Committee recommendations.* The Work Group will make recommendations concerning the ecosystem alternatives, and the Management Committee will be responsible for the final approval.

*January-April 2001*: Ecosystem objectives are developed based on the preferred ecosystem alternative.

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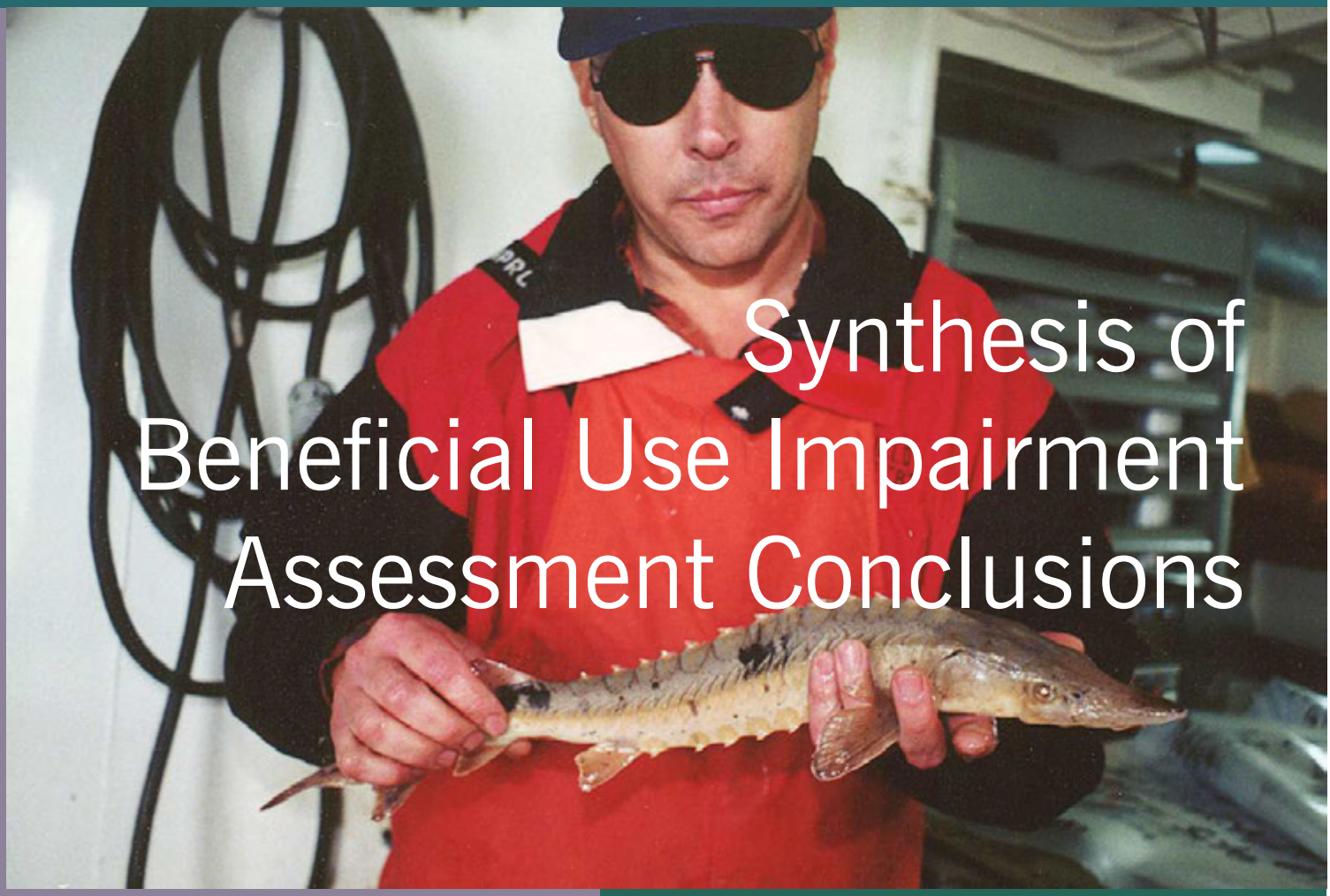


# Synthesis of Beneficial Use Impairment Assessment Conclusions

Photo: John Cooper

# Section 4: Synthesis of Beneficial Use Impairment Assessment Conclusions

## 4.1 Introduction

### Scope

Annex 2 of the Great Lakes Water Quality Agreement requires that each LaMP assess impairment to14 beneficial water resource uses as the first step in identifying restoration and protection actions for each of the Great Lakes. The 14 beneficial use impairments and the criteria for determining impairment are outlined in Table 2.1. The Lake Erie LaMP also recognizes that more than just these 14 beneficial use impairments will need to be addressed before Lake Erie can be fully restored. These other issues, or stressors, are discussed in other sections of the LaMP 2000 document.

The geographic scope of the impairment assessment includes the open waters of Lake Erie, nearshore areas, embayments, river mouths and the lake effect zones of all Lake Erie tributaries. 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. **When an impaired beneficial use is identified in a particular basin in the summary tables throughout this section, it means that impairment is occurring somewhere in that basin, not necessarily throughout the entire basin referenced.**



### The Ecosystem Approach in Action - Step 1

For the Lake Erie LaMP, the term ecosystem approach means: a) remediating both contaminant and noncontaminant causes of impairment is important to the restoration of Lake Erie, and b) management actions must consider impacts to all key components of the Lake Erie ecosystem before they are implemented.

In keeping with item “a”, this preliminary beneficial use impairment assessment treats all impairments and known causes equally, regardless of the type, severity, duration, trend, geographic extent, or magnitude. The primary causes of impairment are chemical contaminants, habitat loss and degradation, exotics and the associated impacts to energy and contaminant flow in the food web. Remediation of any one of these causes without addressing the others will not fully restore Lake Erie.

In terms of item “b”, existing objectives such as those in the North American Waterfowl Management Plan (NAWMP), the National Shorebird Plan, Partners in Flight and the Lake Erie Fish Community Goals and Objectives (FCGO) were used to complete the preliminary beneficial use impairment assessment. Some of these existing objectives were developed with primarily one group of organisms in mind, and not necessarily the entire ecological community. In the case of wildlife, most of the objectives are not Lake Erie specific. It is important to use and fine tune existing objectives with new proposed objectives to prevent conflicting management actions. An example of such a conflict is diked wetlands that protect wildlife habitat from destruction by lake wave action and serve as a refuge for native mussels, but do not provide optimal fish habitat.

The Lake Erie LaMP has developed a model, described in Section 3 of this document, which will allow us to explore the effects of changes in management strategies on all parts of the ecosystem. This model is being used by the LaMP to assist in developing ecosystem objectives specific to Lake Erie. When final ecosystem objectives are selected they will allow us to characterize the severity of a given impairment in relation to LaMP targets for restoration. This will provide the tool needed to prioritize actions that must be implemented to restore beneficial uses.

### Synthesis Approach

It is recognized that many improvements already have occurred in the Lake Erie environment. However, because the intent of the LaMP 2000 Report is to set the stage for future actions in Lake Erie, the text in this section of the document addresses only problems that are still occurring. The impairment conclusions for each of the 15 Lake Erie assessments (fish and wildlife assessments were done separately) are summarized in tables within each subsection and serve as the preliminary problem definition for the lake. Eleven of the 15 assessments concluded that impairment is occurring somewhere within the geographic scope of the Lake Erie LaMP.

In general, more impairments are identified in the western basin and in the lake effect zones of tributaries than in the other two basins. However, this fact must be interpreted carefully. While it is known that contaminant impacts are generally greatest in the western basin, there are several other key considerations. The range of certain sensitive species is limited to the western basin and acreage of certain habitat types was historically greatest in the western basin. For example, in terms of impacts to coastal wetlands, the former Black Swamp alone covered nearly 300,000 acres before land use changes reduced the remaining acreage to the current 30,000 acres. In other cases most of the data is collected from the western basin. Nearly all of the benthos data in existence comes from the western basin. Because the states and province are responsible for regulating surface waters in their respective jurisdictions, an abundance of tributary data is available. Seven of the 12 Lake Erie basin AOCs are located in the western basin or watershed and have already completed extensive beneficial use impairment assessments for those specific geographic areas. And, finally, certain impairments are limited to tributaries and nearshore areas by default (e.g. beach impairments, wildlife consumption advisories, fish tumors or other deformities, and restrictions on dredging activities).



To date, each beneficial use has been examined only in relation to the impairment criteria for that particular use. Therefore, the purpose of this section is to briefly synthesize the 14 assessments by linking the impairment conclusions, causes, and trends among impairments for the first time. Impairment assessment conclusions have been grouped into three broad categories based on the primary areas of public interest to date: human use impairments (section 4.2), impairments due to chemical contaminants (section 4.3), and ecological impairments (section 4.4), with a synthesis narrative for each.

For many of the assessments, there are data gaps that hinder our understanding of impairment and/or its causes. These data gaps are summarized in each subsection below. More detailed technical information is available on-line at http://www.epa.gov/glnpo/lakeerie/buia/index.html for each assessment with an **asterisk (*). The remaining impairment conclusions are draft.**

## 4.2 Human Use Impairments

The human use assessment results answer the questions, are Lake Erie waters: a) fishable, b) swimmable, c) drinkable, d) navigable, and e) clean enough for routine agricultural and industrial use? The impairment conclusions for each are summarized in Table 4.1 and show that Lake Erie waters are not yet completely fishable, navigable, and swimmable. The major causes of these impairments to human use are chemical contaminants and elevated levels of bacteria in recreational waters.

### Table 4.1 Summary of Human Use Impairments

| Impaired Use | Impairment Conclusions by Basin | Causes of Impairment |
|---|---|---|
| Fish and Wildlife Consumption Restrictions* | *FISH* –**Impaired** in all basins (Table 4.2)<br>*WILDLIFE* -**Impaired** in eastern basin; inconclusive for western and central basins | *FISH* - PCBs, mercury, lead, chlordane, and dioxins<br>*WILDLIFE* - PCBs, chlordane, DDE, DDT and mirex |
| Tainting of Fish and Wildlife Flavor* | Not Impaired | None |
| Restrictions on Dredging Activities* | **Impaired** in tributary mouths and harbors of all basins (Table 4.3) | PCBs, heavy metals |
| Restrictions on Drinking Water Consumption or Taste and Odor Problems* | Not Impaired | None |
| Recreational Water Quality Impairments* | **Impaired** in nearshore waters of all basins;<br>Inconclusive for offshore waters of all basins | Exceedances of *E. coli* and/or fecal coliform guidelines, PAHs+, PCBs+ |
| Degradation of Aesthetics* | **Impaired** in nearshore waters, all basins; Inconclusive for open waters of the western basin (Table 4.4). | Excessive *Cladophora*, point/nonpoint source stormwater runoff, floating garbage and debris, dead fish, excessive zebra mussels on shoreline areas. |
| Added Costs to Agriculture and Industry* | Not Impaired | None |

+ PAHs are the basis for a human contact advisory in the Black River Ohio Area of Concern and PCBs are the basis for a human contact advisory in the Ottawa River (Maumee Area of Concern). These advisories were issued by the Ohio Department of Health and mean that it is not safe to go into the water in these areas.

### 4.2.1 Fish Consumption Restrictions

Fish consumption impairments occur when contaminant levels in fish exceed current standards, objectives or guidelines, or public health advisories are in effect for human consumption of fish or wildlife. Impairment to human consumption of Lake Erie fish is occurring. Public health advisories for human consumption of sport fish are in place for many geographic locations within Lake Erie waters. Particularly noteworthy are "DO NOT EAT" consumption advisories for certain species/size classes of fish in Lake Erie, Maumee and Long Point Bays, the Maumee, Detroit, Raisin and Rouge River AOCs, and the Buffalo River/Harbor area. In addition, commercial fishermen in Ontario are prohibited from selling carp that are 32 cm or larger, due to PCBs.

**Table 4.2 Summary of Sport Fish Consumption Advisories by Lake Erie Basin**

| | |
|---|---|
| **Western Basin Nearshore** | Impaired.<br>Fish advisories for Maumee, Portage, Sandusky, Raisin, Rouge, Detroit, and Ottawa River tributaries, and Wheatley Harbor and Maumee Bay. |
| **Western Basin Offshore** | Impaired<br>Fish advisories for Lake Erie waters of all jurisdictions bordering this basin. |
| **Central Basin Nearshore** | Impaired.<br>Fish advisories for Vermilion, Huron, Black, Cuyahoga, Ashtabula, Chagrin River and Conneaut Creek tributaries and Rondeau Bay. |
| **Central Basin Offshore** | Impaired.<br>Fish advisories for Lake Erie waters of all jurisdictions bordering this basin. |
| **Eastern Basin Nearshore** | Impaired.<br>Fish advisories for Presque Isle Bay, Buffalo River/Harbor. Grand River, Ontario, Big Creek, and Long Point Bay. |
| **Eastern Basin Offshore** | Impaired.<br>Fish advisories for Lake Erie waters of all jurisdictions bordering this basin. |



The presence of contaminants in Lake Erie, which are the basis for these advisories, exceeds the Lake Erie Committee (LEC) draft objective related to fish consumption advisories. The goal of this objective is to "reduce contaminants in all fish species to levels that require **no advisory** for human consumption . . ." The existence of fish consumption advisories also does not meet the IJC objective of no restrictions on the human consumption of fish in waters of the Great Lakes Basin Ecosystem.

Fish consumption advisories are issued to assist sport fish consumers in protecting their health. The goal of advisories is to minimize human exposure to chemical contaminants that are present in fish tissue. The choice of which fish to consume, how frequently to consume, and how to prepare remains with the individual. In contrast, commercial fishing restrictions are enforceable standards and are therefore mandatory.

The most common chemical causes of sport fish consumption advisories are PCBs and mercury, although advisories in some areas are issued due to lead, chlordane and dioxins. Additional chemical parameters that are routinely monitored vary by jurisdiction. Sport fish consumption advisories are educational tools that not only identify geographic locations where fish are affected, but also inform consumers of fish species and size classes likely to contain higher levels of chemical contaminants, offer recommendations on frequency of consumption, and recommend preparation and cooking techniques that reduce risk of exposure to contaminants that accumulate in fatty tissues, such as PCBs. The presence of mercury in fish has been of particular concern because it accumulates in the tissue of fish rather than the fat. Food preparation methods such as trimming fat and skin, and broiling rather than frying do not reduce exposure to mercury. The only effective option to minimize exposure to mercury present in fish tissue is to follow fish consumption advisories and to avoid eating the internal organs of the fish.

As an example of jurisdictional efforts to address the mercury concern, Ohio has issued a general precautionary consumption advisory for women of childbearing age and children age 6 and under, for all species of fish in all Ohio waters. This is due to the presence of mercury at low background levels in nearly all Ohio fish samples tested. Due to frequency of consumption or traditional ethnic means of food preparation, subsistence anglers and certain cultural and immigrant groups may also be at greater risk of adverse effects due to contaminant exposure. More restrictive consumption frequency advisories are issued for these groups, such as the statewide Ohio mercury advisory and the Ontario mercury advisory for subsistence fishermen.

Carp is the fish species most frequently identified in consumption advisories, although numerous other species are identified in various locations, particularly channel catfish and freshwater drum. The different species restrictions apply to particular sizes of fish, based on the results of fish tissue sampling and varying rates of bioaccumulation.



#### *4.2.1.1Ongoing Research and Data Gaps*

Fish consumption restrictions may need to be updated in the future as conditions change. For example, reductions in contaminant levels in the food chain may allow some advisories to be lifted. Since 1970, levels of mercury in Lake Erie basin walleye have dropped substantially. However, between 1992 and 1995 levels have varied and may be increasing, at least in Lake St. Clair walleye (Straughan et al. 1999). In 1995, Ontario Ministry of the Environment issued more conservative consumption advisories in the Detroit River for the largest size class of walleye, recommending a drop in consumption from four meals/month to two meals/month. Currently, mercury and PCBs are the only contaminants limiting fish consumption in the Detroit River. Ontario data for mercury levels are not yet conclusive (Straughan et al. 1999), but are consistent with U.S. EPA data (U.S. EPA 1999) presented at a meeting held in response to public and scientific concerns about increased mercury in walleye. However, data from Michigan's whole fish contaminant monitoring program (1990 to present) do not indicate an increasing mercury trend for the Detroit River (Bob Sweet, pers. comm.).

Changes in bioavailability of contaminants may eventually affect fish consumption advisories. Zebra mussel research suggests that PCBs are being more quickly biomagnified up the food chain through a zebra mussel-round goby-small mouth bass connection (Ohio Sea Grant, 1999).

Research is underway to quantify the levels of microcystin present in fish tissue collected in areas where *Microcystis* blooms have occurred. Microcystin is a potent liver toxin produced by the blue-green algae *Microcystis*. In addition to evaluating the effect of microcystin levels on fish health, the results of the current research will identify whether microcystin is present in fish tissue at levels that impact the health of human consumers (Culver, 1999).

### 4.2.2 Wildlife Consumption Restrictions

Wildlife contaminant research has been extensive in the Great Lakes, but generally as it pertains to wildlife, not human health. Of the Lake Erie jurisdictions, only New York has established criteria for implementing wildlife consumption restrictions, although Ontario

and Michigan have done research to evaluate potential need for consumption advisories for waterfowl, and Ohio has research underway for snapping turtles. Public health advisories for human consumption of snapping turtles and waterfowl are in place for New York waters of Lake Erie. The contaminants causing these advisories are PCBs, mirex, chlordane, and DDTs.

### 4.2.3 Restrictions on Dredging Activity

Between 1984 and 1995, 25 navigational areas around Lake Erie were dredged. Twelve of the 25 areas dredged have required the dredged material to be disposed in a confined disposal facility (CDF) at some time during this period. Seven of these sites (Ashtabula, Cleveland, Lorain, and Toledo, Ohio, and Detroit, Rouge River and Monroe, Michigan) currently require confined disposal for most of the sediment dredged from those areas. Because there are restrictions on disposal of dredged materials, this use is considered impaired. Water quality standards and criteria for disposal of sediments vary among jurisdictions, but throughout the basin PCBs and heavy metals are the most commonly identified contaminants that dictate confined disposal. A PAH-contaminated site was remediated by dredging and remedial dredging is planned in at least three other sites around the basin.

**Table 4.3 Summary of Lake Erie Navigational Dredging Activity 1984-1995, by jurisdiction**

| Jurisdiction | Michigan | New York | Ohio | Ontario | Pennsylvania |
|---|---|---|---|---|---|
| # of Locations | 4 locations<br>3 AOCs | 1 location<br>0 AOCs | 12 locations<br>4 AOCs | 7 locations<br>1 AOC | 1 location<br>1 AOC |
| Volume (cu. yd.) | 3,585,200 | 101,400 | 20,928,600 | 788,135 | 177,800 |
| Cost (U.S.$) | $25,642,900 | $382,800 | $71,007,700 | $4,801,400 | $502,300 |



#### *4.2.3.1Ongoing Issues and Research*

The trend of disposing of dredged materials into confined disposal facilities is changing. As concentrations of contaminants in sediment continue to fall and CDFs reach their maximum capacity, there is a greater likelihood that other alternatives such as open-lake disposal, beach nourishment, upland disposal, or other beneficial reuse will occur. Both Canada and the U.S. have funded programs to investigate and demonstrate the use of remedial technologies to treat contaminated sediments and reduce the amounts that need to be placed in disposal facilities.

Although the major point sources of pollutants to sediments have decreased, methods and criteria for assessing the effects of contaminated sediments have become more stringent and could conversely contribute to a greater amount of contaminated sediments to handle. In addition, falling lake levels are necessitating more dredging to maintain navigation than in the previous three decades.

### 4.2.4 Recreational Water Quality Impairments

Annex 1 of the Great Lakes Water Quality Agreement (GLWQA) states that: *"Waters used for body contact recreation activities should be substantially free from bacteria, fungi, or viruses that may produce enteric disorders or eye, ear, nose, throat and skin infections or other human diseases and infections"* (IJC, 1989). Annex 2 of the GLWQA lists "beach closings" as a beneficial use impairment related to recreational waters. According to the International Joint Commission (IJC), a beach closing impairment occurs "*when waters, which are commonly used for total body contact or partial body contact recreation, exceed standards, objectives, or guidelines for such use*" (IJC, 1989).

Therefore, the major human health concern for recreational use of Lake Erie waters is microbiological contamination (bacteria, fungi, viruses, and parasites). Human exposure occurs primarily through ingestion of polluted water, and can also occur through the entry of water into the ears, eyes, nose, broken skin, and through contact with the skin.

Gastrointestinal disorders and minor skin, eye, ear, nose and throat infections have been associated with microbiological contamination.

As noted above, recreational water quality impairment includes situations where partial body contact recreation standards are exceeded. To be complete, an assessment needs to evaluate all recreational water use activities where total or partial body water contact may occur. This includes primary activities such as swimming, windsurfing and water skiing, and also situations where swimming may occur in open waters during secondary contact activities, such as boating and fishing. The assessment considers both nearshore and open water activities in its evaluation of impairment, thus, the change in title from *beach closings* to *recreational water quality impairments*.

Federal, state and provincial recreational water quality guidelines recommend bacterial levels below which the risk of human illness is considered to be minimal. When contaminant indicator levels in the bathing beach water reach levels that indicate contaminants may pose a risk to health, public beaches are posted with a sign warning bathers of the potential health risk. The primary tool to evaluate beach water quality is the measurement of *indicator organisms*, which indicate the level of bacterial contamination of the water. The two indicator organisms most commonly used to measure bacterial levels are *fecal coliform* and *Escherichia coli* (*E.coli).* High levels of fecal coliform or *E. coli* in recreational water are indicative of fecal contamination and the possible presence of intestinal-disease-causing organisms. However, it should be noted that neither *E. coli* nor fecal coliform testing differentiates between human or animal waste, or indicates the presence of viruses or of non-fecal contaminants (e.g. *Staphylococcus*).

#### *4.2.4.1Impairment Conclusions*

Bacterial level exceedances are occurring at beaches throughout the Lake Erie basin. Therefore, Lake Erie basin nearshore recreational water quality is impaired from a human health (i.e. bathing use) standpoint. Bacterial levels data examined in this assessment provide support for a conclusion that recreational use of Lake Erie offshore is unlikely to be impaired by bacteria. However, based on a request from the Binational Public Forum, the Lake Erie LaMP has decided to classify the use impairment for recreationally used "open waters" as "inconclusive", since a recent comprehensive data-set for open lake waters is not available for assessment.



Many sources contribute to microbiological contamination, including combined or sanitary sewer overflows, unsewered residential and commercial areas, and failing private, household and commercial septic systems. However, it is important to note that simply because bacterial levels are present, it does not necessarily mean that sewage overflow is a problem. Other sources may be agricultural runoff (e.g. manure); fecal coliforms from animal/pet fecal waste washed from soil by heavy rains, either from the beach or washed into residential storm sewers; wildlife waste, as from large populations of gulls or geese fouling the beach; direct human contact, e.g. swimmers with illnesses, cuts or sores; or high numbers of swimmers/bathers in the water, which are related to increased bacterial levels; and direct discharges, for example from holding tanks of recreational vessels. Other factors affecting contamination levels are low (shallow) water levels; hot weather/higher temperatures; high winds that can cause increased wave action that can transport bacteria from contaminated, non-recreational areas to recreational-use areas; high winds that can stir up bacteria that are in the sediments; and calmer waters that can slow dispersal and create excess concentrations of bacteria.

### 4.2.5 Degradation of Aesthetics

An aesthetic impairment occurs when any **substance in water** produces a **persistent** objectionable deposit, unnatural color or turbidity, or unnatural odor (e.g. oil slick, surface scum) (emphasis added, IJC, 1989).

For the Lake Erie LaMP process, the IJC listing criteria for evaluating aesthetic impairments in Lake Erie have been adopted with the following additions:

- Whether an aesthetic problem is *naturally* occurring or *man-made* does not affect its potential designation as an impairment;
- The fact that there is currently no known solution to an aesthetic problem does not affect its potential designation as an impairment.

With the exception of beneficial use impairment assessments already completed for Lake Erie AOCs, Lake Erie aesthetic problems have not previously been evaluated collectively. In most cases the locations, frequency, duration, and magnitude of any identified aesthetic problems or impairments have not been regularly tracked through any formal monitoring program. In addition, there is no precise/common definition for a "persistent objectionable deposit." Therefore, detailed information is largely anecdotal and inherently subjective.

The purpose of this assessment is to: a) outline all known instances of aesthetics problems in Lake Erie waters, b) evaluate the nature of these problems, where possible, and c) to distinguish between aesthetic impairments to use of Lake Erie, as defined by the IJC listing criteria, and other aesthetic issues of concern that do not meet the listing criteria. To date, the Lake Erie LaMP process has identified the following list of potential aesthetic problems: high turbidity, obnoxious odor, excessive *Cladophora*, excessive blue-green algae, nuisance conditions at public beaches/ lake shoreline, excessive aquatic plants washing up onto beaches and shorelines, floating garbage/debris, and dead fish.

### *4.2.4.1Impairment Conclusions*

**Table 4.4 Summary of Lake Erie Aesthetic Impairment Conclusions**

| Type of Impairment | Determination of Impairment | Location/Extent of Impairment | Known Causes of Impairment | Notes |
|---|---|---|---|---|
| High Turbidity | **Impaired.** | Maumee, Rouge River and River Raisin AOCs - western basin; Black and Cuyahoga (navigation channel) AOCs - central basin. | Agricultural and urban point and nonpoint source runoff and storms stirring up bottom sediments. | |
| Obnoxious Odors | **Impaired** due to dead fish and *Cladophora*; Inconclusive due to decaying zebra mussels. | Cuyahoga AOC - central basin (fish); *Cladophora* fouling has occurred at Lake Erie State Park Beach, New York and Rondeau Bay, Ontario. | Decaying algae and fish. | Although decaying zebra mussels and combined sewer overflow discharges of raw sewage are known to cause obnoxious odors, it appears from information to date that these problems are not persistent in Lake Erie. |
| Excessive *Cladophora* | **Impaired.** | Eastern and central basin nearshore - nearshore and river mouths in Ontario waters (eastern basin) and Rondeau Bay, Ontario (central basin). | Nutrient enrichment, availability of substrate. | |
| Blue-green Algae | Inconclusive. | Western basin. | Emerging issue. Research is underway to pinpoint cause of Microcytstis bloom. Hypothesis that zebra mussels may be contributing to the problem. | It is not known whether extensive Microcystis blooms will continue to persist. Therefore a definitive impairment determination has not been made. |
| Aquatic Plant Deposits at Public Beaches | Not Impaired/No documentation to date showing a persistent problem. | N/A | N/A | |
| Zebra Mussel Shells at Public Beaches | Inconclusive. | Large deposits of shells have been reported at many western basin beaches and at Presque Isle Bay State Park, central basin. | Deposits of zebra mussels/ shells. | It is not known whether reported problems are persistent and, if so, if they are interfering with human use of shoreline areas. |

| Type of Impairment | Determination of Impairment | Location/Extent of Impairment | Known Causes of Impairment | Notes |
|---|---|---|---|---|
| Floating Garbage and Debris | **Impaired.** | Geographic extent of impairment is localized, Cuyahoga AOC, Headlands Dune State Nature Preserve - central basin. | Large quantities of floating debris (primarily natural), Cuyahoga AOC; interfering with navigational, recreational, and industrial use of affected area in Cuyahoga AOC.<br><br>Large quantities of floating garbage (primarily combined sewer overflow-related) have led to citizen complaints at Headlands Dunes State Nature Preserve. | This issue is significant enough for the Cuyahoga AOC, that a proposal to purchase a debris harvester is being pursued. |
| Dead Fish | **Impaired.** | Geographic extent of impairment is seasonal and localized.<br><br>Cuyahoga AOC - central basin, Ontario eastern basin waters are only documented impairments to date. | Seasonal die-offs due to alewife/other exotics not acclimated to colder water temperatures. | |

N/A = Not Applicable



### *4.2.5.2 Emerging Issues*

There are two current Lake Erie phenomena that have aesthetic ramifications, but are also indicators of much broader ecosystem changes in Lake Erie - *Microcystis* blooms and the reappearance of the burrowing mayfly, *Hexagenia limbata*. Research is currently underway to determine the cause and potential implications of the recent *Microcystis* blooms in the western basin. The LaMP will use the research findings, when available, to reevaluate the status of *Microcystis* blooms as an aesthetic impairment to the western basin of Lake Erie. The emerging issue of mayfly reappearance exemplifies the conflict between traditional indicators of improving ecosystem quality and perceived aesthetic problems. During the final stage of their life cycle, burrowing mayflies emerge from Lake Erie sediments and swarm in such large numbers they have made roads slippery and caused temporary brown-outs. These swarms of mayflies are regarded as a signal of improving Lake Erie water quality, but create a temporary nuisance to humans. Because the mayfly is widely regarded as a signal of improving water quality, any aesthetic problems created by swarming have not been classified as an impairment in this assessment. However, it is acknowledged that there can be temporary conflicts between the improving Lake Erie ecosystem and certain desired human uses of the Lake region during the mayfly swarming period.

## 4.3 Impairments Caused by Chemical Contaminants

### Overview

Both contaminant loadings to the lake and contaminant levels in biota have decreased from levels recorded in the 1960s and 1970s. However, Lake Erie still contains a legacy from the past in the form of contaminated sediments that were deposited before bans on the use of certain chemicals and pollution reduction initiatives were implemented. Contaminants are clearly bioaccumulating in Lake Erie biota on a continuum from benthos to fish to amphibians, reptiles, birds and mammals, resulting in the specific impairments summarized in Tables 4.5 through 4.7. In addition, the filter feeding habits of the non-indigenous invasive zebra mussel are re-introducing contaminants not previously biologically available back into the water column and ultimately into the food web.

The information in this section is organized by trophic level (benthos, fish, birds, and mammals) to more clearly illustrate the biomagnification concept. Benthic organisms spend most or all of their lifecycle in the sediment of the lake. Some fish are benthic feeders or spend most of the time near the bottom; others eat organisms that have spent part of their lifecycle as benthos. Finally, birds and mammals prey on the fish. Each organism has bioaccumulated contaminants during its lifecycle, and the effect magnifies as one moves up the food chain. There are species used as indicators of this phenomenon (midges, mayflies, brown bullhead, bald eagle and herring gull) for which we have the most information. However, the list of species used to monitor contaminant impacts has grown in recognition of widespread bioaccumulation.

It should be noted that contaminant studies tend to look at **effects to a particular organism in a particular location** versus population-wide effects. But when evidence from the ecological impairments (section 4.4) is combined with toxicological results, it can be seen that contaminants are often an important limiting factor to population health.



### Summary Conclusions

Lake Erie basin impairments caused by chemical contaminants include restrictions to fish and wildlife consumption, restrictions on dredging activity, fish tumors or other deformities (section 4.3.2), bird and animal deformities or reproduction problems (section 4.3.3), and benthic deformities (section 4.3.1). Impairment conclusions for restrictions to fish and wildlife consumption and restrictions on dredging activity are summarized in section 4.2, human use impairments. The remainder are summarized below.

PAHs, PCBs, DDE, DDT, mercury, lead, chlordane, dioxins, mirex, dieldrin, and nitrates are all demonstrated to be causing impairment to fish and/or wildlife. As a result, most of these chemicals have already been identified as LaMP pollutants of concern for source trackdown. In particular, PCBs and mercury have been designated as critical pollutants for priority action in the Lake Erie LaMP.

#### 4.3.1 Benthos

Benthos refers to the suite of organisms that live on or in the lake bottom, referred to here as macroinvertebrates. Because macroinvertebrates live in close association with the sediments and are relatively immobile, they are good bioindicators of levels of persistent compounds in the sediments, especially trace metals and organic chemicals (pesticides, petrochemicals, PCBs, PAHs, etc.). Therefore, one of the criteria used for assessing benthic impairment is when toxicity of sediment-associated contaminants at a site is significantly higher than reference controls.

Highly toxic sediments produce profound, but sometimes non-specific, reductions in benthic abundance, richness (numbers of species), and community composition. Lower levels of contaminants may cause sublethal effects in invertebrates, just as they do in vertebrate animals (impairment of growth or development, morphological deformities, chromosomal abnormalities, or production of stress proteins). Contaminant breakdown products are often more toxic than the parent compounds. However, some benthos may tolerate persistent compounds because they lack the ability to break the pollutants down into compounds that can be excreted. Because benthic invertebrates may bioaccumulate these toxic compounds, their body burdens can serve as indicators of the amount of

bioavailable contaminants in the environment, and of the transfer potential to predators at higher trophic levels (fishes, birds, etc.). Bioaccumulation factors for some chemicals can be extrapolated to anticipate whether burdens of top predators are likely to approach toxic thresholds.

For the Lake Erie LaMP assessment, the benthic communities found in contaminated sediments may be designated impaired if one or more of the following occur:

- The community is degraded;
- Bioassays using sediment from an area indicate toxicity to benthic organisms;
- Macroinvertebrates collected from the sediments have significantly elevated incidences of deformities or other abnormalities;
- The contaminant burden of benthic animals is great enough that predators may be at risk of bioaccumulating toxic concentrations of the contaminants.

Impairment was assessed in each of six lake zones: tributaries, wetlands, shorelands, embayments, nearshore and offshore. Draft conclusions, by basin and zone, for benthic impairments due to contaminated sediments are summarized in Table 4.5. Benthic impairments that are due to causes other than contaminated sediments are addressed in section 4.4.

**Table 4.5 Summary of Benthic Impairments Caused by Contaminated Sediments**

| Lake Erie Zone | Lake Erie Basin | Type of Impairment |
|---|---|---|
| Tributaries | Eastern - Buffalo River | Contaminated sediments; elevated incidence of mouthpart deformities in midges |
| | Eastern - Grand River, Ontario | Chemical contamination |
| | Central - Black, Cuyahoga and Ashtabula Rivers | Contaminated sediments |
| | Western - Detroit, Raisin, Ottawa and Maumee Rivers, Swan Creek | Contaminated sediments |
| Embayments | Central - Black, Cuyahoga, Ashtabula Rivers | Harbors dominated by pollution tolerant benthos |
| | Western - Maumee Bay, Toledo Harbor | Contaminated sediments |
| Nearshore *(≤ 5 m depth water depth up to 4 km from shore)* | Western - Detroit and Maumee Rivers | Elevated incidence of mouthpart deformities in midges |
| Offshore *(> 4 km from shore)* | Western - Detroit River discharge current | Low *Hexagenia* population density appears to parallel discharge current band; this needs to be confirmed with maps |
| | Western - Monroe | Adult *Hexagenia* collected in 1994 had the highest contaminant burdens (PCBs, other organochlorines, pesticides) of any Lake Erie samples |
| | Western - Middle Sister Island | *Hexagenia* larvae had high burdens of organochlorines and PAHs |

**Data gaps**

- Most of the identified benthic impairments are in the western basin of Lake Erie because there is almost no data on benthic contaminant burdens in the central and eastern basin. This is an important data gap that must be filled to complete the assessment of Lake Erie benthic health. Scarcity of organisms previously hindered obtaining this information. With the advent of zebra mussels and *Hexagenia* swarms, the biomass is now easily collected, but sample analysis costs are still a barrier.
- Toxicological studies of organisms that prey primarily on benthos are lacking. Therefore, we do not have specific information about the contaminant burdens in benthos at which toxic or sublethal impacts occur to predators. In this assessment to address biomagnification without the above-mentioned data, we determined that if contaminant levels in benthos (lower trophic level) were equal to the contaminant levels in fish (higher trophic level) that trigger a human consumption advisory, the benthos are potentially toxic to top predators.

### 4.3.2 Fish

**Overview**

In Lake Erie and its tributaries, mercury, PCBs, lead, chlordane and dioxins are causing fish consumption advisories. PAHs in contaminated sediments are causing fish tumors and other deformities. The purpose of fish consumption advisories is to minimize potential adverse impacts to human health (section 4.2). However, the contaminant data that support the advisories can also be used as a tool to assess fish and wildlife health. For example, contaminant levels in fish are used to develop bioaccumulation factors used in assessing contaminant impacts to fish-eating birds, mammals, amphibians, and reptiles (see section 4.3.3).



The purpose of assessing the prevalence of fish tumors and other physical abnormalities is to use these as an indicator of both environmental degradation of the aquatic ecosystem and as a measure of health impairment to fish populations. However, this assessment of fish health is limited to fish deformities and PAHs, which do not bioaccumulate. Therefore, the potential impacts of bioaccumulative chemicals on other aspects of fish health, such as reproduction, are not covered. This data gap is acknowledged by the LaMP and explained in more detail in the data gaps section below.

The assessment criteria require identification of fish tumor or deformity impairments: a) regardless of whether a specific cause for the tumor has been identified, b) regardless of whether a cause, when identified, is a chemical pollutant and/or carcinogenic, and c) regardless of whether a tumor is a carcinoma. Only data for types of tumors suitable as impairment indicators were used for this assessment (excludes genetically and virally induced tumors). All sites where fish tumor data suitable for indicating impairment existed, and tumor prevalence exceeded rates at least impacted sites in the Lake Erie basin, were classified as impaired as summarized in Table 4.6.

Where brown bullhead tumor impairment occurs, the cause is known to be PAHs. Because brown bullhead are benthic fish and remain in a specific geographic location during their lifespan, tumors are indicative of local sediment conditions. In surveys of other fish species, although the causes of tumor or deformity impairment are unknown, the presence of more mobile fish species points to broader environmental degradation (versus locally contaminated sediments) as the source of the problem.

## Table 4.6 Summary of Fish Tumor or Deformity Impairments

| | |
|---|---|
| **Western Basin Nearshore** | **Impaired -** in 6 tributaries, the Lake Erie islands, and along the Lake Erie shoreline in 2 Ohio counties. |
| **Western Basin Offshore** | No conclusive documentation of impairment (e.g. freshwater drum tumors). |
| **Central Basin Nearshore** | **Impaired -** in 13 tributaries, 1 bay, and along the Lake Erie shoreline in 4 Ohio counties. |
| **Central Basin Offshore** | No data available to assess impairment. |
| **Eastern Basin Nearshore** | **Impaired -** in 1 tributary and 1 bay. |
| **Eastern Basin Offshore** | No conclusive documentation of impairment (e.g. freshwater drum tumors). |

### Research Needs/Data Gaps

During the review of and comment on Lake Erie beneficial use impairment assessments, concern was raised that there was nothing equivalent to the Bird and Animal Deformities or Reproductive Problems assessment to cover the issue of fish reproductive problems due to chemical contaminants. (Fish reproductive problems from causes other than contaminants are covered in the degradation of fish populations and loss of fish habitat assessments.) As a result of this issue being raised, it was decided that a separate report to address this issue would be produced by the LaMP, when resources are available. This report will examine things such as goiterogens, endocrine disruptors, as well as any chemical contaminant related reproductive problems.

There are two issues with the current fish tumors or other deformities assessment: a) the age of tumor incidence data for certain locations, and b) lack of true reference site data. Because funding for fish tumor studies has generally only been available to analyze locations where contaminants are known to be degrading the environment, little attention has been paid to developing data for unimpacted sites. Therefore, data from "least impacted" sites had to be used to assess impairment in Lake Erie. With true reference site data, the magnitude and severity of existing impairment would likely be greater.

In Canada, the Ontario biomonitoring program to assess fish tumor incidence ended in 1996 due to government budget cuts. To address these issues in the U.S., the United States Geological Service (USGS) is currently coordinating a research and monitoring effort, in partnership with a number of principal investigators, to re-evaluate conditions in all the U.S. Areas of Concern (AOCs). One aspect of this project is monitoring the current rate of tumor incidence in Lake Erie tributaries. Data results are expected to be available in phases over the next two to three years. The USGS project, once completed, will provide an update to the information presented in this assessment report and is also expected to provide some new reference site data. At a minimum, reference site data will be available from the Huron River in Ohio.

Despite these attempts to update information for the U.S. AOCs, there is still a general lack of knowledge about the extent of the occurrence of tumors in fish from Lake Erie, as well as the rest of the Great Lakes, in species other than drum and bullhead. Comprehensive data on fish deformities in other species found along the Lake Erie shoreline exist only for Ohio. Specific data gaps are as follows:

- Data results from systematic evaluation of fish species, other than bullhead, have been provided to the LaMP only for the Ohio tributaries and Lake Erie shoreline. The causes of elevated incidence rates of fish tumors and/or deformities in these other species are unknown.
- Most of the existing information about tumor occurrence deals with the fish of the harbor, bay, and tributary areas. Tumors or deformities in fish of the open lake have been studied much less.
- Studies that use a standardized sampling method are needed so that studies in various states and lakes are comparable. For instance, a statistically valid sample of the most abundant length classes of adult fish of a given species needs to be used instead of including all length classes.
- And finally, studies that characterize other components of the ecosystem inhabited by tumor-bearing fish might indicate the value of tumor prevalence as a predictor of ecosystem health.



### 4.3.3 Wildlife

Toxicological wildlife survey data are used throughout the Great Lakes to confirm the presence of deformities or other reproductive problems in sentinel wildlife species in a particular location. Therefore, by definition, the presence of these problems is enough evidence to confirm that impairment is occurring and is a good indicator of both wildlife health and potential adverse impacts due to contaminants. This assessment is not intended to assess population-wide impairments. Those issues are covered in the degradation of wildlife populations assessment (see Table 4.9).

Because wildlife toxicology surveys are often designed to determine conditions in the Great Lakes basin as a whole, this assessment varies from others in the amount of Lake Erie specific data available and its ability to report results by Lake Erie basin. In addition, the Lake Erie basin populations of some of the species examined such as bald eagle and colonial waterbirds nest primarily in the western basin. Others such as the river otter were extirpated from the Lake Erie basin prior to the 1900s and have only recently been reintroduced by wildlife management agencies. The most abundant data are available for Lake Erie bald eagle and herring gull populations that have been surveyed annually since 1980 and the early 1970s, respectively.

A combination of lowest observable effect concentrations (LOECs), population recovery objectives, and physiological biomarkers was used to establish the scientific weight of evidence for impairment. Ecoepidemiological criteria were used to establish cause-effect linkages, where possible. Reproductive, deformity, and physiological impairments are identified and associated with chemical causes, where known, in Table 4.7. These results indicate that some type of impairment is either clearly or likely occurring in all groups assessed, except for tree swallows. As noted below, tree swallows are very resistant to the effects of chemical contaminants, and may therefore be a poor indicator species.
As noted earlier, per the IJC listing criteria, this assessment is not required or intended to

determine whether population-wide effects are occurring due to the identified impairments. Reproductive effects do not immediately or always translate into population effects. For example, if a population is near its carrying capacity (point at which species is in equilibrium with its environment), then there may not be enough resources (food, nesting habitat, etc.) for all young to survive to reproductive age. Hence, up to a point, a decrease in production of young due to a contaminant may not affect adult population size because many young would have died anyway. However, if the population is below its carrying capacity, a decrease in production of young may prevent the population from reaching carrying capacity. In this situation, the impairments summarized in Table 4.7 can become more significant when all stressors to a particular species group are summed (contaminants, habitat loss, exotics, etc.). It is interesting to note that the results of the degradation of wildlife populations assessment for these same groups of animals conclude that impairment is also occurring at the Lake Erie basin sub-population level.

### Table 4.7 Summary of Bird and Animal Deformity or Reproductive Impairments

| Species/Species Group | Impaired? | Type of Impairment | Likely Cause* | Notes |
|---|---|---|---|---|
| **Bald Eagle** | **Yes**, observed; exposure above effect levels | Reproductive & Deformity | **R**-PCBs, dieldrin, DDE<br>**D**-PCBs | Extent of impairment is probably obscured by hacking/fostering and immigration from less contaminated inland territories |
| **Colonial Waterbirds (herring gulls, double-crested cormorants, common and Caspian terns)** | **Yes**, observed in herring gulls; exposure above effect levels in herring gull, cormorant, and common tern eggs | Reproductive, Deformity & Physiological-immune system, reproductive organs, thyroids, liver enzymes, vitamin A, & porphyrins** | **R**-PCBs and possibly other chemicals<br>**D**- PCBs<br>**P**- PCBs, other organo-chlorines | * Cause of recent reproductive failures of herring gulls on W. Sister Is. may include PCBs, microcystin, and (or) other factors<br>* Tree nesting cormorants are hard to study, but contaminant concentrations are among highest in Great Lakes and are likely associated with embryonic mortality and deformities<br>*Although Caspian terns have attempted to colonize Lake Erie as recently as 1996, they are still too rare in the basin for field study |
| **Tree Swallow** | Not impaired | | | Significant Organochlorine exposure; resistance to effects may make swallow a poor indicator species compared to other insect-eating songbirds |
| **Mink** | Likely; PCBs in food above effect levels | Likely Reproductive and Physiological | **R** - PCBs<br>**P** - no data | |
| **Otter** | Insufficient data, but likely based on predicted high levels of exposure | Likely Reproductive | **R**- PCBs | Too rare in Lake Erie basin for study as they have just recently been re-introduced. |

| Species/Species Group | Impaired? | Type of Impairment | Likely Cause* | Notes |
|---|---|---|---|---|
| **Snapping Turtle** | Likely - not observed, but exposure at some Ohio sites above effect levels | Likely Reproductive, Deformity, Physiological | **R** - PCBs, other organochlorines<br>**D** - PCBs, other organochlorines<br>**P** - organochlorines | |
| **Eastern Spiny Softshell Turtle** | **Yes**, observed; exposure above effect levels | Reproductive | **R** - PCBs, other organochlorines | |
| **Frogs/Toads** | Likely (see notes) | Likely Reproductive | **R**-DDE, nitrates | Nitrate concentrations in Lake Erie watershed often exceed lethal and sublethal concentrations for amphibians studied in laboratory experiments |
| **Mudpuppies** | **Yes**, observed | Deformity | **D**- PAHs and organo-chlorines | |

* R= Reproductive impairment; D = Deformity Impairment; P = Physiological Impairment

** Porphyrins - the liver synthesizes heme for hemoglobin and certain enzymes. Some organochlorines block this process by causing the accumulation of highly carboxylated porphyrins.

**Nitrates**

Nitrates are nutrients and do not bioaccumulate. However, at higher concentrations they have been shown to cause effects to amphibians that are similar to those caused by toxic contaminants. Because less research and monitoring data are generally available for amphibian populations as a group, the mechanisms for the observed biological effects of nitrates are not as clearly defined as those for other organisms. A short summary of what is known is provided below.

A review by Rouse *et al.* (1999) evaluated the risk of direct and indirect effects of nitrate on amphibian populations. This review used a simple comparison of known environmental nitrate concentrations in North American waters to nitrate concentrations known to cause toxicity in a laboratory setting to amphibian larvae and other species that play an important role in amphibian ecology.

Lethal and sublethal effects in amphibians are detected in laboratory tests at nitrate concentrations between 2.5 and 385 mg/L (Table 4.8). Amphibian food sources such as insects and predators such as fish are also affected by elevated levels of ammonia and nitrate in surface waters (Rouse *et al.*, 1999). This may have important implications for the survival of amphibian populations and the health of food webs in general.

**Table 4.8 Toxicity of Nitrate to Amphibians (Rouse *et al.*, 1999)**

| Species | Stage | Endpoint (mg/l) | Concentration of Nitrate |
|---|---|---|---|
| *Bufo americanus* | Tadpole | 96h-LC50 | 13.6 & 39.3 |
| *Pseudacris triseriata* | Tadpole | 96h-LC50 | 17 |
| *Rana pipiens* | Tadpole | 96h-LC50 | 22.6 |
| *Rana clamitans* | Tadpole | 96h-LC50 | 32.4 |
| *P. triseriata* | Tadpole | Developmental | 2.5-10 |
| *R. pipiens* | Tadpole | Developmental | 2.5-10 |
| *R. clamitans* | Tadpole | Developmental | 2.5-10 |
| *Bufo bufo* | Tadpole | 96h-LC50 | 385 |
| *Bufo bufo* | Tadpole | Developmental | 9 |
| *Bufo bufo* | Tadpole | Death | 22.6 |
| *Litoria caerulea* | Tadpole | Developmental | 9 |
| *Litoria caerulea* | Tadpole | Death | 22.6 |
| *Rana temoraria** | Adult | EC50-paper | 3.6 g/m$^2$ |
| *Rana temoraria* | Adult | EC50-soil | 6.9 g/m$^2$ |

* Frogs were placed on moist paper or soil spread with ammonium nitrate granules
LC50=lethal concentration required to kill 50 percent of the test population within 96 hours
EC50=lethal concentration for 50% of the population

Environmental concentrations of nitrate in surface waters in agricultural watersheds in southwestern Ontario and US states in the Lake Erie watershed ranged from 1 to 40 mg/L. Of 8000 water samples from rivers in the watersheds of Lake Erie and St. Clair in the Canadian Great Lakes and in US states in the Lake Erie watershed, 19.8% had nitrate levels above 3 mg/L. This concentration was known to cause physical and behavioral abnormalities in some amphibian species in the laboratory (Rouse *et al.*, 1999). A total of 3.1% samples contained nitrate levels that would be high enough to kill tadpoles of native amphibian species in laboratory tests (Rouse *et al.*, 1997).

**Research Issues/Data Gaps**

Programs and funding for monitoring contaminant concentrations and assessing their biological effects have declined in recent years. Maintenance of these programs is essential for filling the information gaps described in Table 4.7, assessing recovery from impairment,

and detecting the emergence of new problems. Specific survey and monitoring needs are outlined below.

- Most of the major contaminants considered in this assessment are organochlorines, because they caused past and current reproductive impairments and population-level effects. More environmental data are available for this class of chemicals than others. However, many other newer industrial chemicals and pesticides are released into the Lake Erie ecosystem in large quantities. Few biomonitoring studies have examined the concentrations and biological effects of these chemicals in Lake Erie wildlife. Recent advances in laboratory and field toxicology have shown that some of these chemicals (e.g., nonylphenol, bisphenol A, atrazine, aldicarb) are able to disrupt the function of the endocrine, immune, and nervous systems, even with low level exposure during development.
- Due to improvements in the health of national populations of bald eagle in both the U.S. and Canada, the level of effort to monitor or band Lake Erie bald eagles has decreased in recent years. However, for the Lake Erie subpopulation, contaminant impacts are still affecting the recovery of the overall population. Therefore, it is important to continue studies of reproductive success, deformities, and contaminant concentrations in blood and eggs. It is also important to consider continuing banding/color-marking studies to allow tracking of individual eagles from the territories where they are raised to the territories where they breed. Up until about two years ago, this was done across the entire lake. Today this type of more intensive monitoring is more spotty and declining due to declining funding. Studies of recruitment patterns will be essential for answering questions about the high turnover rate of adult eagles breeding on the Lake Erie shoreline, the survival and reproductive success of eagles exposed developmentally to contaminants from Lake Erie, and the rate of immigration from inland areas to the Lake Erie shoreline.
- The cause of the reproductive impairment in herring gulls on West Sister Island requires further investigation. Toxicologically significant concentrations of microcystin toxin have been found in the livers of one herring gull from West Sister Island and a number of Caspian tern chicks from Saginaw Bay, which bears some similarity to western Lake Erie in terms of primary productivity and PCB concentrations. The accumulation of microcystin toxin in colonial waterbirds is an emerging issue that deserves further study. Other potential causes of the reproductive failure include PCB-induced wasting syndrome, infectious disease, or some interaction among these factors.
- A formal deformity survey in colonial water birds is needed to better estimate the rate of deformities.
- Birds such as tree swallows that eat emergent aquatic insects can accumulate high concentrations of organochlorines and other contaminants. Although studies of Lake Erie tree swallows from the eastern and central basins have shown only a few biochemical effects and no reproductive effects, biologically significant impacts are possible in more sensitive species, especially in the western basin where organochlorine concentrations are higher. Such studies should be initiated.
- Little is known about the potential exposure of diving ducks to contaminants through consumption of zebra mussels. A significant proportion (52%) of diving ducks (scaup, goldeneye, bufflehead, scoter, and old-squaw) had zebra mussels in their gizzards at the time of collection from Lake Erie (Hamilton and Ankney, 1994). The potential for physiological effects following consumption of contaminated zebra mussels has not been studied.
- Better information is needed for mink and otter in the following areas: population surveys, tissue residues, and contaminant concentrations in food. The Canadian Wildlife Service has initiated a mink carcass collection to take place from 1999-2001 within the Canadian Lake Erie watershed. Trapper-caught carcasses from Lake Erie marshes and inland tributaries will be analyzed for contaminants, and examined histopathologically and morphologically. Measurements of reproductive organs will be made to determine possible contaminant effects on reproductive development. Collections of mink carcasses and potential food items from two Lake Erie marshes were made in 1998, and will be analyzed for carbon and nitrogen stable isotope ratios, a technique that provides

information on the diet of marsh-living mink. Ongoing monitoring of mink populations in shoreline marshes using track censuses is planned.

- Few studies exist that examine both the levels and associated effects of contaminants on reptiles living in the Lake Erie watershed. The few studies that exist for Lake Erie have primarily examined contaminant concentrations in tissues and eggs. Contaminant concentrations in Lake Erie water snakes from Pelee Island are high enough to justify a study of health and reproductive effects. The Canadian Wildlife Service, World Wildlife Fund and Upper Thames River Conservation Authority recently initiated such a study.
- Contaminant concentrations in the threatened eastern spiny softshell turtle and the corresponding low rates of egg hatching in the Lake Erie basin suggest that further investigation of contaminant effects is warranted. The Canadian Wildlife Service, World Wildlife Fund and Upper Thames River Conservation Authority recently initiated such a study.
- Further investigation of contaminant levels and effects in the common snapping turtle is warranted in coastal wetlands of Lake Erie, especially the western basin and marshes in the U.S. Hatching success and deformity rates should be examined. Other endpoints, such as differential effects on males versus females and behavioral effects in snapping turtles from Lake Ontario and the St. Lawrence River, are being studied by the University of Guelph and the Canadian Wildlife Service. These endpoints could be examined in Lake Erie populations in the future.
- Data is needed about the sensitivity of amphibian eggs, larvae and adults to DDT concentrations presently occurring in water and the food web of coastal wetlands, especially in Point Pelee National Park.
- The sensitivity of mudpuppies, frog tadpoles, and adult frogs to TFM use in the Great Lakes has been noted (Gilderhus and Johnson, 1980; NRC, 1985; Matson, 1990; Weisser *et al.*, 1994). The lampricide TFM is used to control the exotic sea lamprey that otherwise would impair populations of lake trout and other species (see Section 4.4.2.2). There are conflicting opinions about the significance of this sensitivity and its implications for potential impairment. Therefore, the impact of TFM on amphibian populations needs to be assessed by monitoring populations of mudpuppies and other amphibians pre- and post-treatment. These studies need to establish the significance of any mortality to these populations in treated streams and in the Lake Erie basin as a whole. From a reproductive standpoint, it is particularly important to determine if TFM has greater impacts on certain age classes and/or egg-bearing females.
- Nitrate concentrations in agricultural watersheds of Lake Erie (3.1 % of water samples) are high enough to exceed the LC50 or sublethal effect (19.8% of water samples) on amphibian tadpoles of various species. However, these predictions are based on laboratory-based studies and need to be tested in wild populations.



## 4.4 Ecological Impairments

Ecological beneficial use impairments are intimately interconnected, and in Lake Erie include: degraded fish, wildlife, phytoplankton and zooplankton populations; loss of fish and wildlife habitat; eutrophication or other undesirable algae; degraded benthos; fish tumors or other deformities; and bird or animal deformities or reproduction problems. Therefore, the status of these beneficial use impairments needs to be integrated to develop a more comprehensive understanding of stressor impacts to the system as a whole. Fish tumors or other deformities, bird or animal deformities or reproduction problems, and benthic impairments caused by chemical contaminants are covered in detail in section 4.3, but are also mentioned in this section because dysfunction in the ecosystem is caused by contaminants as well as other stressors. Table 4.9 summarizes both the types of impairment and impairment conclusions for the noncontaminant related ecological impairments.

The ecological beneficial uses were assessed in relation to historical conditions, existing management goals and objectives, out-of-system references (where available), and recent concerns, as applicable. Impairments occur to all of the beneficial ecological uses of the lake. To fully understand the causes of impairment as outlined below, it must be understood

that population impairments are often a subset of habitat impairments. Therefore, this ecological use synthesis starts by addressing habitat to document the causes and extent of impairment. The underlying causes (stressors) of the habitat degradation are examined. Habitat impairment information is grouped by stressor because each stressor generally affected a broad range of habitat types.

Population information is organized by impairment results, rather than by stressors causing impairment, because population impairments integrate across trophic levels to the whole ecological community. One of the criteria for determining habitat impairment is inability to support healthy benthos, plankton, fish, and wildlife populations. So, when the status of these populations is summarized, lost and degraded habitat is one of the key causes of population impairment.

The key reasons for habitat impairment, called primary stressors, are hydrology changes associated with land use, nutrient and sediment loads, invasion of non-indigenous species, and contaminants. All of these primary stressors are the result of human use of the Lake Erie environment. Due to the adverse impacts of primary stressors on the Lake Erie environment, some key secondary stressors have also emerged. For example, due to the irreversible loss of large areas of Carolinian forest habitat, black-crowned night herons and egrets are primarily restricted to breeding on the Lake Erie islands in the western basin. Here they compete for habitat with the booming double-crested cormorant population. The cormorant population is present because of protection from human disturbance and an abundant food supply of exotic pelagic fish (alewife, shad, smelt). The cormorant guano is killing the trees in which herons and egrets nest. In this case, the primary stressor is changing land use that led to the loss of mainland habitat. The secondary stressor is the impact of the cormorant population on the remaining island habitat. Therefore, when examining causes of impairment and means of rehabilitation, it is important to understand the sequential interactions of stressors as well.



### Table 4.9 Summary of Ecological Impairments

| Impairment | Impairment Conclusions | Types of Impairment | Causes of Impairment |
|---|---|---|---|
| Degradation of Phytoplankton and Zooplankton Populations* | **Impaired** - entire *eastern basin*; lake effect zones of certain *western and central basin* tributaries | *PHYTOPLANKTON-eastern basin*-total standing crop and photosynthesis are below the potential set by P loading in the nearshore; loss of keystone species; loss of trophic transfer to *Diporeia* *ZOOPLANKTON-eastern basin*-loss of dominant cold-water species; *Eastern and west-central basins*-reduction in mean size points to potential impaired trophic transfer; *west central basin - Bythotrephes* acts as an energy sink; *western and central basin* lake effect zones- habitat loss and degradation | Zebra and quagga mussel grazing; high planktivory |
| Degradation of Fish Populations* | **Impaired** in *all basins* (species impaired vary by basin) | unmet fish population objectives**; loss of spawning/nursery area; loss of population diversity; rare, threatened, endangered and special concern species; reduced predatory function; unnaturally high fish community instability; inefficient use of food web energy | habitat loss and degradation; non-indigenous species (exotics); loss of forage fish availability; overexploitation; loss of native stocks/species, particularly keystone predators |

| Impairment | Impairment Conclusions | Types of Impairment | Causes of Impairment |
|---|---|---|---|
| Loss of Fish Habitat* | **Impaired** in tributaries, shorelands, and nearshore of *all basins* (note-nearshore includes entire western basin area); | unmet fish habitat objectives**; loss of habitat diversity & integrity; loss of spawning/nursery areas; barriers to migration; changes in stream temperature, water quality, and hydrology; high turbidity; loss of aquatic vegetation; changes to benthic species composition; | destruction and draining of wetlands; dams, dikes, dredging/channel modifications, water taking; streambank/ shoreline filling and hardening; sediment/chemical contaminant/ nutrient loadings; navigation/ recreational boating activities; exotics (carp, purple loosestrife, *Phragmites*); *Cladophora* fouling (eastern basin nearshore) |
| Degradation of Wildlife Populations | **Impaired** in *all basins*<br><br>detailed case studies are being prepared for 20 species or wildlife groups (birds, mammals, amphibians and reptiles) to illustrate the key impairment issues affecting the larger group of wildlife species that use the Lake Erie environment | unmet wildlife population objectives**; population fragmentation, isolation, and instability; loss or reduction in species indicative of quality habitat; loss of source populations; rare, endangered , threatened, and special concern species; accelerated rates of parasitism/ predation; competition between wildlife/nonwildlife uses of a given habitat ; changes to ground temperature and moisture conditions in forested areas; loss of travel lanes; loss of range/area-sensitive species (e.g. –amphibians & reptiles, rails, bitterns, sedge wrens, bald eagle) | fire suppression; logging; destruction and draining of wetlands; high water levels, storm surges; dredging/channel modifications, water taking, streambank/shoreline filling, hardening & backstopping; sediment/chemical contaminant/nutrient loadings; navigation/boating activities; exotics (zebra mussel, carp, purple loosestrife, *Phragmites,* garlic mustard, Eurasian milfoil, hybrid cattail, mute swan, gypsy moth, Dutch elm disease, chestnut blight) |
| Loss of Wildlife Habitat | **Impaired** in *all basins*<br><br>16 major habitat types were assessed. 13 were impaired in all Lake Erie jurisdictions where they occur (open lake, islands, sand beach/cobble shore, sand dunes, submerged, floating and emergent macrophytes, wet meadow, shrub swamp, mesic prairie, upland marsh, mesic and swamp forests) | unmet wildlife habitat objectives**; habitat fragmentation and loss of niches; loss of diversity and integrity; population demands exceed available habitat (e.g.- colonial waders that use the Lake Erie Islands); loss of stopover habitat along migratory corridors (birds, butterflies, bats); loss of cover for protection from predation; loss of or accelerated succession patterns; loss of area available for habitat expansion; loss of buffer functions between one habitat type and another; loss or reduction in quantity/quality of nesting/denning areas; loss or reduction in quantity/quality of food sources | fire suppression; logging; destruction and draining of wetlands; high water levels, storm surges; dredging/channel modifications, water taking, streambank/shoreline filling, hardening & backstopping; sediment/chemical contaminant /nutrient loadings; navigation/boating activities; exotics (zebra mussel, carp, purple loosestrife, *Phragmites,* garlic mustard, Eurasian milfoil, hybrid cattail, mute swan, gypsy moth, Dutch elm disease, chestnut blight) |

| Impairment | Impairment Conclusions | Types of Impairment | Causes of Impairment |
|---|---|---|---|
| Degradation of Benthos | **Impaired.**<br><br>*eastern basin*-offshore waters;<br><br>*central basin*-tributary, shoreland, nearshore and offshore waters;<br><br>*western basin*-tributary, shorelands, offshore waters | Degraded benthic community (composition and interactions among components) compared to reference conditions;<br>Dominant species indicate degraded environment;<br>Keystone species absent or nearly gone:<br>**all basins*-unionid mussels, *Gammarus* amphipods;<br>**east & central basins-Diporeia* amphipods;<br>**east and western basins* - fingernail clams;<br>**middle* of western basin-*Hexagenia* (mayflies), see *Table 4.5;*<br>unmet objectives for benthic density, biomass or productivity**;<br>toxicity to benthic organisms (section 4.3.1);<br>elevated incidence of deformities or other abnormalities (section 4.3.1);<br>contaminant burden is high enough that predators may be at risk of bioaccumulating toxics (section 4.3.1) | contaminated sediments, non-indigenous species or exotics (zebra mussel, round goby, etc.), loss and degradation of habitat particularly in wetlands |
| Eutrophication or Undesirable Algae* | **Impaired** - Maumee Bay, lake effect zones of Maumee/Ottawa Rivers, *western basin*; nearshore and river mouth areas of Canadian *eastern basin*<br>Potentially impaired – lake effect zones of certain Ohio tributaries, *western and central basins*; Rondeau Bay and nearby nearshore and river mouth areas, Canadian *central basin* | Excessive *Cladophora* (see Degradation of Aesthetics impairment conclusions), degraded fish communities in lake effect zones of certain tributaries, P levels above Canadian guidelines in tributaries | Phosphorus |

* More detailed technical information is available on-line at http://www.epa.gov/glnpo/lakeerie/buia/index.html for each assessment with an asterisk

** For a discussion of existing objectives and their relationship to Lake Erie LaMP ecosystem objectives, see section 4.1.

### 4.4.1 Habitat Impairments

#### *4.4.1.1 Introduction*

The IJC very broadly defined habitat as the "specific locations where physical, chemical and biological factors provide life support conditions for a given species." Specifically, the IJC indicated that "habitat impairment occurs when fish and/or wildlife management goals have not been met as a result of loss of fish or wildlife due to a perturbation" of the habitat. Management goals have been developed for birds (North American Waterfowl Management Plan (NAWMP), National Shorebird Plan, and Partners in Flight -Flight Plan) and fish (Lake Erie Fish Community Goals and Objectives). In addition, when the IJC developed listing criteria for determining benthic impairment, they included a recommendation that ecosystem health objectives be developed using benthic community structure. This recommendation has been implemented by a number of Lake Erie researchers (particularly for keystone species) and the *objectives* have become widely accepted in scientific circles, even though they do not yet reside in any formal management plan. For other organisms, key indicator species and/or community structure were examined.

To assess the quality of the habitat in the Lake Erie basin, the basin was divided into 18 regions of similar physical, chemical and biological structure. The present evaluations were based not only on the ability of the present habitat to support fish, wildlife, plankton and benthic populations (ecological function) and on local and lakewide objectives as prescribed by the IJC, but also on historical records/out-of-system references, and recent concerns. Table 4.10 summarizes our present information linking stressors and habitats. Loss of natural area to human use (i.e. agriculture, industry, housing) is an impairment in all Lake Erie basin upland habitat types, and extends shoreward to include wet meadows, emergent macrophytes, interdunal wetland and unconsolidated shore bluffs. So much of the original habitat has been lost that fragmentation of habitat and the small size of remaining habitat impaired mesic forest, swamp forest, shrub swamp, mesic prairie, wet meadow, and wetland complexes. Other stressors are further degrading the remaining natural habitat.



#### *4.4.1.2 The Habitat Continuum*

Habitat degradation in the Lake Erie basin is due to a number of stressors, acting in concert. Even if the most critical stressor were alleviated, complete recovery would not occur. Remediation will likely require improvement in a number of areas. Table 4.10 summarizes our understanding of the relationship between stressors, habitat impairment, and impacts to populations of benthos, fish and wildlife. Stressors are listed vertically by category (altered hydrology, changing land use, and other) and the major habitat types assessed in the Lake Erie basin are listed horizontally. Habitat definitions are outlined in Table 4.11. Where X is used, the applicable stressor affects all fish, benthos and wildlife. Where a stressor only affects the habitat of fish, benthos, or wildlife the letter F, B or W was used instead of X. Where there is nothing in a cell, it means that the particular stressor does not significantly affect that particular habitat in the Lake Erie basin. In addition to integrating this information, the table is designed to provide a preliminary tool for developing an action agenda.

The 18 habitat types listed in Table 4.11 form a continuum of changing physical, chemical and biological structure along gradients of water/moisture, light penetration, and substrate type. In sheltered aquatic areas, habitat progresses from open water to submerged macrophytes, floating macrophytes, emergent macrophytes and then wet meadow and shrub swamp or mesic prairie as water depth and flooding decrease and light becomes more available. In exposed aquatic areas, the nearshore habitats progress from sand or cobble substrates below water to beaches, interdunal wetlands in the sheltered hollows behind the beach or foredunes, and sand dunes. These two suites of nearshore habitats absorb the wave energy during storm events, protecting the upland regions from the more severe flooding and erosion events that are present today in comparison with historical conditions. Degradation of the beach and wetland complexes has decreased their ability to absorb the force of storms and is considered a cause of impairment of the dunes, wet meadows, mesic prairie and forests. On land, the dunes and mesic prairie give way to mesic forest. In the uplands, swamp forest, marshes, bogs, fens and vernal ponds develop in depressions and

kettles. A similar progression of habitats radiates out from the larger open water and marsh areas and sheltered regions of tributaries. The floodplains of the tributaries develop shrub swamp and swamp forest.

The interconnectedness of the habitats in the Lake Erie basin means: (1) that degradation in one habitat has consequences for adjacent or downstream habitats, and (2) that stressors generally affect a range of similar or adjacent habitats across a gradient. Some stressors, such as contaminants and loss of habitat area, affect community function in a broad range of habitats. Because habitats are highly interconnected, many species do not spend their entire life cycle in one habitat. For example, many species of birds that are habitat specific during the nesting season utilize a completely different set of habitats during the migration periods and may winter in entirely different regions of the continent. Another example is northern pike that live among submerged macrophytes as adults, but breed in flood pools associated with tributaries. Their young live in the emergent vegetation. Turtles and snakes that live in marshes and swamps lay their eggs in nearby forest and beach ridges. To support intact fish and wildlife communities, it is important for the whole range of habitats to be present and naturally functional.

### Table 4.10 A Summary of the Stressors Affecting the Habitats in the Lake Erie Basin

| ***Habitat Zone*** | Aquatic Habitat | | | Shore Habitat | | | |
|---|---|---|---|---|---|---|---|
| Stressor/Habitat Type | Open Water Offshore | Open Water Nearshore | Tributaries* | Islands | Sand Beaches/ Cobble Shore | Unconsolidated Shoreline | Interdunal Wetland |
| ***Altered Hydrology*** | | | | | | | |
| Altered ground water -wells, logging | | | X | | | | |
| High water levels -erosion, flooding | | X | | W | W | W | W |
| Lack of along shore sand movement | | X | | | W | | W |
| Tributary flow | | X | X | | | | |
| Stream channelization | | X | X | | | | |
| Dams -sediment, water, barrier | | X | X | | W | | |
| Draining | | | X | | | | W |
| Dredging | B, F | X | X | | W | | X |
| Entrainment | | F | | | | | |
| Heated Effluent | | X | | | | | |
| ***Changing Land Use*** | | | | | | | |
| Conversion to human habitat (e.g.farm) | | X | X | X | W | W | W |
| Degradation of adjacent habitat | | X | X | | W | | W |
| Fire suppression | | | | | | | |
| Nutrient addition | B | X | X | | | | |
| Increased sediment loads | | X | X | | | | W |
| Hardening/development of shoreline | | X | X | W | W | W | W |
| Backstopping/dikes | | X | X | | W | | W |
| Quarrying/mining/gas & oil wells | Possibly | W | X | W | | | |
| Logging | | | X | | | | |
| ***Other*** | | | | | | | |
| Exotics | Quagga? | Carp | Carp | Dreissenids. | | NNP | Carp, NNP |
| Contaminants | X | X | X | | | | |
| Cormorants/Deer | | | | Corm. | | | |
| Loss of large mammals | | | | | | | |
| Direct human use of natural habitat (e.g. boating, hiking) | | F,W | X | W | W | | W |

**NNP** = non-native plants; **MS** = mute swan; **Corm**. = cormorant; *Tributary habitat includes floodplain forests and certain swamp forests.

| ***Habitat Zone*** | Shore Habitat | Nearshore Habitat | | | Upland Wetland | | | |
|---|---|---|---|---|---|---|---|---|
| Stressor/Habitat Type | Sand Dunes | Submerged Macrophytes | Floating Macrophytes | Emergent Macrophytes | Wet Meadow | Mesic Prairie | Shrub Swamp | Bogs & Fens |
| ***Altered Hydrology*** | | | | | | | | |
| Altered ground water -wells, logging | W | | | W | W | W | W | W |
| High water levels -erosion, flooding | W | W | W | W | W | | W | |
| Lack of along shore sand movement | W | | | | | | | |
| Tributary flow | | W | W | W | | | W | |
| Stream channelization | | W | W | W | W | W | W | W |
| Dams -sediment, water, barrier | | | | | | | | |
| Draining | W | W | W | W | W | W | W | W |
| Dredging | | X | X | X | X | | | |
| Entrainment | | | | | | | | |
| Heated effluent | | | | | | | | |
| ***Changing Land Use*** | | | | | | | | |
| Conversion to human use (e.g. farm) | W | | | W | W | W | W | W |
| Degradation of adjacent habitat | W | W | W | W | W | W | W | W |
| Fire suppression | | | | W | W | W | W | W |
| Nutrient addition | | W | | | | | | X |
| Increased sediment loads | | W | W | W | W | | W | X |
| Hardening/development of shoreline | W | W | W | W | W | | W | |
| Backstopping/dikes | W | W | W | W | W | | W | |
| Quarrying/mining/gas & oil wells | | | | | | | | W |
| Logging | | | | | | | | |
| ***Other*** | | | | | | | | |
| Exotics | NNP | Carp, NNP, MS | NNP, Carp | Carp, NNP | NNP | NNP | Carp,NNP | NNP |
| Contaminants | | | | | | | | |
| Cormorants/deer | W | | | | W | W | W | W |
| Loss of mammals | | | | | W | W | | |
| Direct human use of natural habitat (e.g. boating, hiking) | W | | W | W | | | | |

**NNP** = non-native plants; **MS** = mute swan; **Corm**. = cormorant

| ***Habitat Zone*** | Upland Wetland | Uplands | |
|---|---|---|---|
| Stressor/Habitat Type | Upland Marsh | Mesic Forest | Swamp Forest |
| ***Altered Hydrology*** | | | |
| Altered ground water -wells, logging | W | W | W |
| High water levels -erosion, flooding | | | W |
| Lack of along shore sand movement | | | |
| Tributary flow | | | W |
| Stream channelization | | | W |
| Dams -sediment, water, barrier | | | |
| Draining | W | | W |
| Dredging | W | | W |
| Entrainment | | | |
| Heated effluent | | | |
| ***Changing Land Use*** | | | |
| Conversion to human use (e.g. farm) | W | W | W |
| Degradation of adjacent habitat | W | W | W |
| Fire suppression | W | W | W |
| Nutrient addition | W | | |
| Increased sediment loads | W | | W |
| Hardening/development of shoreline | | | |
| Backstopping/dikes | | | W |
| Quarrying/mining/gas & oil wells | | W | |
| Logging | | W | W |
| ***Other*** | | | |
| Exotics | Carp, NNP | NNP | NNP |
| Contaminants | | | |
| Cormorants/deer | Deer | Deer | Corm., Deer |
| Loss of mammals | | | |
| Direct human use of natural habitat (e.g. boating, hiking) | W | W | W |

**NNP** = non-native plants; **MS** = mute swan; **Corm.** = cormorant

## Table 4.11 Definitions for Lake Erie Habitats

| Habitat | Definition |
|---|---|
| Islands | With the exception of Mohawk Island, primarily limited to the western basin of Lake Erie. Permanent islands with rock bound shores below dolomite or limestone cliffs. Due to the moderating effects of surrounding lake waters, the climate of the islands has a greater range in annual mean temperature, less precipitation, smaller range of daily temperature, and a longer frost-free season then the neighboring mainland. |
| Sand Beaches/Cobble Shore | Temporary open shorelands controlled by shifting sands and fluctuating water levels. Composed of rock fragments ranging from fine sand to large boulders. Devoid of or have minimal vegetation. |
| Unconsolidated Shoreline | Restricted to the eastern and central basins. Bluffs consisting of a rock or clay base with a thin topsoil layer along the top. |
| Interdunal Wetlands | An integral component of the marsh complex and the wetlands closest to the lake proper. Formed behind the active shoreline when lake levels have been stable enough to provide elevated dune areas. Wet pockets behind the foredunes or beaches and lakeward of the inner dunes or ridges. |
| Sand Dunes | Formed by deposits of sand and gravel along the lake shore in areas that are no longer under the effect of the active wave zone. Three communities are found in the Lake Erie basin: a) grassland dune complexes; b) wooded beach ridge; and c) the sand barrens found on ancient beach ridges. |
| Submerged Macrophytes | Occurs in marsh and open lake settings. Characterized by pondweeds, milfoils, coontail, wild celery, and bladderworts that depend on water pressure/buoyancy for support of their thin, pliable stems. |
| Floating Macrophytes | A transition from open water habitat to emergent marsh vegetation. Occurs in shallow, protected water within streams and coastal marshes. Dominated by rooted plants with floating leaves such as water lily, spatter-dock, water-lotus, water smartweed, and floating-leaved pondweeds. |
| Emergent Macrophytes | Consists of 2 community associations: a) robust emergents (cattail and hardstem bulrush) occurring lakeward, and b) narrow-leafed emergents (bulrushes, smartweeds, millets, burreed, rice-cutgrass, wild rice, etc.) occurring shoreward. Survive best in stable water levels, but can tolerate fluctuations for short periods. |
| Wet Meadow | Occurs as a band of vegetation in a transition zone above normal water levels. Soil is moist and may be inundated for a period of time sufficient to reduce the establishment of woody vegetation. Dominant species include bluejoint grass, northern reed grass, slough grass and sedges. |
| Mesic Prairie | A series of tall and short-grass prairie complexes governed by water availability. Historically fire prevented this habitat from succeeding to wooded habitat. |
| Shrub Swamp | Distinct from marsh in being dominated by woody vegetation (pussy and sandbar willow, swamp rose, meadow-sweet, silky dogwood, and buttonbush). Generally occur in glacial kettles or around the margins of lakes or marshes. Highly dependent on natural hydrology. |
| Bog and Fens | Bogs are acidic, peat-accumulating, wetlands with as many as 5 distinct vegetative zones. Fens are also peat accumulating wetlands, where mineral rich (alkaline) spring water comes to the surface, and typically have a marl zone dominated by sedges. Generally bogs and fens are successional habitats that naturally advance to upland habitats in the absence of intervention. |
| Upland Marsh | Found in low areas of the upland landscape in kettle lakes or pothole-type wetlands. All portions of the coastal wetland complex can also occur in upland marshes. |
| Mesic Forest | Mature stage of the deciduous forest consisting of oak-hickory and beech-maple communities. Historically, fire was a key controlling factor of this habitat type. |
| Swamp Forest | Consists of floodplain forest and deciduous swamp forest. Floodplain forests occur with stream and river channels which are at least periodically flooded and common species include silver maple, cottonwood, sycamore, black willow, green ash, box elder, and Ohio buckeye. The typical dominant species of swamp forest include red and silver maple, black ash, and swamp, white and pin oaks. |

Tributaries provide an excellent example of the importance of the health, inter-dependence, and connectivity of adjacent habitats frequently emphasized in the beneficial use assessments (see Figure 4.1). Tributary flow regime (the magnitude, timing, duration, frequency, and rates of change of water movements within a watershed) is intimately connected with the watershed tablelands. Formerly, natural drainage patterns through wet forest and meadow habitat water retention areas controlled the amplitude and frequency of spring floods and maintained summer base flows. Cultural land use practices associated with settlement, deforestation, and agriculture increased drainage efficiency.

The amplitude and frequency of spring flooding in basin tributaries increased, as well as the amount of physical energy entering the stream courses. Due to accelerated spring run-off with reduced groundwater recharge, summer base flows were reduced. The draw down of the water table for human use has reduced the flow of spring water to certain rivers in eastern Ontario. This has further reduced summer base flow in these systems and impaired the spawning reaches of cold-water anadromous fish, such as trout.

The damming of lake basin tributaries is almost universal in scope. Dams alter the connectivity of stream systems and are barriers to migrations and other ecological interactions. Dams with sediment trapping abilities alter the physical hydrology and sediment dynamics in downstream reaches. Floodplains provide periodic connectivity between stream channel habitats and those habitats in these aquatic/terrestrial transition zones. Native terrestrial and aquatic species that are dependent on floodplain habitats evolved in these unique systems under natural flow regime conditions. Floodplains also provide for retention and assimilation of sediments, nutrients, and contaminants that are carried in the stream flow. The loss of assimilation capacity in tributary floodplains and their associated wetland complexes affects environments in inter-dependent nearshore zones (e.g. regions used by larval fish) and diverts the water, nutrients and sediments into the remaining wetlands, causing degradation of the wetland complex and nearshore regions of the lake.



Tributaries and their watersheds naturally provide a certain level of nutrients and sediments to the swamp forest in the floodplain, the lake and the wetland complexes. When the natural pattern of sediment and nutrient flow is altered, problems develop. Dams are a major reason for fish habitat impairments on tributaries. Dams trap the heavy sediments such as sand that are needed downstream to maintain beaches, sand bars and coarse-grained sublittoral habitats. Fine-grained sediments from the erosion of topsoil are suspended in the water and are released by dams. A certain amount of this material is needed by downstream vegetation as a source of minerals and nutrients. Too much can smother the vegetation through siltation and lead to eutrophic conditions. Dams not only trap sediment and water altering both the upstream and downstream habitats, they also isolate populations and block the migration of anadromous fish to upstream spawning grounds. Dams are a major source of impairments on tributaries.

With deforestation the lack of shade, both along the river edge and in the fields that drain into the river, allows the river water to reach warmer temperatures which can be detrimental both to the biota in the river as well as in the downstream wetlands. Expected increases in temperature with climate warming will only heighten this problem. Thus tributaries are affected by activities in adjacent land-based habitats, and effects typically move downstream to the swamp forest, wetland complexes, sand beaches, littoral regions, and finally to the open lake.

Two general impairments are related to the transference of impacts from one habitat to another. First, the shoreline habitats each protect the next inland habitat from storm events. They were each considered impaired due to the impairment of adjacent habitats. Second, modification of the hydrologic regime or water table in one habitat alters the hydrologic regime in all neighboring habitats in a cascading manner. Flowing water forms a geological continuum with a progression of habitat types that develop along the gradient in moisture. Changes in hydrology due to human activities (logging, clearing land, wells, draining, backstopping) have caused impairments in all terrestrial and marginal habitats.

### *4.4.1.3 Stressors of Aquatic and Terrestrial Habitats*

#### Aquatic Habitats

*High Water Levels, Backstopping*

The development and maintenance of the nearshore water-based habitats is a dynamic process controlled by along-shore sediment (sand) load in currents, the degree of shoreline indentation and structure, water levels and storms. Historically, the nearshore habitats moved inland or lakeward in response to changes in water levels. One of the major stressors on nearshore habitats (wetlands, sand/cobble beaches, unconsolidated shore bluffs, interdunal wetlands and sand dunes) in the past 30 years has been high water levels, particularly when coupled with shoreline hardening or development. The shoreline habitats have not been free to move inland, but rather are trapped in a narrow area between the water and man-made structures. When shoreline habitats are trapped, they are much more susceptible to the impacts of strong storms that not only severely alter their physical features, but also flush out detrital and planktonic matter into the nearshore margins faster and in higher amounts than what normally occurs from the marshes.

Sand bars and wide stretches of beach and/or submergent vegetation normally dissipate the force of these storms. Dikes were built or improved in the 1970s to protect the remaining marshes along the south shore of the western basin, which otherwise would have been lost (Metzger, Boggy Bottoms, Deer Park Refuges, Mallard, North Bay, West Bay, and Green Creek Clubs, Magee, Navarre, Toussaint, Trenchard's, Rusk, Moxley, and Erie Marshes, Ottawa and Winous Point Shooting Clubs, Little Portage, Toussaint, Little Portage, Pickerel Creek, Willow Point, Pipe Creek, and Pointe Mouillee Wildlife Refuges, Cedar Point and Ottawa National Wildlife Areas).

The vast biodiversity of the wetland wildlife communities are dependent on a vegetated wetland complex. Dikes to protect the remaining wetlands from the combination of high lake levels and backstopping (to protect human use areas from the lake), storm surges, non-native species (i.e. carp, purple loosestrife, and reed-canary grass), have been the only means of survival for these diverse communities.



While isolation of these wetlands from the lake has provided the sole remaining habitat for many wildlife, invertebrates and bird species, it has also impaired their use as fish habitat. Many fish species utilize wetlands at some point in their life. To fully rehabilitate the fish community in Lake Erie, coastal wetlands must be re-connected to the lake. An experiment is underway at the Metzger Marsh where a dike has been engineered to allow limited entry and exit to selected fish entry and close to natural cycles in water elevation, while still protecting the marsh from storms and carp.

High water levels also promote more extensive erosion of bluffs and beaches. In the past, the resulting sand was carried along shore and used to maintain and build up new beaches, underwater sandbars and shoals, and dunes. Breakwaters and other structures built out into the water, as well as the armoring of shorelines with rip-rap and dikes, have altered the intensity and paths of water currents redirecting much of this sediment load to deeper waters. The beaches have become narrower and more vulnerable to storms and seiches. These changes have decreased the feeding, nesting and resting opportunities for shore and wetland birds and wildlife, and increased the likelihood of their disturbance by people and by domestic and wild animals.

*Turbidity and Nutrients*

Forestry, agriculture, sewage disposal and combined sewer overflows have caused unnaturally high inputs of nutrients and sediments to the lake in the past. Remedial actions have greatly reduced these inputs and their effects on the lake. Eutrophication is no longer considered a widespread issue in the open waters of the lake: phosphorus and chlorophyll *a* levels are close to objectives. Due to periodic anoxia, open waters of the central basin are dominated by tubificid benthos, an indication of impairment. Elevated phosphorus levels, high turbidity, degraded benthic communities (although improved over those in the 1960s), and the abundance of omnivorous fish indicate that tributary mouths are still degraded. Where nutrients have been measured excessive phosphorus remains a localized problem.

Along with nutrients, sediment loading is still a problem in numerous tributaries particularly in the western half of the lake. The offshore waters of the western basin and south shore of the central basin still show residual effects of eutrophication. Benthic communities in these regions are still impaired based on the high densities of tubificid worms, although their densities have been declining through the 1990s. The recolonization of the western offshore regions by *Hexagenia* starting in 1992 is thought to be due to improved oxygen conditions and decreased contaminant concentrations in the sediment throughout much (but not all) of the basin. The increase in the whitefish population indicates that anoxia is no longer a barrier to migration between the western and eastern basins.

Fine sediments have fouled the gravel and coarse substrates in the tributaries, shoreland, and nearshore environments reducing their suitability and use as spawning and feeding areas for fish or habitat for invertebrates. Many river spawning stocks were lost due to a combination of fouled spawning shoals and dams, e.g. northern pike, sauger, muskellunge, whitefish, sturgeon and walleye. Populations in the open lake are now maintained largely by lake spawning stocks. Rehabilitation of streams is allowing the recovery of some walleye river stocks and development of naturalized populations of rainbow trout. Pacific salmon (coho and chinook) are a minor component of stream spawners.

Recent improvements in water clarity during the 1990s can be attributed principally to the high filtering capacity of dreissenid mussels that invaded the lake in the late 1980s. Their impact has been particularly strong in nearshore regions and has allowed the redevelopment of submerged macrophyte beds. Submerged macrophytes in the open lake are not considered impaired. This habitat type is still considered impaired in the tributaries and wetlands due to loss of area (e.g. insufficient area to support wildlife and fish needs), and invasion of non-indigenous (exotic) plant species, but is definitely improving.



*Contaminants*

Contaminants, which enter the aquatic system through run off from the land, direct disposal and atmospheric deposition, presently degrade areas in the open lake, nearshore and tributaries, particularly in the western basin. Contaminant levels are sufficiently high in some regions of the lake that impacts have been observed in both the highest trophic levels (bald eagles, herring gulls, cormorants, and common tern) and the lower trophic levels (benthic invertebrates). Sediment contamination has been listed as an impairment to benthos in the mouths of the Buffalo, Niagara, Grand, Black, Cuyahoga, Ashtabula, Ottawa, and Maumee rivers and Swan Creek. Degraded benthic communities with higher than normal levels of mouthpart abnormalities (a measure of toxic impact) have been found in the nearshore regions off the Detroit and Maumee rivers. Adult *Hexagenia* collected from western basin nearshore regions had higher contaminant burdens than those offshore further suggesting that nearshore environments have contaminant problems.

Contaminants were considered one of the causes for the loss of *Hexagenia* from the majority of the lake in the mid-1950s. Although the *Hexagenia* population has made a remarkable recovery, particularly in the western basin, starting in the early 1990s its densities remain low through the central section of the basin. Contaminants are hypothesized to be the cause, although dissolved oxygen levels and sediment type are also critical to successful *Hexagenia* reproduction. *Hexagenia* larvae from the region of Middle Sister Island had high burdens of organochlorine compounds and PAHs.

*Non-indigenous Invasive Species*

Carp were introduced in the last century and are the most physically destructive of the wetland exotics. They root through soft sediments and macrophyte beds while feeding, resuspending sediments and disrupting stabilizing root systems in the process. Their activities magnify the nearshore sediment and turbidity impacts and reintroduce nutrients and contaminants buried in the sediments to the water column.

Eurasian milfoil has invaded submerged macrophyte beds, while *Phragmites*, purple loosestrife, reed-canary grass and hybrid-cattail have invaded the emergent wetland habitats. These invasive species cause impairments because many grow as monocultures that are not suitable for use by native species, reduce habitat complexity and biodiversity, and are less nutritious for the native birds and wildlife. They are also more vulnerable to disease and

other pests, as well as disturbance from fire and storms that would result in catastrophic loss of cover for all species.

Perhaps the most obvious and most significant exotic species in Lake Erie are the two dreissenid mussels, the zebra and the quagga mussel. Apart from the effects of their filtering activity on water clarity that was mentioned earlier, their physical presence is altering the nature of hard and soft substrates in Lake Erie.

*Terrestrial Habitats*

The main causes of impairment in the terrestrial habitats were loss of habitat area, fragmentation, altered hydrology, logging, the invasion of non-indigenous plant species, contaminants, and sedimentation of upland bogs, fens, marshes, and swamps. Logging has impaired the mesic and swamp forests. Removal of the largest (dominant) trees returns the forest to a lower successional state, decreases biodiversity of the entire system, removes food and nest/den sites, and opens up the canopy. Some of the losses of large trees with nesting cavities have been mitigated through nest box programs for such species as flying squirrels, wood ducks, bluebirds, and prothonotary warblers.

More sunlight can enter the forest, which increases the temperature of the leaf litter and dries the forest floor reducing the amount of wet habitat needed by the associated invertebrate fauna and amphibians. Non-indigenous plants have invaded and often form monocultures through the forest. They include garlic mustard, Japanese knotweed, dame's rocket, buckthorn and, in moister areas, *Phragmites*, purple loosestrife and reed-canary grass. The impairments they cause are: insufficient area to support wildlife populations; loss of plant biodiversity in the habitat; loss of habitat complexity; and decreases in nutritional food sources for wildlife.



### 4.4.2 Fish, Wildlife, Benthos and Plankton Community Impairments

Many species or groups of animals living in the Lake Erie basin were found to be impaired. Impairments were determined on a number of bases: a) population objectives set for key fish, wildlife and benthic species which integrate community function (e.g. mayfly-*Hexagenia*) or represent important functional groups (e.g. diving ducks, top predators etc.), b) ecological function, c) historical records, and d) recent concerns. These translate into impairments in biodiversity, community stability, and food-web structure and function. The causes of these impairments were associated with altered or lost habitat, the invasion of exotic species, human disturbance, and contaminants (Table 4.10).

Contaminant impairment of wildlife was noted for the benthic community, benthic feeding fish (tumors), fish eating birds, mudpuppies in tributaries and possibly for diving birds feeding on dreissenids. Impairments due specifically to contaminants are discussed in Section 4.3. The following sections examine impairments to biodiversity, community stability and food web structure and function, integrating effects across the different trophic levels where possible.

#### *4.4.2.1 Biodiversity and Endangered Species*

Biodiversity refers to the number of species supported by a self-sustaining community. Over time, biodiversity normally declines as a community/habitat becomes severely degraded because native species are often depressed or lost. In Lake Erie, biodiversity has been affected by habitat loss and degradation, human disturbance, commercial fishing, the introduction of non-indigenous invasive species and contaminants.

Thirty-four species of fish have been given the status of rare, threatened, endangered, species of concern or extinct in Lake Erie. Some of these were dominant members of the historical fish communities. A large number of the dominant species in the Lake Erie aquatic community are now exotics: smelt, alewife, gizzard shad, round gobies, white perch, rainbow trout, pacific salmonids, dreissenid mussels, *Echinogammarus*, and *Bythotrephes*. As these exotic species became dominant, the biodiversity of the historical fish, benthic, and plankton communities decreased. Smelt are linked to the decline of blue pike, lake herring, the large calanoid, *Limnocalanus*, the marked decrease in *Mysis*, and to the near demise of lake whitefish. The fish species mentioned above had been strongly

affected by overfishing and habitat degradation prior to the arrival of the exotic smelt in the lake. Alewife and smelt are implicated in the loss of spoonhead, slimy and deepwater sculpins. Recent evidence suggests that contaminants, in particular 2,3,7,8-tetrachlorodibenzo-p-dioxin, may have been responsible for the final loss of lake trout from Lake Ontario, although the role of thiamine deficiency and the resultant early mortality syndrome (EMS) in larval fish cannot be ruled out. This opens the question of the possible roles of contaminants and diet in the loss of lake trout and other species from other Great Lakes. Dreissenids have eliminated the unionid and sphaeriid clams from all but a few refuges in the wetlands, and are hypothesized to be indirectly responsible for the loss of *Diporeia* from the eastern basin. *Echinogammarus* has replaced *Gammarus fasciatus*, itself an exotic, in many regions.

Wildlife species using with wetlands for breeding habitats or as important migration stopover habitats make up the majority of rare, threatened, endangered, concern, or extinct species within the basin. For one jurisdiction over 80% of the listed birds (43 species), 40% of the listed mammals (two species), and half of the listed reptiles (eight species) use the wetland or terrestrial habitats of the Lake Erie basin. Mammals such as snowshoe hare, rice rat, porcupine, timber wolf, marten, fisher, mountain lion, lynx, elk, and bison have all been extirpated or extremely reduced in range and/or population in the Lake Erie basin. For many of these species, rehabilitation cannot be an option. Habitat diversity is so severely reduced or altered in most wetland and terrestrial habitats, coupled with negative impacts of exotic plants on native vegetation, that diversity of the plant community has changed, which in turn has reduced the potential diversity of the wildlife community.

#### *4.4.2.2 Community Stability*



*Open Lake*

The fish community is considered unstable for a number of reasons: loss of critical habitat, loss of stabilizing effect of top predators, overwintering mortality of nonindigenous species (alewife, shad), competition between native and nonindigenous species, and inefficient transfer of energy through the food web. The loss or degradation of critical spawning/nursery habitat has made reproductive success less predictable and leads to reductions and variability in year class strength of most species. The LaMP has yet to assess reproductive problems in fish. When this assessment is conducted it will address the potential for contaminant impacts on community stability through effects on reproduction. As mentioned in section 4.4.2.1, recent evidence suggests that 2,3,7,8-tetrachlorodibenzo-p-dioxin, may have been responsible for the final loss of lake trout from Lake Ontario. This opens the question of the possible role of contaminants in the loss of species from other Great Lakes and in the present reproductive function. Given that contaminants are: a) causing problems with benthos and top predators, b) at high enough levels to cause fish consumption advisories, and c) associated with tumors in brown bullheads, it would not be surprising if they were affecting the productive capacity of some fish populations.

Native stocks of the historical keystone predators (walleye, sauger, blue pike, northern pike, muskellunge) in cool-water habitats were extirpated or markedly reduced during the period from 1930 to 1972. These species were responsible for maintaining the structure and stability of the fish and lower invertebrate communities. Walleye populations recovered through the 1980s. In recent years, walleye distributions (move to deeper waters) have changed as transparency has increased, reducing the community structuring role of this species. Blue pike would normally occupy this habitat, but have been extirpated from Lake Erie and are now biologically extinct. Northern pike and muskellunge are still rare in many regions, leaving some nearshore areas without strong piscivore structuring. Smallmouth bass provide this function in areas of rock substrate.

Lake trout are maintained by stocking and thus their predatory function is not impaired (their reproduction function, however, is impaired). Fisheries managers are trying to maintain the predatory function in the lake through maintaining native walleye stocks, by stocking lake trout, and by controlling sea lamprey populations. The sea lamprey is an exotic species that, as an adult, is parasitic on larger fish. Sea lamprey control was introduced

to allow lake trout to reach sexual maturity, thereby making natural reproduction and self-sustaining populations possible. If the sea lamprey populations are not controlled they can: a) decimate the populations of larger fish, b) prevent lake trout rehabilitation, c) reduce the surplus fish for sport and commercial fisheries, and d) further decrease predator function and energy flow in the lake.

Sea lamprey control provides an excellent example of the potential conflicts involved in managing and trying to restore degraded systems. TFM is applied to tributaries to control the populations of juvenile sea lamprey, but it also kills other species of lamprey, mudpuppies, sculpin, and some invertebrates. Control of sea lamprey is imperative to the health of the fish community. Therefore, alternate strategies of sea lamprey control are presently being investigated by the Great Lakes Fishery Commission to reduce the use of TFM. Between 1990 and 1999, TFM use has been reduced by 39% Great Lakes wide and by 70% in the Lake Erie basin.

The nonindigenous planktivorous fish, alewife and shad, are not well adapted to winter conditions in Lake Erie and often suffer overwintering mortality. The extent of that mortality is dependent on the severity of the winter, which is variable. Native fishes are better adapted to conditions in Lake Erie and are less susceptible to overwintering mortality. Therefore, the population size of native species is less variable and would provide a more stable food source to top predators than that of non-native species. Alewife and shad can outcompete native planktivores, and together with smelt are the dominant planktivores in the lake. With these species as dominants, the stability of the fish community has been decreased. The inefficient transfer of energy through the aquatic food web is discussed in section 4.4.2.3.

The benthic fish community is changing rapidly with the introduction of dreissenids which have altered benthic community structure and productivity, and of gobys which feed effectively on dreissenids and displace native sculpins. This community is not yet stable.



**Terrestrial Communities**

In terrestrial communities, loss of habitat, contaminants and human interference have resulted in degraded community structure, a loss of predatory function and thus decreased community stability. Fragmentation of habitat and the small size of the remaining habitat impairs wildlife in mesic forest, swamp forest, shrub swamp, mesic prairie, wet meadow and wetland complexes. The loss of habitat has altered community structure and increased the intensity of the interactions (competition, predation) within the remaining habitat. The small habitat areas remaining often can not support animals which require large territories; such as eagles from the beach ridges along the south shore of Lake Erie or bison which once inhabited the mesic prairie. Species also become concentrated in small habitats and are then more easily located and vulnerable to predators and parasites. Fragmentation of habitat is also a serious problem. It particularly affects smaller, less mobile creatures, such as, amphibians, reptiles and insects. When habitats are fragmented, little or no migration occurs between isolated parts of the same habitat type. The resultant small, isolated populations are more susceptible to extirpation. Frogs and salamanders are impaired in interdunal wetlands, wet meadows, shrub swamps, upland marshes and swamp forests partly for this reason. Increased probability of extirpation, predation and parasitism, limited gene pools, and lack of top predators or larger mammals all result in decreased community stability.

The large deer population, loss of bald eagles from the system, small populations of coyote and the extirpation of carnivores such as wolves reflect a loss of top predators in the terrestrial as well as the aquatic community. The impact of range expanding species, such as the cormorant, also suggests a decline in community stability. Several bird populations have expanded greatly and are negatively impacting other species or groups.

- The decline in mainland habitat of colonial water birds is pushing black-crowned night herons and egrets into competition with cormorants, which arrived in the Lake Erie basin earlier this century. The breeding population of cormorants in the Lake Erie basin is restricted to the islands in the western basin. The population is expanding and their guano has the potential to kill the trees in which they nest. The loss of mainland habitat is restricting black-crowned night heron and egret breeding to these same islands and

trees. This shrinking habitat base raises long term concerns for the future of these species. Cormorants can nest on the ground, but egret and heron require trees.

- Increasing ring-billed gull populations have displaced common terns from historic nesting sites on beaches, islands, and dune areas and result in increased predation on remaining nesting colonies. This is considered an impairment because the population levels of ring-billed gulls are elevated above historical levels, likely due to the additional sources of food provided by agriculture and human garbage. The piping plover is also impaired from increased ring-billed gull populations and other nest predators such as raccoons and skunks. Human disturbance has been a leading cause of extirpation of breeding piping plovers from the basin.
- Black ducks prefer bog and fen type environments for breeding. Their population is impaired because it is below the objectives set by NAWMP. The recovery of black ducks is hampered by the large populations of mallard which outcompete them in the more open environment created by the altered land uses of the basin. Marsh management creates habitat more favorable for mallard breeding than black duck breeding. Bog and fen habitats cannot be rapidly created or restored for short-term recovery of black ducks.
- Prothonotary warblers, which were considered as representative of the needs of a bird/amphibian complex, are impaired for the most part by habitat changes. However, their existence is jeopardized further by competition with exotic species (European starling, house sparrow) for nest sites and by nest parasitism by cowbirds.

#### *4.4.2.3 Altered Food Web Structure and Function*

*Aquatic Habitats*



Dreissenids have radically changed the food web and in so doing are responsible for impairments to the benthos, plankton and fish communities. The high filtering capacity of dreissenids has probably impaired the phytoplankton community by decreasing phytoplankton biomass and primary productivity in nearshore regions of the eastern basin. This has translated into reduced zooplankton production in those regions and poor recruitment of young-of-the-year fish. Offshore in the eastern basin, dreissenids may be responsible for the decline in diatom species richness and biomass in the spring. An alternate hypothesis is that UVB radiation is responsible. The decline in diatoms is hypothesized to be responsible for the loss of *Diporeia* (benthic impairment), an important food source for fish (whitefish, young lake trout, and smelt) in the hypolimnion.

Dreissenids have also caused the loss of unionid mussels, sphaeriid clams and a shift of the offshore benthic community away from grazing and predacious invertebrates toward oligochaete worms. This new community is less able to support the historic fish community. Loss of *Diporeia* offshore intensified the predation of smelt on mysids and zooplankton. Strong predation on zooplankton by alewife and smelt has resulted in zooplankton communities composed of small species and in lower total zooplankton production.

The addition of *Bythotrephes*, a predatory zooplankter, has inserted another trophic level between herbivorous cladocerans and fish. *Cercopagis*, another predatory zooplankter, is expected to arrive soon. This also decreases the efficiency of energy flow up the food web. The abundance of *Bythotrephes* in this planktivore dominated system further suggests that *Bythotrephes* may be an energy sink. The zooplankton community in the eastern basin is not transferring energy to fish as efficiently as it might. Thus, in total, the food resources of fish in the eastern basin have been reduced. This food web disruption of the pelagia of the eastern basin is an impairment of the fish community as fish community goals and objectives for harvestable surplus fish cannot be met.

In addition to altering the food-base of the pelagic fish community in the eastern basin, dreissenid impacts on water clarity have affected the efficient use of this food by the fish community. The increased transparency of the water column has displaced the principal predator, walleye, from much of the habitat. The smelt population in the eastern basin is in poor condition. There is no longer efficient transfer of energy to a top predator. Thus, the surface waters of the eastern basin are impaired due to lack of a strong predator species, which can utilize the habitat vacated by walleye. The food-web disruption of the pelagia

due to dreissenids has been moving into the central basin. In the eastern and central basins, the decrease in smelt and rapid increase in gobies, which feed on dreissenids, is expected to affect predator feeding patterns and availability of predators to the fishery.

In the western basin, *Microcystis* blooms have developed in association with dreissenids. The cause of these blooms is being investigated and is hypothesized to be due to nutrient release by dreissenids. *Microcystis* is a blue green alga, which can produce toxins and is not readily consumed by other organisms. After many years of being absent, blooms have appeared sporadically for a number of recent years over a wide area, and are therefore likely a signal of impairment.

Dreissenid impacts have also benefited some groups of plants and animals. Increased water clarity has allowed the expansion of submerged macrophyte beds, and therefore the expansion of northern pike, muskellunge and sturgeon populations associated with this habitat. These species are still rare in Lake Erie. The increased macrophyte beds should help protect the emergent marshlands and provide new habitat for macroinvertebrates. Lake Erie is a critical staging area for diving ducks, such as mergansers, redheads, canvasbacks, and greater and lesser scaup, which use this habitat. Vegetation eaters, such as redhead and canvasback ducks, are showing wider use of sites. Mollusc eaters, such as scaup, are remaining for extended periods to feed on dreissenids. Mergansers are able to more efficiently feed on their small fish prey in the clearer water. Diving ducks, except for scaup, are meeting North American Waterfowl Management Plan (NAWMP) objectives and are not impaired.

*Terrestrial Habitats*

In the terrestrial communities, the invasion of exotic plants and harvesting of mast-bearing trees has altered the base of the food webs. Exotic plants, such as garlic mustard, Japanese knotweed, dame's rocket, buckthorn and, in moister areas, *Phragmites*, purple loosestrife and reed-canary grass, often form monocultures thereby reducing the variety of foods and are often less nutritious than the native plants.



Direct human disturbance has also reached the point of impairing wildlife populations thereby affecting community and food web functions. Through recreational use of habitats, people and their pets have negatively impacted these sentinel groups/species: diving ducks, the common tern, piping plover, and other shorebirds, bald eagles, black terns, snapping turtles and eastern spiny softshell turtle. In some instances, animals are scared from roosting or feeding areas, which incurs an energetic cost. In other instances, the reproduction of the organism is affected, which incurs a population cost. Human disturbance was noted as a factor affecting wildlife in a number of different habitat types: open water, islands, beaches, bluff, interdunal wetlands, mesic prairie, mesic forests and swamp forests. Only in submerged and floating macrophyte beds, beaches, and sand dunes was human recreational activity impairing the habitat, per se.

### 4.4.4 Research Issues/Data Gaps

***Plankton***

- Understanding the cycling of phosphorus and nitrogen in the presence of dreissenid mussels: impacts on phytoplankton composition, primary production and the *Microcystis* occurrence.
- Microcystis problem: conditions that promote *Microcystis*, what are the actual quantities, is it producing toxins and when.
- Need to know the partitioning of primary production between the benthic (periphyton) and pelagic phytoplankton: how it changes with depth, substrate and increased light penetration
- What is the role of UV radiation: has it decreased or altered the distribution of primary production through the season, what is the relative importance of UV radiation versus dreissenid filtering in the decline in diatoms in the spring.
- How important is the decrease in food supply (diatoms and zooplankton) after the arrival of dreissenids to the growth rate and survival of the mysid population in the eastern

basin: conversely how important is planktivory now in suppressing the mysid population.
- How important is *Bythotrephes* in depressing energy flow from zooplankton to fish: temporally? Spatially?
- How will *Cercopagis*, a new predatory zooplankton, affect zooplankton community structure and energy flow.
- What is the optimum mean individual size range (0.7-0.9 mm?) of the zooplankton community for effective energy flow up the food chain. – develop as a management tool
- Need for information on zooplankton and phytoplankton biomass and community structure in shallow littoral and nearshore habitats. VERY little information available.

***Benthos***
- Data is needed for benthic community composition in Canadian wetlands, shorelands in both Canada and the U.S., central basin nearshore, especially Canadian waters, and central basin profundal zone.
- An improved understanding is needed of benthic-pelagic processes and benthic biotic/physical feedback loops, especially in the western basin.
- A GIS facilitated, integrated data-base of all historical and current benthic data is needed.

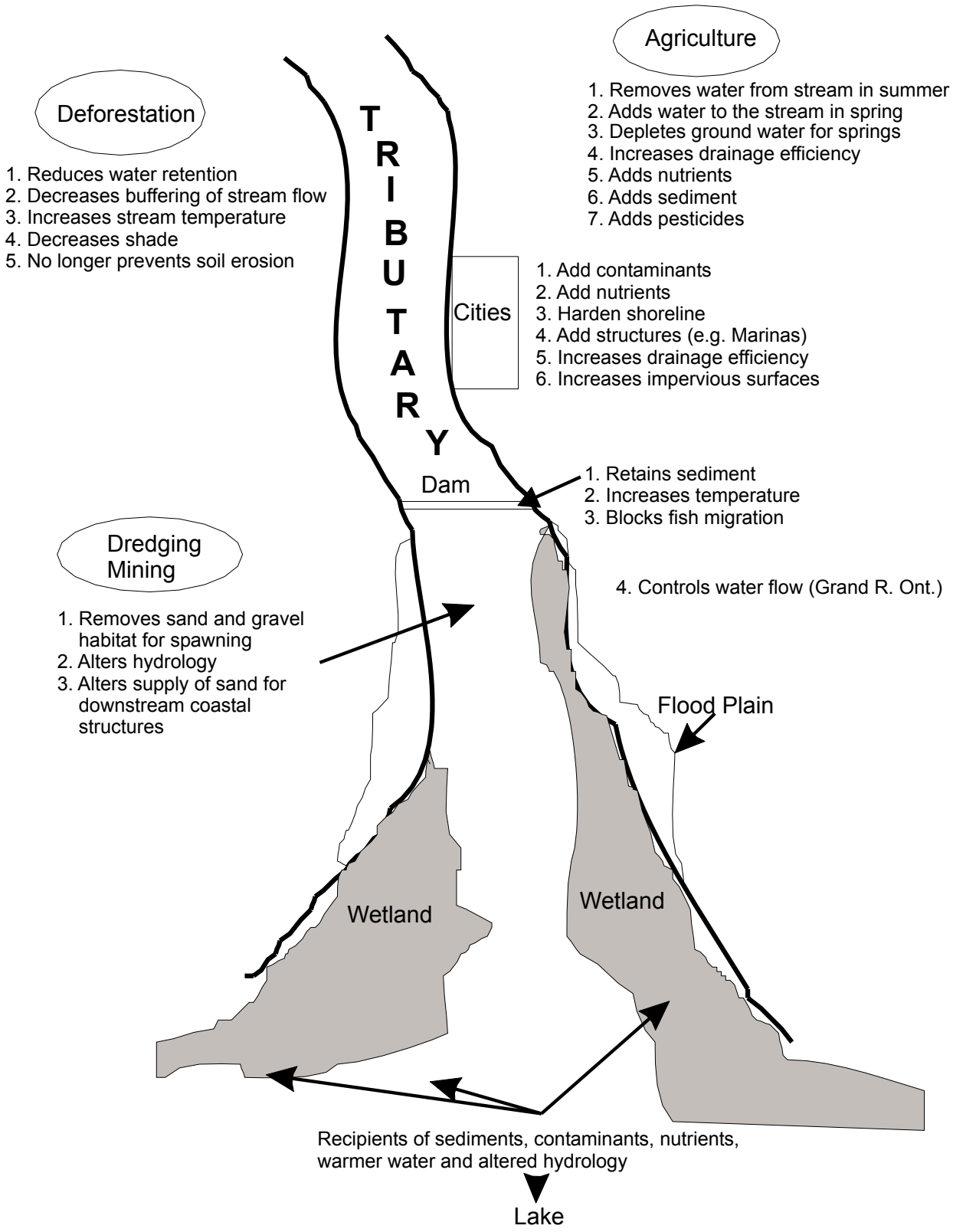
***Fish***
- Data on lakewide phosphorus loadings needs to be collected and reported annually in a manner that allows long-term trends to be discerned.
- A number of Lake Erie fish habitat mapping initiatives are either underway or proposed. These projects will provide inventory data regarding fish habitat quantity, supply, and changes over time. In addition, Ohio Department of Natural Resources (ODNR) has been exploring the relationship between Lake Erie environmental conditions, including habitat, and known fish reproductive centers or *hotspots*. A conceptual framework is under development and will be used to identify the specific driving environmental forces that produce these observed, repeatable patterns in fish community composition and reproduction. It is hypothesized that the driving forces are linked to tributary conditions versus open lake conditions. If this is the case, fish management actions will become more watershed based versus open-lake focused. The LaMP offers an important opportunity to link the results of both projects into a more comprehensive picture of Lake Erie fish habitat needs.
- Genetic diversity in fish is measured by determining whether discreet stocks (i.e. river spawning versus reef spawning) exist within a particular species and population. Research has begun to identify genetic markers for Lake Erie larval fish. If a relatively inexpensive genetic marking technique can be developed, monitoring of fish stocks can be more detailed. The overall result will be better information on the diversity and health of particular Lake Erie fish species.
- Further research into alternative methods of sea lamprey control that maximize effectiveness of the control efforts while minimizing their economic and environmental costs.

***Wildlife***
- Given the conflict between the need for dikes to manage wildlife that use Lake Erie wetlands and the negative impacts of dikes on fish, data is needed on the critical time periods when fish need passage into and out of wetlands and technologies that allow this to happen.
- The known conditions of Lake Erie basin populations of amphibians, reptiles, birds, mammals and Lake Erie wildlife habitats were assessed for the Lake Erie LaMP. The common theme from those experts who provided data was that surveys of population distribution, status, and trends are needed for many Lake Erie wildlife species. In particular, amphibian, reptile, and mammal data is sparse, particularly for nongame species without existing management objectives.
- Ducks and geese - In general, migration and breeding surveys are needed to assess population size, reproductive success, turnover rates during migration, reasons for local population shifts, impacts of human disturbance, and diet. More specific data is needed

regarding particular species, including black duck, canvasback, mergansers, goldeneye, wood duck, greater and lesser scaup, southern James Bay Canada goose. For dabbling ducks as a group, an assessment is needed of factors, other than habitat, limiting populations habitat.

- Passerines (songbirds)-banding is needed to monitor migratory populations and consistent ongoing, long-term censuses are needed. A regional data-base to house data collected is also needed.
- Piping Plover - causes of population decline in Lake Erie basin. Habitat degradation and human disturbance are factors. However, the absence of plovers from Long Point Bay where habitat and disturbance are not problems, indicates that another stressor may be affecting the population.
- Shorebirds - an assessment is needed of factors, other than habitat, limiting populations. For certain species, such as buff-breasted and upland sandpipers, data needs include: number migrating through Lake Erie basin, length of stay, population trends, preferred breeding and migration habitat, and best management practices.
- Herons and egrets - need more detailed data on effects of competition with cormorants.
- Bald eagle - need to clarify relationship between depressed reproduction and contaminants, data on contaminant loads in adults, and role of environmental conditions in effects of contaminants.
- Marsh birds - information is needed on the effect of *Phragmites* on this group. Need to know habitat requirements and threats during migration. Need better survey methods to collect data on population trends.
- River otter/mink - need information regarding changes in distribution within Lake Erie basin. Need more details on predator-prey relationship between mink and muskrat, and its resulting impact on habitat.
- Continued identification, surveys, and preservation/restoration of exemplary habitat with high values for wildlife function is needed.

**Figure 4.1 Summary of impacts on tributaries from adjacent habitats and the impact of tributaries on downstream habitats**



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# Sources and Loads

Photo: Ohio EPA

# Section 5: Sources and Loads

## 5.1 Approach and Direction

From the perspective of reducing the presence of persistent toxic substances in Lake Erie, the Great Lakes Water Quality Agreement (GLWQA) suggests that the Problem Definition stage analysis of the Lakewide Management Plan (LaMP) should include the following:

- A definition of the threat posed by critical pollutants to human health or aquatic life, singly or in synergistic or additive combinations with other substances, including their contribution to the impairment of beneficial uses.
- An evaluation of information available on concentrations, sources, and pathways of the critical pollutants in the Great Lakes system, including all information on loadings of the critical pollutants from all sources and an estimation of total loadings of the critical pollutants by modeling or other identified methods.
- Development of information necessary to determine the schedule of load reductions of critical pollutants that would result in meeting Agreement objectives, pursuant to Article VI of the Agreement and including steps to develop the necessary standard approaches and agreed procedures.

As a preliminary step to meeting these requirements, the Sources and Loads Subcommittee of the Lake Erie LaMP Work Group was given the following charge that primarily addresses the second bullet listed above:



**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.
**4.** Identify gaps in the information needed to identify the sources and loads, and recommend the monitoring needed to fill the gaps.

The first step was to identify and review all of the existing databases that might be of use to calculating loads and tracking down sources. This led to the preparation of the *Characterization of Sources and Source Data for the Lake Erie LaMP Report* (Myers *et al.*, in prep.). The results of this report are summarized in Section 5.3, and partially address charges one and two. The potential sources are categorized as either point or nonpoint, and generic descriptions of size, location, and available data by sector are presented. The next steps will be to characterize ambient concentrations of pollutants of concern, to track down sources more extensively, and to continue to develop and implement a workplan that will complete the Sources and Loads Subcommittee's charge.

## 5.2. Critical Pollutants and Pollutants of Concern

The initial list of chemicals selected for intensive review was identified by the beneficial use impairment assessment reports. The chemicals are presented in Table 5.1. Of these chemicals, the Lake Erie LaMP Management Committee designated mercury and PCBs as **critical pollutants** for priority action. Mercury and PCBs are pollutants documented as creating impairment across the Lake Erie basin, particularly in relation to fish and wildlife consumption advisories. As the Lake Erie LaMP progresses and specific problems and causes become more well-defined, additional chemicals may be designated as critical pollutants.

The Sources and Loads Subcommittee also compiled a second, more comprehensive list of pollutants and their degradation products designated by a variety of agency programs as being pollutants of concern throughout the Lake Erie basin. This list is presented in Table 5.2. These pollutants include those listed in Table 5.1. This expanded list allows the subcommittee to begin evaluating information on all the pollutants of concern in Lake Erie and to determine the suitability of the data for estimating loads and whether the data represent a contaminant source or pathway to the Lake Erie ecosystem.

### Table 5.1 Pollutants Causing Beneficial Use Impairments in the Lake Erie Basin

| BENEFICIAL USE IMPAIRMENT | CAUSES OF IMPAIRMENT |
|---|---|
| Fish & Wildlife Consumption Restrictions | *Fish*- PCBs, mercury, lead, chlordane, and dioxins<br>*Wildlife*- PCBs, chlordane, DDE, DDT, and mirex |
| Fish Tumors or Other Deformities | PAHs |
| Bird or Animal Deformities or Reproduction Problems | PCBs, other organochlorines, dieldrin, DDE, PAHs, nitrates |
| Degradation of Benthos | Sediments contaminated with PCBs, other organochlorines, pesticides, PAHs |
| Restrictions on Dredging Activities | PCBs and heavy metals |
| Eutrophication or Undesirable Algae | Phosphorus |
| Recreational Water Quality Impairment | PCBs[1], PAHs[1], Exceedances of *Escherichia coli* or fecal coliform guidelines |

[1]PAHs are the basis for a human contact advisory in the Black River Area of Concern (Ohio), and PCBs are the basis for a human contact advisory in the lower Ottawa River, part of the Maumee Area of Concern (Ohio). The human contact advisories were issued by the Ohio Department of Health and indicate that it is not safe to go into the water in these areas.

## Table 5.2 Contaminants Identified as Lake Erie LaMP Pollutants of Concern.

| Contaminant(s) | Common Source(s) |
|---|---|
| **Organochlorine insecticides and biocides** | |
| *DDT*[2,3,4,5,6,8] | Historical use on crops, microcontaminant in dicofol. |
| • *DDD, DDE* | |
| *Chlordane*[2,4,5,8] | Historical use on crops and for termite and ant control. |
| • *Alpha-chlordane , Gamma-chlordane, cis-nonachlor, trans-nonachlor* | |
| Dieldrin[2,4,5,6,8] | Historical use on crops, termite and moth control. |
| Toxaphene[3,4,5,6,8] | Historical use on crops, topical insecticide. |
| *Mirex*[3,4,5,6] | |
| • *Photomirex* | Historical use for fire ant control and flame retardant. |
| Alpha-hexachlorocyclohexane | Agricultural and topical insecticides. |
| Beta-hexachlorocyclohexane | |
| Delta-hexachlorocyclohexane | |
| Gamma-hexachlorocyclohexane | |
| **Industrial organochlorine compounds or byproducts** | |
| *PCBs*[2,3,4,5,6,8] | Transformers, hydraulic fluids, capacitors, heat transfer fluids, inks, casting waxes. |
| *Dioxin (2,3,7,8-TCDD)*[4,5,6] | Combustion byproducts, contaminant in pentachlorophenol wood preservative, other chlorophenols and derivatives, including herbicides. |
| 1,4-Dichlorobenzene[4,5] | Mothballs, household deodorants, other biocides. |
| Pentachlorobenzene[4,5] | Chemical synthesis. |
| 1,2,3,4-Tetrachlorobenzene[4,5] | |
| 1,2,3,5-Tetrachlorobenzene[4,5] | |
| Pentachlorophenol[4,5] | Chloroalkali plants, wood preservatives. |
| Hexachlorobenzene[4,5,8] | Byproduct of chemical manufacturing, historical wood preservative and fungicide. |
| 3,3'- Dichlorobenzidine[4,5] | Plastic manufacturing, glues and adhesives, dyes and pigments for printing inks. |
| 4,4'-Methylenebis(2-chloroaniline)[4,5] | Plastics, adhesives. |
| **Polynuclear aromatic hydrocarbons (PAHs)**[4,5,8] | |
| *Anthracene, Benz(a)anthracene*<br>*Benzo(a)pyrene, Benzo(b)fluoranthene*<br>*Benzo(k)fluoranthene, Benzo(g,h,i)perylene*<br>*Chrysene, Fluoranthene, Phenanthrene*<br>*Indeno(123-cd)pyrene* | Coal, oil, gas, and coking byproducts, waste incineration, wood and tobacco smoke, and forest fires, engine exhaust, asphalt tars and tar products. |
| **Trace Metals** | |
| Alkyl lead[4,5,6] | Leaded gasoline. |
| Cadmium[4,5] | Batteries, pigments, metal coatings, plastics, mining, coal burning, metal alloys, rubber, dye, steel production. |
| Copper[6] | Same as cadmium, plus plumbing and wiring. |
| *Lead*[6] | Same as cadmium, plus solder. |
| Zinc[6] | Same as cadmium, plus roofing. |
| *Mercury*[3,4,5,6] | Batteries, coal burning, chloroalkali plants, paints, switches, light bulbs, dental material, medical equipment, ore refining. |
| Tributyl Tin | Antifouling paint, mildewcide, plastic stabilizer. |
| **Current-use herbicides**[7] | |
| Atrazine, Cyanazine, Alachlor, Metolachlor | Agricultural herbicides. |
| *Other Contaminants* | |
| *Total phosphorus, Nitrate-nitrogen* | Fertilizers and sewage. |
| Fecal coliform, *Escherichia coli* | Sewage and animal waste. |
| *Total suspended sediments* | Soil erosion. |

*[1]Contaminants indented are degradation products; those shown in italics have been identified as chemicals of concern;*
*[2]Lake Erie Chemicals of Concern identified by Lake Erie LaMP in 1994; [3]Great Lakes Initiative Bioaccumulative Chemical of Concern (BCC); [4]COA-Tier 1 or Tier 2 contaminant, [5]Binational Toxics Strategy contaminant; [6]Contaminant identified by the IJC or in Remedial Action Plans; [7]U.S. EPA; [8]Canadian Toxic Substance Management Policy-Track 1*

## 5.3. Results of Characterization of Sources and Source Data Report

This section provides a brief summary of the *Characterization of Sources and Source Data Report* (Myers *et al.*, in preparation). Many contaminants arising from past and present agricultural, industrial, and municipal sources are reported to have the potential to impair the beneficial uses of Lake Erie and to threaten the quality of aquatic life and human health. To adequately characterize the contribution of these varied and sometimes subtle sources, a description of what is known about point and nonpoint sources within the basin is needed. By focusing on broad categories of pollutant sources as the first step of the process, a better understanding of available data, data gaps, and data limitations can be developed.

Of all the Great Lakes, Lake Erie receives the highest discharge volume of domestic wastewater. Wastewater or sewage treatment plants (STPs) represent a potentially significant source of pollutants. The sewage treatment process is essentially designed to remove suspended solids and, for larger STPs, is enhanced to remove 90 percent or more of the influent phosphorus load to meet the objectives of the Great Lakes Water Quality Agreement. Incidentally, as a result of the chemical properties of other pollutants of concern, STPs also represent a significant line of defense against the discharge of contaminants to the environment. For example, from studies elsewhere in North America, removal efficiencies of polychlorinated biphenyls (PCBs) by STPs can be as high as 97 percent (Durell and Lizotte 1998). Nevertheless, typical concentrations of PCBs in STP effluents range from 5 to 55 ng/L (Fikslin and Greene 1998). Municipal/industrial programs, such as industrial pre-treatment and municipal sewer use bylaws, also contribute significantly to minimize the input of contaminants to STPs. In Ontario, *optimization* of the treatment process further improves treatment efficiency without modification of the existing facilities and reduces operating costs.



Industrial sources both within the watershed and beyond the Lake Erie watershed were displayed in the report, using the U. S. Toxic Release Inventory (TRI) and the Canadian National Pollutant Release Inventory (NPRI). It documented that air emissions are significant, hence the need to consider areas beyond the Lake Erie watershed when considering possible sources.

Releases of mercury and PCBs from industrial facilities were reported in TRI and releases of mercury were reported in NPRI. Of the mercury and PCB releases reported in TRI and the mercury releases reported in NPRI, virtually all of the 1996 releases were to the atmosphere. The TRI and NPRI programs can be used to identify sources, but because they represent process-based estimates and not actual releases to the environment, they cannot be used to compute loads.

Unlike contaminants from municipal and industrial facilities that discharge directly to surface waters, agricultural chemicals applied to the land surface normally do not pose a significant or immediate threat to surface waters. Once agricultural chemicals have been applied to the land surface, their ultimate environmental fate is decided by several factors. These include the method of application, the time elapsed from application, the physical and chemical properties of the chemicals, and the physical characteristics of the land where the chemicals were applied. Approximately 67 percent of the land in the Lake Erie basin is used for intensive, row crop agriculture, most of it concentrated in the western basin (Environment Canada and U.S. EPA 1995). This is much higher than the agricultural use around the other Great Lakes. Nutrients, pesticides and bacteria are issues linked to agricultural practices. Field applied nitrogen loss to streams can be as high as 50 percent, phosphorus loss can be as high as 17 percent (Fuhrer *et al.* 1999). The use of buffer strips, conservation tillage, no-till and a variety of best management practices can greatly reduce the loss of nutrients to streams, and are in use throughout the basin. Pesticide loss can be as high as 10 percent (Larson *et al.* 1997). Atrazine use is significant in the basin and environmental concentrations reflect proximity to application.

The suitability of available environmental and ancillary data to describe contaminant concentrations and loads in the Lake Erie basin was evaluated in the report. Data were from point and nonpoint sources, the connecting channels, tributaries, and the atmosphere. Particular emphasis was placed on analyzing data for PCBs and mercury. Although the various contaminant monitoring programs may be adequate for their intended purposes,

results of the analysis for the source characterizaion report indicate that available data for PCBs, organochlorine pesticides, mercury, and PAH compounds are not suitable to describe the occurrence and distribution of contaminant concentrations or to compute contaminant loads. An explanation of the selection criteria used to screen the databases for applicability of the data to determining ambient contaminant concentrations or loads is presented in Appendix B.

The minimum criterion established to characterize concentrations of contaminants discharged from point sources was 10 observations if all reported data were above the detection limit. If some of the data were less than the detection limit, at least 25 percent of the observations should be above the detection limit. The minimum criterion established to compute loads discharged from point sources was at least 25 percent of the observations above the detection limit. The detection limits for concentrations of PCBs, organochlorine pesticides, PAHs and mercury reported by point source monitoring programs in the United States and Ontario are too high to measure the typically low concentrations of these contaminants found in STP discharges. PCBs were monitored at 15 facilities in the United States, but only five percent of the nearly 1,000 observations were reported above the detection limit.

Mercury was regulated at 21 facilities in Ontario in 1995 but, like PCBs, the percentage of observations indicating a detection of mercury was less than 25 percent, too low to compute a load. In the United States, 170 point sources monitor and report mercury concentrations, but only 23 percent of the reported observations were above detection limits. A large number of samples were collected at many point sources and very few of the reported concentrations were less than the detection limit for total phosphorus, nitrate-nitrogen and total nonfilterable residue (suspended solids). Basin-wide characterization of concentrations and computation of loads for these substances appear to be possible.



Tributary and connecting channel monitoring programs were evaluated for their adequacy to characterize concentrations and compute loads. The minimum criterion established for the characterization of concentrations was at least 10 samples. If censored data (data below the detection or reporting limit) were included, the minimum criterion was that at least 50 percent of the samples be reported above the detection limit in at least 25 samples. The minimum criterion for the computation of loads was at least 50 samples in which at least 25 percent of the analyses are reported above the detection limit. In addition, samples must represent the range of streamflows measured at the collection site. Data for organochlorine compounds, PAHs and mercury reported for tributaries or connecting channels did not meet these minimum criteria - mercury and PCBs in particular did not. Only the atmospheric data from the Integrated Atmospheric Deposition Network (IADN) were sufficient to estimate loads for the contaminants for trace organic contaminants, including PCBs. Data from 1995 to 1998 that are suitable for the computation of mercury deposition are available from the Mercury Deposition Network (MDN). Nutrient data appeared to be suitable to characterize concentrations and to compute loads.

Although environmental data from point sources and surface waters for most trace organic substances were not suitable for characterizing concentrations or computing loads, other available data may be used in their place for some types of analyses. Near-surface streambed and lakebed sediments can indicate the recent deposition or resuspension of contaminants to the aquatic environment. Fish tissue can help integrate the bioaccumulation of contaminants by aquatic life and the potential for human health impacts. The detection frequency of organochlorine and trace metal contaminants in aquatic sediments is markedly higher than in water. Contaminants such as PCBs, organochlorine pesticides, PAHs, and mercury that are reported with few or no detections in point source effluents and surface waters are reported at concentrations above detection limits at frequencies of 25 percent or more in aquatic sediments.

The weight of evidence from the locations of point and nonpoint sources, their potential chemical impacts, and the known contaminant impacts in water and sediments as determined by comparison to guidelines suggests that the Lake Erie basin as a whole, and in particular the western portion, is impaired by contaminants. Contaminant concentrations in the environment often reflect proximity to sources, particularly those contaminants for which local sources are significant relative to long-range transport. Atrazine, nitrate, and

phosphorus concentrations in water, and concentrations of mercury and PCB in sediment, are just a few examples.

## 5.4 Results of USGS Bed Sediment Report and Implications

In cooperation with the Lake Erie LaMP, the U.S. Geological Survey (USGS) analyzed contaminants of concern in the surficial bed sediments of the Lake Erie-Lake St. Clair Basin within U.S. boundaries (USGS in prep.) All samples were taken as part of the National Water Quality Assessment (NAWQA) Program of the USGS. The sediment report describes the occurrence and distribution of contaminants of concern in streambed sediments, compares bed sediment concentrations to guidelines that indicate contaminant levels either acutely or chronically toxic to aquatic macroinvertebrates, and discusses the extent and magnitude of contamination within and outside of areas of concern (AOCs). The study utilizes four large databases that cover portions of the Lake Erie-Lake St. Clair Basin: the National Sediment Inventory (NSI), Ohio Sediment data Inventory (OSI), U.S. EPA-Fully Integrated Environmental Locational Decision Support system (FIELDS) database, and the USGS-NAWQA sediment data. Only surficial bed sediment samples collected within the top five inches of sediment over the period 1990 through 1997 were evaluated to reflect recent conditions.

The concentrations of selected contaminants of concern in surficial sediments were compared to three freshwater bed sediment quality guidelines: 1) Ontario Ministry of the Environment guidelines for the protection and management of Canadian freshwater sediments; 2) U.S. EPA guidelines for Great Lakes sediments; and 3) Environment Canada and the Great Lakes guidelines for ecosystems throughout Canada and the Great Lakes basin. Results are discussed in relation to the potential toxicity of the contaminant to biota according to these regional bed sediment quality guidelines. Only results of analysis for which sample concentrations were found to be equal to or greater than guidelines indicating a probable or severe effect level were reported. Finding that a sample contains a contaminant concentration equal to or exceeding a probable or severe effect level does not imply such effects are actually occurring at a location. Rather, these findings suggest that sediments with concentrations exceeding these guidelines have the potential to impair aquatic life. Further investigation to determine the presence of adverse effects on aquatic biota at these locations is warranted.



The study found that chlordane, total PCBs, and total PAHs were most often detected at concentrations equal to or greater than a probable and/or severe effect level within AOCs. The study showed that the 75th percentile concentrations of benzo(a)pyrene, chlordane, dieldrin, total PAH, and total PCBs were greater than the probable effect level in tributaries of the Lake Erie-Lake St. Clair Basin within AOCs. The 75th percentile concentrations of dieldrin and total PAHs were also greater than probable effect levels in samples from a few streams in major urban areas outside AOCs. In Michigan, the highest concentrations of anthracene, total PAH, phenanthrene, benz(a)anthracene, chrysene, benzo(a)pyrene, total PCB and chlordane in surficial bed sediments were found in the Clinton River AOC, Detroit River AOC, River Raisin AOC, and River Rouge AOC, respectively. In Ohio, the highest concentrations of these contaminants were found in the Maumee and Cuyahoga River AOCs.

Basinwide, the greatest number of contaminants equal to or greater than a probable or severe effect level were found in samples from the Ottawa River within the Maumee AOC. Samples from the River Raisin AOC contained the highest concentrations of PCBs in the Lake Erie-Lake St. Clair Basin; some of which exceeded the severe effect level by more than 100 times. Concentrations of total DDT, dieldrin, lindane, and other isomers of hexachlorocyclohexane in surficial bed sediments were detected equal to or greater than a probable effect level at a range of urban and agricultural sites throughout the basin. The detection of these contaminants in urban and agricultural areas may indicate residues of past use of these compounds in both areas are still reaching the lake. Mirex and hexachlorobenzene were not detected in bed sediments in the Lake Erie-Lake St. Clair Basin. Unfortunately, detection limits for these two contaminants were too high to make

the data useful for evaluating occurrence, distribution and potential effects on aquatic life. Further investigation of these contaminants using methods capable of detecting lower concentrations may be needed.

Concentrations of trace metals and arsenic were detected more frequently but at lower concentrations relative to effect levels than were organochlorine compounds or PAHs. The study showed that the 90th percentile concentrations of arsenic, cadmium, lead, and zinc were greater than the probable effect level in major tributaries both within and outside of AOCs. The 90th percentile concentration for mercury samples was greater than the probable effect level within AOCs but not outside of AOCs. The highest concentrations of arsenic, cadmium, copper, lead, mercury, and zinc were found in the Clinton River AOC, Detroit River AOC, and River Raisin AOC, respectively, in Michigan; and in the Ottawa River (Maumee AOC) and Cuyahoga River AOC, respectively, in Ohio. Samples from the Trenton Channel of the Detroit River AOC contained the highest concentrations of mercury in surficial bed sediments in the Lake Erie-Lake St. Clair Basin; some of which were equal to or greater than the probable and the severe effect levels. The dominant factor influencing the distribution of sample concentrations of cadmium, copper, lead, and mercury in samples of surficial bed sediments appears to be urban land use. Because of the potential presence of arsenic and zinc in geologic materials and because of past use in agricultural pesticides, distinguishing the relation between land use and concentrations in bed sediments of arsenic and zinc in the Lake Erie-Lake St. Clair Basin may be more complex than for other contaminants.

Data from this report will provide a baseline of information for long-term trend analysis and source track down of contaminants. A forthcoming report will include analysis of data from Lake Erie proper as well as the watershed. The report will attempt to describe how sources of contaminants, land use, and natural factors may affect the concentrations of contaminants in bed sediments and if the relation between the occurrence of sources and contaminant concentrations can be related.



## 5.5. Initiation of Source Track Down Process

The next step in the Lake Erie LaMP process to identify sources and provide a scientific basis for sound management decisions will be to track down sources more extensively. Known point sources can be identified from the data compiled for the *Characterization of Sources and Source Data Report*. Maps of discharge locations, pesticide use, agricultural areas, abandoned landfill sites and other land use will be compared to ambient water column concentrations, aquatic biota tissue concentrations, and sediment concentrations to identify major source areas and the most highly contaminated areas in the lake. An assessment of whether or not the most contaminated areas and major sources already have been targeted for priority action will be accomplished by identifying and cross-referencing implementation and remediation actions already underway. The Lake Erie AOCs have already been identified as priority areas for source control and remediation. This exercise may further confirm the RAP sites as priority areas, but may also point out additional areas where further action or attention may be needed, whether it is monitoring, additional research or remediation.

Several projects independent of the Lake Erie LaMP are underway which may support the source track down effort. The Great Lakes Binational Toxics Strategy (BTS) is investigating sources of contaminants of concern to the Great Lakes both within and outside of the basin. This strategy is designed to further identify pollutant sources and develop and implement the actions needed to move us closer to the goal of virtual elimination of persistent toxic substances in the Great Lakes. Several contaminated sediment and landfill remediation projects recently were completed or are underway in the River Raisin, Ashtabula River, and Ottawa River/Maumee AOCs. The Lake Erie LaMP Action Plans for PCB and mercury will also help in the source track down.

An analysis will be done of the ambient concentrations of pollutants in all media compared to the specific objectives listed in Annex 1 of the GLWQA, and possibly other more recent objectives, such as the U.S. Great Lakes Water Quality Guidance (GLI). This

analysis will offer the potential to identify other chemicals as *likely to impair* pollutants and ensure a thorough evaluation of sources and potential critical pollutants. Selected databases examined for the *Characterization of Sources and Source Data Report* will also be used for these purposes.

A significant amount of data appropriate for the analysis of the impacts of contaminated bed sediment on benthos, fish and humans are available, but not readily accessible. National, state, and provincial governments have analyzed contaminants in bed sediment as well as fish tissue in generally discrete, but sometimes widespread, locations throughout the Lake Erie basin. However, the information gathered has never been compiled into one, basinwide data set facilitating the overall usefulness of assessing the impacts of contaminants in sediments to the lake. An effort has been initiated in cooperation with the U.S. EPA, the Lake Erie LaMP, Ohio EPA, U.S.G.S., and Environment Canada to compile such a database to look into a cause and effect type relationship between concentrations of contaminants of concern found in sediments and concentrations found in aquatic organisms.

Uptake of a number of key compounds, such as mercury and PCBs, has led to numerous fish consumption advisories in Lake Erie. Pinpointing the location of contaminated sediments and assessing the resulting effects on the biota will help the Lake Erie LAMP and various other managers with decisions concerning sources of the contaminants and designing recommendations for their cleanup.

## 5.6 Conclusions



There is no question that Lake Erie is in flux. To better understand pathways of critical pollutants, additional research is needed on changes in food web dynamics and the linkages in energy and contaminant flow between the lake bottom and the water column. For example, contaminant concentrations in fish have fluctuated over the years, even as point and nonpoint source loads appear to have decreased. Is this a reflection of food web changes, impacts from non-indigenous invasive species, climate change or something else? While it may be possible to further decrease contaminant loads into the lake, it is also important to understand what is happening to the contaminants already in the lake.

Over the long term, it is important to note continually the data gaps, prioritize the importance of those gaps and identify actions to fill them. Although models are valuable to calculate and evaluate total loads of critical pollutants over time, the use of models for Lake Erie must be considered carefully, given the current flux of the Lake Erie food web. Once the major sources of contaminants and the most seriously contaminated areas are identified, it is recommended that resources and remedial actions be focused immediately on those areas rather than spent on further attempts to estimate total loads.

There are many activities already underway to reduce loads of contaminants of concern, including pollution prevention, waste minimization, various regulations that restrict discharge, remediation of contaminated sediments and old landfills, agricultural BMPs, etc. All of these activities will be reviewed at some point as to their utility in meeting the goals of the Lake Erie LaMP.

The Lake Erie LaMP also recognizes that there may be potential and emerging sources of contamination. The potential for an accidental contaminant spill does exist and has been addressed at all levels of government. Even though containment and cleanup contingency plans have been created for the most part, there is still the possibility that a spill could have some impact on the ecosystem. Increasing populations, land use changes and increased impervious surfaces have changed the way we view some sources and the contaminant pathways. Future assessments will need to consider these changes.

## 5.7 References

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# Human Health

Photo: USDA Natural Resources Conservation Service

# Section 6: Human Health

*(This section presents a preliminary summary of the work of the Lake Erie LaMP Human Health Subcommittee to date. The subcommittee has drafted a detailed background document to assess the threat to human health from critical pollutants and other contaminants of concern in Lake Erie, but it has not yet undergone a comprehensive LaMP review.)*

## 6.1 Introduction

There is concern about the effects that Great Lakes' contaminants and, in particular, persistent, bioaccumulative toxic chemicals, may have on human health. The 1987 Protocol to the Great Lakes Water Quality Agreement of 1978 (GLWQA) states that Lakewide Management Plans (LaMPs) for open lake waters shall include: "A definition of the threat to human health or aquatic life posed by Critical Pollutants, singly or in synergistic or additive combination with another substance, including their contribution to the impairment of beneficial uses." Critical pollutants are those persistent bioaccumulative toxic chemicals that have caused, or are likely to cause, impairments of the beneficial uses of each Great Lake. Three of these beneficial uses (fish consumption, drinking water consumption and recreational water use) are directly related to human health. The goal of this Lake Erie LaMP 2000 section is to fulfill the human health requirements of the GLWQA, including:



- to define the threat to human health and describe the potential adverse human health effects arising from exposure to critical pollutants and other contaminants (including microbial contaminants) found in the Lake Erie basin;
- to address current and emerging human health issues of relevance to the LaMP but not currently addressed in the other components of the LaMP; and
- to identify implementation strategies currently being undertaken to protect human health and suggest additional implementation strategies that would enhance the protection of human health.

In defining the threat to human health from exposure to the Lake Erie LaMP critical pollutants, (PCBs and mercury) and the other Lake Erie LaMP pollutants of concern (Table 5.2), this assessment applies a weight of evidence approach, which uses the overall evidence from wildlife studies, experimental animal studies, and human studies in combination. In addition to examining the chemical pollutants of concern to human health for Lake Erie, this section also examines microbial pollutants in recreational and drinking water.

The World Health Organization defines human health as a "state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity" (World Health Organization, 1984). Therefore, when assessing human health, all aspects of well-being need to be considered, including physical, social, emotional, spiritual and environmental impacts on health. Human health is influenced by a range of factors, such as the physical environment (including environmental contaminants), heredity, lifestyle (smoking, drinking, diet and exercise), occupation, the social and economic environment the person lives in, or combinations of these factors. Exposure to environmental contaminants is one among many factors that contribute to the state of our health (Health Canada, 1997).

Consideration of human health in the Lake Erie basin must also take into account the diversity of the Lake Erie basin population, which includes a range of ethnic and socioeconomic groups. Certain subpopulations, such as high fish consumers, may have higher exposures to persistent toxic chemicals than the general population. In addition, some subpopulations, such as the elderly, immunologically compromised, women of child-bearing age, the fetus, nursing infants, and children may be more susceptible to the effects of persistent bioaccumulative toxic chemicals (Johnson *et al.*,, 1998; Health Canada, 1998d).

Therefore, the discussion of health issues in this section looks at the health of the general population as well as subpopulations at increased risk of exposure and health effects.

Section 6.2 describes the pathways of exposure relevant to human health - drinking water, recreational water use and fish/food consumption. Section 6.3 explains and applies a weight of evidence approach to looking at potential health effects. Section 6.4 describes proposed indicators of human health for Lake Erie. Conclusions and recommended actions to be taken to protect human health are presented in Section 6.5. References are listed in Section 6.6. A list of Lake Erie relevant human health Internet resources and additional references is included in Appendix H.

## 6.2 Pathways of Exposure and Human Health

The three major routes through which chemical and microbial pollutants enter the human body are by ingestion (water, food, soil), inhalation (airborne), and dermal contact (skin exposure). The goal of the Lake Erie 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" (Lake Erie LaMP Status Report, 1999). Awareness of the underlying causes of these restrictions (e.g. chemical and microbial contaminants) and the associated health consequences will allow public health agencies to develop societal responses protective of public health. Desired outcomes for human health and the exposure pathways they relate to are identified in Table 6.1.

### Table 6.1: Human Health-Related Desired Outcomes, and Pathways of Exposure



| Desired Outcomes | Pathway of Exposure |
|---|---|
| Fishable - We can all eat any fish | Ingestion of food (fish) |
| Drinkable - Treated drinking water is safe for human consumption; We can all drink the water | Ingestion of water |
| Swimmable - All beaches are open and available for public swimming; We can all swim in the water | Incidental ingestion of water, dermal contact, inhalation of water spray from splashing, etc. |

The scope of the Lake Erie LaMP includes pathways of exposure through the water. Therefore, air pollution is not discussed in this human health paper. Nonetheless, air pollution as it relates to the air we breathe is a key health issue for the Lake Erie basin, and programs and initiatives are in place in both the U.S. and Canada that address this issue. For the United States, the Clean Air Act, implemented by the U.S. EPA and state agencies, is primarily responsible for ensuring the quality of ambient air by regulating point and mobile source emissions to the environment (for more information refer to http://www.epa.gov/oar/oarhome.html). The Occupational Safety and Health Administration implements the Occupational Safety and Health Act which protects health in the workplace - including health related to air quality (for more information refer to http://www.osha.gov).

In Canada, Health Canada conducts air pollution health effects research, risk assessments and exposure guidelines creation through the Air Pollution Health Effects Research Program in its Environmental Health Directorate (http://www.hc-sc.gc.ca/ehp/ehd/bch/air_quality.htm). The Province of Ontario also has programs targeted at the protection of humans from exposure to air pollution.

The critical pollutants and chemical pollutants of concern in Lake Erie include organochlorines and metals that are known to cause adverse health effects in animals and humans. These chemicals do not break down easily, persist in the environment, and bioaccumulate in aquatic biota, animal and human tissue; thus they are called *persistent bioaccumulative toxic* chemicals (PBTs). Organochlorines tend to accumulate in fat (such as adipose tissue and breast milk), and metals tend to accumulate in organs, muscle and flesh. Food is the primary route of human exposure to these PBT chemicals, and consumption of Great Lakes' fish is the most important source of exposure originating directly from the lakes. Sources from air, soil/dust, and water constitute a minor route of exposure (Health

Canada, 1998e; Johnson *et al.*,, 1998).

Since the 1970s, there have been steady declines in many PBT chemicals in the Great Lakes basin, leading to declines in levels in human tissue, for example, lead in blood and organochlorine contaminants in breast milk. However, PBT chemicals, because of their ability to bioaccumulate and persist in the environment, continue to be a significant concern in the Lake Erie basin. Although contaminant levels in the Great Lakes are declining in general, recent trends suggest that concentrations for some pollutants may be leveling off. However, health concerns from environmental contaminant exposures in the Lake Erie basin remain. Therefore, public health advisories and other guidelines should be followed to minimize contaminant exposures. Most of the health effects studies for Great Lakes PBT chemicals have focused on fish consumption.

Access to clean drinking water is essential to good health. The waters of Lake Erie and surrounding areas are a primary source of drinking water for people who live in the Lake Erie basin. The average adult drinks about 1.5 liters of water a day, so health effects could be serious if high levels of some contaminants are present (Health Canada, 1993, 1997).

A variety of contaminants can adversely affect drinking water, including micro-organisms (e.g. bacteria, viruses and protozoa, such as *cryptosporidium*), chemical contaminants (both naturally occurring, synthetic and anthropogenic), and radiological contaminants, including naturally-occurring inorganic and radioactive materials (IJC, 1996; Health Canada, 1997; Lake Erie LaMP, 1999; OME, 1999). Some contaminants in raw water supplies, such as aluminum, arsenic, copper and lead, can be both naturally occurring and resulting from human activities. Other contaminants, such as household chemicals, industrial products, fertilizers (including nitrates), human and animal wastes, and pesticides may also end up in raw water supplies (U.S. EPA, 1999a; Health Canada, 1998b).

Microbial contamination of drinking water can pose a potential public health risk in terms of acute outbreaks of disease. The illnesses associated with contaminated drinking water are mainly gastro-intestinal in nature, although some pathogens are capable of causing severe and life-threatening illness (Health Canada, 1995b). In most communities, drinking water is treated to remove contaminants before being piped to consumers, and bacterial contamination of municipal water supplies has been largely eliminated by adding chlorine or other disinfectants to drinking water to prevent waterborne disease. By treating drinking water and wastewater, diseases such as typhoid and cholera have been virtually eliminated. Although other disinfectants are available, chlorination still tends to be the treatment of choice. When used with multiple barrier systems (i.e. coagulation, flocculation, sedimentation and/or filtration), chlorine is effective against virtually all infective agents (U.S. EPA/Government of Canada, 1995; Health Canada, 1993, 1997, 1998f).



The Great Lakes are an important resource for recreation, including activities such as swimming, water-skiing, sail-boarding and wading that involve body contact with the water. Apart from the risks of accidental injuries, the major human health concern for recreational waters is microbial contamination by bacteria, viruses, and protozoa (Health Canada, 1998a; WHO, 1998). Many sources or conditions can contribute to microbiological contamination, including sewer overflows after heavy rains (Whitman *et al.*,, 1995). On-shore winds can stir up sediment or sweep bacteria in from contaminated areas. Animal/pet waste may be deposited on the beach or washed into storm sewers. Agricultural runoff, such as manure, is another source. Stormwater runoff in rural and wilderness area watersheds can increase densities of fecal streptococci and fecal coliforms as well (Whitman *et al.*,, 1995). Other contaminant sources include infected bathers/swimmers; direct discharges of sewage from recreational vessels; and malfunctioning private systems (e.g. cottages, resorts) (Health Canada, 1998a, Whitman *et al.*, 1995; WHO, 1998).

Human exposure to micro-organisms occurs primarily through ingestion of water, and can also occur via the entry of water through the ears, eyes, nose, broken skin, and through contact with the skin. Gastro-intestinal disorders, respiratory illness and minor skin, eye, ear, nose and throat infections have been associated with microbial contamination of recreational waters (Health Canada, 1998a; WHO, 1998; Prüss, 1998).

Studies have shown that swimmers and people engaging in other recreational water sports have a higher incidence of symptomatic illnesses such as gastroenteritis, otitis, skin infection, and conjunctivitis, and acute febrile respiratory illness (AFRI) following activities

in recreational waters (Dewailly, 1996; WHO, 1998). Although current studies are not sufficiently validated to allow calculation of risk levels (Health Canada, 1992), there is some evidence that swimmers/bathers tend to be at a significantly elevated risk of contracting certain illnesses (most frequently upper respiratory or gastro-intestinal illness) compared with people who do not enter the water (Dufour, 1984; Seyfried *et al.*,, 1985a, b; U.S. EPA, 1986; WHO, 1998; Prüss, 1998). In addition, children, the elderly, and people with weakened immune systems are those most likely to develop illnesses or infections after swimming in polluted water (Health Canada, 1998a).

Chemical contaminants such as PAHs have been identified as a possible concern for dermal (skin) exposure in recreational waters. Dermal exposure may occur when people come into contact with contaminated sediment or contaminated suspended sediment particulates in the water. PAHs adsorbed to these particulates would adhere to the skin. There is little information available regarding chemical contaminants with the potential to cause effects such as skin rashes, or how much of a chemical might be absorbed through the skin, with the potential to cause systemic effects, such as cancer (Hussain *et al.*, 1998; Lake Erie LaMP, 1999).

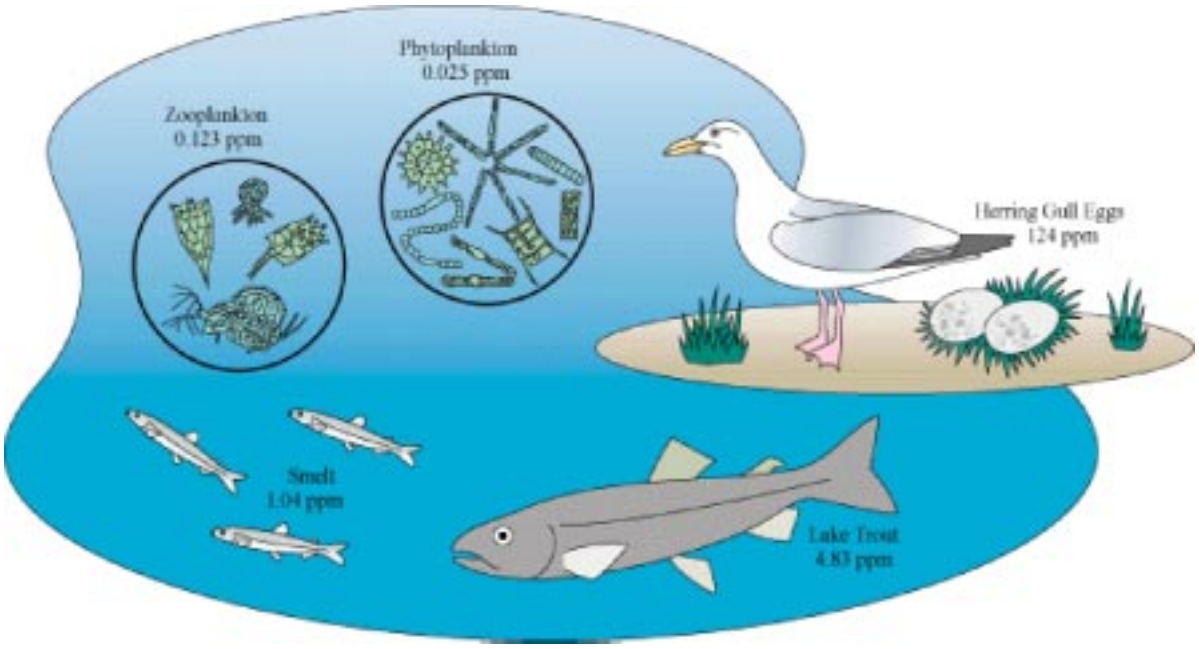
Exposure assessments from all sources (air, water, food and soil) were completed for the Canadian Great Lakes basin general population for 11 PBT chemicals, including PCBs and mercury. The total estimated daily intake averaged over a lifetime was well below the Tolerable Daily Intake (TDI) established by Health Canada (Health Canada, 1998c). Consequently, the approach by various agencies has been to examine groups at higher risk of exposure to PBT chemicals from Great Lakes' sources, such as high consumers of sport fish.

Fish are low in fat, high in protein, and may have substantial health benefits when eaten in place of high-fat foods. However, chemicals such as mercury and PCBs enter the aquatic environment and build up in the food chain. The levels of the chemicals in fish from the Lake Erie basin are generally low and do not cause acute illness. Continued low level exposure to these chemicals, however, may result in adverse human health effects. People need to be aware of the presence of contaminants in sport fish and, in some cases, take action to reduce exposure to chemicals while still enjoying the benefits of catching and eating fish.



Contaminants usually persist in surface waters at very low concentrations. They can bioaccumulate in aquatic organisms and become concentrated at levels that are much higher than in the water column. This is especially true for substances that do not break down readily in the environment, like the Lake Erie LaMP critical pollutants PCBs and mercury. As contaminants bioaccumulate in aquatic organisms, this effect biomagnifies with each level of the food chain. As a result of this effect, the concentration of contaminants in the tissues of top predators, such as lake trout and large salmon, can be millions of times higher than the concentration in the water. Figure 6.1 illustrates an example of the changes in PCB concentration (in parts per million, ppm) at each level of a Great Lakes aquatic food chain. The highest levels are reached in the eggs of fish-eating birds such as herring gulls.

### Figure 6.1: Persistent Organic Chemicals Such as PCBs Bioaccumulate and Biomagnify as They Move Up the Food Chain






*This diagram shows the degree of concentration in each level of the Great Lakes aquatic food chain for PCBs (in parts per million, ppm). The highest levels are reached in the eggs of fish-eating birds such as herring gulls.*

Text and figure from *The Great Lakes: An Environmental Atlas and Resource Book* Government of Canada/U.S. EPA, 1995

## 6.3 Evidence for Potential Health Effects - Weight of Evidence Approach to Linking Environmental Exposure

*(Due to the importance of using a weight of evidence approach in assessing human health impacts, this section represents most of the information included in the draft background report prepared by the Human Health Subcommittee.)*

The following three subsections describe selected studies that have reported associations between PBT chemical exposures and effects in wildlife, laboratory animals and human populations. Because of the ethical issue of exposing humans to toxic substances and factors such as a small sample size and presence of multiple chemicals, human studies are often limited in their ability to establish a causal relationship between exposure to chemicals and potential adverse human health effects. In addition, human studies looking at causal relationships between human exposure to environmental contaminants and adverse health outcomes are limited and the results uncertain. Therefore, a weight of evidence approach is used, where the overall evidence from wildlife studies, experimental animal studies, and human studies is considered in combination. It utilizes the available information from wildlife and controlled animal experiments to supplement the results of human studies toward assessing the risks to human health from exposure to PBT chemicals. The use of wildlife data assumes that animals can act as sentinels for adverse effects observed in humans (Johnson and Jones 1992).

### 6.3.1 Wildlife Populations

Research over the past 25 years has shown that a variety of persistent, bioaccumulative contaminants in the Great Lakes food chain are toxic to wildlife (Health Canada, 1997). Reproductive impairments have been described in avian, fish, and mammalian populations in the Great Lakes. For example, egg loss due to eggshell thinning has been observed in predatory birds, such as the bald eagle, within the Great Lakes (Menzer and Nelson, 1980). After feeding on Great Lakes' fish for two or more years, immigrant birds (eagles) were shown to have a decline in reproductive success (Colburn *et al.*,, 1993). Developmental effects in the form of congenital deformities (e.g. crossed mandibles, club feet) have also been reported in the avian population within the Great Lakes basin (Stone, 1992).

Effects to the endocrine system and tumor formations have been detected in fish populations. Researchers have reported enlarged thyroids in all of the 2 to 4 year-old Great Lakes salmon stocks that were examined (Leatherland, 1992). Tumors associated with exposure to high levels of PAHs have been detected in brown bullhead in the Great Lakes area (Baumann *et al.*,, 1982).

Effects on the immune system have also been a notable finding. At a number of Great Lakes sites, a survey of herring gulls and Caspian terns demonstrated a suppression of T-cell-mediated immunity following prenatal exposure to organochlorine pollutants particularly PCBs (Grasman *et al.*,, 1996). Section 4 provides a more detailed description of the effects of chemicals on wildlife, but the point here is to show that adverse effects can occur when exposure is sufficient (Health Canada, 1997).

### 6.3.2 Animal Experiments

A number of animal experiments have demonstrated a wide range of health outcomes from exposure to PCBs, mercury and chlorinated dibenzo-p-dioxins (CDD).



*PCBs (polychlorinated biphenyls)*: Animals exposed orally to PCBs developed effects to the hepatic, immunological, neurological, developmental and reproductive systems. Effects have also been reported in the gastrointestinal and hematological systems (ATSDR 1998). Animal ingestion studies strongly support the finding that more highly chlorinated PCBs (i.e., 60% chlorine by weight) are carcinogenic to the livers of rats, while the lower chlorinated PCBs are weaker animal carcinogens (i.e. lower incidence of total tumors and more benign tumors)
(Buchmann *et al.*,, 1991; Sargent *et al.*,, 1992).

*Mercury*: Long-term, high level animal ingestion exposure to mercury has been associated with cardiovascular (Arito and Takahashi, 1991), developmental (Fuyuta *et al.*,, 1978; Nolen *et al.*,, 1972; Inouye *et al.*,,1985), gastrointestinal (Mitsumori *et al.*,, 1990), immune (Ilback, 1991), renal (Yasutake *et al.*,, 1991; Magos *et al.*,, 1985; Magos and Butler, 1972; Fowler, 1972) and reproductive effects (Burbacher *et al.*,, 1988; Mitsumori *et al.*,, 1990; Mohamed *et al.*,, 1987). The studies also indicate that the nervous system is particularly sensitive to mercury exposure by ingestion (Fuyuta *et al.*,, 1978; Magos *et al.*,, 1980, 1985). In addition, growth of kidney tumors has been reported in animals administered methylmercury in drinking water or diet for extended periods (Mitsumori *et al.*,, 1981, 1990).

*CDDs (chlorinated dibenzo-p-dioxins)*: In specific species (e.g. guinea pig), very low levels of 2,3,7,8-TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxin) have resulted in the death of the exposed animal after a single ingestion dose (NTP, 1982). At non-lethal levels of 2,3,7,8-TCDD by ingestion, other effects reported in animals include weight loss (NTP, 1982), biochemical and degenerative changes in the liver (NTP, 1982; Kociba *et al.*,, 1978), and a decline in blood cells (Kociba *et al.*,, 1978). Dermal effects in animals (e.g. hair loss, chloracne) have also been reported by ingestion exposure (McConnell *et al.*,, 1978). In many species, the immune system and fetal development are particularly susceptible to 2,3,7,8-TCDD exposure. Offspring of animals receiving oral exposure to 2,3,7,8-TCDD developed birth defects such as skeletal deformities and kidney defects, weakened immune responses, impaired reproductive system development, and learning and behavior

impairments (Giavini *et al.*,, 1983; Gray and Ostby, 1995; Tryphonas, 1995; Schantz and Bowman, 1989; Schantz *et al.*,, 1992). Reproductive effects in the form of miscarriages were reported in rats, rabbits, and monkeys exposed orally to 2,3,7,8-TCDD during pregnancy (McNulty, 1984). Rats of both sexes were observed to have endocrine changes in the form of alterations in sex hormone levels with dietary exposure. Other reproductive effects include a decline in sperm production in male rats, and carcinogenic effects of cancer of the liver, thyroid, and other sites in rats and mice exposed orally to 2,3,7,8-TCDD (NTP, 1982; Kociba *et al.*,, 1978). Research evidence is also increasing supporting the neurotoxic effect for mammals and birds from ingestion exposure to dioxin-like compounds, including certain PCBs and CDFs. Changes in thyroid hormones and neurotransmitters, singly or together, at critical periods in the development of the fetus are considered responsible for the neurological changes (Brouwer *et al.*,, 1995; De Vito *et al.*,, 1995; Henshel *et al.*,, 1995b; Henshel and Martin, 1995a; Vo *et al.*,, 1993).

**6.3.3 Human Health Studies**

Demonstrating health effects in humans from chronic, low-level exposure to persistent organic pollutants typically encountered in the Great Lakes region is a challenge for researchers. Exposure to contaminants from Great Lakes fish is dependent upon the amount eaten and species consumed. Overall, there is limited information available on exposure levels, body burdens and health effects for people who consume Lake Erie fish. Currently, the Agency for Toxic Substances and Disease Registry (ATSDR) is funding studies investigating populations that reside in the Lake Erie basin and consume Lake Erie fish. The ATSDR studies will determine exposure and body burden levels, and potential health effects. In addition, two Health Canada fish consumption studies include participants from the Lake Erie basin. Along with results from the Lake Erie studies, research examining other Great Lakes will be used to assess risks and benefits of eating Great Lakes fish.



***Exposure Studies***

Due to the effects of bioaccumulation and biomagnification, fish consumption has been shown to be a major pathway of human exposure to PBT chemicals such as PCBs (Birmingham *et al.*,, 1989; Fitzgerald *et al.*,, 1996; Humphrey, 1983; Newhook, 1988), exceeding exposures from land, air, or water sources (Humphrey, 1988). Humphrey (1988) reported that PCBs were the dominant contaminants detected in Lake Michigan trout (3,012 parts per billion or ppb) and chinook and coho salmon (2,285 ppb), surpassing other contaminants such as DDT (1,505 ppb, 1,208 ppb), hexachlorobenzene (5 ppb, 5 ppb), oxychlordane (25 ppb, none shown), trans-nonachlor (195 ppb, 162 ppb), and dieldrin (75 ppb, 53 ppb), respectively in trout and salmon. Fish specimens collected from the dinner plate of study participants were used to determine these median PCB concentrations. Recently, total PCB levels have decreased in most Lake Michigan fish species and appear to remain below the FDA action level of 2000 ppb, but the concentrations in chinook and coho salmon have risen slightly since the late 1980s (Stow *et al.*,, 1995).

Early investigations of Lake Michigan fish consumption have broadened our knowledge about transmission of contaminants from fish to humans, including maternal exposure of the fetus and infant. Investigating a cohort of State of Michigan fish eaters, Humphrey (1988) discovered that sport anglers who regularly consumed Great Lakes salmon and trout (consumption rate of $24 pounds/year - or $11 kg/year) had median serum PCB levels approximately four times higher (56 ppb) than those who consumed no Great Lakes fish (15 ppb). PCBs have also been detected in adipose tissue, breast milk, and cord blood, and associated with consumption of contaminated fish (ATSDR, 1998). Schwartz *et al.*, (1983) demonstrated that consumption of Lake Michigan fish was positively associated with the PCB concentration in maternal serum and breast milk. Maternal serum PCB concentrations were also positively associated with the PCB levels in the umbilical cord serum of the infant (Jacobson *et al.*,, 1983).

Although the levels of PCBs have declined in most species of Lake Michigan fish, lipophilic pollutants, such as PCBs, have a tendency to bioaccumulate in the human body. Hovinga *et al.*,, (1992) reported a mean serum PCB concentration of 20.5 ppb in 1982 for persons consuming >24 pounds of Lake Michigan sport fish per year, and 19 ppb in 1989

demonstrating little decline within the 7 year interval. For those ingesting <6 pounds of Lake Michigan sport fish per year, the mean serum PCB concentrations were 6.6 ppb in 1982, and 6.8 ppb in 1989. The mean serum PCB concentrations for those consuming <6 pounds of Lake Michigan fish per year are comparable to the mean serum PCB levels of 4 to 8 ppb found in the general population who do not have occupational PCB exposure (Kreiss, 1985).

Research has shown that at risk communities for exposure to contaminants from fish consumption include Native Americans, minorities, sport anglers, elderly, pregnant women, and fetuses and infants of mothers consuming contaminated Great Lakes fish (Dellinger *et al.*,,1996, Fitzgerald *et al.*,, 1996, Lonky *et al.*,, 1996, Schantz *et al.*,, 1996). These communities may consume more fish than the general populations or have physiologic attributes, such as physical and genetic susceptibilities, that may cause them to be a greater risk. Higher body burdens of mean serum PCBs and DDE were found in an elderly cohort of Lake Michigan fish eaters (i.e. $50 years of age) who were compared to non-fish eaters (Schantz *et al.*,, 1996). Fish eaters had mean serum PCB levels of 16 ppb while the non-fish eaters had mean levels of 6 ppb. For DDE, fish eaters had mean serum levels of 16 ppb and the non-fish eaters had a mean level of 7 ppb.

Gender difference in fish consumption is an issue of interest that is being investigated, toward better identifying at-risk populations. One Michigan sport anglers study, with subjects between the ages of 18-34 years, demonstrated gender differences with males tending to consume more fish than female subjects (Courval *et al.*,, 1996). Conversely, Health Canada=s Great Lakes Fish Eaters Study (discussed below) found that women in the high fish consumption group eat more fish than men (Kearney, 2000, personal communication).



In a recent Health Canada study carried out in five areas of concern in the lower Canadian Great Lakes, 4,637 shoreline fishers were interviewed. The demographic data show that there is no such thing as *a typical* fisher. People who like to fish come from different cultural backgrounds, are different ages and have different occupations. Thirty-eight percent of the shoreline fishers interviewed reported eating at least one meal of fish during the previous 12 months. Twenty-seven percent of shoreline fishers interviewed reported eating more than 26 meals of fish in a year. As the number of fish meals consumed increased, so did the likelihood that parts of the fish other than the fillet were being consumed. Approximately one third of the fish eaters said that they used the *Guide to Eating Ontario Sport Fish* (Health Canada, 2000).

A concurrent project, the Great Lakes Fish Eaters Study (not yet released) took a more in-depth look at exposure to environmental contaminants in people eating large amounts of Great Lakes fish. Environmental contaminant levels were measured in blood samples collected from the study participants. As well, nutritional and social benefits associated with consumption of Great Lakes fish were examined (Kearney, 2000, personal communication).

In a study by Kearney *et al.*, done in 1992-93 blood levels of PCBs in men and women between Great Lakes fish eaters and non-fish eaters were compared for Mississauga and Cornwall (in the Lake Ontario basin) combined. For male fish eaters the median level was 5.5 ppb, for male non-fish eaters it was 3.9 ppb. For women fish eaters and non-fish eaters the median levels were 3.4 and 3.2 ppb, respectively. These differences were statistically significant for men only. Relative to fish eaters and families on the north shore of the St. Lawrence River (geometric mean 35.2 ppb) and Quebec Inuit (geometric mean 16.1 ppb), these values are low. Total mercury levels measured in the same participants were also low; the median levels for male Great Lakes fish eaters and non-eaters were 2.65 and 1.70 ppb, respectively. Median levels for female Great Lakes fish eaters and non-eaters were 2.10 and 1.45 ppb, respectively. Levels were generally at the lower end of the *normal acceptable range* (< 20 ppb) as defined by the Medical Services Branch of Health Canada and based on WHO guidelines.

Hanrahan *et al.*, (1999) corroborated previous findings relating frequent Great Lakes sport fish consumption to a higher body burden for PCBs and DDE. The study examined relationships between demographic characteristics, Great Lakes sport fish consumption, PCB, and DDE body burdens. The blood serum PCB and DDE levels in a large cohort (538)

of sport fish consumers for Lakes Michigan, Huron and Erie were significantly higher than in reference groups. Body burdens varied by exposure group, gender, and Great Lake. Years of consuming Great Lakes fish was the most important predictor of PCB levels, while age was the best predictor of DDE levels.

Falk *et al.*, (1999) examined fish consumption habits and demographics in relation to serum levels of dioxin, furan, and coplanar PCB congeners in one hundred subjects. Body burdens varied by gender and lake (Michigan, Huron, and Erie). Between-lake differences were consistent with fish monitoring data. Consumption of lake trout and salmon was a significant predictor of coplanar PCBs. Consumption of lake trout was also a significant predictor of total furan levels. Fish consumption was not significantly correlated with total dioxin levels.

***Health Effects***

Developmental, reproductive, neurobehavioral or neurodevelopmental, and immunologic effects of exposure to lipophilic pollutants (i.e. organochlorines) have been examined in studies conducted within the Great Lakes basin and outside the basin. The following are selected studies that have reported an association between exposure through sport fish consumption and these outcomes.

Developmental effects in the form of a decrease in gestational age and low birth weight have been observed in a Lake Michigan Maternal Infant Cohort exposed prenatally to PCBs (Fein *et al.*,, 1984). These findings have also been observed in offspring of women exposed to PCBs occupationally in the manufacture of capacitors in New York (Taylor *et al.*,, 1989).

Reproductive effects have also been reported. Courval and coworkers (1997 and 1999) examined couples and found a modest association in males between sport-caught fish consumption and the risk of conception failure after trying for at least 12 months. Studies of New York state anglers have not shown a risk of spontaneous fetal death due to consumption of fish contaminated with PCBs (Mendola *et al.*,, 1995), or an effect on time-to-pregnancy among women in this cohort (Buck *et al.*,, 1997).



Neurobehavioral or neurodevelopmental effects have been reported for exposure to PBT chemicals in newborns, infants, and children of mothers consuming Great Lakes fish. Early investigations of the Lake Michigan Maternal Infant Cohort revealed newborn infants of mothers consuming >6.5 kg/year of Lake Michigan fish had neurobehavioral deficits of depressed reflexes and responsiveness, when compared to non-exposed controls (Jacobson *et al.*,, 1984). The fish-eating mothers consumed an average of 6.7 kg of Lake Michigan contaminated fish per year equal to 0.6 kg or 2 to 3 salmon or lake trout meals/month. Prior to study admission, exposed mothers were required to have fish consumption that totaled more than 11.8 kg over a 6-year period. Subsequent studies of the Michigan Cohort have revealed neurodevelopmental deficits in short-term memory at 7 months (Jacobson *et al.*,, 1985) and at 4 years of age (Jacobson *et al.*,, 1990b), and also growth deficits at 4 years associated with prenatal exposure to PCBs (Jacobson *et al.*,, 1990a). A more recent investigation of Jacobson=s Michigan Cohort revealed that children most highly exposed prenatally to PCBs showed IQ deficits in later childhood (11 years of age) (Jacobson and Jacobson, 1996). Highly exposed children received prenatal PCB exposure equal to at least 1.25 ppm in maternal milk, 4.7 ppb in cord serum, or 9.7 ppb in maternal serum. The authors attributed these intellectual impairments to in utero exposure to PCBs.

The Oswego Newborn and Infant Development Project examined the behavioral effects in newborns of mothers who consumed Lake Ontario fish that were contaminated with a variety of PBT chemicals. These infants were examined shortly after birth (12-24 and 25-48 hours). Lonky *et al.*,, (1996) found that women who had consumed >40 PCB equivalent pounds of fish in their lifetime had infants who scored more poorly in a behavioral test (Neonatal Behavioral Assessment Scale) than those in the low-exposure (<40 PCB equivalent pounds of fish) or control group. In a follow-up study, Stewart *et al.*, (1999) concluded that the most heavily chlorinated and persistent PCB homologues were elevated in the umbilical cord blood of infants whose mothers ate Great Lakes' fish. The concentration was significantly dependent on how recently the fish were consumed relative to pregnancy. A further study attempting to relate the level of PCBs to scores in infants is underway.

Mergler and coworkers (1997) reported early nervous dysfunction in adults who consumed St. Lawrence River fish. However, in initial testing, neurotoxic effects were not observed by Schantz and coworkers (1999) in an elderly adult population (i.e. $50 years) of Lake Michigan fish-eaters with exposure to PCB and DDE. This study is ongoing. Immunologic effects have also been reported. Smith=s study (1984) demonstrated that maternal serum PCB levels during pregnancy were positively associated with the type of infectious diseases that infants developed during the four months after birth. In addition, incidence of infections has been shown to be associated with the highest fish consumption rate for mothers - i.e., at least three times per month for three years (Swain, 1991; Tryphonas, 1995).

Other health effects have been documented with PCB exposure. Elevated serum PCB levels were associated with self-reported diabetes and liver disease in cohorts of Red Cliff and Ojibwa Native Americans (Dellinger *et al.*,, 1997, Tarvis *et al.*,, 1997). Fischbein and coworkers (1979) found that workers exposed to a variety of PCB aroclors reported joint pain.

A summary of health effects studies inside and outside the Great Lakes basin can be found in the recent paper published by Johnson and coworkers (1998). Toxicological Profiles for hazardous substances, including PCBs and mercury, have been published by the U.S. Agency for Toxic Substances and Diseases Registry (ATSDR). The full reports can be obtained from ATSDR, and information is available on ATSDR=s website at http://www.atsdr.cdc.gov/toxpro2.html .

## 6.4 Human Health Indicators



Human health indicators have not yet been developed for the Lake Erie LaMP. However, a preliminary set of proposed human health indicators was forwarded as part of the LaMP's participation in the SOLEC'98 meeting focussed on *Indicators for the Great Lakes basin Ecosystem*. A preliminary suite of indicators is presented in Table 6.2.

Indicators are being developed as part of a number of initiatives, including SOLEC, LaMPs, the IJC Indicators Implementation Task Force, and the IJC Health Professionals Task Force. Health Canada has used existing data to develop a preliminary suite of health-related indicators as per the list above. They are published in the document *Health-Related Indicators for the Great Lakes Basin Population: Numbers 1-20* (Health Canada, 1998b). These indicators were presented at the State of the Lakes Ecosystem Conference (SOLEC) 1998. This is not meant to be a comprehensive list, but rather a springboard for discussion toward enhancing/revising these preliminary indicators and developing others.

### Table 6.2: Proposed Human Health Indicators for Lake Erie

| Human Health Indicator | Short Description |
|---|---|
| Environmental Health Indicators | Monitor for contaminants, including radionuclides, in various environmental media, including food originating in the Great Lakes basin (e.g. fish and wildlife), drinking water, recreational water, and air. Levels would be compared to current guidelines and standards. |
| Body Burden Indicator | Concentration of toxic contaminants in human tissue to serve as an indicator of exposure. |
| Health Effects Indicator | Traditional indicators such as cancer and birth defects. |
| Public Perception Indicator | Indicator to gauge if people are not using certain resources because of perceived health risks. |

## 6.5 Conclusion and Implementation Plan for Human Health

### Conclusions

For persistent bioaccumulative toxic chemicals, the current weight of evidence regarding human health effects is supportive of the need for continued reductions in the levels of PBT chemicals in the environment. While public health advisories and other guidelines can be followed to protect human health from current environmental exposures, continued reductions in the level of persistent pollutants in the environment, both globally and regionally, are ultimately the most effective long-term solution to minimizing the health risks to the Lake Erie basin population.

Although progress has been made in defining the health threat from Great Lakes pollutants (including Lake Erie pollutants), important issues remain requiring our diligent effort. To protect human health in the Lake Erie basin, actions must continue to be implemented on a number of levels. The Great Lakes Water Quality Agreement calls for ". . . develop[ing] approaches to population-based studies to determine the long-term, low-level effects of toxic substances on human health" (IJC 1987). For the public health arena, there are a number of issues that will help to identify these long-term, low-level health effects. Research in these areas will provide a more comprehensive view of the threat to human health from environmental contaminants, and enable public health agencies to utilize this knowledge to protect the public health more effectively. A shift in priorities is now needed to prevention, intervention, and collaborative activities, including the work of LaMPs. In particular, contaminant levels monitoring in environmental media and in human tissues is an activity in particular need of support, to better quantify the extent of exposure. Health risk communication is also a crucial component to protecting and promoting human health in the basin. The LaMP can play a key role in informing people about human health impacts of environmental contaminants and what they can do to minimize their health risks. This includes linking people to information that is packaged in a variety of ways and targeted to a range of audiences, to enable people to make informed choices about their health.



### Drinking Water

Over time, public water systems have been found to supply drinking water of good quality. Monitoring and corrective measures to reduce and eliminate levels of contaminants in treated water are essential components in continuing to assure the safety of drinking water supplies. As the population grows and more people rely on the drinking water supply from the lakes, these control measures must be adequate to reduce the risk from exposure to microbes in Great Lakes waters (Health Canada, 1997). Ultimately, however, source water protection (protection of the raw waters) is the key to maintaining the good quality of drinking water supplies. The Lake Erie LaMP has designated the drinking water use of Lake Erie as unimpaired (see Section 4).

### Recreational Use

Pollution controls and remediation, such as reducing combined sewer overflows, and improvements in sewage treatment, have continued to improve water quality in many areas of the Great Lakes basin in recent years. Long term planning for remediation of microbial contaminants in recreational water needs to include identification of sources of contamination, determination of which sources can be remediated and the costs involved, and timelines for implementation (Health Canada, 1998a; Lake Erie LaMP, 1999; U.S. EPA, 1998a). Although it may not be feasible to eliminate microbial level exceedances completely in recreational waters, it is expected that as sources continue to be remediated, exceedances will continue to decline. (Lake Erie LaMP, 1999; U.S. EPA, 1998a). The Lake Erie LaMP has designated recreational use as impaired (see Section 4).

### Fish Consumption

Diet contributes over 95% of the PBT chemical intake for the general population, with drinking water, recreational water, and air constituting very minor exposure routes. Consequently, the approach by various public health agencies has been to focus on groups at higher risk of exposure to PBT chemicals from Great Lakes sources, such as high consumers of sport fish. Due to the presence of PCBs, organochlorine insecticides, mercury, and other chemicals in fish from the Lake Erie basin, fish advisories are issued which recommend restrictions on fish consumption. Tighter restrictions are recommended for pregnant women, women of childbearing age and children, in some cases to the point of completely eliminating fish from the diet. When communicating health risk information to fish consumers, it is important to remember that fish are also a good source of low-fat protein, and that the activity of sport fishing has social and cultural benefits.



### Additional Exposure and Health Effects Research for PBT Chemicals

Since the 1970s, there have been steady declines in many PBT chemicals in the Great Lakes basin, leading to declines in levels in the environment, and in animal and human tissues. Within the ecosystem, there are encouraging signs and successes. For example, contaminant declines have been observed at most Great Lakes sites sampled for contaminants in the eggs of herring gulls (Environment Canada and U.S. EPA, 1999).

Reductions of PBT chemicals in human tissues include lead in blood and organochlorine contaminants in breast milk. This translates into a reduced risk to health for these contaminants. However, PBT chemicals, because of their ability to bioaccumulate and persist in the environment, continue to be a significant concern in the Lake Erie basin. Human health research has identified fish consumption as the major pathway of exposure to contaminants from Lake Erie and other Great Lakes. Body burdens from consumption of contaminated fish have been noted in highly exposed populations and human health effects have subsequently been reported. Despite these findings, issues related to environmental exposures and human health still remain. This supports the need for continued reductions of PBT chemicals in the Lake Erie basin. Health research needs to continue, but a shift in priorities is now needed to prevention and intervention strategies. Efforts on public health advisories to protect health from current environmental exposures, and public outreach related to risks and benefits of fish consumption, need to continue where appropriate.

Additional research is needed in the following areas:

**1.** Continue to assess the role of PBT chemicals on neurobehavioural and neurodevelopmental effects.
**2.** Improve the assessments of chemical mixtures.
**3.** Assess the role that endocrine disruption may play in human health effects, such as reproductive health.
**4.** Research on PCB congeners.
**5.** Research on biologic markers.

Recommendations for public health interventions and research have been identified throughout the paper. Proposed and ongoing actions to further public health intervention and research are presented in Table 6.3.

## Table 6.3 Human Health Action/Implementation Plan Matrix

| Description | Project Lead | Funding Status |
|---|---|---|
| **Drinking Water** | | |
| Assess sources of drinking water.<br>• For the U.S., U.S. EPA and all the Lake Erie states, tribes and local water utilities have adopted a Source Water Protection Protocol for use in source water assessments to be conducted by 2003. The standardized protocol for conducting assessments of public drinking water supplies will delineate source areas and assess significant potential sources of contamination in order to protect water supplies and inform beach managers.<br>• In Canada (Ontario), assessment of drinking water supply sources is done by the Ontario Drinking Water Surveillance Program and reported to the public. | U.S. states working with U.S. EPA and local communities<br><br>Ontario Drinking Water Surveillance Program | A<br><br>A |
| Protect drinking water sources. This would include specific actions such as: wellhead protection plans and protection plans for water supply intakes on Lake Erie | U.S. states working with U.S. EPA and local communities; Health Canada/Ontario/local communities | A |
| Raise awareness and publicize the availability of drinking water monitoring information to the general population B Confidence Reports, U.S., Drinking Water Surveillance Program, Ontario. | U.S. and Canadian Water Systems; state/provincial and federal health and environmental agencies; local governmental agencies | A & B |
| Promote epidemiological research (exposure and health effects) on drinking water borne diseases in the Great Lakes and for the Lake Erie basin in particular. This should include an evaluation on public vs. private sources. | Funded research from NIEHS, U.S. EPA, Health Canada and academic researchers | A & B (funding needs to be targeted towards the Great Lakes) |
| Continue to research the implications of aluminum and chlorination disinfection by-products on human health and promote the development of guidelines for water treatment to minimize any risk to health that may exist. | U.S. EPA, Health Canada/ Ontario | A |
| Improve the identification/diagnosis and promote the reporting of water borne disease incidences to help in response to disease outbreaks, improving information for epidemiological studies and for tracking trends over time (indicator). | U.S. CDC, state and local health departments; Province of Ontario and local Health Units | C |
| Research and development of technologies and methods for the detection and treatment of Giardia, Cryptosporidium and other parasites in drinking water to protect human health. | U.S. federal and state health agencies, U.S. EPA; Health Canada | A & B |
| Promote ambient monitoring of Lake Erie drinking water intakes, and tributaries that can potentially degrade water quality at these intakes, and storage of data in electronic databases. Microbiological and turbidity monitoring should be included in the monitoring program. | IJC Indicator Implementation Task Force; U.S. EPA OGWDW; EPA GLNPO; Great Lakes Commission | A & B (In Canada this is done and reported. U.S. may be done but not required to be reported.) |

| Description | Project Lead | Funding Status |
|---|---|---|
| **Recreational Water** | | |
| Continue to promote and expand the U.S. BEACHs surveillance program and corollary programs for the Canadian shoreline. This would include outreach to local governments along the Lake Erie shoreline for their involvement. In parallel a Lake Erie indicator of recreational water quality that includes microbial data supplemented by beach postings should continue to be developed. | U.S. EPA; Health Canada; state/provincial and local governments. | A |
| Continue the development of rapid sampling technologies and techniques for microbial and viral contamination and promote the dissemination and use of the instrument and sampling methods to local governments along the Lake Erie shoreline. | U.S. EPA BEACHs program; Health Canada; Ontario, state and local governments | A & B |
| Promote epidemiological research on recreational water borne diseases in the Great Lakes and for the Lake Erie basin in particular. This should also include research on the health implications of interstitial bathing waters, CSO/SSO discharges and inhalation of water spray. | Funded research from NIEHS, U.S. EPA, Health Canada and academic researchers | A & B |
| **Fish Consumption** | | |
| Research the health benefits of fish consumption to better quantify those benefits for use in risk assessment for developing fish consumption advice. | U.S. EPA/OST | B & C |
| Develop a meaningful Lake Erie indicator for fish consumption. Promote the reporting of contaminant levels in edible portions of fish collected by state agencies responsible for fish consumption advisories. Indicator would track these levels over time. | Lake Erie LaMP partners, SOLEC | A & B |
| Increase awareness, use and effectiveness of fish advisories in the Lake Erie populations targeting sensitive populations (minorities, women of childbearing age, immigrants, the elderly, etc.) | State and Province Government Agencies, U.S. EPA, Health Canada, local governments | A & B |
| • U.S. EPA grant to Delta Institute for Outreach of Fish Consumption Advisories to Minority and At Risk Populations This is a pilot grant to develop and promote the outreach of fish consumption advice to minority and at risk populations in the Lake Erie Basin. The grant emphasizes the development and promotion of culturally sensitive and effective outreach materials. | U.S. EPA | A |
| • ATSDR grant to Consortium for the Health Assessment of Great Lakes Fish Consumption<br>This is an ongoing project to conduct a Great Lakes basin wide outreach program to distribute sport-fish advisory materials to women of childbearing age and to host a conference to establish a forum for exchange of information on successful distribution of the sport fishing advisory to women of childbearing age and other high risk populations. The Consortium of Great Lakes states developed outreach materials for women of childbearing age and minority groups which are being utilized by seven of the eight Great Lakes states (Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Wisconsin). These outreach materials such as posters and recipe cards are being adapted by each of the states for their specific needs, and are being distributed at women and children's clinics, health fairs, state fairs, and fishing shows to increase health advisory awareness. | ATSDR/State of Wisconsin | A |

| Description | Project Lead | Funding Status |
|---|---|---|
| **Exposure and Health Effects Research** | | |
| Promote exposure, outcome and epidemiological research for PBT chemicals in the Great Lakes and specifically within the Lake Erie basin. This research should include the five needs for the future listed in Section 6.5. | ATSDR; NIEHS; U.S. EPA; Health Canada; Environment Canada; state, provincial and local health departments | A & B |
| • Shoreline Survey - In a recent Health Canada study carried out in five Areas of Concern in the lower Canadian Great Lakes (Dawson, 2000), 4,637 shoreline fishers were interviewed. The demographic data show that there is no such thing as a Atypical@ fisher. People who like to fish come from different cultural backgrounds, are different ages and have different occupations. A report of the results is expected to be available by mid-year 2000. | Health Canada | A |
| • Great Lakes Fish Eater Study - A concurrent project, the Great Lakes Fish Eaters Study (not yet released) has taken a more in-depth look at exposure to environmental contaminants in people eating large amounts of Great Lakes fish. Environmental contaminant levels were measured in blood samples collected from the study participants. As well, nutritional and social benefits associated with consumption of Great Lakes fish were examined. | Health Canada | A |
| **Other** | | |
| Development of a Human Health Resource Home Page for the Great Lakes with pages specifically oriented towards human health issues in the Lake Erie basin | LaMP HH Subcommittee; U.S. EPA; Health Canada; ATSDR; States and Provinces working with the Great Lakes Commission and other LaMP partners | B |
| Assessment of social dimensions of health in the Lake Erie basin. Identify references available, and the need to address the social dimensions of health, further to the WHO definition of health. | LaMP HH Sub-committee and Public Forum HH Task Group, working with LaMP partners; Health Canada; U.S. EPA | B |
| Literature review of wildlife consumption issues. | | B |

***Funding Status Codes:**

A. Funded actions

B. Unfunded actions (or uncommitted — those actions which are high priority for the committee or a state/tribe but no funding presently exists)

C. Future Actions (those actions that are on your wish list but are “not ready for prime time”)

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# Public Involvement




Photo: Michael Saletra

# Section 7: Public Involvement

## 7.1 Overview

A major tenet of ecosystem management is continuous involvement of the public that is inclusive and respectful of all viewpoints and stakeholders. All the partners involved in the LaMP process, i.e. states, provinces, federal agencies, the tribes/First Nations, industry, the public and others, have long been committed to an open, fair and significant public involvement process. LaMP 2000 is not an end to this process, but provides an opportunity for full public review and input on what has been developed to date, and ongoing involvement in the revisions and updates to come in future LaMP publications. Public input and support will help ensure the actions recommended in the LaMP are carried out, leading the way to restoring and protecting the Lake Erie ecosystem. The key to public support and the program's success is effective communication between the government agencies and the diverse population of the Lake Erie basin.

LaMP 2000 is presented as a working document, based on existing information. It was the goal of the Binational Executive Committee (BEC) to provide a *current* foundation for discussion not necessarily a *complete one*. The LaMP will be modified every two years based on new findings and public input. This is a necessary step if we are to institute adaptive management on an ecosystem scale.

Formal comments on the LaMP 2000 document will be received for 60 days following its release. The Public Involvement Subcommittee is responsible for gathering comments submitted by the public and ensuring that the proper agency staff receive the comments in order to take them into consideration in the ongoing LaMP process and for the LaMP 2002 document. Responses will then be prepared so that those who made submissions will know what happened as a result of their comments. **The LaMP 2000 document will not be revised.** As the LaMP 2000 report is available on our web sites, it is also possible to use the on-line submission form to submit your comments. The website addresses are **www.cciw.ca/glimr/lakes/erie/** and **www.epa.gov/glnpo/lakeerie/.** We also plan to set up a page on the website that will be used to display the comments. This will allow members of the public to review all comments received by the agencies.

Over the coming months, there will be public meetings in the Lake Erie basin to educate stakeholders about the LaMP, receive their input and to encourage actions to improve the ecosystem of the Lake Erie basin. Many of the meetings will be held in local Areas of Concern so that we can continue to better integrate the LaMP and RAP processes. A short summary of each of the RAPs can be found in Appendix A of this document.

We invite you to stay involved in the LaMP process after April 2000. As actions are implemented and evaluated, new data gathered and analyzed, and new background documents drafted, this information will be placed on our website for public review and input. Although the LaMP document will not be published again until April of 2002, there will be many opportunities for input and involvement during the two-year period.

## 7.2 Background and History

The original public involvement strategy for the LaMP was completed in April 1995. It described a three-tiered approach to involving the public. Tier I is the Lake Erie LaMP Binational Public Forum, which is composed of members who are familiar with LaMP activities, who have the most active level of public involvement in the LaMP and who have direct contact with the Lake Erie LaMP Work Group. Tier II, the Lake Erie Network, is composed of individuals and groups who have expressed an interest in the LaMP by attending meetings and workshops or by commenting on documents, and who have requested additional information about the LaMP. They form the mailing list for the Lake Erie LaMP. Tier III is the general public with members being unfamiliar with the Lake Erie LaMP.

The Public Involvement Subcommittee provides information to the media about ongoing binational and local LaMP activities as a way of keeping the general public informed. Because the LaMP is an evolving program, new information is distributed as it becomes available. Information is also available on the Internet at **www.cciw.ca/glimr/lakes/erie/** or **www.epa.gov/glnpo/lakeerie/.** In 1995, a questionnaire was distributed assessing the knowledge and involvement level of all individuals on the mailing list. The information requested was used to develop a public involvement and communication program to build teamwork between citizens and government agencies involved in accomplishing the goals of the LaMP.

### Ecosystem Objective Workshop

During the months of May and June 1995 the Public Involvement Subcommittee held four ecosystem objective workshops in Sandusky, Ohio; Dunkirk, New York; and in Simcoe and Leamington, Ontario. The government agencies used these workshops to solicit public input toward identifying ecosystem objectives for Lake Erie. These workshops served to bring members of the public together with agency representatives to direct Lake Erie LaMP efforts. These early workshops set the stage for what was to become a working group of concerned, involved residents of the Lake Erie basin who have joined together as the Lake Erie Binational Forum.



### Lake Erie LaMP Binational Public Forum

The concept of a Lake Erie LaMP Binational Public Forum was developed as part of the overall public involvement strategy. It was introduced to the public with the publication and distribution of the Lake Erie LaMP Concept Paper in 1995. Involvement of the public is important to assist in creating and implementing a LaMP that truly reflects the concerns and expectations of Lake Erie basin citizens.

The goal of creating the Forum was to have a formal group of citizens that was knowledgeable about the process and issues; was accountable to both the Management Committee and to the public; that would increase public understanding and involvement in the Lake Erie LaMP's development; and that may be interested in undertaking their own activities in support of protecting and restoring Lake Erie. The Forum would be the most involved level of public participation, and would consist of individuals representing a broad range of interests and geographic areas from around the Lake Erie basin.

## 7.3 Public Involvement Activities

### Status Report and Update

In its support role to the Work Group, the Public Involvement Subcommittee assisted in the production and distribution of the *Lake Erie LaMP Status Report* in the Spring of 1999. A companion piece, entitled the *Lake Erie LaMP Update '99*, was written and produced as the main distribution document to inform people about the issues in, and availability of, the *Status Report*. The *Update '99* mailing also served as a vehicle for informing the public about the availability of the various Beneficial Use Impairment Assessment Reports that the committee is responsible for distributing.

### Other Activities

In addition to the activities already mentioned, the Public Involvement Subcommittee was involved in a variety of outreach activities. These include the production of the following documents: 1) fact sheet giving an overview of Lake Erie LaMP development, printed in Fall 1995 and revised in November 1996; 2) distribution of educational posters entitled *Lake Erie Fish and Fishery* and *Waterbirds of Lake Erie* that were developed by various United States and Canadian government agencies involved with the LaMP; and 3) creation and distribution of bookmarks with the URL for the binational LaMP website.

## 7.4 Ongoing and Upcoming Activities

The Public Involvement Subcommittee is at present working on the improvement of the Lake Erie LaMP Binational website. Placed online in 1998, the site currently has basic information about the LaMP and its organizational structure, as well as publications or products of the LaMP. The goal is to make the website a place where the public can go to answer their questions and learn about the Lake Erie LaMP.

The subcommittee will also be preparing future editions of the *Lake Erie LaMP Update*. As *Update '99* was successful in getting the word out about the *Lake Erie LaMP Status Report* and in encouraging people to join the Lake Erie Network, it was decided that there should be future editions to get information out to the public in a succinct fashion.

As the development of ecosystem objectives for the lake has progressed, it is expected that another series of workshops will be held in autumn 2000, to obtain the public's views on the direction that efforts should take in restoring uses of the lake. The Lake Erie LaMP Work Group has prepared four *ecosystem alternatives* that will be presented to the public to learn which are most desired by the people in the Lake Erie basin. These workshops will be publicized through the press, Lake Erie LaMP partners and on our website. If you are interested in learning more about this subject and/or participating in the workshops, please contact: in Canada, Teresa Hollingsworth and in the United States, Kate Blumberg. (Contact information is found at the end of this chapter.)

## 7.5 How to Get Involved

There are a number of ways for you to get involved in the Lake Erie LaMP. If you would like to receive information as it becomes available, join the Lake Erie Network. This can be done by contacting Marlene O'Brien in Canada, or Rita Garner in the United States. (Contact information is found at the end of this chapter.)
You can read about the LaMP at our binational websites: **www.cciw.ca/glimr/lakes/erie/** and **www.epa.gov/glnpo/lakeerie/.**

If you would like to become a member of the Forum, please contact, in Canada, Teresa Hollingsworth and in the United States, Kate Blumberg.

## 7.6 Contact Information

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# Lake Erie Binational Public Forum

Photo: FOCAL Erie

# Section 8: The Lake Erie Binational Public Forum

*[This section was prepared with substantial input from the Lake Erie Forum. In addition to the Forum's role in supporting preparation and review of LaMP technical background documents, it highlights in particular the accomplishments of the various Lake Erie Forum Task Groups.]*

## 8.1 Purpose

In 1993, the United States and Canada began planning for the Lake Erie Lakewide Management Plan (LaMP). Public participation in the development and implementation of the LaMP was recognized as a critical component in achieving the goals of the LaMP. The government agencies involved in the Lake Erie LaMP established the Lake Erie Binational Forum to provide a direct public link into the Lake Erie LaMP process.

The Lake Erie Binational Public Forum is a self-governing, self-directed, self-implementing group of Lake Erie basin citizens focused on the development of the Lake Erie LaMP. Forum members provide input on the planning and implementation of the LaMP, and provide a means of fostering effective two-way communication with the diverse population of the Lake Erie basin. Forum members come together three times annually, at locations around the basin, to work on tasks associated with the goals of the Lake Erie LaMP. Due to the widespread geographical representation of Forum members, meeting locations are alternated on each side of the border to eliminate any unfair travel burdens.



## 8.2 Membership

The Forum is a binational group of individuals representing various interests and geographic areas from around the Lake Erie Basin. By bringing personal experience and talents to the table, Forum members provide a broad base of expertise that can be utilized to accomplish LaMP goals. Forum members represent a number of diverse interest areas, including the following:

- Agriculture
- Community Organizations
- General Public
- Sport & Commercial Fishing
- Local Government
- Recreation and Tourism
- Business and Industry
- Education
- Environmental and Special Interest Groups
- Labor
- Public Health

The Forum membership continues to change and grow over time and continues to seek interested, involved citizens to join this binational group. Procedures for becoming a member, recruiting new members, and the responsibilities and rights of members are under the guidance of the Forum's Membership Task Group.

## 8.3 Roles and Functions of the Forum

The following five concepts underlie all Forum roles and functions:

**1.** A successful Lake Erie LaMP must be consistent with the priorities of the citizens of the Lake Erie basin.
**2.** Implementation ultimately depends upon citizens' actions.
**3.** Government agencies need to effectively interact with a large number of basin residents and a diversity of interests.
**4.** The Lake Erie LaMP will be a model for how government and citizens will interact now and in the future.
**5.** The Forum will support the restoration of Lake Erie.

### Roles and Functions

**1.** The Forum shall play a significant role in the LaMP process with real involvement and proactive initiatives by:
- Acting as partners with governments and government agencies in goal setting and decision-making.
- Assisting the LaMP technical subcommittees in drafting 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.
- Promoting the Forum's vision 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.
- 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.

## 8.4 Vision and Mission

**Vision:**
A Lake Erie basin where diverse life forms exist in harmony, social and economic benefits co-exist at maximum sustainable levels, citizens and governments are committed to binational cooperation, and a philosophy of stewardship ensures a clean, safe environment.

**Mission:**
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.

## 8.5 Ground Rules

One of the Forum's first tasks was the adoption of a number of organizational and procedural ground rules that are followed at Forum meetings. Organizational ground rules help to insure that meetings are run efficiently and effectively. These rules deal with such items as: time limits, specific agendas, consideration, confidentiality, and the preparedness of Forum members. Procedural ground rules address the formation and guidelines of task groups, the prioritization of issues, preparation of meeting minutes, timetables for material distribution, and other items that are important to meeting productivity. These rules, developed by Forum members themselves, have helped to provide a protocol and functional framework for meetings.

## 8.6 Forum Task Groups

In order to maximize efforts of the group, the Forum membership was broken down into a number of technical and non-technical task groups. Forum members selected membership on task groups based on their interest and expertise. The task groups have each developed their own objectives and action plans that are consistent with LaMP goals. Certain task groups such as Beneficial Use Impairment Assessment, Ecosystem Objectives, and Sources and Loadings, follow closely and in some cases work alongside, the LaMP technical subcommittees. Other task groups, including Land Use, Pollution Prevention, and Environmental Justice, were formed by the Forum in response to what was considered a gap or deficiency of the LaMP Work Group structure. The Human Health task group was also created to fill such a gap, but now works closely with the recently formed Human Health Subcommittee of the LaMP Work Group.



During each Forum meeting, time is set aside for both technical and non-technical task groups to deal with agenda items that they have determined to be important to their specific group. All task groups report back to the overall Forum, and seek the group's approval for proposed actions. The overall Forum is asked to vote on actions and proposals from the individual task groups. No task group is allowed to take action without the awareness and approval of the overall Forum. This format allows all Forum members to be aware of the work of individual task groups even though they do not sit on each of the twelve groups currently established.

**Existing Task Groups:**

Beneficial Use Impairment Assessment
Ecosystem Objectives
Education and Outreach
Environmental Justice
Funding
Human Health
Internal Communications
Land Use
Membership
Roles and Objectives
Sources and Loadings
Pollution Prevention

Of the twelve existing task groups, not all function continually or meet on a regular basis. For example, the Membership, Roles and Objectives, and Internal Communications groups were all much more active in the first few years of the Forum and are currently inactive.

## 8.7 Task Group Accomplishments

The following examples are provided to demonstrate some of the accomplishments of each of the task groups:

### 8.7.1 Beneficial Use Impairment Assessment

The Beneficial Use Impairment Assessment Task Group receives impairment assessment reports prepared by the Beneficial Use Impairment Assessment Technical Subcommittee. Members of the task group review the assessments and conclusions reached by the respective authors, discuss the report as a group during meetings or conference calls, and develop feedback and recommendations based upon both the technical accuracy of the report and the appropriateness of the impairment conclusion reached by the report's author. The group presents a summary of the report with recommendations concerning the impairment conclusions to the full Forum and the Forum is asked to accept/not accept the recommendations of the task group. In the event there are significant dissenting opinions, a minority opinion report is prepared and sent to the technical subcommittee and the Management Committee, along with the majority opinion. The task group's main difficulty for some of the assessment reviews was the length of time given the group to review the report, meet, and discuss the report prior to formulating the recommendations and reporting these to the entire Forum to gain consensus or develop constructive feedback.

### 8.7.2 Ecosystem Objectives

This task group follows closely the work of the Ecosystem Objectives Technical Subcommittee. Activities have included reviewing the development of the ecosystem model, providing feedback on the model's presentation to the public and communicating with the Forum.



### 8.7.3 Education and Outreach

The primary function of the Education and Outreach Task Group is to increase awareness of the LaMP and its activities, and educate the public with respect to their role in lakewide management and stewardship. In order to meet this objective, the group initiated a media campaign to inform newspaper, radio, and television stations throughout the basin about the LaMP and the work of the Binational Forum. The task group also organized an informational letter campaign to political representatives from both sides of the border. Most recently, the task group worked with Forum members to have them send personal messages along with the 1999 Status Report to interested political leaders and stakeholders around the basin. The task group also works closely with agency outreach specialists to review progress on educational publications, displays and the web page development.

### 8.7.4 Environmental Justice (EJ)

*Environmental Justice* is a term originating in the United States, which refers to 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. The environmental justice movement first emerged in the United States in the early 1980s, with an initial focus on concerns of minority populations over the siting of hazardous waste landfills in their communities. A broader debate over environmental justice issues resulted in Presidential Executive Order 12898 on environmental justice, which made this issue a priority for U.S. federal agencies. See Appendix C for more specific information on environmental justice.

The EJ Task Group was formed during the January 1998 Forum meeting. The primary catalyst for forming the task group was several Forum members' interest in educating environmental justice communities regarding existing fish consumption advisories. The goal of the task group is to acknowledge the unique characteristics of environmental justice communities, recognize the needs of these diverse populations, and share critical information pertaining to Lake Erie with these communities in such a way as to enhance their quality of life.

In September 1999, the EJ Task Group was successful in securing two grants, from U.S. EPA and from the George Gund Foundation, for development of fish consumption advisory

materials and outreach to low-income and minority communities along the Lake Erie shore. The goal of the project is to make available easy-to-read and culturally sensitive educational brochures and other materials, to alert at-risk families to the dangers of contaminated fish consumption and to provide positive alternatives for cooking, cleaning and selecting fish in order to decrease risk.

This project targets lower income, primarily minority communities in the Buffalo, Ashtabula, Cleveland, Sandusky, Toledo, and Detroit areas with proximity to fishable sites of demonstrated high toxicity levels. These communities have been shown to be more vulnerable to health risks due to: culturally or economically-based reliance on fish as a food source; lack of resources to access less contaminated fishing sites; culturally-based preferences for more highly contaminated species; educational disadvantages; and mistrust of, or lack of access to, traditional government fish consumption advisories.

Brochures, posters and site postings will be colorful and readable at an 8th grade level and will make use of local children's art. A recipe card, including a reiteration of the cooking and cleaning guidelines stated in the brochure, will be incorporated as a perforated attachment to a mail-back evaluation card. The brochure will be printed and ready for distribution by the start of the fishing season, in April 2000. The brochure will also be posted on the Lake Erie Forum's website, **www.erieforum.org**.

The Environmental Justice Task Group feels that more work needs to be done in the next phase of LaMP development to internalize environmental justice principles throughout the various actions of the LaMP. The task group is currently working on a separate report that will outline additional recommendations for LaMP actions to assist environmental justice communities in the Lake Erie basin.

### 8.7.5 Funding



The Funding Task Group's role is to seek funding on behalf of the Forum for administrative costs such as travel, mailings, the cost of publications, etc. The role of the task group also includes the following activities: 1) encouraging non-profit organizations, agencies and other organizations to apply for funding to carry out activities that would support the LaMP; 2) helping to coordinate LaMP-related activities among cooperating organizations; and 3) presenting to the Forum proposed resolutions of support for cooperating organizations' grant proposals.

### 8.7.6 Human Health

The Human Health Task Group was established in February 1999 and began discussions on mission, scope and framework for a study. An agency Human Health Subcommittee of the Lake Erie LaMP was authorized in March 1999 with representatives from U.S. EPA Region 5, Health Canada, and ATSDR, as well as three Forum members. The initial charge to the task group was to identify human health issues not addressed by beneficial use impairment assessment reports (BUIAs), to summarize evidence for human health effects, and to identify key considerations related to human health issues.

The task group and subcommittee reviewed the BUIAs, finding that they did not directly address human health exposure and impacts, nor did they discuss any relevant individual research studies. While the BUIAs indirectly measure human exposure and provide exposure data sources, there were no discussions of policy implications, detection limits, emerging issues (such as endocrine disrupters), environmental health pathways, and media relationships. Variations in risk analysis and risk based standards were identified as a concern.

The task group and subcommittee are developing a human health paper which will address the GLWQA Annex 2 requirement to provide a "definition of the threat to human health from critical pollutants," address human health issues not addressed in the BUIAs, and provide a mechanism for incorporating emerging health issues. The paper is to define relevant human health concepts, including the weight of evidence approach, describe human health objectives for Lake Erie, define pathways of exposure and associated critical pollutants, summarize the latest knowledge on health effects and identify data gaps. Implementation measures are to be identified as well as human health indicators for measuring progress.

### 8.7.7 Internal Communications

The Internal Communications Task Group's primary function is to facilitate efficient networking within the Forum membership and with associated agencies. The first task was to collect detailed information on the Forum's networking capabilities through a *Networking Survey*. In order to come full circle in the process, a communication system/database unique to the needs of Forum networking is being developed and will be added to the Lake Erie Forum's website.

### 8.7.8 Land Use

In recognition of the importance of changing land use practices around the basin to developing a LaMP for a healthy Lake Erie, the Land Use Task Group was formed. The primary objective of the task group is to educate local decision-makers and governments, state, federal and provincial agencies and the public about watershed management and stewardship ethics.

The task group is currently educating itself and the Forum on land use practices around the basin and seeking funding to develop information sharing possibilities and demonstration projects. Additional action items for the Land Use Task Group include: investigate opportunities for sharing information and positive results, including demonstrations, technical assistance and displays; investigate urban/urbanizing/industrial *good practices*; collect information on completed and ongoing projects, with the goal of producing a directory that could be made widely available; link existing projects and programs to the LaMP, including the identification of gaps and the integration of information from the RAPs; facilitate the flow of information across political borders; and learn about latest technologies being used for land use planning.



### 8.7.9 Membership

This task group is currently inactive but originally played a role in developing guidelines and categories of Forum membership.

### 8.7.10 Roles and Objectives

The goal of the Roles and Objectives Task Group is to provide support in developing guidelines or procedures for the overall functioning and operation of the Forum. To date, the Roles and Objectives Task Group has drafted a vision and mission statement, both of which were adopted by the Forum. In addition, the task group has drafted a summary of the Forum's roles and function that was also adopted by the Forum.

### 8.7.11 Sources and Loadings

The Sources and Loadings Task Group follows closely the work of the Sources and Loads Technical Subcommittee. They are active in reviewing and providing constructive comments on subcommittee reports and in seeking the completion and publication of these documents. The objectives of this task group include: provide input to the technical subcommittee and review of decisions and documents; coordinate with the Pollution Prevention Task Group to develop pollution prevention strategies for targeted sources; and provide feedback and updates for the Forum.

### 8.7.12 Pollution Prevention

The primary function of this task group is to include pollution prevention as a component of the LaMP activities. To achieve that goal the task group has produced a concept paper defining what pollution prevention is and outlining its role in the LaMP process. This concept paper has been shared with the Forum and is currently under review.

Photo: John Cooper

# Paths to Achievement

# Section 9: Paths to Achievement

## 9.1 Introduction

Many different projects and programs have been implemented in the Lake Erie basin over the years, some of them binational in scope. Most previous programs have focused on one particular issue or medium, such as water quality, fish populations, contaminated sediments, physical processes, reducing phosphorus, controlling discharge from industries and wastewater treatment plants, monitoring, etc. The LaMP addresses these same issues but from an ecosystem perspective. The ecosystem approach allows a more holistic, comprehensive assessment of problems and the management actions needed to address them. To the extent possible, implications of management actions will be reviewed for the entire ecosystem and not just the ecosystem component the action is meant to address. Many times research, assessment and management needs are not coordinated with each other. With the involvement of all the jurisdictional agencies around the lake, researchers, the private sector and the public, it is the LaMP's intention that programs are not designed in a vacuum, that the most important issues will be identified, and that limited resources will be applied to the highest priorities.

The goal of the LaMP is to describe the current state of the lake and set objectives to achieve what we, as the Lake Erie community, envision for a sustainable Lake Erie ecosystem in the future. As described in Section 3, ecosystem objectives will be selected by considering ecological issues (fisheries, wildlife, habitat, etc.), socio-economic issues (human uses/ benefits from the lake), and health issues (both ecological and human). Once the ecosystem objectives are set, the LaMP will provide a road map to lead us toward those objectives. Many of the management and remedial actions that will be recommended in the LaMP will need to be adopted and implemented under other programs and by the agencies that have jurisdiction over those particular areas/issues in question. The LaMP has already leaned heavily on some existing programs for objectives and beneficial use impairment assessments. A number of federal, state, provincial and local government programs and policies are already in place serving to improve Lake Erie environmental quality. Many of these complementary programs are referenced throughout the Lake Erie LaMP 2000 document. Listed in Section 9.2 are the binational programs that support LaMP goals and represent some binational paths to achievement.



Habitat loss has already been defined as a major stressor and a beneficial use impairment by the Lake Erie LaMP. Several habitat projects have been completed over the years, and a number of others are underway or proposed. Section 9.3 presents a preliminary list of ongoing and proposed projects, as well as several that have recently been completed. More importantly, it proposes a foundation for developing a Lake Erie habitat restoration and protection plan, and also outlines screening criteria to assist in selecting and highlighting habitat projects that will most strongly support the goals of the Lake Erie LaMP.

The Lake Erie LaMP has identified mercury and PCBs as critical pollutants. Preliminary action plans listing ongoing and proposed actions to further assess and reduce these contaminants in the lake are presented in Sections 9.4 and 9.5. By establishing such a baseline of activities, we will be able to track implementation of efforts to reduce these chemicals. All of the LaMP partner agencies and organizations are encouraged to provide additional actions.

## 9.2 Connections to Existing Programs

### Remedial Action Plans

In addition to the development of LaMPs, the GLWQA called for the development of remedial action plans (RAPs) for the Great Lakes areas of concern. There are 12 areas of concern in the Lake Erie watershed (Appendix A). The RAPs and the LaMP process are very similar in that they use an ecosystem approach to assessing and remediating environmental degradation, focus on the 14 beneficial use impairments listed in Annex 2, and utilize a structured public involvement process. The RAPs for the St. Clair River and the Detroit River are also binational in scope. However, although the RAP and LaMP programs are alike in theory, they are very different in practice.

The RAPs have a much smaller geographic focus, looking at single watersheds or parts of watersheds. Although there is a component that considers the impact of that particular area of concern on Lake Erie, the main focus is on environmental degradation in that specific area and remediating the beneficial use impairments locally. Public participation in the RAPs is quite robust and very *hands-on* as the stakeholders are working on projects in their own backyards, and many times have the lead on those projects. Implementation has been underway in most RAPs for a number of years using a combination of federal, state, provincial and local resources. In most cases, the causes of impairment are related to sources within the area of concern.

Any improvement in an area of concern will eventually help to improve Lake Erie, but the effect will be much more visible and measurable locally. In some cases, remediation of a contaminated site within an area of concern may have impacts on the entire lake, particularly if the cleanup involves removal of a source of persistent toxic substances. It is important to continue to cultivate a stronger connection between the RAPs and the LaMP, particularly in establishing priority actions that will be most effective in restoring the Lake Erie basin. Updates and the current status of Lake Erie's RAPs are included in Appendix A.



### Great Lakes Fishery Commission

The Great Lakes Fishery Commission oversees a binational, Great Lakes basinwide, fisheries management program. The role of the Great Lakes Fishery Commission is to conduct coordinated fisheries research on the lakes and recommend measures which will permit the maximum sustained productivity of stocks of fish of common concern between the U.S. and Canada. They also have the responsibility to formulate and implement a program to eradicate or minimize sea lamprey populations in the Great Lakes. The Great Lakes Fishery Commission takes into account water quality, habitat and other environmental factors, with the main goal of preserving and enhancing the fish community by supporting establishment of a healthy Lake Erie ecosystem. The Lake Erie Committee (LEC) of the Great Lakes Fishery Commission develops and implements the management strategy specific to Lake Erie. Members of the LEC have been very active in developing ecosystem objectives for the Lake Erie LaMP, and some of the LEC's goals and objectives for Lake Erie were used as the basis against which to determine the status of several of the beneficial use impairments. The LEC is also the *major action arm* of the Great Lakes Fishery Commission that oversees the implementation and development of operational plans under the binational inter-jurisdictional *Joint Strategic Plan for Management of Great Lakes Fisheries.* The Joint Strategic Plan was adopted in 1981 in response to the need to better coordinate fisheries and ecosystem management initiatives. The Joint Strategic Plan was revised in 1997 to strengthen fisheries and ecosystem management coordination based on lessons learned since the 1981 signing and in regard to implementation of the Great Lakes Water Quality Agreement. Building stronger ties with LaMPs and RAPs is particularly specified in the goals of the Plan.

### North American Waterfowl Management Plan

The North American Waterfowl Management Plan (NAWMP) is a strategic framework to protect, enhance and create 6 million acres of wetland habitat critical to waterfowl and other wetland wildlife in Canada and the U.S. The goal is to restore waterfowl populations to the averages observed during the 1970-1979 period. The NAWMP was developed in

cooperation with all the applicable state and federal wildlife management agencies. Objectives are translated into action through "joint venture areas." Joint ventures are regional public/private partnerships where the partners agree to develop goals and objectives for a particular species or habitat in a particular geographic region. An example is the Lake Erie Marshes Focus Area Plan, which applies to the Lake Erie basin in Ohio. The plan calls for enhancement and restoration of 7,000 acres of existing protected wetland habitat and acquisition or protection of 11,000 additional acres.

### Great Lakes Binational Toxics Strategy (BTS)

Although there has been significant reduction in the amount of contaminants released directly into the Great Lakes, there is a continuing presence of persistent toxic substances resulting from atmospheric deposition, contaminated sediment, releases from certain industrial processes, nonpoint source runoff and the continuous cycling of substances within the lakes themselves. Interbasin transfer of persistent toxic substances from one lake to another, and the short-range and long-range movement and deposition of these substances from air prompted U.S. EPA and Environment Canada to sign the Great Lakes Binational Toxics Strategy (BTS) in 1997. The goal of the binational strategy is to work towards the virtual elimination of persistent toxic substances resulting from human activity, particularly those that bioaccumulate. Specific reduction targets for the Great Lakes basin have been set for many of the contaminants of concern in the Lake Erie LaMP, with a primary emphasis on achieving reductions using pollution prevention.

The BTS states that more strategic and coordinated interventions are required at various geographic scales from the local watershed/area of concern to the lakewide, basinwide, national and international arenas. The Lake Erie LaMP will be looking to the BTS to provide some support for the reduction of out-of-basin sources, particularly those related to atmospheric long-range transport. The BTS reaffirms the two countries' commitment to the sound management of chemicals, as stated in *Agenda 21: A Global Action Plan for the 21st Century* and adopted at the 1992 United Nations Conference on Environment and Development. The BTS will also be guided by the principles articulated by the International Joint Commission's Virtual Elimination Task Force.



### Lake Erie at the Millennium Plan

The Lake Erie at the Millennium Plan (LEMP) was initiated in 1998 by scientists at the University of Windsor and the National Water Research Institute - Burlington in Ontario, the F.T. Stone Laboratory of The Ohio State University, and the U.S. EPA Large Lakes Lab at Grosse Ile, Michigan. The objective was to foster and coordinate research that will identify and solve basic ecological questions relevant to the Lake Erie ecosystem through a binational, collaborative network.

To be relevant to regional and binational groups responsible for Lake Erie's health, the research must address management needs as well as further basic knowledge of the ecosystem. To this end, the active sponsorship of agencies and organizations whose mandate concerns Lake Erie was solicited. Twelve binational, national, regional, state, and provincial organizations have contributed funds to sponsor LEMP activities. Additionally, 13 collaborating organizations are active participants in the planning, information transfer or research aspects of the LEMP, providing in kind and/or technical support that further Plan activities. Goals of the LEMP are:

**1.** To collectively document the research and management needs of users and agencies;
**2.** To summarize the current status of Lake Erie from process and ecosystem function perspectives; and
**3.** To develop a framework for a binational research network to ensure coordinated collection and dissemination of data that addresses the research and management needs.

In November 1998 a *Prevailing Issues Workshop* held at the University of Windsor brought together Lake Erie managers, researchers, and other interested parties to discuss the major questions and management issues for Lake Erie. The workshop participants reviewed and distilled over 90 issues that had been identified as management concerns in response to a

broader request for issues. The panel identified 48 separate topics, which were then organized into seven subject areas. Participants then evaluated the ecological, economic, human health and societal importance of each issue, the perceived understanding of the issue, and the priority that each issue was receiving from agencies. The seven subject areas were: physical features; loadings and flux; environmental features; open-water biotic processes; nearshore and coastal biotic processes; invaders; and human-related concerns. These subject areas became focal directions for a modeling summit held in June 1999 and the binational *Lake Erie at the Millennium Conference* held in April 1999.

The purpose of the LEMP Conference was to compile current knowledge of Lake Erie processes, forecast trends for the next three to five years, and identify critical research gaps. Over 170 individuals attended the four-day event. The 48 invited speakers were additionally asked to cast their special expertise in the context of the previously identified management and data needs. The conference culminated in a *research needs* workshop that summarized consensus on the seven themes. The conference program, and major findings and recommendations of the workshop are summarized at the LEMP website, which is maintained through collaboration with the IJC's Council of Great Lakes Research Managers (URL: http://www.ijc.org/boards/cglr/erie2000).

Invited presenters' peer-reviewed manuscripts will appear as a monograph summarizing Lake Erie's present status, possible future states, and unresolved ecological issues. Seven subject editors' summary chapters will integrate and focus the conclusions and research needs of groups of related chapters. Contributed presentations are being compiled to appear as a special issue of the *Journal of Great Lakes Research.* Both publications should appear in late 2000.

The binational conference and workshops have refined and focussed researchers' and managers' needs into several suites of ecological problems. Each suite will be the focus of a two to three day research definition meeting. The first meeting was held October 1999 and addressed the processes regulating energy flux at the base of the food chain. Subsequent workshops will deal with issues of habitat, fish community dynamics, contaminants, exotic species invasions, and human health. Each workshop will produce a statement of our current understanding of issues, and a proposal to develop suites of key studies that will resolve each of the most pressing research issues. The resulting coordinated four to five year research programs will concurrently generate the data needed to resolve uncertainties in the fundamental management issues.



Linked Canadian and U.S. research proposals will be generated from each workshop for submission to granting agencies. Canadian participants will target *the Natural Sciences and Engineering Research Council* (NSERC) grant program to fund collaborative research proposals. U.S. participants will target U.S. EPA Office of Research and Development's *Science to Achieve Results* (STAR) grant program and other suitable granting agencies. Explicit in the goals of this network is the need for secure, longer-term (four to five year) commitment to the collection, compilation, interpretation and application of data. Lake Erie LaMP member agencies and many of the individuals involved in the LaMP process are also participating in the LEMP program. The LEMP and the LaMP will proceed hand-in-hand to identify and address the most important needs for Lake Erie.

### State of the Lakes Ecosystem Conference (SOLEC)

The State of the Lakes Ecosystem Conference (SOLEC) and resulting report are an effort initiated by the U.S. EPA and Environment Canada pursuant to the reporting requirements of the GLWQA. Conferences are held biennially and a report is issued based on the presentations and discussions at the conference. The whole purpose of SOLEC is to provide an update and a forum for discussion on the current state of the Great Lakes ecosystem and the factors impacting it. Three SOLEC conferences have been held to date and an over-arching recommendation from each has been the realization that standard indicators must be developed to be able to measure clearly and accurately the state of the lakes. In fact, the main theme of SOLEC '98 was *indicators*.

The SOLEC exercise has developed a list of 80 proposed indicators. This list is available on line at: www.cciw.ca/solec/ or www.epa.gov/glnpo/solec/98/. The State of the Great Lakes Report (U.S. EPA and Environment Canada 1999) presents the first attempt at

an indicator-based format, giving information on 19 of the proposed 80 indicators. The work of the SOLEC team and the work of the Lake Erie LaMP will be coordinated and consolidated to best address the needs of Lake Erie. Several other indicator-based initiatives, such as the IJC's Indicator Implementation Task Force and Ohio's Lake Erie Quality Index effort will be referenced as the Lake Erie LaMP proceeds.

## 9.3 Current and Proposed Habitat Actions in the Lake Erie Basin

### Introduction

The 1995 Lake Erie LaMP Concept Paper identified habitat loss and degradation as one of three key stressors that must be addressed to restore Lake Erie. The 1999 Lake Erie LaMP Status Report reinforced this position by specifically identifying loss of wetlands habitat as a key issue. Wetlands, both coastal and inland, are ecologically, economically, and socially important to the overall health of the Lake Erie ecosystem. In addition, the loss of fish and wildlife habitat beneficial use impairment assessment reports identified impairments to the following habitat zones of Lake Erie: open waters, islands, tributaries, shoreline, and mesic and swamp forests.

### Developing a Lake Erie LaMP Habitat Restoration and Protection Plan

In July 1999, the Lake Erie LaMP Management Committee made a commitment to begin the process of developing a LaMP Habitat Restoration and Protection Plan. Three things are needed to fully develop and prioritize LaMP habitat restoration and protection goals:

- Individual assessments of habitat conditions (i.e. plankton, benthos, fish and wildlife) must be integrated to determine where habitat degradation is impairing most or all of these groups;
- A clear understanding of the factors which control or limit the use of the remaining habitat to sustain healthy populations and their relative importance (i.e. contaminants, food web, direct human disturbance, etc.) must be outlined; and
- Objectives that identify the type of Lake Erie ecosystem that is both achievable and supported by Lake Erie agencies and the public must be identified.



The current status of each of these needs is summarized below. Our current understanding of habitat conditions in Lake Erie, including key stressors, is integrated for the first time in Table 4.10 (see Section 4). Although key human-induced stressors have been identified, it is not always clear which of these factors is the driving force behind effective use of existing habitat and restoration of future habitat. Even for those stressors that are known to be driving the system, there are still many questions about how the stressors affect natural communities and species.

These questions were explored at the April 1999 Lake Erie at the Millennium Conference with the intent to develop a binational research agenda. The outcome of the conference was the identification of seven suites of ecological problems that require in-depth research. One of the seven suites was habitat. The next step of the Millennium Plan will be to convene a two to three day workshop to develop specific research proposals for Lake Erie habitat. The Lake Erie Millennium Conference conveners expect habitat to be the last of the seven workshops to be held, given the complexity of the issues involved.

### Laying the Foundation

Only parts of the three items needed to complete a LaMP habitat action plan are currently available. Therefore, the LaMP 2000 approach is to focus on identifying and describing examples of both existing and proposed habitat projects. The intent of this report is to provide the information needed for LaMP agencies to:

- Knit together existing and proposed projects with identified habitat impairments and LaMP goals;
- Identify proposed projects that are ready to proceed, but need funding; and,

• Identify key gaps that existing and proposed projects will not fill.

To address the first bullet item, preliminary lists of ongoing and proposed projects are presented. *Existing projects* are those that are in progress or have been completed and meet the criteria outlined below even though they were not necessarily initiated with those criteria in mind. Eight of the projects listed are complete as noted in the project narratives. Second, *proposed projects* are those which are in the planning stages, or awaiting funding. In each project, a variety of resource needs are identified. The proposed projects represent the breadth of needs in the Lake Erie basin, but are not all-inclusive. Many additional projects will be needed to remove impairments. The two lists presented are by no means comprehensive. They represent the first attempt at compiling habitat project information. All of the existing and potential projects described in this section were selected as examples because they meet the preliminary screening criteria listed below:

The project:
• is leading to reduction or removal of impairment to beneficial use;
• has ecological benefits of significance to the Lake Erie ecosystem;
• has baseline data available that can be used to measure success of the project;
• is logistically and financially viable;
• has multiple partners interested;
• is relatively non-controversial; and,
• has information readily available within LaMP deadlines.

These criteria were used to identify projects that are currently most ready to proceed and relevant to the goals and objectives of the LaMP. Examples are included from across the Lake Erie basin, representing both aquatic and terrestrial work, and showing the extent of work in both urban and rural settings. Additional projects and a further prioritization of these projects will be forthcoming as the LaMP progresses, the loss of wildlife habitat assessment is completed, and new information comes to light.



Because there are many unanswered questions about Lake Erie habitat issues, a number of different types of projects are necessary to adequately address habitat restoration. A brief description of each type of project mentioned in this summary, and the question it is designed to answer is provided below.

**Assessment/research:** the first phase of work to determine local natural and human resources within a defined geographic area. What is the problem?

**Inventory/classification:** intensive data collection on specific species, communities, or historical and sociological information. What is the status of the resource?

**New tool/technology demonstration:** on-the-ground application of a new technology or tool on a small, local scale that has the potential for broad application in protection or restoration projects. What actions work or don't work to restore habitat?

**Planning/coordination/collaboration:** partnership building, evaluation of data or project progress, formulation of strategies for protection and restoration activities. What can we do together to solve the problem or continue restoration?

**Protection:** on-the-ground protection, management, and evaluation of progress of ecosystem processes and functions at a specific geographic area. What actions work or don't work to protect habitat from degradation that may eventually need restoration?

**Restoration:** on-the-ground restoration, enhancement, or remediation and evaluation of success in improving ecosystem processes and functions at a specific geographic area. What actions work or don't work to restore habitat?

**Monitoring:** the long-term measuring of the success of the project. Did the actions work?

**Education/outreach:** the communication of both status of the resource and success of the project to the public. What can the public learn about project activities and do about natural resource and habitat issues?

### Summary Observations

Thirty-seven existing projects were identified for this report. Twenty-three of the 37 projects have an on-the-ground restoration component. The projects cover a wide range of habitat types including Carolinian forest, alvar, oak openings, river and tributary restoration, fish and mussel habitat, and bird habitat. A wide range of stressors to these habitats is represented as well, including: non-indigenous invasive species, nonpoint source pollution, and development pressures. Eight of the projects described have been completed. The remaining are ongoing or in progress. Each of the incomplete projects needs additional resources for completion that are listed at the end of the description. An exact determination of the monetary needs for these projects has not yet been compiled.

Nineteen proposed projects are included. Twelve of these have a strong restoration component. Many deal with agricultural lands and nonpoint source pollution. A few are concerned with non-indigenous invasive species. Others are concerned with fish habitat. Although several proposed projects have determined total cost to complete, all resource needs have not been compiled because many of the projects are in the preliminary planning stages.

The next steps are:

- Continue to compile examples of habitat projects that meet LaMP goals and are being implemented.
- Continue to compile proposed projects.
- Compare existing and proposed projects to the needs determined through the LaMP process.
- Collaborate to prioritize on future projects.

The following two tables, Table 9.1 and Table 9.2, provide a summary of the existing and proposed habitat projects that have been compiled to date. The projects are categorized by project type. Detailed descriptions of all the existing and proposed projects are listed in Appendix D.

### Table 9.1 Summary of Examples of Existing Habitat Projects

| TYPE OF PROJECT | Assessment/ Research | Inventory/ Classific. | New Tool/ Technology Demo. | Planning/ Coord/ Collab. | Protection | Restoration | Monitoring | Education/ Outreach |
|---|---|---|---|---|---|---|---|---|
| **EXISTING PROJECTS** | | | | | | | | |
| 1. Buffalo River, NY | | | | | | x | | x |
| 2. Carolinian Reforestation, ON | | | | | | x | | |
| 3. Cazenovia Creek, NY | | | | | | x | | x |
| 4. Chagrin R., OH | | | | x | | | | |
| 5. City of Trenton, MI | | | | | | x | | x |
| 6. Sheldon Marsh, OH | | | | | x | x | | |
| 7. Conservation Farm Plan, ON | | | | | | x | | |
| 8. Huron R., MI | | x | | | | | | |
| 9. Conserving Alvar Habitats, OH | | x | | | x | | | |
| 10. Cummings Farm. ON | | | | | | x | | x |
| 11. Cuyahoga River, OH | | | x | | | x | | x |
| 12. D'aubigny Creek, ON | x | | | | | x | x | |
| 13. Detroit River Candidate Sites, MI | x | x | | | | | | |
| 14. Detroit River Lake Sturgeon, MI | x | x | | | | | | |
| 15. Conservation Ethic, OH | | | | | | | | x |
| 16. Biodiversity Essex Region, ON | | | | | | x | | |
| 17. Friends of watersheds, ON | | | | x | x | x | | x |
| 18. Grand River Lowlands, OH | | | | x | x | x | | |
| 19. Great Lakes Greenness | | | | | | | x | |
| 20. St. Clair Riv. Waterways, MI, ON | | | | x | | x | | |
| 21. Lake Erie Grasslands, OH | | | | | | x | | |
| 22. Long-term wetlands NPS, OH | x | | | | | | | |
| 23. Managing Agricultural Drains, ON | | | | | | x | x | |
| 24. Marsh Monitoring, ON | x | | | | | | x | x |
| 25. Migratory Bird Habitat, ON | | | | | | x | | |
| 26. Nearshore Habitat Priorities, NY | x | x | x | | | | | |
| 27. Ojibway Prairies & Savannas, ON | | | | | x | | | x |
| 28. Penn Soil Riparian, PA | | | | | | x | | |
| 29. Plant Community Survey, OH | | x | | | | | | |
| 30. Portage R., OH | | | | | | x | | |
| 31. Freshwater Unionid, OH | | | | | | x | | |
| 32. Presque Isle, PA | | | | | | x | | |
| 33. Oak Openings, OH | | | x | | | x | | x |
| 34. Springfield Township, MI | | | | x | | | | |
| 35. St. Clair River Lakeplain, MI | | x | | x | | x | | |
| 36. Toussaint R., OH | | | | | | x | | |
| 37.Urban Dynamics, MI, ON | x | x | | | | | | x |

Table 9.2 Summary of Preliminary List of Proposed Habitat Projects

| TYPE OF PROJECT | Assessment/ Research | Inventory/ Classific. | New Tool/ Technology Demo. | Planning/ Coord/ Collab. | Protection | Restoration | Monitoring | Education/ Outreach |
|---|---|---|---|---|---|---|---|---|
| **PROPOSED PROJECTS** | | | | | | | | |
| 1. Aquatic Renewal Program, ON | | | | x | | x | | x |
| 2. Atlas, MI, ON | x | x | | | | | | x |
| 3. Lake Trout Mercury, NY | x | x | | | | x | | |
| 4. Caledonia Fishway, ON | | | | | | x | | |
| 5. Detroit R. Eco Risk, MI | x | x | | | | | | |
| 6. Detroit R. GIS, MI | x | x | | | | | | x |
| 7. Detroit R. Soft Shore, MI | | | | | | x | | x |
| 8. Ephemeral Wetlands Conf. | | | | | | | | x |
| 9. Lake Trout Mortality | | | | x | | x | x | |
| 10. Lake Erie water snake, OH | x | x | | | | | | |
| 11. Hillman Marsh, ON | | | | | | x | | |
| 12. Land Stewardship Incentive, ON | | | | | | x | | |
| 13. Lower Trophic Levels, ON, States | | | | x | | | x | |
| 14. Conservation Reserve, ON | | | | | | x | | |
| 15. Phragmites Control, ON | x | | | | | x | x | |
| 16. Round Goby, NY, OH | x | | | | | | x | |
| 17. Rural Non-Point Source, ON | | | | | | x | | |
| 18. Western L. ER CREP, OH | | | | | | x | | |
| 19. Ashtabula NRDA | | | | x | | x | | |



## 9.4 PCB Action Plan

### 9.4.1 Introduction

To date, the following beneficial use impairments have been identified in the Lake Erie basin due to PCBs:

- Majority of fish consumption advisories
- Wildlife consumption advisories for snapping turtles and waterfowl in New York State
- Human contact advisory in the Ottawa River (Maumee AOC) in Ohio
- Bird or animal deformities or reproduction problems particularly in mink, bald eagles, reptiles and amphibians
- Restrictions on dredging activities

For the above reasons, on May 1, 1998, the Lake Erie LaMP Management Committee designated PCBs as a critical pollutant for priority action. The GLWQA (1978 as amended 1987) defines critical pollutants as substances that persist at levels that, singly or in synergistic or additive combination are causing, or are likely to cause, impairment of beneficial uses despite past application of regulatory controls due to their: 1) presence in open lake waters; 2) ability to cause or contribute to a failure to meet Agreement objectives through their recognized threat to human health and aquatic life; or 3) ability to bioaccumulate (IJC, 1994). PCBs have been shown to meet all three of these criteria for Lake Erie. Additionally, in Lake Erie, 65 percent of all consumption advisories are because of PCBs. Mercury, as methyl-mercury, is the cause of the remainder of the advisories. Furthermore, in Lake St. Clair and the St. Clair and Detroit River, 40 percent of all consumption advisories are because of PCBs.

### 9.4.2 Current PCB Reduction Plans and Goals

Many efforts are being undertaken to reduce the level of PCBs in the environment, including or specifically in the Great Lakes basin and, consequently, Lake Erie. Examples of on-going mechanisms that coordinate and focus various regulatory, pollution prevention, and remediation programs are: the Commission for Environmental Cooperation's North American Regional Action Plan (NARAP) for PCBs involving Canada, Mexico, and the United States; the Great Lakes Binational Toxics Strategy (BTS) involving Canada and the United States; the Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem (COA); and the Remedial Action Plans (RAPs) in the Great Lakes AOCs.

***The relevant goals of the NARAP for PCBs are:***

Virtual elimination of PCBs in the environment. Seek to achieve no measurable release of PCBs to the environment and the phase-out of PCB uses for which release cannot be contained. Strategies adopted for virtual elimination of PCBs should account for risks to human health and the environment, and should consider economic and technical factors. Environmentally sound management of PCBs throughout their life cycle should take into account usage, storage, domestic and transboundary movement, and treatment/disposal of PCBs.

***The relevant goals of the BTS for PCBs are:***

*In the United States:* Seek by 2006, a 90% reduction nationally of high-level PCBs (>500 ppm) used in electrical equipment. Ensure that all PCBs retired from use are properly managed and disposed of to prevent accidental releases within or to the Great Lakes Basin.



*In Canada:* Seek by 2000, a 90% reduction of high-level PCBs (>1 percent PCB) that were once, or are currently, in service and accelerate destruction of stored high-level PCB wastes which have the potential to enter the Great Lakes Basin, consistent with the 1994 Canada-Ontario Agreement (COA).

*In both the U.S. and Canada:* Complete or be well advanced in remediation of priority sites with contaminated bottom sediments in the Great Lakes basin by 2006. Assess atmospheric inputs of PCBs to the Great Lakes. If ongoing long-range sources are confirmed, work within international frameworks to reduce releases.

As a result of actions undertaken to date, the BTS has reported: In Canada, just over 50 percent of the high-level PCBs (>1 percent PCB) and about 23 percent of the low-level PCBs have been destroyed compared to the 1988 baseline, consistent with the Canada-Ontario Agreement (COA). U.S. EPA fully expects the U.S. challenge in the BTS for PCB reductions will be met by 2006. Significant reductions have already been and continue to be made based on discussions with the utility, steel, and automotive industries; required removal of PCBs as negotiated during settlements of cases involving violations of regulations; and continued activities at permitted storage and disposal facilities.

### 9.4.3 Current PCB Controls

PCBs were produced in the U.S. between 1929 and 1977. They were and continue to be used primarily as cooling liquids in transformers, capacitors and other electrical equipment. Past or historical applications of PCBs also included such uses as heat transfer and hydraulic fluids, plasticizers, surface coatings, and as dye carriers in inks, adhesives, and paints.

PCBs can be released to the environment from several sources including: contaminated sediments, leachate from old landfills and other environmental sinks of past PCB contamination; spills or leaks from accidents or gradual wear of transformers, capacitors, or other electrical equipment containing PCBs; uncontrolled combustion of materials containing PCBs; improper disposal of PCB-containing equipment or materials; and inadvertent generation during certain industrial processes involving carbon, chlorine and elevated temperatures.

Toxic Substances Control Act (TSCA) regulations in the U.S., and Canadian Environmental Protection Act (CEPA) regulations in Canada dictate restrictions on the

manufacture, sale, use, disposal, import and export of PCBs. The statutes also include provisions for allowable uses. In the U.S., PCB releases are also targeted by the Clean Air Act (CAA), Clean Water Act (CWA), Resource Conservation and Recovery Act (RCRA), and PCB releases are also reported in the Toxic Chemical Release Inventory (TRI). In Canada, the storage of PCBs is regulated under the Storage of PCB Material Regulations; the export and import of PCBs is regulated under the PCB Waste Export Regulations; and the chlorobiphenyl regulations control the manufacture, sale, use, and disposal of PCBs. In Ontario, PCBs are classified as no discharge substances. Therefore, in Ontario, no permits are given to discharge either substances to the environment.

As a result of all of these regulations, along with voluntary phaseouts and remediation, from the late 1970s to the early 1990s, PCB concentrations in the Great Lakes environment have declined. Despite the extensive regulations, PCBs continue to exist at levels that result in restrictions on fish or wildlife consumption. As a result, there is a need for continuing these controls and pursuing voluntary actions.

**9.4.4 Summary of Known PCB Sediment Hotspots and Remedial Actions Underway**

All 42 existing AOCs in the Great Lakes Basin have contaminated sediments. In approximately half of these AOCs, PCB contaminated sediments are a source of identified impairments to the ecosystem. Several of these sites contribute PCBs to the lakewide ecosystem and contribute to lakewide impairments. Much characterization work has been done at the AOCs and many tons of contaminated sediment have been removed. For example, recent U.S. sediment remediation projects dealing with PCB contaminated sediments within the Lake Erie basin have been completed and/or planned at River Raisin (27,000 yds3), the upper Rouge River (6,989 yds3), NewBurgh Lake (400,000 yds3), Willow Run Creek (400,000 yds3), Monguagon Creek (25,182 yds3), the Ottawa River (10,000 yds3), the Trenton Channel in the Detroit River (20,000 yds3), Ashtabula Harbor (1,000,000 yds3), and the Fields Brook Superfund site.



**9.4.5 Future PCB Reduction Actions**

Reducing levels of PCBs in the environment involves many different partners from governments, communities, environmental organizations and industries. As stated, efforts to reduce PCBs are already being undertaken at an international, national, regional, and local level. This section includes those actions that the Lake Erie partners have committed to undertake in the next two years or are proposed as doable in the next two years but for which funding is currently not available.

Table 9.3 lists specific actions that Canada and the U.S. are committed to undertake, primarily under the BTS within the next two years.

## Table 9.3 Committed Actions for PCB Reduction

| Committed Action (Funded) | Lead Agency or Funding Source |
|---|---|
| **Pollution Reduction** | |
| Work with automotive, iron and steel sector, and electrical facilities in the Lake Erie basin to establish voluntary commitments to reduce the use, discharge or emissions of PCBs. | EC and U.S. EPA |
| Continue to follow-up with Inland's commitment to reduce high level PCBs in electrical equipment by 95% by 2006 and eliminate PCBs that are present in hydraulic systems in their plants. | U.S. EPA |
| Coordinate LaMP and BTS efforts with all related partners in order to produce a cohesive, unified program to address PCBs in the Great Lakes. | EC and U.S. EPA |
| U.S. EPA Superfund commits to completing the remedies for Springfield Twp. Dump (MI); G&H Landfill (MI); Metamora (MI); and Fields Brook (OH), all of which PCB remediation is part of the cleanup by the end of FY 2002. | U.S. EPA |
| U.S. EPA will work with the states to incorporate the recently promulgated limits under 40 CFR part 503, for dioxin, PCBs and furans in land applied biosolids at 300 nanograms per kilogram to incorporate these limits in permits issued to generators and land appliers of biosolids. | U.S. EPA |
| Continue efforts with the Ashtabula River Partnership (ARP), U.S. EPA, US Army Corps of Engineers (USACE), and Ohio EPA to lead to the Remediation of Contaminated Sediments in the Ashtabula River and Harbor where dredging is to begin in 2002. | U.S. EPA, ARP, Ohio EPA, USACE |
| U.S. EPA will identify point source discharges of those pollutants of concern which are monitored by the NPDES permittees using the permit compliance system. | U.S. EPA |
| Continue to target inspections and enforcement and promote the removal of PCBs during settlement negotiations for enforcement actions. | U.S. EPA |
| Formalize the PCB Phasedown Program pilot project with the major utilities in the Great Lakes Basin that is designed to encourage the utilities to phase out their remaining PCB equipment. | U.S. EPA |
| Identify federally owned PCBs in the Lake Erie basin and seek their removal by the departments or agencies that own the PCBs. | U.S. EPA |
| Complete the PCB and mercury clean sweep pilot project that includes a component to collect PCB contaminated oil in the Great Lakes basin, treat the oil to remove the PCBs, and recycle PCB-free oil. | U.S. EPA |
| **Information** | |
| Finalize the PCB Sources and Regulations Background report. This report includes updated information regarding changes to the U.S. EPA PCB regulations, and new PCB data and updated information on PCB sources and regulations in Canada. | EC and U.S. EPA |
| Finalize PCB Options Paper under the BTS that identifies options that can be undertaken to reduce PCBs in the environment. | EC and U.S. EPA |
| Upgrade National PCB database of PCB electrical equipment through 1997 thereby improving its tracking capabilities. | EC |
| Report on an annual basis the status of sediment remediation at priority sites within the Lake Erie basin. | EC and U.S. EPA |
| Assess atmospheric inputs of PCBs to the Great Lakes. If on-going long-range sources are confirmed, work within international frameworks to reduce releases. | EC and U.S. EPA |
| U.S. EPA Superfund commits to completing maps of the Great Lakes shoreline using GIS technology that include detailed data on location of sensitive species, tribal lands, natural areas and managed lands, economic resources and potential spill sources. | U.S. EPA |
| U.S. EPA Superfund commits to working with the LaMP/RAP partners on site assessment work to identify potential new sites in the Lake Erie Basin. | U.S. EPA |
| U.S. Geological Survey, Biological Resources Division, Great Lakes Science Center Grant-Monitoring Trends of Selected PCB Congeners and Pesticides in Great Lakes Predator Fish Collected during 1994-1997. | U.S. EPA |
| Coordinate LaMP and Binational Toxics Strategy efforts with all related partners in order to produce a cohesive, unified program to address PCBs in the Great Lakes. | U.S. EPA |
| Promote the application and use of a computerized, searchable and user-friendly Sediment Technology Directory (GLOBETECHS) of 250 innovative technologies for the safe handling and treatment of contaminated sediments. | EC |
| The Ontario Ministry of the Environment continues to maintain a current electronic database of on-site PCB waste storage sites and makes the information publicly available on a regular basis (presently current to mid-1999). | MOE |

The following table includes actions that have been proposed by Canada and the U.S that could be accomplished in the next two years if funding were made available.

**Table 9.4 Proposed Actions for PCBs**

| Proposed Action | Lead Agency |
|---|---|
| **Pollution Reduction** | |
| - Organize Small PCB owner workshops in the Lake Erie Basin to exchange information on PCB management, decommissioning and destruction. The expected outcome for these workshops would be to:<br>- Encourage owners of PCB bearing equipment to monitor and document the on-going status of the equipment until the equipment is removed;<br>- Encourage PCB owners to destroy PCBs in use or storage;<br>- Encourage owners of transformers and capacitors to test their equipment to identify any remaining PCBs;<br>- Identify and highlight licensed PCB destruction capacity for low level PCB containing materials;<br>- Provide information on the renewal of the Canadian Environmental Protection Act ;<br>- Encourage PCB Amentors (facilities that have already removed their PCBs) to assist in smaller facilities that do not have access to as much environmental expertise.<br>- Cooperation will be promoted so that PCB owners can reduce the cost of contracted PCB services (i.e. treatment of PCB contaminated mineral oil, on-site decontamination of capacitors and transformers, shipment of PCBs to high temperature incineration facilities). | EC and MOE |
| - Encourage PCB owners to destroy PCBs in use or storage | U.S. EPA |
| - Encourage PCB Amentors (facilities that have already removed their PCBs) to assist in smaller facilities that do not have access to as much environmental expertise. | U.S. EPA |
| - Continue to implement remediation of PCB contaminated sediments in the Ashtabua River AOC. | Ohio EPA, U.S. EPA, ARP, USACE |
| - Continue to target grant funds for reduction of PCBs | U.S. EPA |
| **Information** | |
| - Collect data on reductions of PCB electrical equipment from the major electric utilities in the Great Lakes basin which are participants in PCB Phasedown Program and track the progress of the reductions. | U.S. EPA |
| - Compile data on PCBs remaining in use and in the environment in the Lake Erie Basin. | U.S. EPA |

More detailed project descriptions are presented in Appendix E.



### 9.4.6 Conclusions

Much work has been done and will continue in order to eliminate the environmental threat from PCBs. Stakeholder participation is key to realizing success in the reduction of PCBs, particularly on issues involving long-term planning for the phase out of PCBs, management options, incentives, and the benefits of PCB reduction. Implementation of the committed and proposed actions will contribute to reducing sources of PCBs and presumably levels in the environment. The LaMP will be instrumental in monitoring the lake's response to recently completed projects as well as these on-going and proposed future actions.

### 9.4.7 References

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## 9.5 Mercury Action Plan

### 9.5.1 Introduction

Mercury is used in industries worldwide because of its distinctive properties. It conducts electricity, acts as a biocide, is useful in measurement of temperature and pressure, and forms alloys with almost all other metals. With these and other properties, mercury plays an important role in several industrial sectors (*Mercury Draft Sources and Regulations 1999 Update*).

On May 1, 1998, the Lake Erie LaMP Management Committee designated mercury as a critical pollutant for priority action, based on the number of fish consumption advisory impairments caused by this chemical. In Lake Erie, 35 percent of all consumption advisories are due to mercury, with the remaining percent due to PCBs. In Lake St. Clair and the St. Clair and Detroit Rivers, 60 percent of all consumption advisories are due to mercury. As of 1997, there were mercury advisories in three western basin tributaries, four central basin tributaries, and one bay and open waters of the Ontario eastern basin as well as Long Point Bay.



Much of the mercury entering the waters of the region settles from the air or is deposited in rain or other precipitation. In the ambient air, mercury levels are not dangerous; it is the cumulative amount of mercury deposited to water bodies and its subsequent chemical transformation to methyl-mercury that creates problems. Fish absorb and retain methyl-mercury, causing it to bioaccumulate until it is concentrated up to millions of times above the level in the surrounding water, particularly in older, predatory fish.

There are many sources of mercury in the environment. Although natural sources of mercury exist, recent research suggests that background concentrations of this metal in the atmosphere and sediments have increased by a factor of two to five since pre-industrial times. This suggests that anthropogenic sources have significantly increased mercury levels in the environment. The continuing presence of mercury in the environment is the result of atmospheric deposition, contaminated sediments and other nonpoint sources. (BTS)

While air deposition is the largest current source of mercury, sediments contain the greatest mass of mercury in the system. Mercury enters the atmosphere through the mobilization or release of geologically bound mercury by natural processes and human activities. Mercury is also re-emitted to the atmosphere by biological and geological processes drawing on a pool of mercury that was deposited to the earth's surface after initial mobilization by either human or natural activities. In addition to local anthropogenic mercury sources, Lake Erie receives mercury deposition as the result of inputs from the global reservoir of atmospheric mercury emitted by natural sources and global anthropogenic sources. Mercury can be intentionally released as in production processes or consumer products, or incidentally released from energy production, mobile sources or manufacturing processes.

Mercury (Hg) has been studied more than most toxic pollutants relative to long range transport. The global reservoir of Hg is estimated to contribute 40 percent of the total Hg deposited to the U.S. mainland. This makes mercury a primary focus of long-range transport

and fate research for U.S. EPA. U.S. EPA's Mercury Report to Congress (1997) noted the 1994-1995 mercury contribution from U.S. anthropogenic sources to the atmosphere was 158 tons, of which 87 percent was from combustion sources (waste incineration, utility fossil fuel plants). Estimated total annual input from all mercury sources was 5,500 tons worldwide, indicating that U.S. anthropogenic sources represent only three percent of global releases in 1995. Fifty-two tons (thirty percent) of U.S. source emissions of mercury are deposited within the U.S. borders, while the remainder is deposited to the global reservoir (107 tons). Depositional input to the U.S. from non-U.S. sources of mercury was estimated at 35 tons. Computer simulation on which these estimates were developed has recognized uncertainty that needs to be resolved by additional data; nevertheless, it appears that the solutions to the mercury problem will require international effort (Delta Institute, 1999).

**9.5.2 Current Mercury Reduction Plans and Goals**

As stated in the Great Lakes Binational Toxics Strategy (BTS), Environment Canada (EC) and the United States Environmental Protection Agency (U.S. EPA), in consultation with other federal departments and agencies, Great Lakes states, the Province of Ontario, Tribes and First Nations, will work in cooperation with their public and private partners toward the goal of virtual elimination of persistent toxic substances resulting from human activity, particularly those which bioaccumulate, from the Great Lakes basin, so as to protect and ensure the health and integrity of the Great Lakes ecosystem. The anthropogenic sources of pollution will be targeted, when warranted, for reduction through a life-cycle management approach so as to achieve naturally-occurring levels. The primary emphasis will be on pollution prevention.

In addition to pollution prevention, the following goals are targeted:

- For the U.S., seek by 2006 a 50 percent reduction nationally in the deliberate use of mercury and a 50 percent reduction in the release of mercury from sources resulting from human activity. The release challenge will apply to the aggregate of releases to the air nationwide and of releases to the water within the Great Lakes basin. This target is considered as an interim reduction target and, in consultation with stakeholders and new information, will be revised if warranted. Between 1990 and 1995, there was an estimated 25 percent reduction in U.S. air mercury emissions. Although estimates are uncertain, we are confident that there has been a significant decrease, particularly in incinerator emissions, and that these reductions have continued beyond 1995. Between 1995 and 1997, there was a 21 percent reduction in mercury use.

- For Canada, seek by 2000 a 90 percent reduction in the release of mercury, or where warranted the use of mercury, from polluting sources resulting from human activity in the Great Lakes basin. This target is considered as an interim reduction target and, in consultation with stakeholders and new information will be revised if warranted. It is currently estimated that there is close to an 80 percent reduction. (BTS)

- Assess atmospheric inputs of mercury to the Great Lakes. The aim of this effort is to evaluate and report jointly on the contribution and significance of long-range transport mercury from worldwide sources. If ongoing long-range sources are confirmed, work within international frameworks to reduce releases of such substances.

- Complete or be well advanced in remediation of priority sites with contaminated sediments in the Great Lakes basin by 2006.

**9.5.3 Current Mercury Controls**

Mercury releases are regulated under numerous statutes, under the jurisdiction of multiple agencies. Regulations developed to control the release of mercury into the environment can have either direct or indirect effects on sources of mercury. Use or release-related regulations have a direct effect on sources of mercury or release of mercury into the environment. These regulations specify, for individual mercury sources, the amounts or concentrations that can be released to the environment, and the ways mercury may be used, transported, and disposed of, all of which influence the costs associated with using or

releasing mercury. Environmental management standards, have an indirect effect on individual sources and are numeric criteria that specify a maximum acceptable mercury concentration for different media, based on scientific or risk-based criteria. For instance, mercury standards exist for water, sludge, fish tissue, drinking water, and several other media. These standards provide a yardstick against which to measure the effectiveness of mercury release regulations. There are also reporting requirements, such as the U.S. Toxics Release Inventory (TRI), the Canada National Pollution Release Inventory (NPRI), and U.S. EPA Requests for Information, to enhance public awareness of mercury releases and aid in the crafting of regulations. Further information on specific regulations can be found in the *BTS Draft Report Mercury Sources and Regulations, 1999 Update* document at http://wwwepa.gov/bns/mercury/.

U.S. EPA regulates mercury content in pesticides, and mercury releases into the environment through air, water, and land disposal limits. The Food and Drug Administration (FDA) regulates mercury in cosmetics, food, and dental products. The Occupational Safety and Health Administration (OSHA) regulates mercury exposures in the workplace. In addition to regulations governing mercury release, there are regulations limiting the use of mercury. In Canada, regulatory programs which address mercury include: the Canadian Environmental Protection Act, the Fisheries Act, the Canadian Environmental Assessment Act, the Pest Control Products Act, the Ontario Environmental Protection Act, the Ontario Water Resources Act, the Ontario Environmental Assessment Act, and an array of other federal and provincial acts that address protection of the Great Lakes basin ecosystem from the polluting effects of all targeted toxic substances. In Ontario, mercury is classified as a *no discharge* substance; therefore, no permits are given to discharge mercury into the environment. In the U.S., regulatory programs which address mercury include the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), the Resource Conservation and Recovery Act (RCRA), the Clean Water Act, the Clean Air Act, the Toxic Substances Control Act (TSCA), the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), and other regulatory programs. (BTS)



These existing regulations have encouraged a dramatic decline in mercury use, and have begun to lead to reductions in releases as well. In the U.S., new Maximum Available Control Technology (MACT) Standards are expected to result in further drops in mercury releases. Many additional regulatory and voluntary efforts to reduce mercury, particularly in states that have identified local fish contamination problems, are underway due to public concern.

**9.5.4 Summary of Known Mercury Sediment Hotspots and Remedial Actions Underway**

A study of historic sediment samples by Pirrone *et al.* (1998) reported that air deposition was found to be a major contributor of mercury to the Great Lakes as indicated by sediment core analysis of mercury deposition rates over time. Atmospheric deposition flux in the Great Lakes was estimated to be almost an order of magnitude higher than the background to the whole of North America (Delta Institute, 1999). Sediments, for the most part, are contaminated due to historic (pre-1970s) practices. Point source loadings to sediments have decreased dramatically and are basically under control. Sediments are both a sink and a source of contamination. The BTS has a commitment to have completed or be well advanced in addressing contaminated sediments by 2006.

Fish are exposed to mercury through sediments. Sediments downstream from historic chlor-alkali plants tend to have the highest mercury levels. There have been numerous studies that document the elevated levels of methyl-mercury in freshwater fish across the northeast U.S. and Canada. Mercury levels in freshwater fish have been monitored in the northeast U.S. since the 1970s. The results of these monitoring programs indicate that levels of mercury significantly exceed acceptable values in fish species from certain water bodies in the region. In the Lake Erie basin, fish consumption advisories due to mercury exist in Ontario waters of the eastern basin, in Long Point and Rondeau Bays, and in nine tributaries. Mercury is the chemical that drives the advisories for the Sandusky, Chagrin and Ashtabula rivers in Ohio. Pregnant women, women of childbearing age, and children are at particular risk because the developing nervous system of fetuses and children are very sensitive to the toxic effects of mercury.

Data on U.S. sites analyzed in 1996 showed high concentrations of mercury in bed sediment were found in the Trenton Channel of the Detroit River and at the mouth of the Little Cuyahoga River near Akron, Ohio. At these locations, detected concentrations ranged from 6.06 to 16.0 mg/kg and were from 12 to 32 times greater than the Probable Effects Level (PEL) and from three to eight times greater than the Severe Effects Level (SEL). Other locations with concentrations of mercury in bed sediments greater than the PEL (listed in decreasing concentrations) were the mouth of River Raisin, Michigan; Lake St. Clair; Monroe Harbor and out into Lake Erie; the mouth of the River Rouge, Michigan; and the mouth of the Clinton River, Michigan (USGS, in preparation).

*St. Clair River:*
In 1977, 1985 and 1990, on the Ontario side, the highest mercury concentrations in the river sediments (58, 51 and 16 mg.kg-1 or ppm, respectively) were found in the upper river, near or downstream of Dow Chemical (OMOE, 1979; St. Clair River RAP Team, 1991; Geomatics International, 1993). A comparison of stations sampled in both 1990 and 1994 by the Ontario Ministry of the Environment revealed that, although the average mercury level decreased from 4.7 to 2.8 mg.kg-1 respectively, this change was not significant ($p > 0.05$) (Farara & Burt, 1997). Furthermore, this comparison does not include sampling at additional (new) locations in 1994, which found surface sediment concentrations of mercury as high as 163 mg.kg-1 in the Dow area (Kauss & Nettleton, 1999). The latter is the highest known sediment mercury level in the Lake Erie basin. This is of concern since sediments in this area of the St. Clair River nearshore are subject to high rates of resuspension and downstream transport (St. Clair River RAP, Experimental Study of Deposition and Erosion on St. Clair River Sediments, 1997).



*Lake St. Clair:*
Historically sediment levels are less contaminated than tributaries. Recent 1998 sediment data from Michigan Combined Sewer Overflows (CSOs) in Lake St. Clair point to localized sources of heavy metals. Assessment of these potential sites is warranted, as is assessment of the area near the head of the Detroit River. *Note:* In the summer of 2000, the MDEQ and EPA/GLNPO plan to conduct joint monitoring in the St. Clair River (25-75 sites) and Lake St. Clair. Additionally, the Macomb County Health Department is planning on partial grid sample network from the shipping channel of Lake St. Clair to the U.S. mainland (about 100 grab surface samples). The focus for of these surveys is mercury.

*Detroit River, including Trenton Channel:*
The Ontario Ministry of the Environment's (OMOE) 1991 sediment quality and benthic invertebrate community study identified a number of areas in the river with impaired sediment quality and benthic invertebrate communities. These were largely concentrated along the Michigan shoreline, i.e., near Detroit, the Rouge and Ecorse River discharges, and in the Trenton Channel (Farara & Burt, 1993). The three highest surface sediment mercury concentrations were found adjacent to the Detroit shoreline (9.5 mg.kg-1), downstream of the Ecorse River discharge (11.7 mg.kg-1) and in the Trenton Channel, downstream of Firestone Steel (5.0 mg.kg-1).

Comparison of the 1991 sediment data with an earlier OMOE study showed that the average mercury concentration in U.S. sediments of the Detroit River did not change significantly ($p > 0.05$) from 1980 (0.62 mg.kg-1) to 1991 (0.81 mg.kg-1). The average of Canadian sediments increased slightly (but not significantly) from 1980 (0.19 mg.kg-1) to 1991 (0.24 mg.kg-1) (Farara & Burt, 1997).

The worst mercury contamination is along the Michigan mainland side in depositional pockets of fine silt in relation to historic discharges and industrial activity, mostly in the Trenton Channel. MDEQ-SWQD along with U.S. EPA-GLNPO and Region 5 has assessed the entire stretch of river. The report for the Trenton Channel is complete. The report for the rest of the river will be completed soon (data available).

Approximately 1,000,000 cubic yards of extremely contaminated sediments exist in this system. MDEQ is moving forward with a remediation of an orphan site (Black Lagoon) in 2000 using conventional CDF disposal, and an innovative sediment treatment

demonstration. Potentially responsible parties for other Trenton Channel and Detroit River sites are known.

The MDEQ plans on developing plans and specifications for remediation of all sites in conjunction with the USACE Detroit District. The Contaminated Sediments Action Team of the Detroit River RAP is an active stakeholder group (see: http://cosat.homepage.com).

*Rouge River (from turning basin to Detroit River):*
This area has been completely assessed by MDEQ and U.S. EPA. A report is in draft form. There is approximately 1,000,000 cubic yards of extremely contaminated material in this stretch. Plans and specification for remediation will be developed with USACE (cost share). Other initatives include sediment-related work MDEQ-SWQD is doing with the USACE, GLNPO and Region 5.

*Western Lake Erie*
Western Lake Erie is the immediate receptor of Detroit River contaminant discharges, and a number of stations in this basin have been sampled over the years by the OMOE. Surface sediment data from these 11 stations indicates a significant ($p < 0.05$) decrease in average mercury concentrations between 1970 (1.1 mg.kg-1) and 1991 (0.22 mg.kg-1) (Beak Consultants, 1993). Continued sampling at one of these stations shows that since 1991, the decline has been slower and also somewhat variable.

## Table 9.5 Lake Erie LaMP Mercury Reduction Actions and Lead Agency/Organization

| COMMITTED (FUNDED) ACTIONS FOR MERCURY | LEAD AGENCY OR FUNDING SOURCE |
|---|---|
| Establish a household hazardous waste collection facility to collect and recycle household products containing mercury in the Cities of London and Waterloo (requires strategic alliance with both municipalities). | EC |
| Provide Pollution Prevention training at hospitals in London, Ontario with emphasis on the removal of mercury containing devices. | EC |
| Promote to school boards in the Lake Erie basin a mercury stewardship school curriculum program. (Pilot being developed in the Toronto School Board) | EC |
| The P$^3$ERIE Partnership GLNPO Grant: The P3ERIE partnership has successfully worked on practical projects and educational efforts throughout the grant period. P3ERIE's successes have gained media attention and the P3ERIE partners are pleased with project results and positive spin-offs from the project. P3ERIE's partnership efforts have occurred. (See appendix for specific amounts of mercury reductions) | Pennsylvania DEP, Gannon University, P3Erie Partnership. Funded by U.S. EPA-GLNPO |
| Detroit Water and Sewerage Department (DWSD) PCB/Mercury Minimization Program: The DWSD has undertaken a number of special programs to effectively control mercury in hospitals, dental practices, industrial laundries, laboratories, and households. DWSD has initiated an Atmospheric Deposition Study, made revisions to its Local Limits Ordinance, and established an Education/Outreach Program for the general public. | DWSD |
| ***Lake Erie Basin*** | |
| Promote the Great Art for Great Lakes Virtual Classroom, with its mercury millennium theme, in primary schools within the Lake Erie basin - www.cciw.ca/glimr/classroom. | EC |
| U.S. EPA will continue its work on hazardous waste management in the western basin of Lake Erie. To support the mercury reduction effort to reduce the use and release of bio-accumulative toxic compounds, U.S. EPA will commit extramural funds to support RCRA corrective action efforts. | U.S. EPA |
| Continue the implementation of the Elemental Mercury Collection and Reclamation Program (www.epa.state.oh.us/dist/nwdo/er/mercury.htm). | State of Ohio U.S. EPA |
| For RCRA treatment, storage and disposal facilities, U.S. EPA Region 5 will consider emphasizing pollution prevention components in Consent Agreements and Consent Orders Supplemental Environmental Projects (SEPs). Implementation of this approach will be based on a case by case determination. | U.S. EPA |
| By April 2002, finalize a U.S. EPA Total Maximum Daily Loads (TMDL) Strategy for mercury reduction in Lake Erie *(see Appendix G for discussion of TMDLs). | U.S. EPA and States |
| U.S. EPA Superfund commits to working with LaMP/RAP partners on site assessment work to identify potential new sites in the Lake Erie basin. | U.S. EPA |
| A mercury reduction strategy is being developed for Ohio. | Ohio EPA |
| Support of Ohio Hazardous Waste Removal Program to properly remove, dispose of, or recycle hazardous and explosive chemicals from school chemistry labs. | Ohio Environmental Education Fund (OEEF) |
| Collection of 98% pure mercury from Ohio dentists | Ohio Dental Assoc. OEEF |
| ***Great Lakes Basin*** | |
| U.S. EPA (Air and Radiation Division) has committed funds to support mercury research in a number of priority areas including transport, transformation and fate; and human health and wildlife effects of methyl-mercury | U.S. EPA |
| U.S. EPA filed civil complaints against seven electric utility companies operating coal-fired power plants in the Midwest and Southeast | U.S. EPA |
| By December 2000, EPA (Air and Radiation Division) will make a determination about whether to regulate mercury emissions from electric utilities. | U.S. EPA |
| Michigan Department of Agriculture: Michigan Mercury Manometer Disposal Grant-The grantee will use grant funds to replace mercury manometer gauges used on dairy farms with non-mercury gauges. Mercury gauges will also be collected from inactive dairy farms. Project Period: 10/1/99 to 9/30/00 | U.S. EPA-GLNPO |
| Michigan Department of Agriculture: Michigan Clean Sweep Grant - This Clean Sweep program shall remove and dispose of old, unwanted, suspended, or canceled pesticides from the agriculture community, industry, and homeowners in Michigan at no fee to the end-user. Project Period:10/1/99 to 9/30/00 | U.S. EPA-GLNPO |

| COMMITTED (FUNDED) ACTIONS FOR MERCURY | LEAD AGENCY OR FUNDING SOURCE |
|---|---|
| University of Wisconsin: Mercury Education Program for Schools Grant. This project will focus on developing, adapting, and disseminating high-quality mercury related educational materials for schools. The focus will be on reducing the use of mercury in the school, in students' homes, and in the communities of participating schools throughout the Great Lakes basin. Project Period: 10/1/99 to 9/30/00. | U.S. EPA-GLNPO |
| Indiana University: Deposition of toxic organic compounds to the Great Lakes: The Integrated Atmospheric Deposition Network Grant-This agreement will provide funds for the sixth year of operation and maintenance of the Integrated Atmospheric Deposition Network (IADN) by Indiana University. Project Period: 1/22/99 to 1/22/00 | U.S. EPA-GLNPO |
| Integrated Atmospheric Deposition Network Quality Assurance and Quality Control Program Grant. The Great Lakes National Program Office (GLNPO) is collaborating with Environment Canada to implement the binational Integrated Atmospheric Deposition Network (IADN) as mandated by Annex 15 of the Great Lakes Water Quality Agreement and Section 112(m) of the Clean Air Act. Project Period: 10/1/99 to 9/30/01. | U.S. EPA and EC |
| U.S. Army Corps of Engineers - Great Lakes and Ohio River Division: Sediment Assessment and Remediation Support Grant -This amendment to the existing interagency agreement augments the existing funds for procuring the support of the U.S. Army Corps of Engineers in the collection and analysis of sediment samples, review of feasibility studies and remediation design plans, and other technical support for sediment assessment and remediation studies. Project Period: 12/01/98 to 9/30/00. | U.S. EPA-GLNPO |
| By the end of 2000, the U.S. EPA will work with states to develop a permitting strategy consistent with the Clean Water Act for reducing loading of mercury from industrial, municipal, and storm water sources to further the goals of the LaMP. | U.S. EPA |
| U.S. EPA will identify point source dischargers of mercury which are monitored by NPDES permittees using the permit compliance system and commit to share this information with the wastewater treatment plants, industry, tribes and other contributors of mercury to the extent they are relevant sources of these pollutants. U.S. EPA will also inform states and regulated communities about sources of unregulated pollutants of concern and share available information regarding potential substitutes and waste minimization strategies. | U.S. EPA |
| U.S. EPA is committed to continuing to require compliance with numeric water quality standards and technology based pollutant limits. | U.S. EPA |
| U.S. EPA Region 5 will support the rigorous development and refinement of the Regional Air Toxics Emissions Inventory of all hazardous air pollutants, including those of concern to the Great Lakes and other inland water bodies and which have a tendency to bioaccumulate. U.S. EPA will work closely with all eight Great Lakes states to assure every possible known source of all magnitudes of emissions are identified and that good emission estimates are developed and updated to reflect implementation of control technologies and progress in emission reductions for input to air dispersion and deposition models. | U.S. EPA |
| U.S. EPA commits to ensuring that all Region 5 states will have enforceable regulations and the permit applications that are required to be submitted for municipal waste combustors and for hospital/medical/ infectious waste incinerators by December 2000. U.S. EPA commits to pursuing a strategy for assuring 100 percent compliance with these regulations. This strategy will involve close coordination including an effort to expedite state rulemaking as appropriate. | U.S. EPA |
| U.S. EPA commits to providing technical assistance to at least two generators of biosolids containing the highest permissible concentration of mercury in their biosolids with the objective of assisting the generators in identifying sources of mercury and reducing mercury in their biosolids. | U.S. EPA |
| On January 24, 2000, the Ministry of the Environment announced new provincial emission limits (caps) plus a monitoring and reporting program for the power generating industry in Ontario, including the two facilities (Lambton, Nanticoke) located in the Lake Erie basin. Mandatory reporting of broad range of emissions (including mercury) to the Ministry will be instituted as of May 2000 (see www.ene.gov.on.ca/envision/news/00600mb.html). | OME |
| The Ontario Ministry of the Environment is working to set new emissions performance standards for mercury emissions from the coal-fired power plants including those located in the Lake Erie basin (Lambton, Nanticoke). These Canada-wide standards are being set in conjunction with the other Provinces, the Territories and the Federal Government (see www.ccme.ca/3e_priorities/3ea_harmonization/3ea2_cws/3ea2.html). | OME |
| Draft emissions standards have recently been announced (November 1999) by the Ontario Ministry of the Environment that would affect several point sources of mercury in the Lake Erie basin. | OME |

| COMMITTED (FUNDED) ACTIONS FOR MERCURY | LEAD AGENCY OR FUNDING SOURCE |
|---|---|
| As of early 2000, federal, provincial and territorial environment departments are investigating the releases of mercury to the environment from various commercial products and some forms of wastes. A focus on dental amalgam, fluorescent lamps and sewage sludge that is land-applied is expected to result in Canada-wide standards in late 2000. | OME |
| The Ontario Ministry of the Environment along with Environment Canada have been working with the Ontario Dental Association to develop a "best management practices" document for dentists, scheduled for completion in May 2000. | OME |
| **Information** | |
| ***Locally Based*** | |
| The Detroit River RAP Pollution Prevention Action Team will take a lead role to advance many of the voluntary pollution prevention programs within commercial, industrial and residential areas, as well as support other River stakeholders' implementation of other programs. | Detroit RAP |
| State University of New York at Buffalo: A Mercury Screening Model for Lake St. Clair-This grant will support the development of a model for the transport and fate of mercury in Lake St. Clair, where mercury is a well documented problem. Project Period: 09/1/99 to 2/28/01. | U.S. EPA-GLNPO |
| The Pollution Prevention Team organized by Ohio EPA-NWDO will continue to promote pollution prevention efforts in northwest Ohio | Ohio EPA |
| Provide cost and management procedural information to the city of Windsor on how to establish a municipal collection depot for mercury containing devices. | EC |
| ***Lake Erie Basin*** | |
| Report on an annual basis, the status of sediment remediation at priority sites within the Lake Erie basin. | EC and U.S. EPA |
| If on-going long-range sources of mercury to the Great Lakes are confirmed, work within international frameworks to reduce releases. | EC and U.S. EPA |
| The Michigan Mercury Pollution Prevention task force has accomplished: a household hazardous waste collection program in 22 counties (sponsored by the MDEQ), resulting in the collection of 200 pounds of mercury; distributed 16,000 copies of the "Merc Concern" brochure throughout Michigan; developed a mercury pollution prevention web page at www.deq.state.mi.us/ead/p2sect/mercury and, distributed mercury outreach materials to science teachers. | Michigan and U.S. EPA |
| Agencies will work with facilities in the Lake Erie basin to establish voluntary agreements to reduce the use, discharge or emissions of mercury. | U.S. EPA and Michigan |
| Delta Institute: Creation and Dissemination of Targeted Fish Advisory Materials and a Forum Website in Cooperation with the Lake Erie Binational Public Forum. The project will continue creating and making available an easy-to-read and culturally sensitive fish advisory brochure. The advisory work will alert at-risk families, both low-income and minority, in the Lake Erie Basin to the dangers of contaminated fish consumption and will also provide positive alternatives for cooking, cleaning and selecting fish in order to decrease risk. (www.erieforum.org). | U.S. EPA |
| EPA Superfund commits to completing maps including data on location of sensitive species, tribal lands, natural areas and managed lands, economic resources and potential spill sources and providing these maps to LaMP/RAP partners by the end of FY 2002. | U.S. EPA |
| ***Great Lakes Basin*** | |
| Ohio's Office of Pollution Prevention will produce two fact sheets that focus on ways to reduce mercury and other PBTs. | Ohio EPA |
| U.S. EPA Office of Water has developed a Clean Water Action Plan, identifying non-point sources including atmospheric deposition as the most important threat to water quality. | U.S. EPA |
| EPA will continue to focus on research efforts and potential regulation of mercury emissions from coal-fired utilities. | U.S. EPA |

| COMMITTED (FUNDED) ACTIONS FOR MERCURY | LEAD AGENCY OR FUNDING SOURCE |
|---|---|
| Great Lakes United, Inc.: Clean Production Project for Basin Communities. GLU will support and develop a Great Lakes "clean car campaign", and promote dioxin and mercury reduction in medical waste disposal. Project Period: 10/1/99 to 9/30/00 | U.S. EPA-GLNPO |
| U.S. Navy, Great Lakes Naval Station, Naval Dental Research Institute: Mercury Removal from the Dental-Unit Waste Stream-The interagency agreement provides funds to the Naval Dental Research Institute to examine the mercury removal from the dental-unit wastewater stream. Project Period: 9/1/99 to 8/31/00. | U.S. EPA-GLNPO |
| The Delta Institute: Sector Based Pollution Prevention -The Delta Institute will focus on achieving toxics reductions through commitments from private and public sector owned and operated energy production units. Project Period: 9/1/99 to 9/30/00. | U.S. EPA-GLNPO |
| National Wildlife Federation: Local & Sector-based Pollution Prevention in the Binational Strategy- The National Wildlife Federation will focus on 1) building on existing efforts to implement pollution prevention, by way of sector-based strategies; and 2) coordinated Environmental Non-Governmental Organization participation in the Binational Toxics Strategy. Project Period: 10/1/99 to 9/30/00. | U.S. EPA-GLNPO |
| Ohio Healthy Hospital Pollution Prevention Initiative. A formal agreement has been signed with the Ohio Hospital Association (OHA) to develop and implement a strategy to virtually eliminate mercury containing waste from the health care industry's waste stream. | Ohio EPA and OHA |
| U.S. EPA will assist utilities in developing mercury control technology. Assistance may or may not take the form of funding. | U.S. EPA |
| U.S. EPA will encourage pollution prevention projects at hospitals, clinics, and medical,_and veterinary offices with an emphasis on removing mercury and making the offices "mercury free." U.S. EPA is working with AHA to virtually eliminate mercury from hospital waste. | U.S. EPA |
| U.S. EPA will encourage proper management of dental wastes that contain mercury. | U.S. EPA |
| U.S. EPA Great Waters Program- an ongoing program involving research and reporting requirements related to the atmospheric deposition of hazardous air pollutants to the "great waters" which include the Great Lakes. | U.S. EPA |
| The U.S. EPA will track disposition and status of the U.S. Federal Government's mercury stockpiles. | U.S. EPA |
| Agencies will assist schools in seeking out and disposing of mercury on school property. | U.S. EPA and Michigan |
| The Great Lakes Binational Toxics Strategy should be pursued to meet the short-term, interim goals (e.g. 50% reduction in mercury deposited from U.S. sources by 2006 and, for Canada, a 90% reduction in the release of mercury from polluting sources by 2000). | U.S. EPA and EC |
| Michigan will evaluate and begin the development of purchasing policies to eliminate use of products that might include mercury equipment (e.g. buildings, vehicles, and laboratory equipment). Policies will also examine phase-out of existing mercury containing items. | Michigan |
| Michigan agencies will evaluate a variety of economic incentives or disincentives to promote verifiable or innovative reductions. Possible incentives include early reduction credits, tax relief, low-interest loans, grants, rebates and bounties for achievers. Possible disincentives include fees, taxes or caps on mercury bearing products or uncontrolled sources of any of the nine designated chemicals. | Michigan |
| Michigan agencies will encourage home and industry energy audits. | Michigan |
| Michigan agencies will work with operators of medical waste incinerators to pursue reductions of mercury, dioxin and hexachlorobenzene through source reduction elimination/segregation, including the removal of noninfectious waste from the incinerator waste stream. | Michigan |
| Michigan agencies will support partnerships with dental associations to develop training materials and programs for dental offices regarding the proper handling, collection, and disposal of amalgam wastes. | Michigan |
| Sampling will begin in 2000 for the National Study of Chemical Residues in Lake Fish Tissue, a new effort to develop a National picture of the distribution of a variety of potential fish contaminants in the Nation's lakes. Bioaccumulative organic chemicals and mercury will be analyzed. | U.S. EPA Region 5 |
| Funds will be committed to support mercury research in a number of priority areas including transport, transformation and fate; and human health and wildlife effects of methyl-mercury. | U.S. EPA Region 5 |
| EPA will complete the pilot projects to establish TMDL allocations for two waterbodies receiving mercury from atmospheric deposition in order to evaluate the integration of air and water program technical tools and authorities and to examine emission reduction options. | U.S. EPA Region 5 |

The following table includes actions proposed by Canada and the U.S that could be accomplished in the next two years if funding were made available.

### Table 9.6 Proposed Mercury Actions Needing Funding

| PROPOSED ACTIONS FOR MERCURY | LEAD AGENCY OR FUNDING SOURCE |
|---|---|
| **Pollution Reduction** | |
| ***Locally Based*** | |
| Green Community thermostat and thermometer collection program for the City of London, Ontario (requires an alliance with Honeywell and City of London). | EC |
| Clean Sweep pesticide program in the city of London, Ontario (requires an alliance with the Ontario Ministry of the Environment and the City of London). | EC |
| Provide Pollution Prevention training at hospitals in Sarnia, Ontario with emphasis on the removal of mercury containing devices. | EC |
| ***Lake Erie Basin*** | |
| Agencies will promote energy conservation programs (e.g. U.S. side: EPA Energy Star Program) within the Lake Erie basin; agencies will especially urge the publicly-owned facilities, schools and universities in the Lake Erie basin to participate in energy conservation programs. The agencies will also work with the utilities operating in the basin to coordinate government and utility energy conservation programs. | U.S. EPA and States |
| Agencies will seek funding to initiate or continue permanent household and agricultural (e.g. pesticides) hazardous waste (HAHW) collection depots in the largest Lake Erie basin cities. Furthermore, U.S. agencies will seek funding to initiate and continue periodic or mobile collections for the more remote locations within the Lake Erie basin. Collections will not be limited to pesticides but will include a focus on mercury containing products (e.g. thermometers, abandoned appliances). U.S. agencies will seek funding to initiate and continue Lake Erie basin HAHW education programs that will include information about how individuals can practice home environ- mental stewardship; how to identify HAHW; and how to properly dispose of HAHW. | U.S. EPA and States |
| ***Great Lakes Basin*** | |
| Agencies will provide indirect or direct financial support to businesses, organizations and local governments for pollution prevention projects. Possible projects include clean sweeps, bounties on mercury products, mercury swaps for alternative products, education, purchasing policies, energy conservation, water conservation, pay-as-you-throw trash disposal fees and others. | U.S. EPA and States |
| Agencies will encourage a nationwide dialogue on the import of mercury bearing products. Nationwide labeling of mercury products will also be encouraged. | U.S. EPA and Michigan |
| Agencies will identify facilities that use wet scrubbers to treat emissions. If mercury is accumulating in the scrubber water, the feasibility of recycling the water in a closed loop system rather than being discharged will be evaluated. | U.S. EPA and Michigan |
| Agencies will work with communities to provide sector-specific pollution prevention outreach such as workshops for the medical and dental communities, and other important sectors. | U.S. EPA and States |

### 9.5.5 Conclusions

In order to bridge the data gaps identified, the following recommendations should be followed:

1. Emissions inventory databases need to be extended to include area and mobile sources and other minor sources that might provide a local or regional input to models which predict deposition rates.
2. More accurate inventories of both natural and anthropogenic sources and the chemical species emitted are needed to better delineate long-range transport of pollutants like mercury.
3. Locational information for mobile sources and area sources that may impact model predictions of deposition rate, seasonal variations, etc., is needed.

The Lake Erie LaMP is looking to focus on reducing anthropogenic sources of mercury from the environment and restoring the beneficial uses of Lake Erie. The committed actions and proposed recommendations lay a foundation for completing this goal.

### 9.5.6 References

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U.S.G.S. (in prep.) Water Resource Investigation Report: Occurrence and distribution of contaminants of concern in surficial bed sediments of the Lake Erie-Lake St. Clair basin, 1990-97. U.S. Geological Survey, Department of the Interior, National Water Quality Assessment Program (NAWQA).

## 9.6 Plans for LaMP 2002 Report

As noted throughout this report, there is still much work needed to document the current and projected state of the Lake Erie ecosystem. For example, the invasion of the zebra mussel has had far-reaching impacts on the system, thus requiring identification of additional research that will be needed just to redefine the current baseline. Based on items presented in this LaMP 2000 document, LaMP 2002 will highlight the following activities at a minimum.

- All of the BUIA background documents and impairment conclusions will be finalized.
- Investigations will begin/continue on the causes of the BUIAs.
- Source track down activities for the critical pollutants and the additional pollutants of concern in Lake Erie will be implemented.
- A comparison of ambient environmental concentrations of contaminants will be made with existing standards and GLWQA Annex 1 objectives to identify additional critical pollutants and "likely to impair" pollutants.
- The work/results of the Lake Erie at the Millennium project will be available and used to determine additional research needs and monitoring on Lake Erie.
- Ecosystem objectives and indicators will be selected.
- Short-term and long-term activities to achieve the selected ecosystem objectives will be identified.
- Monitoring and surveillance programs will be designed to measure the changes in the Lake Erie ecosystem and compared to the selected ecosystem indicators so progress in restoring the lake's beneficial uses can be tracked.
- Efforts will be made to strengthen the links between RAPs and the LaMP to assist in establishing priorities in selecting the remedial actions that will be most effective in protecting and restoring Lake Erie.
- The LaMP will incorporate the implications of significant ongoing and emerging issues into its overall workplan.
- Progress of the existing projects in the three action plans will be tracked.
- Efforts will be made to implement the proposed projects in the three action plans.
- Follow-up and updates to all of the other issues presented in the LaMP 2000 Report will be presented.
- Lake Erie LaMP websites will be improved and updated.
- Habitat restoration strategy will be developed.
- Lists of ongoing and proposed habitat projects will be updated.

# Tracking Progress

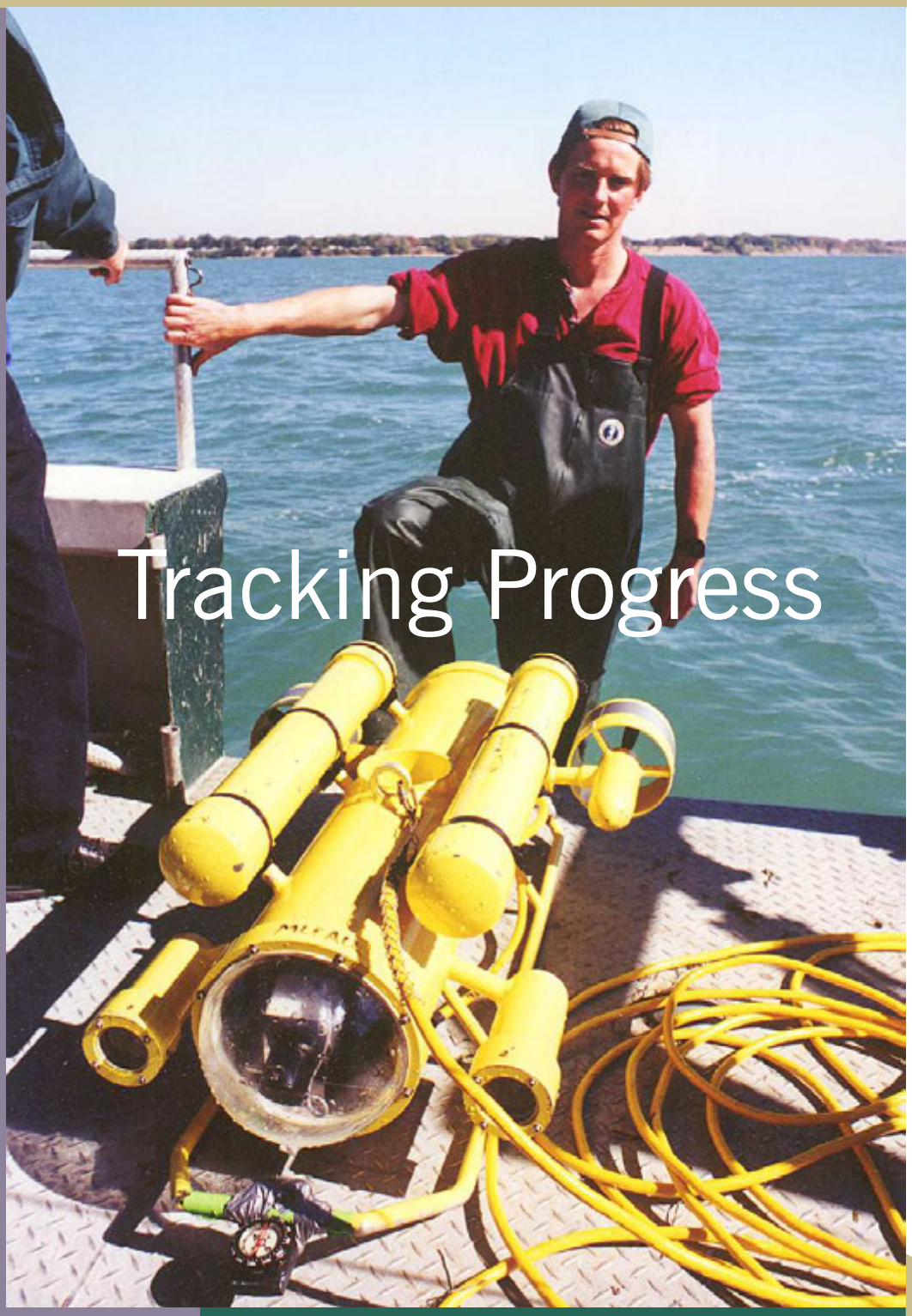

Photo: John Cooper

# Section 10: Tracking Progress

For the Lake Erie LaMP 2000 Report, this section is necessarily sparse. The LaMP is nearing completion of the problem definition stage, so neither ecosystem objectives nor ecosystem indicators have yet been selected. As Lake Erie ecosystem objectives and indicators are developed, they will be tied to the Great Lakes-wide State of the Lakes Ecosystem Conference (SOLEC) indicator exercise wherever appropriate.

Environmental indicators are measures of environmental conditions such as ecological integrity, aquatic health, human health, or quality of life. In addition to providing baseline data, environmental indicators can also provide: a) a measurement of environmental trends over time; b) an early warning signal for identifying environmental concerns; and c) valuable tools for measuring progress towards achievement of identified environmental goals. When properly developed and utilized, environmental indicators present the linkage between environmental actions and environmental improvements. Therefore, tracking environmental indicators is a tool to communicate environmental successes or failures and to identify remaining or new challenges.

Two critical pollutants have been identified for Lake Erie: PCBs and mercury. The LaMP 2000 document presents an initial list of actions that are underway or proposed to remove or further reduce these contaminants in the Lake Erie environment. These lists serve as a baseline to measure how much effort has been applied to addressing these chemicals and to assess what still needs to be done.

Loss of habitat has been identified as a key stressor and a beneficial use impairment. The LaMP 2000 document presents an initial list of the habitat projects proposed or underway that may enhance or restore habitat within the geographic scope of the Lake Erie LaMP. LaMP 2000 also lays the foundation for developing a Lake Erie Habitat Restoration and Protection Plan.

The action plans presented for PCBs, mercury and habitat provide the first overview of actions already underway to improve Lake Erie. For now, the ecosystem objectives and indicators needed to track any future progress under the LaMP are not yet in place. The schedule to begin this process is outlined at the end of Section 3. The Lake Erie LaMP will also need to develop monitoring plans to track the progress or implementation of the LaMP, as well as to measure the impact of implementation on protecting and restoring Lake Erie.

# Significant Ongoing and Emerging Issues

Photo: Center for Great Lakes and Aquatic Sciences

# Section 11: Significant Ongoing and Emerging Issues

## 11.1 Introduction

This section provides some insight into the issues that will be important for the Lake Erie LaMP to address now and report on in the LaMP 2002 Report. Some of these issues are ongoing, and much research and policy discussion has already been applied to management decision making. Others are setting the stage for how future conditions may impact the Lake Erie basin and what we, as the Lake Erie resident population, will have to do to adjust to those changes. Referring back to Figure 2.2 in Section 2, the issues of concern in Lake Erie will continue to change over time. This section keeps the door open to new issues and encourages research and management approaches to be flexible.

## 11.2 Non-indigenous Invasive Species in Lake Erie

*(Prepared by Lynda D. Corkum, Department of Biological Sciences, University of Windsor for the Lake Erie LaMP)*

### Introduction

Non-indigenous invasive species (NIS) are successfully reproducing organisms transported by humans into an area outside their historic or geographic range including both foreign (i.e. exotic) and transplanted (i.e. outside its native geographic range but within the country where it naturally occurs) (Fuller *et al.*, 1999). The risk of NIS is that they may lead to catastrophic changes in the existing natural community composition and the extinction of native species, resulting in the overall decline in biodiversity of aquatic (Mills *et al.*, 1993) and terrestrial (Heywood, 1989) communities. Introduced species, free from constraints of their home regions, can lead to the extinction of native species through predation, competition, modifications in habitat, and inhibition of reproduction (Elton, 1958; Moyle *et al.*, 1986). If a single species dominates an area, the value of the habitat is reduced.

Although some terrestrial introductions may be viewed as providing economic benefit to humans (crops, horticulture, game species), aquatic introductions have been a "mixed blessing" (Fuller *et al.*, 1999). About 15% of all NIS taxa in the U.S. cause "severe harm" (United States Congress 1993). Mills *et al.* (1993) estimated that about 10% of these NIS taxa (21% invertebrates and diseases, 20% fish, and 5% algae and aquatic plants) are considered to be harmful to ecosystem health in the Great Lakes. The apparent lack of effect of most NIS does not mean that there has been no effect from these species, but that they have not been well studied.

There are over 50,000 NIS in the United States. Even if only a fraction of the total number of invaders is harmful, this represents significant damage to natural and managed ecosystems and public health (Pimentel *et al.*, 2000). A recent estimate of damage and control of the zebra mussel alone is $100 million (U.S.) per year (Charles R. O'Neill, New York Sea Grant, cited in Pimentel *et al.*, 2000). Pimentel *et al.* (2000) estimate that the economic damages associated with NIS effects and their control amount to approximately $137 billion (U.S.) per year. The challenge, however, is not to determine exact costs of invading species impacts, but to prevent additional damage to natural and managed ecosystems caused by NIS (Pimentel *et al.*, 2000).

Lake Erie, from the shallow, nutrient-rich, historically productive western basin to the progressively deeper and less productive central and eastern basins, provides numerous habitat, temperature and trophic gradients that are reflected in the diversity of native and non-native communities among the three basins (Edwards and Ryder, 1990). The major changes in Lake Erie over the years have been attributed to the introduction of NIS, habitat destruction, commercial overfishing and fluctuating levels of nutrient enrichment (Leach, 1995).

### Vectors

The Laurentian Great Lakes are particularly susceptible to invading species owing to the presence of canals and international ship traffic. The historic canal era in the early 1800s connected Lake Erie to waters outside of the Lake Erie drainage basin (i.e. Erie Canal, Miami Canal), and the Welland Canal, opened in 1829, allowed invaders, such as sea lamprey and alewife, to move upstream from Lake Ontario. The opening of the St. Lawrence Seaway in 1959 enhanced the migration of species into Lake Erie as "hitchhikers" in the ballast water of foreign ships. The rate of invasion has increased dramatically since the opening of the Seaway. Different taxonomic groups are associated with the type of ballast discharged by ships. Before 1900, plants (seeds), molluscs and insects were predominately transported in mud or rock used for ballast. Later, fish, invertebrates and plankton were transported in liquid ballast. Other mechanisms by which exotics entered the Great Lakes include intentional management decisions, release/escape of ornamental species, bait-bucket transfer, and fouling from shipping activities and other transportation routes.

Ballast discharged from ships that took on water from foreign ports has been the pathway for many invading species including zebra mussels *(Dreissena polymorpha)* and the round goby fish (*Neogobius melanostomus).* The mandatory ballast water exchange program under the U.S. Non-indigenous Aquatic Nuisance Species Prevention and Control Act of 1990 did not take effect until 1993 (Leach *et al.*, 1999). Similar laws have not been enacted in Canada. Although vessels entering the Great Lakes must have exchanged ballast water in mid-ocean and arrive with salinity concentrations in excess of 30 ppt, brackish water species (including algae and crustaceans) may survive ballast exchange. Additional ballast water treatment is needed to prevent future invaders from entering the Great Lakes or from intrabasin transfer among port harbors.



### Invaders

It should be noted that the invasion of NIS is a dynamic process with "new species" being found with regularity, particularly among the plant community.

### Plants

The Invasive Plants of Canada (IPCAN) monitoring project, developed by the Canadian Wildlife Service as part of the Biodiversity Mapping Program (BIOMAP), was established for documenting the biology, range and control of invasive plants and for computer mapping of NIS harmful plants (http://infoweb.magi.com/~ehaber/ipcan.html). In the U.S., the University of Florida Center for Aquatic and Invasive Plants has similar resources for documenting NIS plants (http://aquat1.ifas.ufl.edu/).

Two species of red algae *(Bangia atropurpurea* and *Chroodactylon ramosum)*, native to the Atlantic coast and presumed to have entered Lake Erie in ship ballast, are common along shorelines. Green algae *(Enteromorpha prolifera* and *Nitellopsis obtusa)* that occur in Lake St. Clair and the St. Clair and Detroit connecting channels have been observed flowing into Lake Erie (Manny *et al.*, 1991; Mills *et al.*, 1993). It is a challenge to detect established populations of small organisms; however, several species of invasive diatoms have been reported in Lake Erie (Mills *et al.*, 1993). One species, *Stephanodiscus binderanus*, causes water quality problems in sewage treatment facilities (Stoermer and Yang, 1969).

Lake Erie has many invasive submerged, emergent and terrestrial plants. Examples of submerged invasive plants are European water clover *(Marsilea quadrifolia)*, water cress *(Rorippa nasturtium aquaticum)*, Eurasian watermilfoil *(Myriophyllum spicatum)*, curly pondweed *(Potamogeton crispus)*, spiny naiad *(Najas marina)*, and minor naiad *(Najas minor)* (Stuckey 1979, 1985; Mills *et al.*, 1993). Common invasive plants of Lake Erie wetlands include: bristly lady's thumb *(Polygonum caespitosum* var. *longisetum);* bitterdock *(Rumex obtusifolius);* poison hemlock *(Conium maculatum);* bittersweet nightshade *(Solanum dulcamara);* western water horehound *(Lycopus asper);* mint *(Mentha* spp.*);* smooth field sow thistle *(Sonchus arvensis* var. *glabrescens);* flowering rush *(Butomus umbellatus);* the narrow leaved cattail *(Typha angustifolia);* and grasses *(Alopecurus geniculatus, Echinochloa crusgalli, Poa trivalis)* (Stuckey 1968, 1969, 1985,

1987, 1988; Aiken *et al.*, 1979; Mills *et al.*, 1993).

Garlic mustard *(Alliaria petiolata)* is one of the most rapidly expanding NIS of woodland habitats in North America. It forms such dense monocultures that many native plants, such as the endangered wood poppy, *Stylophorum diphyllum*, and the threatened white wood aster, *Aster divaricatus*, have disappeared from areas into which it has spread (White *et al.*, 1993). Garlic mustard plants produce thousands of seeds that scatter several feet from the parent plant. The extended period of germination makes it especially difficult to eradicate.

Purple loosestrife, a tall perennial herb, spreads aggressively by underground rhizomes and can produce over 2.5 million seeds per plant per year. It has formed dense monocultures in Lake Erie wetlands that are impenetrable by birds and wildlife seeking shelter or escape. The spread of purple loosestrife is particularly troublesome because the plant cannot be used effectively as a food source by native wildlife. Migratory and breeding use of the affected wetlands is also impaired. The tall feathery *Phragmites* is another plant that has been invading wetlands and roadside ditches. It also eliminates many native plants and creates monocultures of low food value. The jury is still out regarding whether this species is native or a NIS strain (J. Robinson, pers. comm.).

Eurasian watermilfoil can form large floating mats of vegetation that impede navigation nearshore and prevent light penetration for native submerged macrophytes (Mills *et al.*, 1993). It has a much lower food value for waterfowl compared to native plants. Large decaying mats washed to shore create conditions conducive to botulism outbreaks in waterfowl and shorebirds. Eurasian watermilfoil is considered to be the cause of the current degraded state of Rondeau Bay in Ontario. The native submergent plant community was displaced by milfoil in the 1960s with the milfoil dying out in 1977 for unknown reasons. This left the bottom sediments bare and unprotected by rooted aquatic plants. The subsequent sediment resuspension in the water column made the water too turbid to allow significant re-growth of native aquatic plants in the bay. This habitat alteration resulted in the loss of the warmwater fishery and use by waterfowl (J. Robinson, pers. comm.). Various management actions have since been implemented to try to restore the bay.



**Invertebrates**

Several species of crustaceans have invaded Lake Erie including the cladocerans *Bythotrephes cederstroemi* (now *Bythotrephes longimanus)*, *Bosmina (Eubosmina) coregoni* and *Bosmina (E.) maritima*, and the amphipod *Echinogammarus ischnus* (Mills *et al.*, 1993; Witt *et al.*,1997). The amphipod, *E. ischnus*, was first observed in Lake Erie in 1995 and has since expanded in abundance and distribution (Witt *et al.*, 1997). The *Bosmina* species are benign invaders (De Melo and Hebert, 1994). However, *Bythotrephes longimanus* (formerly known as *Bythotrephes cederstroemi*, or "B.c.," the "spiny water flea") is a cladoceran with a long, sharp, barbed tail spine that feeds on native zooplankton (MacIsaac *et al.*, 2000). The spiny water flea likely competes with fishes (especially young-of-the-year yellow perch) for zooplankton. Because the barbed spine affords the organism protection from fish predators, *Bythotrephes* has flourished.

Of the 15 species of crayfish in the Lake Erie basin, two species, *Procambarus (Scapulicambarus) clarkii* and *Orconectes (Procericambarus) rusticus*, are NIS (R. Thoma, pers. comm.). *Procambarus clarkii* was accidentally introduced into the Sandusky Bay and Grand River areas of Ohio and may affect native crayfish populations of *P. acutus.* There is evidence that the rusty crayfish, *O. rusticus*, invaded Lake Erie through the Miami Canal which was constructed between the years of 1825 and 1847 to join the Miami River (its native range) to the Maumee River (R. Thoma, pers. comm.). The large, aggressive rusty crayfish may displace native crayfish *(O. virilis* and *O. propinguus)*, and substantially reduce aquatic plants which are important habitat for invertebrates and fishes (Olsen *et al.*, 1991) and which reduce erosion by stabilizing the sediments and minimizing wave action (Gunderson, 1995).

Numerous molluscan species have invaded Lake Erie, but many species of gastropods (snails) *(Bythinia tentaculata, Radix auricularia, Valvata piscinalis)*, sphaeriids *(Pisidium amnicum, P. supinum, Sphaerium corneum)* and the corbiculid *Corbicula*

*fluminea* have not had detrimental effects on the Lake Erie community (McMahon, 1983; Mackie, 1996). McMahon (1983) suggested that the Asian clam, *Corbicula fluminea*, would unlikely be a pest in Great Lakes waters because the clam cannot tolerate cold water temperatures in winter.

The first records of the zebra mussel, *Dreissena polymorpha*, and quagga mussel, *D. bugensis*, in Lake Erie are 1988 and 1989, respectively. Dreissenids form colonies on both hard and soft bottom substrates. Quagga mussels dominate the colder deeper eastern basin of Lake Erie, but have recently colonized the western basin (Mills *et al.*, 1999). These NIS molluscs have had the most dramatic ecological and economic influence on the Lake Erie ecosystem. Dreissenids have been implicated in the reduction of lake productivity (Dahl *et al.*, 1995) and change in contaminant dynamics within the lake (Morrison *et al.*, 1995). Makarewicz *et al.*, (1999) concluded that there were significant reductions in select divisions of phytoplankton (e.g. Chlorophyta, Bacillariophyta, Cyanobacteria) in the western basin of Lake Erie, but the effect of dreissenids on the phytoplankton community in the central and eastern basins has been minimal. Zebra mussels have eliminated most native unionids (mussels) through their biofouling habits (Schloesser *et al.*, 1996). Dermott and Munawar (1993) demonstrated that the amphipod, *Diporeia hoyi* (a dominant prey of smelt which is itself an exotic) has declined dramatically because of competition with *D. bugensis.* In contrast, other species have increased owing to enhanced food (i.e. pseudofaeces) or habitat complexity provided by dreissenids (Dahl *et al.*, 1995; Steward *et al.*, 1998).

The filter-feeding capacity of dreissenids has created another complication in the Lake Erie ecosystem. Contaminants in the water, sediment and organisms ingested by the mussels accumulate rapidly in zebra mussels. This creates a link that increases biomagnification up through the food chain. Ohio Sea Grant-funded research being conducted by Fisher and Baumann (Jentes, 1999) shows a connection from zebra mussels to round gobies to smallmouth bass. After eating contaminated sediments and algae, PCB concentrations in zebra mussels were approximately 100 ppb. PCB concentrations in round gobies, another NIS that feeds on zebra mussels, were found to range from 200 to 800 ppb. PCB concentrations in smallmouth bass, a Lake Erie fish that has become a predator of gobies, ranged from 1,100 to1,800 ppb. This new situation could have dire consequences for the rest of the Lake Erie fauna and humans.



From an economic perspective, zebra mussels have coated and clogged many water intake pipes for drinking and cooling water drawn from Lake Erie. Millions of dollars have been spent to clean pipes and install treatment systems to prevent zebra mussels from attaching to intake pipes or being drawn in further to foul the water treatment and distribution systems.

**Fish**

There are 143 fish species in the Lake Erie basin (USFWS 1995) and 95 species in the lake proper (Cudmore, 1999). Within Lake Erie, there are 34 NIS, 19 of which are established and 15 others that have been reported. Ten fish species have been extirpated from Lake Erie and one subspecies, blue pike *(Stizostedion vitreum glaucum)*, is extinct (Corkum *et al.*, 2000). Introduced fishes (e.g. rainbow smelt, white perch) have represented part of the commercial fishery and, since 1950, NIS species have represented a major part of the harvest.

As an example of the impacts invasive fish species are having on the lake, there have been changing patterns of trophic guilds between commercial landings of native and NIS species from Lake Erie in the last century (Corkum *et al.*, 2000). From 1900 to 1950, piscivores, planktivores, and to a lesser extent omnivores comprised native landings. Benthivores were present in very low numbers. The NIS landed species were benthivores (carp and goldfish). From 1950 to the present, NIS represented the major component of the fish harvest. Omnivores and piscivores now dominate native landings. Planktivores (rainbow smelt) dominate the NIS catch, with benthivores and omnivores also very common (Corkum *et al.*, 2000).

Some of these changes in feeding guilds resulted from a combination of species invasions, reductions in nutrient concentrations in Lake Erie, and changes in the

commercial fishery (e.g. "fishing up" the food chain) (Regier and Loftus, 1972). "Fishing up" describes the process where there is a shift in fishing effort from higher to lower valued fishes as preferred species decline in abundance. Overfishing reduced lake herring, a native planktivore; however, the presence of NIS rainbow smelt and alewife, which feed on larval fish, kept lake herring from recovering (Ryan *et al.*, 1999). The increasing rainbow smelt population fueled a new commercial fishing interest, particularly in the eastern basin. However, that fishery is now collapsing as the burrowing amphipod *Diporeia*, a food source to smelt, has declined from 38% to 1.8% of the biomass in the eastern basin since the advent of dreissenids (Dermott and Kerec, 1997). Thus, NIS can disrupt the functioning of the ecosystem and the passage of energy up the food chain and impair the aquatic community (Johannsson and Millard, 1998).

There is strong evidence that a diet dominated by smelt and alewife results in a thiamine deficiency in lake trout causing a reproductive impairment called early mortality syndrome (EMS). Should this dietary linkage prove correct, full restoration of lake trout in Lake Erie is unlikely as smelt now constitute the major part of the diet (Fitzsimons and Brown, 1998). The EMS problem is unfolding as one of the more insidious impacts of NIS in the Great Lakes.

Because of the lack of spawning and nursery habitats in stream riffle areas with clean sand and gravel, the earliest invasions of sea lamprey did not proliferate in Lake Erie as it did in the other Great Lakes (Trautman, 1981; Leach, 1995). Populations of sea lamprey increased to the point that they were sufficiently abundant to impact populations of lake trout, particularly in the eastern basin, and may have prevented the success of lake trout restoration efforts. Control efforts (1986-1987, 1990, 1994) on New York tributaries of Lake Erie for sea lamprey were successful in reducing the population, enabling lake trout to increase after 1992 (Culligan *et al.*, 1999). Cornelius *et al.* (1995) demonstrated the dramatic improvement in survival of lake trout following these stream treatments. This increase in survival was essential in establishing the stock of mature lake trout that exist today at an abundance sufficient to effectively reproduce in the lake. Nevertheless, sea lamprey continue to parasitize older lake trout. In 1998, the attack rate by sea lamprey on lake trout was 34 wounds per 100 lake trout (>532 mm), representing a five-fold increase from 1991. Accordingly, the Lake Erie Committee (of the Great Lakes Fishery Commission) recommended that increased control efforts be applied to Lake Erie tributaries where sea lamprey spawn and ammocoetes develop (Culligan *et al.*, 1999).



Two bottom-dwelling fishes, the round goby, *Neogobius melanostomus*, and tubenose goby, *Proterorhinus marmoratus*, entered Lake Erie in 1993 and 1996, respectively. The more aggressive round goby now occurs in all of the Great Lakes. Reasons for proliferation of round gobies include their tolerance of a wide range of environmental conditions, a broad diet that includes dreissenids (Ray and Corkum, 1997), aggressive behaviour, an ability to spawn repeatedly, parental care by males to facilitate successful recruitment, and a large body size compared with species of a similar benthic lifestyle (Charlebois *et al.*, 1997). Concerns about the round goby include their ability to transfer contaminants through the food web, their effect on native species (Jude *et al.*, 1995; Dubs and Corkum, 1996), and their ability to proliferate owing to their multiple spawning habits (Corkum *et al.*, 1998; Wickett and Corkum, 1998). The round goby has become an important prey of smallmouth bass and also contributes to the diet of yellow perch, walleye, burbot and other fishes (Lake Erie Forage Task Group, 1999).

In 1997, the rudd, *Scardinius erythrophthalmus*, a large, deep-bodied minnow with blood-red fins, native to western Europe and the Ponto-Caspian (Fuller *et al.*, 1999) was reported in eastern Lake Erie at Crystal Beach (Ontario MNR, 1998). The effects of rudd on native species are unknown, but they may hybridize with the native golden shiner, an important bait fish species.

One of the most destructive NIS fish species is the common carp, *Cyprinus carpio*. It was introduced to the Great Lakes by a government stocking program in 1879 (Trautman, 1981). Carp proliferated, hybridized abundantly with goldfish, and became a major component of the Lake Erie commercial fishery, particularly in the western basin. They have caused much habitat destruction in nearshore areas and wetlands, digging up vegetation and increasing turbidity with their aggressive mating habits.

**Future Invaders**

Characteristics of successful invaders include high fecundity, rapid dispersal mechanisms, wide tolerance of environmental factors, and access to climatically matched habitats through pathways or corridors (Lodge, 1993). Rarely have ecologists been able to predict the success of colonizers, yet statistical regularities are known about the proportions of successful invaders (Williamson and Fitter, 1996). Ecologists can develop a list of potential invaders by examining comparable characteristics of invading species (Lodge, 1993; Mills *et al.*, 1994; Leach, 1995), donor and recipient habitats and climates, vulnerability of recipient communities such as disturbance (Lozon and MacIsaac, 1997), and international trade routes and dispersal mechanisms (Carlton 1985; Williams *et al.*, 1998).

Despite the mandatory ballast water exchange program, NIS will continue to enter Lake Erie (Locke *et al.*, 1993). It is virtually impossible to eliminate organisms from the bottom sludge in ballast tanks of ships without treatment (Leach *et al.*, 1999). Accordingly, future NIS will most likely be those estuarine species from foreign ports that can tolerate fresh water (Witt *et al.*, 1997). Future invaders into Lake Erie will also come from nearby drainages. Future alterations in the thermal regime and ice cover of the lake related to climate change could also affect habitat and the ability of NIS to become established in the basin.

Attention must be given to the impacts of NIS in the Lake Erie drainage basin as a whole. Insect pests and diseases can devastate the remaining forests in the basin, altering land cover and influencing runoff to Lake Erie as well as destroying habitat. Dutch elm disease and chestnut blight affected many of the basin forest communities as well as city and suburban landscapes. Gypsy moths and Japanese long horn beetles are major NIS pests of concern. The introduction of NIS vertebrates can upset terrestrial communities as well as the aquatic communities that play a role in their food chain.



The European water chestnut, *Trapa natans*, is a significant nuisance aquatic weed that reproduces rapidly and forms extensive floating mats. It was likely spread through aquarium release or escaped from private ponds. *Trapa natans* occurs in the northeastern U.S. including New York (e.g. Sodus Bay on the south shore of Lake Ontario) and Pennsylvania (Groth *et al.*, 1996). The plant was reported in Canada in 1998 in southwestern Quebec in a tributary of the Richelieu River. Mechanical control methods have been used at Sodus Bay annually since the 1960s (Mills *et al.*, 1993), but the plant persists. Hydrilla *(Hydrilla verticillata)* is another nuisance aquatic weed likely spread through aquarium release or escaped from private ponds. It creates densely branched mats on the water surface. It has not entered the Great Lakes yet, but it is the most abundant aquatic weed in Florida and has spread up the east coast of the U.S. Once introduced, it has the potential to become prolific, especially in Lakes Ontario, Erie and St. Clair (Madsen, 2000, ANS Conference).

The zooplankton, *Daphnia lumholtzi*, native to eastern Australia, India, and east Africa, was reported in reservoirs in Missouri and Texas in the early 1990s (Havel and Herbert, 1993; Havel *et al.*, 1995). The long spined (helmet and tail) zooplankton has expanded its distribution throughout the U.S. and is now in reservoirs in Michigan and Ohio (D. Culver, pers. comm.). Because *D. lumholtzi* prefers warm waters, the species will likely invade the shallow western basin of Lake Erie. The spiny zooplankton has an advantage over other zooplankton in obtaining food resources and in deterring predators.

*Cercopagis pengoi*, a predatory crustacean with a long barbed tail, was reported from Lake Ontario in 1998 (MacIsaac *et al.*, 1999). Although the effects of *Cercopagis* are unknown, it is likely that the crustacean will exert predation pressure on smaller cladocerans and may compete with young-of-the-year fishes for zooplankton. Given the transportation links between Lakes Ontario and Erie, this exotic species will soon enter Lake Erie.

*Potamopyrgus antipodarum*, the New Zealand mudsnail, has been documented along the southern and eastern shores of Lake Ontario (Zaranko *et al.*, 1997). Densities of *P. antipodarum* are up to 5,650 snails/$m^2$ in Lake Ontario; these densities are substantially lower than other records of the mudsnail invasion in western U.S. (up to $10^5$ snails/ $m^2$) (Bowler, 1990; Zaranko *et al.*, 1997). Bowler (1990) anticipates the high densities of the

New Zealand mudsnail will adversely affect native snails.

It is likely that three fishes (blueback herring, *Alosa aestivalis*; fourspine stickleback, *Apeltes quadracus*; and ruffe, *Gymnocephalus cernuus*) will enter Lake Erie within the next five years. The blueback herring was first reported in Lake Ontario near Oswego in 1995 (Owens *et al.,* 1998). This marine fish, a pelagic planktivore and a relative of the alewife (*Alosa pseudoharengus*), likely entered the lake from the Erie Barge Canal that links the Hudson River drainage and Lake Ontario. This species is even more sensitive to cold temperatures than is the alewife, and the thermal regime of Lake Erie may not provide a suitable habitat for it to become established (R. Lange, pers. comm).

The fourspine stickleback is native to the Atlantic coast and now occurs in the Hudson River and Susquehanna River drainage of Pennsylvania (Fuller *et al.,* 1999). It is likely that the fourspine stickleback could enter Lake Erie. Although the potential effects of this invader are unknown, the fourspine stickleback may feed on eggs of other native fishes.

The bottom-dwelling ruffe was introduced into Lake Superior by ship ballast and presumably spread within the basin by intralake shipping (Stepien *et al.,* 1998). It was first collected in the St. Louis River, Duluth, in 1986, and subsequently dispersed along the south shore of Lake Superior and to Alpena, Lake Huron (Fuller *et al.,* 1999). Competition between ruffe and perch is likely because they consume the same food and because ruffe are generalists in habitat use (Ogle, 1995; Ogle *et al.,* 1995). Thus, when ruffe arrive in Lake Erie, it may adversely affect yellow perch (*Perca flavescens*) and walleye (*Stizostedion vitreum*), valuable commercial and sport fishes.

A concern greater than tallying new species that enter Lake Erie is to determine the effect of NIS on native species. Of all the recent changes in Lake Erie, it is likely that the round goby will be influential in transferring energy from the lake bottom up through the food chain. In 1999, the round goby was reported in commercial catches from the western and central basins (T. Johnson, pers. comm.) and their numbers in agency gillnet surveys have increased substantially since their first appearance in Lake Erie in 1993 (Lake Erie Forage Task Group, 1999). The round goby may affect other fishes by interfering with their reproductive behaviours. Also, the round goby has been reported to feed on eggs of lake trout (Chotkowski and Marsden, 1999) and lake sturgeon (Nichols *et al.*, 1999). Just as zebra mussels were responsible for transferring energy from the pelagic zone to the benthos (Leach, 1995) round gobies are positioned to reset the system by transfering energy and contaminants from the benthos into organisms that dwell in the water column. Overall, the round goby will impact the community structure of Lake Erie.



The effect of invasive species on the Great Lakes ecosystem is a complex problem that cannot be resolved by funding studies one species at a time. One solution is for governments to fund long-term studies that examine the effect of multi-species invaders on food web dynamics.

Clearly, the invasion of organisms into new areas results in economically and environmental devastating consequences (Kareiva, 1996). A special feature of the 1996 issue of the journal, *Ecology*, challenged researchers to make invasion ecology a predictive science. Ecologists still do not know why some invaders are so damaging (e.g. sea lamprey and zebra mussels) and the effects of others are negligible. Large sums of money are spent on the control of *exotics* through programs such as the Great Lakes Fishery Commission. Recently, the United States Congress allocated one million dollars for "the Chicago Barrier," a project to install an electric fence on the Chicago Sanitary and Ship Canal. This electric barrier is designed to prevent the exchange of exotics between the Great Lakes and Mississippi Drainage basins. However, an inadvertent bait bucket transfer of a NIS could easily eliminate any anticipated benefit of a barrier.

Kareiva (1966) argues that the most striking feature of studies on species invasions is "the absence of manipulative experiments in the tradition of modern community ecology." Large scale, multi-species, manipulative experiments have been underexploited owing to the absence of funds for long term ecological studies that focus on food web dynamics. Granting periods are typically one to two years and often focus on three species or less. Unless agency and institutional partnerships are funded for the long term (10 years or more), resource management of Lake Erie and other Great Lakes is futile.

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## 11.3 Climate Change



Scientists have known for over a century that gases such as carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide produce a *greenhouse effect* by allowing short wave solar radiation to enter the atmosphere, while at the same time preventing long wave terrestrial radiation to pass back out. This is a natural and beneficial process, without which Earth would be a frozen and lifeless planet. Scientists are concerned, however, that human activities, such as the burning of fossil fuels and the destruction of tropical rain forests, are elevating the concentrations of greenhouse gases to the point where they could have a dangerously disruptive effect on the atmosphere by producing an artificially *enhanced greenhouse effect*.

For most of history, human sources of greenhouse gases have had a negligible effect on the atmosphere. However, with the beginning of the Industrial Revolution, concentrations of carbon dioxide, methane, and nitrous oxide have increased by 30 percent, 145 percent, and 15 percent, respectively. Scientific experiments with computer models of the atmosphere have shown that these increases are sufficient to have induced a rise in global mean temperature of 0.4 to 1.3 C. This warming has been confirmed, moreover, by measurements, which have shown that over the last century, average temperatures have increased by 0.5 C globally, 1.0 C nationally, and 0.6 C in the Great Lakes-St. Lawrence Basin (Southam *et al.*, 1997). There is now a general consensus in the scientific community that anthropogenic activities have significantly increased the atmospheric concentrations of $CO_2$ and other greenhouse gases, and that this has produced a discernible influence on global climate. It is expected that there will a doubling of carbon dioxide concentrations in the atmosphere in the 21st century, with a corresponding increase in average global temperatures of one to four degrees C (Intergovernmental Panel on Climate Change, 1996).

Based on projections using several state-of-the-art models (Mortsch and Quinn, 1996; Croley, 1991), experts from the U.S. National Oceanic and Atmospheric Administration (NOAA) and Environment Canada believe that global warming could result in a lowering of lake levels by a meter or more by the middle of the 21st century. This development would cause social, economic and environmental impacts throughout the Great Lakes region (IJC, 2000). The results of the models predict the same general results, but to

varying degrees. Air temperature, overall precipitation, evapotranspiration, runoff, and lake surface water temperatures will increase. Total basin moisture, snow, soil moisture, groundwater levels, lake levels and percent ice cover are predicted to decrease.

In addition to changes in the type of precipitation, there will be an increase in precipitation variability and intensity caused by the greater frequency of intense cyclones, and the reduction of mild ones. The effect of this, coupled with increased evapotranspiration, will be a corresponding increase in both the frequency and severity of floods (IPCC, 1996) and droughts.

A water quality model for Lake Erie, developed by Lam *et al.* (1987), although designed for current climatic conditions, indicates that global warming can impact significantly on nutrient and dissolved oxygen concentrations. Statistical calculations for the central basin of Lake Erie show a definite correlation between anoxia occurrence and climate-induced changes in the thermal characteristics of the lake. Another study by Blumberg and DiToro (1990), that examined the effect of a doubling of $CO_2$ scenario on the dissolved oxygen levels in Lake Erie, found that losses of 1.0 mg/L in upper layers and 1.0-2.0 mg/L in the lower layers can be expected, as can an increase in the area of the lake that is anoxic. For shallow lakes, such as Lake Erie, changes in water levels can also affect oxygen levels by altering the dynamics of the mixing processes (Arnell *et al.*, 1996). Added to this is the possibility that buoyancy driven turnovers will be less frequent or may not even occur in some years, as previously discussed. Considering these factors, Hofmann *et al.* (1998) hypothesize that "the water quality (nutrient and dissolved oxygen distributions) may be adversely affected. Increased temperature, changed nutrient and oxygen conditions are expected to impact on ecosystem components such as fisheries habitat and health."



Of particular concern are the predictions of poorer water quality and shifts in species composition. Increases in fish yields (warm water species) will be concurrent with eutrophic-like conditions and increased contaminant loading and bioavailability. While a warmer climate will provide longer seasons for agriculture and commercial shipping, changes in seasonal runoff patterns, decreases in total basin moisture and lake level decline will have negative consequences. Lake level decline will also result in significant loss, migration and changes in wetlands. Most impact assessment efforts have been concentrated on physical responses. The biological consequences of the physical responses to climate change have yet to be seriously explored.

It should not be assumed that climate change impacts on the Great Lakes basin ecosystem will take place only gradually over the next several decades. Human-induced climate change will be superimposed on normal climate variability and natural events, intensifying storm events or climate conditions. Due to the predicted impacts of climate changes on lake levels, it is suggested that considerable caution be exercised with respect to any factors potentially reducing water levels and outflows (IJC, 2000).

The Lake Erie LaMP decided early in the development process that addressing the issue of water levels in Lake Erie was beyond the scope of the LaMP and was being addressed under other venues. However, the Lake Erie LaMP may to need to further discuss this issue from the perspective of linking lake levels to climate change and all the other potential impacts that climate change could have on the entire lake ecosystem.

As part of its Great Lakes St. Lawrence Basin (GLSLB) Project, Environment Canada has developed future scenarios for the Great Lakes region based on predicted climate changes and physical conditions. A report that examines in detail these scenarios and the potential impact they would have on the communities and ecosystems in and around Lakes Erie and Ontario is in preparation (Jessup, in prep.). A summary of Jessup's report has been drafted by Environment Canada to use as an issue paper to initiate discussion for LaMP 2002.

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## 11.4 Endocrine Disruption

### Overview

The endocrine system is responsible for regulating and maintaining biological functions that are critical for normal growth, development and reproduction. It includes the brain, reproductive organs, and various endocrine glands. Endocrine glands regulate biological processes through chemicals called hormones (e.g. estrogen, testosterone, and thyroxine), that provide a means of communication between glands and tissues. These chemical messengers act on specific locations in the body, called receptor sites, where they deliver their messages. The action of natural hormones binding to their specific receptor sites is a crucial step in the endocrine system's normal operations, and interference with this process can have profound effects on an organism's behavior and physiology. Moreover, the immune and nervous systems interact closely with the endocrine system, and any one of these systems can influence the others.

Recently, government, industry, and environmental groups are attempting to learn more about the environmental endocrine issue. Some man-made chemicals (e.g. certain pesticides, plastics, detergent ingredients, and food products) have the potential to interact with the endocrine system of humans and wildlife. Such chemicals are called ***endocrine modulators*** or, as often described in the media, ***endocrine disruptors***.

Endocrine disruption by exogenic (originating externally) chemicals is not a new concept. Scientists generally agree that some chemicals could interfere with the endocrine system at high doses. For example, birth control pills, and some pesticides, such as DDT and toxaphene, now banned from use, are endocrine disruptors by design. The main question to be answered most recently is whether the health of humans and wildlife around the world is being adversely affected by the presence of *small amounts* of many different types of man-made chemicals in air, water, and food. With this and many other questions still unanswered, the potential risk associated with endocrine disruption by contaminants in the environment has become an intensely debated issue.



The Center for the Study of Environmental Endocrine Effects maintains a website with information on current developments as well as a bibliography of additional references. The Internet address is http://www.endocrine.org. U.S. EPA also maintains a website that provides details on the EPA Endocrine Disruptor Screening Program and links to other relevant websites. The Internet address is http://www.epa.gov/scipoly/oscpendo/.

### Endocrine Disruption

Endocrine disrupting chemicals work through several mechanisms, usually by either mimicking natural hormones, blocking receptor sites, or by delivering the inappropriate message. Reports describing endocrine-related ailments in both human and wildlife populations are emerging. Some of the more notable human physiological concerns are increases in reproductive tract cancers and abnormal sexual development. While several studies assert that there is a downward trend in male sperm counts, this is still an ongoing debate within the scientific community. Some of the more documented observations in wildlife populations are decreasing hatching success in birds, alligators, and turtles, the synthesis and secretion of a female hormone by male fish, changes in immune response, and behavioral modification. While there is disagreement among scientists on the cause and extent of the issue, there is a consensus that environmental endocrine disruption is a potential risk requiring immediate attention.

Some of the chemical classes that are receiving significant endocrine-related publicity are alkylphenols, carboxylate derivatives, and dioxins, which are found in many consumer products and industrial wastes. Also receiving attention are certain pesticides and medicinal products. Many of these chemicals are pervasive in our environment and human exposure occurs through several pathways, including inhalation, digestion, and dermal contact. Similar routes of exposure occur in wildlife. While many specific chemicals are labeled suspect, significant questions remain about their potency and efficacy to act as endocrine disruptors at environmental concentrations. Therefore, three major questions that still need to be answered are:1) what chemicals still need to be added to the list of those classified as endocrine disruptors; 2) how serious of a risk to humans and wildlife are

endocrine disruptors at ambient environmental concentrations (in particular what is the actual level of exposure from all sources, including dietary intake); and 3) how widespread in the environment are endocrine disrupting chemicals?

### Current Research Efforts

Evaluation of risk associated with hormonally active chemicals in the environment is based on: a) *hazard*- the harmful effect that a chemical might have on the body even if it only happens at exposure levels that are unrealistic or never encountered in real life; b) *potency*- measures how little of a substance is needed to cause a particular effect; and c) *exposure*- the amount of chemical that comes into contact with the body.

There are currently efforts underway to address these issues and the above-mentioned questions by the U.S. National Academy of Sciences, the U.S. EPA Risk Assessment Forum, and researchers at both Health Canada and Environment Canada. The Endocrine Disruptor Screening and Testing Advisory Committee (EDSTAC) is an advisory committee called together by U.S. EPA to provide guidelines for developing a screening and testing program for suspected endocrine disrupting chemicals. Under this strategy, further testing would be performed on those chemicals with significant endocrine disrupting potential. In Canada, Health Canada participates in the international Organisation for Economic Cooperation and Development (OECD) to develop regulatory chemical testing protocols on endocrine disruptors. Both Health Canada and Environment Canada researchers are testing the efficiency of procedures to identify endocrine disruptors and are studying the toxic potential of these, and other chemicals. For example, through epidemiological and laboratory research Health Canada assesses the potential for these chemicals to induce reproductive or neurological dysfunction and breast or prostrate cancers.



### Great Lakes

The Canadian government has invested $40 million in the Toxic Substance Research Initiative which supports a large number of collaborative research projects between government and university laboratories to address the endocrine disruptor issue in the Great Lakes basin.

To evaluate the potential for widespread endocrine disruptor effects in fish, U.S. EPA Region 5 initiated a program to assess whether endocrine disruptors may be adversely affecting fish populations in tributaries, harbors, and open waters of Lakes Superior, Michigan, and Erie. This effort is focused on chemicals that have only recently been shown to be endocrine disruptors to fish rather than evaluating endocrine disrupting chemicals such as PCBs and dioxins, which have already received considerable attention. Specifically, an effluent screening study funded by Region 5 and conducted by USGS at several large wastewater treatment plants in the Region was published in 1999. Survey results showed that degradation products of alkylphenol polyethoxylate nonionic surfactants (APEs) were present in the effluents at concentrations significantly higher than endocrine effect levels reported in the literature. This study is continuing and will analyze effluent, influent, and sludge samples at wastewater treatment plants in the following proposed locations: Duluth, Green Bay, Milwaukee, Akron (Cuyahoga River) and Detroit. Special emphasis is being placed on quantifying human hormone concentrations in these effluents, in addition to APEs. This study will also undertake a toxicity identification evaluation to determine the major chemicals and hormones responsible for fish endocrine disruption.

A second major study by the U.S. Department of Agriculture, funded by the U.S. Great Lakes National Program Office, can be characterized as a reconnaissance survey to assess whether there is potential for widespread endocrine disruption in Great Lakes tributaries and Lake Michigan, as typical of open water. This survey is evaluating known endocrine disruptor biomarkers to determine whether endocrine disruption may be occurring in fish populations in these locations. The study is also documenting concentrations of APE and a number of brominated flame retardants in fish tissue.

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## 11.5 Phosphorus Revisited

Phosphorus is an important nutrient that controls the amount of algae in the water column. Algae, or phytoplankton, are an important component of the aquatic foodweb. In the past, too much phosphorus resulted in too much algae which, when decayed, depleted the oxygen in the lake, creating *dead zones* where no organisms could survive. To alleviate the impacts of excessive phosphorus, a loading target of 11,000 metric tonnes/year was established under the Great Lakes Water Quality Agreement for Lake Erie. This target was reached by the late 1980s and has been fluctuating around this figure ever since.

Past and current phosphorus management practices have resulted in tremendous benefits to Lake Erie since their implementation in the 1970s. Reduced loadings of phosphorus have resulted in smaller quantities of algae and more oxygen in the system to support a healthier aquatic community.



In the 1990s, Lake Erie experienced profound ecological changes. These changes have raised concerns about the declining productivity in certain components of the aquatic ecosystem in Lake Erie. The most dramatic of these changes have been experienced in the eastern basin. In the 1970s, phosphorus had been deemed the culprit in making the lake too productive. Now that phosphorus loadings are under control, another factor has entered the equation, pushing productivity in the other direction. The invasion of zebra mussels is heavily implicated as that factor.

With the zebra mussel population explosion in Lake Erie, another organism that feeds on algae at the base of the food chain was added to the productivity equation. Zebra mussels' voracious feeding filtered suspended algae out of the water column. What was not used for maintenance and growth was expelled in little packets that sank to the bottom, resulting in fewer algae available to other organisms in the food web. Overall, the effect has been to change how efficiently energy is transferred and distributed in the aquatic foodweb.

While declining productivity is occurring in certain species throughout Lake Erie, some nearshore areas and tributaries continue to suffer from the impacts of nutrient enrichment (cultural eutrophication). These conditions also need to be considered in any evaluation of the role of phosphorus in the Lake Erie ecosystem.

Considering the many problems that arose from phosphorus over-enrichment of the lake during the 1960s and 1970s, and the uncertainties of the 1990s, the Lake Erie LaMP supports the position that phosphorus loadings to Lake Erie should continue to be limited to 11,000 metric tonnes per year. Future management decisions focused on the productivity of Lake Erie will need to be made based on overall foodweb dynamics and not just phosphorus management practices.

## 11.6 Other Emerging Issues

As the Lake Erie LaMP process progresses, it is likely that additional issues of concern will be reviewed for incorporation into the LaMP. Some of these issues may be beyond the scope the LaMP. If this is the case, the LaMP may still serve to educate stakeholders about these issues.

### Long-Range Transport of Air Pollutants

One issue in particular that was not addressed in much detail in Lake Erie LaMP 2000 is that of the transport of air pollutants over long distances, and their subsequent deposition into Lake Erie. This phenomenon is also referred to as "long distance atmospheric transport", or "long-range transport" of air pollutants.

This is an issue important to all of the Great Lakes, but one that the Lake Erie LaMP has not yet explored in any detail. Much information is available for review to determine the importance of this issue to Lake Erie. That will be a task for LaMP 2002.

# Summary and Conclusions

Photo: John Cooper

# Section 12: Summary and Conclusions

The Lake Erie LaMP process was altered in July 1999 by a resolution passed by the Binational Executive Committee (BEC). In order to accelerate the LaMP process and move from planning and document review to implementation, the four-stage process outlined in the GLWQA was collapsed into a single stage that would concurrently address problem definition, selection of remedial and regulatory measures, and implementation. Reports would be prepared biennially to provide updates on the current status and research needs of the lake and actions underway to restore beneficial uses. This revised approach would allow for more flexibility in the process and the ability to focus more readily on the most pertinent issues for the lake.

This first biennial report for the Lake Erie LaMP focuses primarily on problem definition, identification of data gaps and the remedial actions that we can implement now. The history of the issues of concern in Lake Erie over time is presented, primarily to highlight that Lake Erie is constantly changing as human uses of the land and water in the watershed change. The overview section describes where the lake has been and what is happening now. The physical characteristics of Lake Erie that make it unique and are important to how the whole lake system functions are presented. The overall message is that Lake Erie is continually changing and must have a monitoring and surveillance program that can adapt to adequately assessing ongoing and emerging issues.

The Lake Erie LaMP is being developed by 20 federal and state government agencies along with the Lake Erie Binational Public Forum, a group of Lake Erie basin citizens actively interested in improving the lake. All comments and opinions of the Lake Erie Binational Public Forum are considered when LaMP documents and decisions are produced. In addition to assisting in preparing and reviewing LaMP technical documents, the Lake Erie Binational Public Forum has an agenda to address further public outreach and education. They have adopted the promotion of environmental justice, land stewardship and pollution prevention as concepts to be considered throughout the LaMP process, in both assessment and implementation. The Public Involvement Subcommittee of the LaMP works directly with the Forum to ensure public information and involvement needs are incorporated into the overall LaMP work plan.



Ecosystem objectives for the lake are currently under development. The first step is to select an ecosystem alternative or scenario that is scientifically supportable as well as socially and economically acceptable. Ecosystem alternatives are generally described as various levels and combinations of reduced loadings, land use and preservation of natural areas. They are ***qualitative*** descriptive statements of desired future conditions for the lake. Future management direction for the lake will revolve around whatever alternative is selected. The ecosystem objectives selected will be the more specific end-points that future actions must achieve. Ecosystem indicators will be developed to measure the success of the management actions in achieving the ecosystem objectives. The ecosystem alternative selected for Lake Erie cannot be a return toward the pristine pre-settlement conditions of the 1700s, as the level of change in the ecosystem has been extensive, and in many cases appears irreversible.

Availability of natural undisturbed land is the single most important *condition* affecting the restoration of Lake Erie. Nutrient loading and land use practices are the primary human *activities* (management actions) affecting the future state of the lake. The Lake Erie LaMP developed a model including many ecosystem components of the lake that were grouped into the major categories of management levers, ecosystem health, and beneficial use to humans. The model allows movement of the management levers in different directions and monitors the response to ecosystem health and beneficial use. From this modeling exercise, seven distinct ecosystem alternatives emerged. Three of these alternatives represented conditions that were more highly degraded than the existing environment and were dropped from any further consideration. The four remaining alternatives, one of which represents the status quo, were described in general terms. These alternatives will be presented to the

public in a series of workshops to evaluate which one will be most accepted and supported by public actions. This exercise will also result in further defining specific ecosystem objectives. The LaMP Management Committee will take into account the results of the workshops, reviews by LaMP agencies, the Work Group and the Binational Public Forum to decide on the preferred ecosystem alternative for Lake Erie.

Beneficial use impairment assessments have been completed for all but two of the 14 GLWQA listed beneficial use impairments. Draft impairment conclusions are presented for the two uncompleted BUIAs: benthos and wildlife populations and habitat. The impairment assessments focussed only on whether the use was impaired or not, and where it was impaired. In some cases, the causes of impairment are known, but additional work will be required to more definitively identify the causes and track down the sources. The conclusions for all 14 beneficial use impairments are presented in detail in Section 4. This report includes a synthesis of the use impairments, examining them from the perspective of impacts on human use, those caused by chemical contaminants and ecological impairments. This approach presents a clearer picture of the lake environment as a whole rather than the narrow perspective of the individual assessments that focused on only one beneficial use at a time.

Of the seven BUIs considered to be human use impairments, four are considered impaired: fish and wildlife consumption restrictions; restrictions on dredging; recreational water quality impairments; and degradation of aesthetics. The five BUIs categorized as being caused by chemical contaminants are all considered to be impaired: restrictions on fish and wildlife consumption; restrictions on dredging; fish tumors and other deformities; animal deformities or reproduction problems; and benthic deformities. All of the seven BUIs addressed under ecological impairments are impaired: degradation of phytoplankton and zooplankton populations; degradation of fish populations; loss of fish habitat; degradation of wildlife populations; loss of wildlife habitat; degradation of benthos; and eutrophication or undesirable algae.



Chemicals of concern to Lake Erie were identified from the beneficial use impairment assessment reports, those listed as being persistent and bioaccumulative under the GLWQA, the U.S. Great Lakes Water Quality Guidance (GLI), the Canada-Ontario Agreement, the Binational Toxics Strategy, the Canadian Toxic Substance Management Policy, and RAPs. Due to their association with a number of beneficial use impairments across the lake, PCBs and mercury were identified as critical pollutants for priority action under the Lake Erie LaMP.

As a preliminary step to identifying sources and loadings of the above mentioned chemicals of concern to Lake Erie, all existing databases that might contain any information on the list of chemicals were examined for their utility to calculate loadings. Although the databases may be adequate for their intended purposes, this LaMP exercise concluded that available data for PCBs, organochlorine pesticides, mercury and PAHs were not suitable for describing the occurrence and distribution of contaminant concentrations or to compute contaminant loads. Nutrient data, however, do appear to be suitable for characterizing both concentrations and loads. Since existing data could not be used to calculate loads, the LaMP is pursuing using the data for source trackdown. The next steps will be to map contaminated sediment locations for the entire lake and compare this with fish tissue concentrations, proximity to populated areas and point sources, land use particularly as associated with agriculture, and concentrated industrial areas. The intent is to locate source areas for particular chemicals of concern by comparing the results illustrated on the maps.

The GLWQA requires that the LaMPs define "…the threat to human health posed by the critical pollutants…" in the lakes. It was determined during the evolution of the Great Lakes LaMP process that this meant something more than addressing the BUIs that relate to human health. Connecting human health issues to environmental conditions is a difficult problem to address. For concerns outside of the identified BUIs, the key concepts to consider are a weight of evidence approach, pathways of exposure, and bioaccumulation. The human health section presents an overall approach to Great Lakes human health, identification of data gaps and emerging issues, and any situations of particular concern to Lake Erie. This is another area where members of the Lake Erie Binational Public Forum have worked directly to raise and support additional focus on human health components.

The Lake Erie LaMP must connect and coordinate with many existing or concurrent programs to ensure that the most important needs for Lake Erie are identified, prioritized and addressed in the most effective manner. Much of the information already compiled under RAPs, the Great Lakes Fishery Commission, the Binational Toxics Strategy, the North American Waterfowl Management Plan and others has been used for problem definition and goal setting. Stronger connections with these programs must be cultivated, particularly to ensure widespread and effective implementation of management actions to protect and restore Lake Erie. The binational Lake Erie at the Millennium Plan is a collaborative network to support and coordinate research to solve the basic ecological questions relevant to the changing Lake Erie system. It will pursue the resources to implement the research needed to help define the management actions needed.

In addition to fostering close connections to the above programs, and in response to the Binational Executive Committee's LaMP resolution, ongoing and potential actions under three areas were reviewed and presented. These areas include habitat restoration, PCB reductions, and mercury reductions. The framework for developing a LaMP habitat restoration strategy is presented along with the description of 37 ongoing or recently completed habitat projects that may assist in improving or restoring habitat. Nineteen proposed habitat projects that require additional resources are also described. For PCBs and mercury, a brief history of the use of these critical pollutants and what actions are currently underway and proposed are presented.

As noted throughout the Lake Erie LaMP 2000 document, Lake Erie is constantly changing. We must always keep an eye on significant ongoing and emerging issues that may necessitate changes in management decisions for protecting and remediating the lake. For example, non-indigenous invasive species have been introduced to the lake numerous times as human settlement became increasingly intense. The ease of worldwide transport and trade has done much to accelerate the number of exotic species introduced. Most recently, zebra mussels have profoundly impacted the lake ecosystem. Many, many other species, both aquatic and terrestrial, have recently invaded or are poised to invade. Efforts must continue to prevent further invasions and to eradicate or at least control the species that have already taken hold.



Other emerging or ongoing issues of concern include climate change, long range transport of persistent contaminants, and the potential discharge and impacts of endocrine disrupting chemicals.

Much detailed information on the current state of Lake Erie is presented in the Lake Erie LaMP 2000 document. Much more is presented in the background technical documents that support the summaries presented in this report. The following list highlights the major findings and conclusions determined by the Lake Erie LaMP process to date.

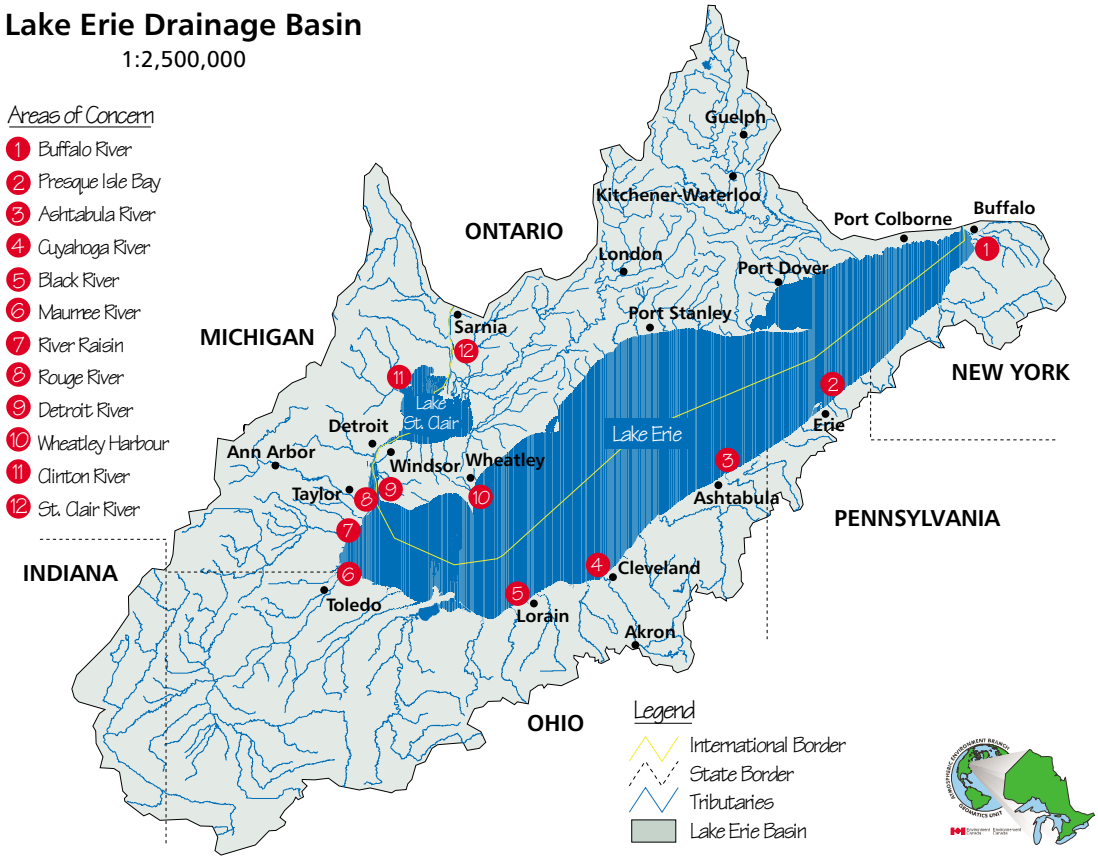
1. The physical characteristics of Lake Erie have a direct bearing on how the lake ecosystem reacts to various stressors.
2. Of all the Great Lakes, Lake Erie is exposed to the greatest stress from urbanization, industrialization and agriculture.
3. As land use and lake use changed, so to did the issues of concern in Lake Erie.
4. Phosphorus continues to be an issue in Lake Erie. However, the issue has become much more complicated than just monitoring loading to the lake. Internal processing, energy transfer, zebra mussels, spotty eutrophic conditions and oligotrophic conditions are all now part of the equation. The phosphorus management issue needs to be evaluated from a total ecosystem perspective.
5. For Lake Erie, it is not a feasible approach to try to return to the pristine conditions of the pre-1700s. The level of change in the ecosystem has been extensive and, in many cases, appears irreversible.
6. The systems model developed by the Lake Erie LaMP has identified four potential ecosystem alternatives for Lake Erie to guide future management. All four represent varying levels of natural land availability.

7. Based on the LaMP modeling exercise, land use practices and nutrient loading are the primary human activities affecting the future state of the Lake Erie ecosystem. Land use practices affect habitat, influence hydrology and sediment runoff, and contribute to loadings of contaminants.
8. Of the 14 potential beneficial use impairments listed in the GLWQA, only three are not impaired in Lake Erie: tainting of fish and wildlife flavor; restrictions on drinking water; and added costs to industry or agriculture.
9. PCBs, mercury, lead, chlordane, dioxin, DDE, DDT, mirex, dieldrin, PAHs, nitrates, phosphorus, fecal coliform and E.coli, other organochlorine compounds and pesticides have all been identified as impairing beneficial use in the Lake Erie LaMP boundaries.
10. Other causes of use impairment are: habitat loss, non-indigenous invasive species (exotics) and sediment loading.
11. PCBs and mercury have been identified as Lake Erie LaMP critical pollutants for priority action.
12. Existing databases are not suitable for calculating loads for PCBs, PAH, organochlorine pesticides and mercury.
13. The Lake Erie LaMP will be taking a source trackdown approach by mapping contaminant concentrations in sediment and fish tissue, and reviewing ambient water quality data.
14. Stronger connections must be built with other ongoing programs such as RAPs, GLFC, Binational Toxics Strategy, North American Waterfowl Management Plan, Lake Erie in the Millennium Plan, and others.
15. Actions to restore and protect habitat, and reduce PCBs and mercury are priority considerations for implementation.
16. Ongoing and emerging issues must continue to be monitored. Issues of particular concern are: non-indigenous invasive species (exotics), the effects of climate change, long range transport, endocrine disrupting substances/pesticides, and the further work on the role and impacts of phosphorus management in the present day Lake Erie system.

# **Appendix A:** Remedial Action Plan (RAP) Summaries

# **Appendix A:** Remedial Action Plan (RAP) Summaries

**Figure A-1. Map of Areas of Concern around the Lake Erie Basin.**




## Buffalo River Remedial Action Plan

### History

The Buffalo River Area of Concern (AOC) is located in the City of Buffalo in western New York. The river empties into the far eastern end of Lake Erie and most of its flow moves directly into the Niagara River. Technically, it is considered a source to Lake Ontario rather than to Lake Erie. The AOC extends from the mouth of the Buffalo River upstream approximately 10 km. There are three major streams in the watershed that feed the Buffalo River: Cayuga Creek, Buffalo Creek and Cazenovia Creek.

The RAP process identified five of 14 beneficial uses as impaired including: restrictions on fish and wildlife consumption; fish tumors or other deformities; degradation of benthos; restrictions on dredging activities; and loss of fish and wildlife habitat. The Buffalo River and its sediments have been impaired by past industrial and municipal discharges and disposal of waste. The known causes of use impairments are chemical contamination and physical disturbances to the river bottom and shoreline. Sources of contaminants include: sediments, inactive hazardous waste sites, combined sewer overflows (CSOs), and other point and nonpoint sources in the watershed. Fish consumption, fish and wildlife populations, and habitat within the AOC have been

impaired by PCBs, chlordane and PAHs. Navigational dredging of the river and bulkheading, along with other alterations of the shoreline, also contributed to these impairments. In addition, metals and cyanides in the sediment prevent open lake disposal of sediments dredged from the river. Use of the river shoreline by industrial development continues to be important although some river bank areas can be seen in various stages of abandonment.

### Project Milestones

- 1987: Buffalo River Citizens' Committee (BRCC) and its work groups established.
- 1989: Remedial Action Plan published (Combined Stage 1 and Stage 2).
- 1990: Remedial Action Committee (RAC) formed for RAP implementation.
- 1993: RAP Annual Report update.
- 1995: RAP Status Report update.
- 1999: RAP Status Report update.

### Projects Underway

Within the AOC and its watershed a number of studies, assessments and remedial measures will continue to be priorities. These include fish and wildlife consumption restrictions, habitat evaluation and improvements, sediment and water quality investigations and remedial decisions, inactive waste site remediation, and contaminant track down. Three habitat improvement projects have been constructed to address habitat impairments with funding provided through U.S. EPA. Erie County developed habitat project plans in cooperation with the City of Buffalo, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, and NYSDEC. These habitat projects were recently completed. The Buffalo Sewer Authority has received Bond Act funding to address combined sewer overflows.



### Gaps and "To Be Done"

Ongoing assessment activities include the evaluation of remedial options through the modeling of scour and deposition characteristics. Needs include further sampling, treatment assessment, and sediment criteria guidance development to assist the decision making process in addressing contaminated sediments.

## Presque Isle Bay Remedial Action Plan

### History

Presque Isle Bay is located in the northwestern corner of Pennsylvania on the southern shore of Lake Erie. The primary tributaries are Mill Creek (including Garrison Run) and Cascade Creek, which together account for about two-thirds of the water flowing into the bay.

The RAP process identified two of 14 beneficial uses as impaired including restrictions on dredging and fish tumors or other deformities. Most of the watershed comprises urban and industrial areas within the City of Erie and Millcreek Township. The land use within the Presque Isle Bay watershed is approximately 80% urban. Being a relatively closed system with a flushing time of almost 2.5 years, the bay has suffered from the accumulation and degradation of wastes discharged by point and nonpoint sources. The impairments identified are directly related and have been linked to elevated levels of nitrosamines and Polycyclic Aromatic Hydrocarbons (PAHs) in the sediments. The naturally forming nitrosamines appear to be highly variable, not only by season but also by location within the bay. Most of the PAHs in the sediments are of pyrogenic origin (incomplete combustion of organic matter, generally fossil fuels). The pyrogenic PAHs are derived from deposition of airborne particulate from various combustion sources, runoff from roadways via combined sewer overflows (CSOs) and from various historic and current industrial practices.

### Project Milestones

- 1991: Presque Isle Bay was designated as the 43rd Great Lakes Area of Concern (AOC) by the U.S. Department of State. An Ecosystem Study and Background Report was issued.
- 1993: Stage 1 Remedial Action Plan (RAP) was submitted to the International Joint Commission (IJC).
- 1995: RAP Update submitted to International Joint Commission
- 1997: Battelle Sediment Study was completed recommending that, once source control measures are implemented, the sediment management strategy should be natural recovery.

### Projects Underway

Stage 2 of the Presque Isle Bay RAP is tentatively scheduled for 2000. This document will detail the remedial and regulatory measures - as determined by the Public Advisory Committee - which will restore beneficial uses in the Bay.

Investigations to date indicate nonpoint source pollution to be the largest contributor of contaminants to Presque Isle Bay. The City of Erie has entered into a Consent Decree with PADEP to spend an estimated $90 million to upgrade and double the capacity of the WWTP, construct a four million gallon overflow retention facility, and eliminate the remaining 42 CSOs in the city's system.

### Projects Pending

The Battelle sediment management strategy has been presented to the PAC and is currently under consideration. The final decision will be based on defensible scientific analysis in conjunction with community based economic and social considerations. This sediment management decision appears to be the most viable, both environmentally and economically, in areas such as Presque Isle Bay which are characterized by widespread, low-levels of contamination with no known hot spots.



## Ashtabula River Remedial Action Plan

*"The goal of the Ashtabula River Partnership is to look beyond traditional approaches to determine a comprehensive solution for the impairment of beneficial uses posed by the contaminated sediments in the Ashtabula River and Harbor not suitable for open lake disposal."*

### History

The Ashtabula RAP process began in 1988 with the establishment of the Ashtabula River RAP Advisory Council. Years of unregulated discharge and mismanagement of hazardous wastes along the river and Fields Brook (now a superfund site) seriously contaminated sediments and degraded biological communities. The lower two miles of the river encompass the area of concern. The 1991 Stage 1 Report documented at least six of 14 beneficial uses impaired, all related to contaminated sediments. Both the commercial and recreational uses of the river were in danger of being shut down because there was no disposal site for contaminated sediments if they were dredged. An interim dredging project in 1993 removed several feet of relatively uncontaminated surface sediments to keep the recreational harbor open.

The Ashtabula River Partnership (ARP) was created in 1994 as a comprehensive, structured, concentrated effort to get the river dredged, and as an alternative to the impending designation of the river as an extension of the Fields Brook superfund site. An oversight coordinating committee was established as well as several technical committees, and a local coordinator was hired. The nonprofit Ashtabula River Foundation was incorporated in 1997 to manage financing for the river cleanup.

Since 1990, extensive sediment characterization studies have been implemented, including: mapping of pollutant concentrations (particularly PCBs); estimation of

sediment volume to be removed; delineation of PAH distribution; TCLP testing to ensure sediments did not qualify as hazardous waste; screening for low level radioactive waste; modeling sediment transport, scouring and deposition rates. A creative mix of funding from local partners, U.S. EPA, USACE, GLNPO and Ohio EPA provided seed funding for initial ARP formation, preliminary comprehensive management plan and environmental impact statement preparation (CMP/EIS), preliminary engineering design and location of the disposal facility, and the aforementioned studies. Extensive reviews of all agencies' authorities were conducted to determine the critical decision points and whose responsibility they would be. Extensive internal communication and cross program coordination has been employed.

### Projects Underway

- Review and respond to draft CMP/EIS comments. Public meeting held 9/99 generated overwhelmingly positive response from the community.
- Reviewing analytical results of PAH and low level radionuclide testing, mapping and determining if they pose any additional requirements for disposal.
- Evaluating landfill design and operation, alternative dredging scenarios, dewatering treatment and environmental monitoring components associated with dredging.
- Extensive and up-to-date public education and outreach concerning remedial actions.
- Negotiations with Potentially Responsible Parties (PRPs) concerning potential Natural Resource Damage Assessment (NRDA) actions.
- Review of habitat restoration projects associated with any NRDA actions.
- Investigation of various funding mechanisms to finance remediation.

### Projects Pending



- Recommendations on landfill design, dredging scenario, dewatering and monitoring.
- Determination of all permits and certifications needed.
- Determination of final disposal site location and any mitigation requirements.
- Completion of final CMP/EIS in spring 2000.

### Gaps and "To Be Done"

- Local sponsor to sign Project Engineering Design Agreement.
- Final decision on cleanup and disposal option and who pays for what.
- Execute Project Cooperative Agreement, line up nonfederal funds and place in escrow, obtain lands, easements and right-of-ways.
- Construct disposal site.
- Complete dredging, dewatering and disposal of contaminated sediments by 2005.
- Review post-cleanup monitoring and determine the need for any additional remedial actions.

## The Cuyahoga River Remedial Action Plan

*"Our vision as we enter the 21st Century is to restore and protect the Cuyahoga River and nearshore area of Lake Erie as a natural resource which we can use, enjoy, and bequeath with pride as our heritage to our children and future generations."*

*"Our mission, with the participation of the community, is to plan and promote the restoration and preservation of beneficial uses of the lower Cuyahoga River and nearshore area of Lake Erie through remediation of existing conditions and prevention of further pollution and degradation."*

### History

The 33-member Cuyahoga River RAP Coordinating Committee (CCC), representing multiple sectors, was appointed by Ohio EPA in 1988. The non-profit Cuyahoga River Community Planning Organization (CRCPO) was formed to receive funds and provide local staff to support RAP activities. The 1992 Stage 1 Report identified 10 of 14 beneficial use impairments in the AOC. The Stage 1 Report was updated in 1995, followed by the Early Implementation Report in 1996 that documented activities underway that addressed the identified use impairments.

The RAP worked with Ohio EPA to develop navigation channel water quality standards, resulting in their promulgation without litigation. The RAP is cited in the regulations as the responsible party for evaluating reaeration technology and cost feasibility as the first phase of a TMDL for the navigation channel. Feasibility and technology studies have been completed with additional work underway concerning habitat and environmental benefit. Many partnerships have been formed to assist in realizing the goals of RAP partners, and have supported the many studies necessary to better understand the river. Fish tissue monitoring conducted by the RAP led to the issuance of a fish consumption advisory in 1994. The RAP promoted use of soil bioengineering techniques for streambank restoration, held several workshops and completed construction at six sites in the AOC. The RAP spearheaded a nomination effort that resulted in the 1998 designation of the Cuyahoga River watershed as an American Heritage River. This will allow more focus on economic and social issues in addition to the environmental focus of the RAP. A five-year strategic plan was adopted in early 1999 to guide future CCC activities.

The Cuyahoga River RAP is recognized as an international leader in the RAP community; members have received numerous awards for their partnership and stewardship efforts and have given many presentations on the institutionalization of the RAP process.



### Projects Underway

- Active public involvement, outreach and education program.
- Big Creek and Yellow Creek Stream Stewardship programs providing coordinated cleanup, restoration and protection activities at the smaller watershed/community level.
- Multi-year larval fish survey of navigation channel and lower river.
- Investigations into the need for and financing of a debris harvestor for lower river and harbor.
- Urban streams program initiated in 1998 to focus on stewardship of small urban streams.
- Participation in preparation of updated 208 plan for NE Ohio.
- Organization and implementation of American Heritage River program.
- Committees established to carry out various initiatives listed in the 1999 Strategic Plan.

### Projects Pending

- Negotiations underway with USACE for the preparation of a navigation channel habitat restoration feasibility study and the potential construction of demonstration project(s).
- Preparation of Stage 1 Update.
- Preparation of Action Agenda/Stage 2 Report.
- Expansion of stream stewardship program into other subbasins of the Cuyahoga River.

- Purchase and maintenance of debris harvestor for cleanup of floating river debris.
- Identification of fish anomaly (DELT) hotspots and tumor surveys.
- Study of potential sources of *Giardia* and *Cryptosporidium* to area.

### Gaps and "To Be Done"

- Bird and wildlife deformity/reproduction studies.
- Input into the development of the lower Cuyahoga River TMDL to be done in 2002.
- Additional focus on potential human health concerns as connected to environmental conditions.
- Additional work on reducing/eliminating combined and separate/sanitary sewer overflows (CSOs and SSOs).
- Remediation of dissolved oxygen problems in the navigation channel.
- Implementation of additional programs to reduce sediment loads to the river.
- Considerable habitat and wetland restoration and rehabilitation is still needed.

## Black River Remedial Action Plan

### History

The Black River RAP process began in 1991 with the establishment of the Black River RAP Coordinating Committee. Several major remedial actions had occurred on the river prior to the initiation of the RAP process, particularly in regard to point source dischargers, but much still needed to be done. The entire watershed was designated as the area of concern. The 1994 Stage 1 Report documented 10 of 14 beneficial uses as impaired, with nonpoint source runoff identified as the main cause of impairments in all but the lower section of the mainstem, where point sources also still significantly impact the river. The 1999 Ohio EPA basin survey report revealed environmental improvement compared to the 1994 report, but the improvements were not as dramatic as those seen between the 1994 and 1987 reports. This is most likely a reflection of when point source controls were implemented. A USS/Kobe dredging of PAH-contaminated sediments, implemented under enforcement action, resulted in dramatic lowering of the incidence of cancer in brown bullhead by 1998. The RAP adopted a Riparian Corridor Resolution in 1996 that outlined the need for riparian corridor establishment and protection. A Strategic Long Range Plan completed in 1997 outlined RAP direction for the next several years. A symposium titled "Protecting What's Been Gained in the Black River" held with IJC Water Quality Board in 1998 celebrated accomplishments and hardened the resolve to do more.



### Projects Underway

- A model zoning ordinance to encourage environmentally friendly development in wake of urban sprawl pressures from Cuyahoga County is being developed for Carlisle Township. It is to be used as a model for other townships throughout the county.
- ODNR Urban Stream Specialist program added a new RAP member to help improve, restore, and protect urban waterways and to create self-sustaining local watershed groups.
- The citizen-popular Constructed Wetlands program for home sewage disposal systems (HSDS), begun in 1993, is still being evaluated for the most efficient flora-types for this region.
- Watershed Education Projects (many).
- Volunteer Monitoring provides tracking of water quality and stream stewardship.
- Annual Great Blue Heron Rookery Survey is showing great success in restoring habitat.
- 319 Upper Black River Watershed Project is addressing agricultural runoff and HSDS failure.

### Projects Pending

- Grove Site Project and Cromwell Park Site Project are two exciting Lorain riverfront brownfield DOD development projects. These projects have the potential for significant river enhancement.
- Countywide Urban Sediment Control - RAP involved program addressing NPS control.
- Black River Study Team to re-evaluate use impairments of the 1994 Stage 1 Report.
- Comprehensive modeling of the Black River lacustuary (lake/rivermouth zone).
- Outcome of 319 project - mountains of data, how to manage, analyze and identify next steps.
- Western Lake Erie Basin Watershed Initiative/Conservation Reserve Enhancement Program.
- Ohio Lake Erie Buffer Initiative to add 600-700 acres of riparian buffers in watershed.

### Gaps and "To Be Done"

- The nonpoint sources identified as the major causes of impairment are not easily alleviated by conventional means: 1) Urban and Suburban Storm Water Runoff; 2) Animal Feedlot Runoff; 3) Combined and Separate Sewer Overflows; 4) Home Septic System Malfunctions; 5) Agricultural Sediment Runoff; and 6) Construction Site Runoff.
- Denitrification and depleted DO levels remain major problems, especially in the shipping channel. These problems are due in part to 1) deep ship channel; 2) nutrient loading from Elyria, French Creek and Lorain WWTPs; 3) thermal pollution from steel industry; and 4) heavy sediment loads from the upper watershed. The RAP is negotiating with the dischargers, all RAP members, to develop a comprehensive model to define the problems and causes in this portion of the river.
- Linking results of the 319 project to remedial actions needed, and other NPS programs.
- Storm water management must be watershed based and RAP partners are working on solutions.
- The greatest benefit to this troubled river would be enhanced, ensured, and protected riparian corridors. This can be done with the RAP, but not solely under the authority of the Ohio EPA.



## Maumee Remedial Action Plan

Mission Statement: *"The Maumee Remedial Action Plan is a community effort to restore the health and beauty of the Maumee River Ecosystem for the benefit of all who live here."*

### History

The RAP process began in 1987 and was organized under the Toledo Metropolitan Area Council of Governments with oversight by Ohio EPA. Over 100 stakeholders participated in preparation of the Stage 1 Report, which was completed in 1990. Ten of 14 beneficial uses were documented as impaired. A "Recommendations for Implementation Report" was completed in 1991 and identified five high priority areas: agricultural runoff; landfills and dumps; wetlands and open space; urban stormwater runoff; and community involvement. Action groups were formed to focus on each of these issues as well as overall support. Two action groups were formed to specifically focus on the myriad problems of the Ottawa River and Swan Creek. A $3.5 million study (special line item federal budget appropriation) was completed to assess current conditions in the AOC and link waste sites to contamination in streams. Many programs have been initiated or supported to reduce agricultural runoff. Remedial actions at the Dura, Stickney, Tyler and King Road landfills have reduced significant loads of PCBs to the Ottawa River. Soil and sediment remediation at the Textileather and Fraleigh Creek (formerly unnamed tributary) sites removed more than 57,000 lbs of PCBs from the Ottawa River. Many educational workshops have been conducted covering such topics as: agricultural runoff; urban runoff; pollution prevention; drinking water and pesticides; watershed planning; environmental risk, etc. A RAP Strategic Plan was completed in 1997.

### Projects Underway

- A very active public outreach and education program.
- Establishment of watershed partnership to focus on the remediation of Duck and Otter Creeks.
- Swan Creek upper watershed Ohio Partnership for Urban Streams project.
- Development and implementation of Swan Creek Watershed Plan of Action.
- Economic and environmental benefits to dredging the Ottawa River study.
- Wetlands inventory project with USACE (Corps).
- StreamKeepers program on Swan Creek to monitor *E.coli* and fecal coliforms.
- Toledo Metropolitan Area Stormwater Utility Plan.
- Sediment distribution in lower Maumee and Ottawa rivers.
- Toledo Harbor Longterm Management Plan to address reduction and disposal of sediment in the Maumee River navigation channel.
- Ottawa River Remediation Team, a partnership of environmental professionals (including Ohio EPA), is working to expedite the restoration of the Ottawa River.
- Demonstration project on Ottawa River using AquaBlok for capping sediments.
- Streambank restoration using biotechniques on Swan Creek and the Toussaint River.
- Toussaint River 319 project to reduce agricultural sediment runoff.

### Projects Pending

- North Cove Landfill remediation.
- Sediment sampling on Duck and Otter Creeks.
- Development of strategic plan for restoration of Duck and Otter Creeks.
- Sediment transport modeling in Maumee mainstem.
- Implementation of Conservation Reserve Enhancement Program in NW Ohio.
- Implementation of Ohio Buffer Initiative to increase buffer strips along streams in the Ohio Lake Erie basin.



### Gaps and "To Be Done"

- Recreational channel dredging on Ottawa River. Need to address contaminated sediments and funding issues.
- Need strategy for further assessment and remediation of Duck and Otter Creeks.
- Identification of PCB sources in the Maumee River mainstem.
- Wetland and habitat restoration.
- Further reduction of sediment loads to the Maumee River basin.
- Continue implementation of Toledo metropolitan area upgrades to CSO and SSO overflows.

## River Raisin Remedial Action Plan

### History

The River Raisin Area of Concern (AOC) is located in Monroe County, Michigan. The AOC includes the lower 2.6 miles of the River Raisin from the low head dam (Dam #6) at Winchester Bridge in the City of Monroe and extends 1/2 mile out into Lake Erie, following the federal navigation channel. It also includes the nearshore zone of Lake Erie, one mile north and south from the river mouth.

The Remedial Action Plan (RAP) process documented five of 14 beneficial uses as impaired: restrictions on fish and wildlife consumption; degradation of benthos; restrictions on dredging activities; degradation of aesthetics; and loss of fish and wildlife habitat. These impairments are caused primarily by historical discharges of oils and grease, heavy metals, and polychlorinated biphenyls (PCBs) to the river from industrial facilities in the area. Additionally, industrial and municipal waste disposal sites adjacent to the river are suspected of contaminating river water and sediments with PCBs and heavy metals and have also resulted in a loss of fish and wildlife habitat.

**Project Milestones**

- 1987: The River Raisin Remedial Action Plan was reviewed and completed;
- 1988/89: Michigan Department of Natural Resources sampling of the river showed that the area most impacted by PCB and heavy metal contamination was from the turning basin to the mouth.
- 1992: River Raisin Remedial Action Plan Team was formed. Membership consists of representatives from various federal, state and local agencies such as the Natural Resources Conservation, MDEQ, Michigan Department of Public Health, Monroe County Health Department and Monroe County Soil and Water Conservation District.
- 1993: The River Raisin Public Advisory Council was formed. Membership consists of citizens representing a wide range of interests such as the River Raisin Watershed Council, local government, businesses, industries, and environmental groups.
- 1997: Ford Motor Company completed an environmental dredging project in the river.

**Projects Underway**

- In addition to the work occurring within the River Raisin AOC, MDEQ is investigating several Environmental Response Act (Act 307) sites of contamination such as landfills and industrial sites that are adjacent to or near the river. These sites are possible sources of some of the contaminants that are present in the River Raisin AOC. Input of contaminants to the river from these sites may be occurring through overland runoff, wind blown contaminated soils, or groundwater discharges.

**(Projects Pending)**

**(Gaps and "To Be Done")**



## Rouge River Remedial Action Plan

**History**

The oldest and most heavily populated and industrialized area in southeast Michigan is located within the Rouge River watershed which covers 1,210 $km^2$ in southeastern Michigan. The river has four main branches, totaling 125 miles of waterways, includes more than 400 lakes and ponds, and more than 50 miles of parkland along its banks. The river winds its way through 48 communities and provides recreational opportunities for more than 1.5 million people. The lower four miles of the river are maintained as a shipping channel from the turning basin to the river's mouth at the south end of Zug Island.

The Remedial Action Plan (RAP) process documented five of 14 beneficial uses as impaired, including: restrictions on fish and wildlife consumption; degradation of fish and wildlife populations; fish tumors and other deformities; degradation of benthos; and restrictions on dredging activities. Combined sewer overflows (CSOs), urban storm water discharges, nonpoint source pollution, and municipal and industrial discharges all contribute to the use impairments.

**Project milestones**

- 1989: The Rouge River final working RAP was completed and adopted.
- 1992: An Annual Progress Report was completed.
- 1994: A Rouge River RAP Update was published.
- 1998: The Rouge River RAP Update, a biennial report on implementation of the Rouge River RAP, was published.

**Projects Underway**

The Rouge River RAP institutional framework for updating the RAP is being modified to better meet the needs for implementation and to insure accountability in the planning process. The institutional structure includes: MDEQ staff with responsibilities to update the RAP; a Rouge Program Office created for the Rouge River National Wet Weather Demonstration Project (NWWDP); technical advisory groups; a newly revised Rouge

River Steering Committee to oversee implementation activities with the Voluntary Stormwater Permit; and a Rouge RAP Advisory Council (RRAC) to advise the MDEQ and assist in updating and implementing the RAP. The RRAC includes representatives of industry, environmental interests, citizens, universities, the Natural Resource Conservation Service, local and county governments, and parks and health departments. MDEQ and its partners will be using a biennial progress report card as a mechanism to help celebrate implementation, make mid-course corrections, provide public accountability, and further develop the RAP.

Nearly all of the initial CSO control construction projects proposed in the 1994 RAP have been completed or are nearing completion. Many retention/treatment basins are now in the evaluation phase to determine their effectiveness during various rain events. In general, it appears that the basins are capturing 85% of previous CSO discharges. As a result of these efforts, odor and bacterial problems have been reduced.

University of Michigan researchers conducted a study of the fisheries potential of the river. The results show that the downstream, larger reaches of the Rouge River have the greatest potential for developing recreational sport fisheries. However, current fisheries in these areas are severely degraded by poor water quality. The recently augmented flow of the Lower Branch of the Rouge River has greatly enhanced its potential as a fishery. Researchers state that watershed-wide reductions in storm water runoff will likely be necessary to rehabilitate fish communities.

### Projects Pending

### Gaps and ATo Be Done



The relative importance of different sources of pollution has changed. Pollution caused by sanitary overflows and CSOs has been significantly reduced, while other sources of pollution (e.g. urban storm water runoff, illegal connections, failing septic systems, flow, habitat loss) are becoming a higher priority. Subwatershed Advisory Groups have been formed to address local issues relating to storm water, flow management, habitat, and other locally identified issues.

The foundation of the revised RAP will be the watershed management plans being developed by the storm water advisory groups.

Key issues still needing to be adequately addressed include the pressures of ever-increasing urbanization, which destroys habitat and decreases fish, wildlife, and other aquatic populations. Critical habitat needs to be preserved and development needs to be done in an environmentally sensitive manner.

## Detroit River Remedial Action Plan

### History

The Detroit River is a 32 mile (51 kilometre) long channel linking Lake St. Clair and the upper Great Lakes to Lake Erie. The Detroit River Area of Concern (AOC) includes the areas which drain directly to the river and the drainage area of its tributaries in Michigan and Ontario (700 square miles), as well as the City of Detroit "sewershed" area of 107 square miles. It is a binational AOC. Approximately 75 percent of the total land area of the watershed is in Michigan (607.7 square miles).

The 1996 RAP document listed nine impaired beneficial uses. The 2000 Detroit River Canadian Cleanup Committee Report includes three additional impaired uses. Therefore, the RAP process to date has identified 12 beneficial uses as impaired: restrictions on fish consumption; tainting of fish flavor; degraded fish and wildlife populations; fish tumors or other deformities; bird or animal deformities or reproductive problems; degradation of benthos; restrictions on dredging activities; restrictions on drinking water consumption (taste and odour problems); beach closings; degradation of aesthetics; loss of fish and wildlife habitat; and exceedances of water quality standard objectives. The 1991 RAP Stage 1 Report outlined the following causes for these impairments: contaminated sediments; point and nonpoint sources; combined sewer overflows (CSOs); and, habitat loss and degradation. The report notes additional environmental concerns including: the introduction of exotic species; changes in fish community structure; and reductions in wildlife populations (primarily due to the loss of habitat).

In January 1998, Environment Canada sponsored a workshop that brought interested individuals and organizations from the Canadian side of the Detroit River together to re-establish a working group for Detroit River issues. The workshop resulted in the formation of the Detroit River Canadian Cleanup Committee (DRCC). Canadian pollutant sources account for approximately 10 percent of the total annual load in contaminants to the Detroit River. Estimates for progress on the Canadian side are that 60 percent of the required actions have been implemented. After a year of effort between U.S. EPA, MDEQ and local stakeholders, in June 1999, the U.S. announced its new structure for addressing the 1996 report recommendations. Both Canadian and U.S. organizations have been very active and are continually working on ties with each other toward an overall ecosystem approach. Each group is coordinating numerous RAP implementation projects.



### Project Milestones

- 1991: Stage 1 RAP forwarded to IJC.
- 1992: Water use goals endorsed.
- 1996: RAP Report forwarded to IJC.
- 1998: Four Agency Letter of Commitment signed.
- 1998: The Detroit River Canadian Cleanup Committee established.
- 1999: U.S. Implementation Committee begins.
- 2000: Release of RAP Update Documents: 1) Canadian Detroit River Update Report prepared by the DRCC; and 2) binational progress report prepared by U.S. EPA.

### Projects Underway

*Remediation and Research*

- Black Lagoon Sediment Remediation (US)
- US Army Corps Environmental Reconnaissance Survey (US)
- Windsor Riverfront Pollution Control Planning Study provides an implementation strategy for CSO control and reducing pollutant loadings to meet RAP objectives (CAN)
- Data Management and Modeling Framework for the Detroit River which will: describe the current environmental health of the river; document significant changes of contaminant inputs over time; quantify the linkage between inputs and impairment of the natural environment; quantify Canadian contaminant loadings; determine the location and extent of contaminated sediments in Canadian waters; and help to assess the need for sediment remediation in Canadian waters (CAN)
- Detroit River bathymetry study (US)

*Habitat*
- Survey of candidate sites on the Detroit River for potential habitat rehabilitation/ enhancement (US)
- Support of American Heritage Rivers Soft Shoreline Engineering Initiative, specifically development of Best Practices Manual (US)
- Biodiversity Conservation Strategy implementation identifies priority habitat restoration sites and includes the development and implementation of restoration plans (CAN)

*Human Health*
- Profile of fishing and fish consumption in the Detroit River Area (CAN)

*Pollution Prevention and Nonpoint Source*
- Promote pollution prevention outreach within metal finishing sector (US)
- Provide recommendations for water use/reuse opportunities in non-contact cooling water applications (US)
- Initiating a pollution prevention program for marinas (US)
- Remediation is continuing to address rural non-point source pollution entering the Detroit River watersheds of Canard River, Turkey Creek, and Little River (CAN)

*Education/Outreach/Stewardship Sustainability*
- Urban Group Session (US)
- Detroit Boat Show display and survey (US)

**Projects Pending**



*Remediation*
- $184 million in Windsor CSO control and an upgrade to secondary treatment at the WWTP (CAN)
- Grassy Island National Wildlife Refuge (US)

*Habitat*
- US Army Corps of Engineers 206 Study for Hennipen Marsh (US)
- Detroit River sturgeon study (US)
- Biodiversity atlas (US)
- Detroit River ecological risk assessment (US)

*Human Health*
- Detroit urban fisheaters study (US)

*Pollution Prevention and Nonpoint Source*
- Expand PCB minimization program (US)
- Expand hospital mercury reduction project to other medical/clinical facilities (US)

*Education/Outreach/Stewardship Sustainability*
- Detroit River framework to implement the Detroit River RAP (US)
- Development of Environmental Justice strategy (US)
- Detroit River reconnaissance survey outreach meeting (US)

**Gaps and "To Be Done"**
- Detroit River GIS and outreach mapping project (US)
- Contaminant survey (US)
- Binational monitoring strategy
- Binational delisting criteria

## Wheatley Harbor Remedial Action Plan

### History

The boundaries of the Wheatley Harbour Area of Concern (AOC) include the harbor and Muddy Creek watershed (ca. 10 $km^2$).

The RAP process identified four of 14 beneficial uses as impaired including: restrictions on dredging activities; eutrophication or undesirable algae; degradation of fish and wildlife populations; and loss of fish and wildlife habitat. These use impairments are caused by contaminants in sediments, high phosphorus concentrations, reduced water clarity, bacterial contamination, and habitat loss. PCBs in the sediments have been tracked to historical fish processing operations. PCBs are concentrated in the fatty organs and tissue of fish not consumed by humans and removed in the processing of the fish fillet. These processing wastes were historically discharged directly back to the harbour. As a result of this practice, PCBs concentrated in the sediments.

### Project milestones to date include:

- 1970s:Wheatley Harbour was designated as an AOC due to dissolved oxygen depletion, elevated bacteria counts, nutrient enrichment and PCB contaminated sediments.
- Omstead Foods, the largest fish and vegetable processor, installed an advanced wastewater treatment system. The remaining processing facilities and the residential area on the east side of the harbor are now served by a municipal sewage treatment plant that discharges directly to Lake Erie.
- Combined Stage 1/Stage 2 Report was submitted to the IJC.
- Laboratory bioassays and field based assessments of *Cladophora*, mussels, benthos, fish, and tree swallows, indicate that sediments now have a low degree of biological effect and organic chemical bioavailability.
- 1998:Major sampling effort was undertaken including water bacteriology, water toxicity, sediment chemistry, sediment toxicity and benthic macroinvertebrate studies.



### Projects Underway

- reducing nonpoint sources of phosphorus discharge into Muddy Creek;
- improving water clarity in the harbor;
- eliminating malfunctioning septic tanks as the source of bacterial contamination in the harbor and area beaches;
- preserving and rehabilitating wetland areas along Muddy Creek.

### Projects Pending

- The 1998 sampling data needs to be used to determine if the Wheatley Harbor AOC meets the water use goals defined by local residents. If so, the AOC can be delisted.

### Gaps and "To Be Done"

- Long-term monitoring to insure that the water use goals continue to be met must be implemented.

## Clinton River Remedial Action Plan

### History

The Area of Concern (AOC) includes the entire Clinton River watershed (1,968 $km^2$/760 square miles), located just north of Detroit, and flowing 80 miles (128 km) from its headwaters to Lake St. Clair near the city of Mt. Clemens. About half of the river's flow is treated wastewater from six municipal wastewater treatment plants. Land use on the north branch of the river is agricultural. The main industries in the area are automotive-related. Through the RAP process, eight of 14 beneficial uses are identified as impaired including: restrictions on fish and wildlife consumption; degradation of fish and wildlife populations; degradation of benthos; restrictions on dredging activities; eutrophication or undesirable algae; beach closings; degradation of aesthetics; and loss of fish and wildlife habitat.

### Project Milestones

- 1988: The initial Clinton River RAP document was completed.
- 1995: Second iteration of the Clinton River RAP document was completed.
- 1998: Clinton River RAP Update Report reviewed and completed.
- Two years of sediment sampling to locate areas of contamination outside the lower river.
- Macomb County special prosecutor for water quality hired.
- Enforcement actions taken on failing septic systems, illegal connections, wetlands violations, etc.
- Aquatic habitat survey completed.
- Storm water management guides developed for local governments and site development.



### Projects Underway

- Control of CSOs addressed with new permits, construction of required improvements underway
- Sanitary sewer overflows have been recognized and corrections are underway.
- Field work to discover and correct illegal connections underway.
- Wetlands functional assessments completed.
- Subwatershed management planning for wetlands protection and storm water management.
- NPS control plan completed for urban subwatershed (Bear Creek), with implementation underway.
- Options for improved operation and management of onsite sewage systems identified and are being implemented.
- Volunteer stream monitoring program for schools.
- Public education and outreach with newsletters, forums, workshops, public events, etc.
- Oakland County established infrastructure fund to financially assist municipalities with pollution control efforts.

### (Projects Pending)

### Gaps and "To Be Done"

- Solutions to many of the most serious problems (i.e. stormwater management plans, habitat protection) in the Clinton River Watershed require implementation at the local level through mechanisms such as land use planning. Because the watershed encompasses over 50 local units of government, comprehensive and coordinated efforts will be difficult.

## St. Clair River Remedial Action Plan

### History

The St.Clair River is part of the boundary between the United States and Canada, and flows southward about 40 miles (64 km) connecting the southern tip of Lake Huron to Lake St. Clair. The St. Clair River branches into several channels near its mouth at Lake St. Clair, creating a broad delta region including wetlands from St. Johns Marsh on the west (near Anchor Bay) to the north shore of Mitchell's Bay in Ontario.

The RAP process originally identified seven of 14 beneficial uses as impaired including: restrictions on fish & wildlife consumption; bird or animal deformities or reproductive problems; degradation of benthos; restrictions on dredging activities; beach closings; degradation of aesthetics; and loss of fish & wildlife habitat. Agricultural and industrial (in Port Huron and Sarnia) land use are the predominant causes of these impairments.

### Project Milestones

- 1992: Stage 1 Report and Public Use Goals submitted to IJC.
- 1993: Stage 1 Update describing remedial options produced.
- 1994: Preferred options were identified and draft implementation plans were produced.
- 1995: Stage 2 RAP Recommended Plan was formally presented to provincial, federal and state representatives.
- 1997: RAP Stage 1 Update Implementation Annex.
- 1998: Stage 1 Update/Stage 2 Implementation Annex submitted to the governments stating that tainting of fish and wildlife flavor, restrictions on drinking water consumption or taste and odor problems, and added cost to agriculture or industry, are "not impaired." Draft binational Habitat Management Plan submitted for review.



### Projects Underway

- Specific activities to address data gaps in the 1995 sediment characterization study are ongoing.
- A model is being used to evaluate sediment dynamics and contaminant transport over a period of more than 10 years given different remediation scenarios (no action-natural recovery, dredging, and capping).
- An environmental risk assessment, toxicity identification evaluation, establishment of reference condition, investigation of fathead minnow toxicity when exposed to aquatic sediments, and data comparison to Great Lakes benthic reference data base are all underway to provide the specific data needed to provide the rationale for remediation.

### Projects Pending

- Removal or capping of a less than 2 hectare zone of contaminated sediments which is expected to remove or isolate 85% of the sediment bound contaminants in the area.

### (Gaps and "To Be Done")

## Lake St. Clair

Although Lake St. Clair is not designated an Area of Concern (AOC) under the Great Lakes Water Quality Agreement, two rivers that discharge into the lake are AOCs. These are the binational St. Clair River and the Clinton River in Michigan. Also, Lake St. Clair discharges directly into the Detroit River, also a binational AOC, which then empties into Lake Erie. Lake St. Clair is a highly utilized recreational lake that has been affected by numerous environmental insults in recent years. On the U.S. side the problems have been exacerbated by the impacts of urban sprawl, increased density of development and suburbanization in the surrounding area. On the Canadian side the problems are due more to agricultural land use in the watershed and the highly industrial area located upstream in Sarnia, Ontario. The lake's ecology has also been drastically altered and influenced by the invasion of exotic species such as the zebra mussel.

Environmental problems include: high levels of bacteria from combined sewer overflows and failing septic systems leading to beach closures and human health issues; chemical contamination of water and sediments including persistent bioaccumulative toxics; loss of fish and wildlife habitat; economic impacts on property values and businesses; and a decrease in the overall recreational quality of the lake. These problems have long been an issue with the various government agencies, stakeholders and the public.

The *Macomb County Blue Ribbon Commission Report on Lake St. Clair* in 1997 provided an impetus to gather a broad array of stakeholders into the debate. In January 1998, U.S. EPA staff met with members of the Commission to discuss the findings and recommendations of the report. One of the Commission's key recommendations to U.S. EPA was that it could play a pivotal role in facilitating a dialogue not only with local governments and stakeholders (which they had been very successful in doing) but also with other U.S. state and federal agencies and the Canadian and Tribal governments.



In May 1998, U.S. EPA hosted an information sharing meeting with the Blue Ribbon Commission and the four governments - two federal, state and provincial. At that meeting it was decided that a larger scale conference to help determine the state of the lake would be beneficial in providing an opportunity to share scientific data and research and in identifying opportunities for future collaboration. U.S. EPA, Region 5 took the initial lead to develop and implement such a conference. A stakeholder group was formed to assist in the planning of the conference. The group included the four governments, Walpole Island First Nation, local governments, environmental organizations and industry.

The conference was held in late 1999 and was attended by more than 230 people from Canadian and U.S. environmental agencies, watershed groups, local governments, First Nations, industry and academia. Information was exchanged about the state of Lake St. Clair, its problems, and responsibilities for future management of the lake's resources. The conference was funded by the U.S. EPA Great Lakes National Program Office along with several dozen other sponsoring organizations and facilitated by the Great Lakes Commission.

Topics covered included: 1) habitat and biodiversity; 2) human health, beach closures and drinking water; 3) loadings, toxics, transport and sources and; 4) physical conditions and processes. The numerous speakers represented a range of perspectives on each topic. The breakout sessions on the second day solicited many innovative suggestions and ideas for future actions and opportunities for collaboration. The conference achieved its goals of allowing an exchange of current information; a review of programs, policies and institutions responsible for managing the lake and; identifying opportunities for future actions and collaboration. The conference proceedings were issued in January 2000 by the Great Lakes Commission.

Since the conference, the following commitments have been made to address Lake St. Clair:

- The four government parties (EPA, MDEQ, OME and EC) have agreed to include the lake in the "Four Party Letter of Agreement" that, up to this time, covered only the binational Areas of Concern.

- GLNPO has committed funding to host a biannual Lake St. Clair Conference. WD has committed funding for an outside facilitator to help develop a management framework for the various stakeholders.
- Lake St. Clair will be given a spot on the agenda at the Binational State of the Lakes Ecosystem Conference (SOLEC) in October 2000 along with the five Great Lakes.

# **Appendix B:** Selection Criteria for Screening Data Used in Source Characterization Report

# **Appendix B:** Selection Criteria for Screening Data Used in Source Characterization Report

The first purpose of this section is to identify data that can be used to characterize contaminant concentrations. To use these data with confidence requires that the reported sample concentrations are representative of the environmental media and location from which samples were taken. Concentration data can be used to track down sources of contaminants in the environment. Concentration data also can be used for the evaluation of contaminants in relation to standards or criteria for the protection of aquatic life and human health. Some degree of confidence in the data is needed for either of these purposes. Concentration data along with data such as that found in the TRI, NPRI, PCS, and SRDS can be used to corroborate environmental release information. This type of analysis relies on the weight of evidence from multiple data sources.

The other purpose of this section is to identify data that can be used for the computation of loads. Identification of the contaminant loading sources to Lake Erie can provide information on when, where, and how contaminants enter Lake Erie and the comparative magnitude of loading from streams and point sources relative to atmospheric deposition.

### Minimum Criteria for Estimating Concentrations and Loads

The objectives of this report are to characterize concentrations and loads. Available data with which to achieve these objectives were collected by many agencies for various purposes. To determine which data are suitable to characterize concentrations and loads requires a screening procedure and selection criteria. The basis for the data-selection criteria is a review of published literature on techniques for analyzing environmental data and techniques for estimating fluvial loads. The objective of screening criteria is to extract as much suitable data as possible from the available data sets so that concentrations can be characterized and loads can be computed with confidence.



Minimizing errors and maximizing confidence in the information presented in this report is a primary goal because management actions might arise from conclusions drawn from the data. There can be many sources of error in any reported data. Variability in an estimate of a concentration or load is dependent on the sampling errors and nonsampling errors in the data. Nonsampling errors can be random or nonrandom. Random nonsampling errors tend to cancel each other out in large data sets (Iman and Conover, 1983) and so will not be considered a serious problem for the data sets discussed in this report.

Biases (nonrandom errors) in the data may not cancel each other out and elimination of bias is important to data quality. Biases can be minimized by the use of selection criteria that provide the analyst with only data applicable to the purposes of the data analysis. Sampling error is the other type of error that is an important consideration. Sampling theory dictates that the magnitude of the error in any data is inversely proportional to the square root of the number of samples (Richards, 1999, in press). To reduce this error by one-half requires that four times as many samples be collected. This knowledge translates into certain minimum sample sizes for data sets intended to be used to characterize contaminant concentrations and compute loads. The questions are 1) how many samples are enough, and 2) how much confidence in the sample estimates is desired or needed?

### Selection Criteria

One consideration is how well the samples represent the environment from which they were obtained such as point sources, the lake, connecting channels, tributaries, sediments, fish, or airshed. Even for simple descriptions of concentration and loading data, it is important that the samples collected represent the range of environmental conditions. For example, the concentrations of contaminants that are primarily delivered during runoff and high streamflows will be underestimated when samples are collected only during low or moderate streamflows. In much the same way, contaminant concentration in rain is dependent on

rainfall volume. Samples collected from streams, lakes, and the atmosphere at daily, weekly, monthly, or seasonal frequencies were deemed suitable and were included in data analysis for this report. Only where data are reported for a representative number of locations across the range of environmental conditions, were they deemed suitable for lakewide assessment purposes.

For aquatic sediments, single or multiple surficial sediment samples were deemed to be most representative of recently deposited sediments and associated contaminants. Another consideration is the period of record of data collection. Only water quality collected from October 1, 1985, to September 30, 1996, were inventoried for selected contaminants. The distribution of data sites is also a consideration.

### Minimum Criteria for Concentrations

The distribution of contaminant concentrations in hydrologic environments can be highly variable. Estimates of the mean, median, and range of concentrations cannot be described adequately with very small sample sizes (Helsel and Hirsch, 1995). Summary statistics used for this report are measures of center of the data (median or mean), the variability of the data (variance and standard deviation), the symmetry of the data distribution (kurtosis), and estimates of data quantiles and extremes (minimum, maximum or some large or small percentiles) (Helsel and Hirsch, 1995). For purposes of this report, concentration data sets with a sample size of at least 10 in which no sample results are reported below the limits of detection are deemed suitable for the description of contaminant concentrations. A sample size of 10 provides sufficient information for computation of median, mean, estimates of variability, and percentiles of the distribution.

A further complication is that the concentrations of certain contaminants are often reported as being censored or "below the detection or reporting limit." Censored data may present an interpretation problem. For example, censored data may be of limited use for evaluating the presence or absence of a contaminant if the reporting limit is higher than an environmentally relevant concentration. Concentration and (or) loading data can be used for evaluating a discharge or permit limit. To a lesser degree, concentration data can be used for evaluating compliance with a standard or criteria for the protection of aquatic life or human health. Data censoring is considered severe at the level of 50 percent or more (Helsel and Hirsch, 1995). At censoring levels greater than 50 percent, the median concentration, for example, may have to be estimated because it is not a detected value.



Statistical techniques that substitute values for censored data can be used to overcome the detection limit problem. The MLE (Maximum Likelihood Estimate; Cohen, 1959) is one technique that substitutes values for censored data based on what is known about the distribution of the data reported above the detection limit and the percentage of data below the detection limit. The MLE is a favored method to compute the median and other percentiles of a data set because it is less biased compared to simpler techniques that substitute zero, one-half, or the detection limit value for censored data (Helsel and Hirsch, 1995). The MLE works best with sample sizes greater than 25 (Helsel and Hirsch, 1995). If the MLE is used with lognormally distributed data, estimates of the mean and standard deviation may require some adjustment (Gilliom and Helsel, 1986). For purposes of this report, the MLE is the desired method for addressing censored data.

Data sets with censored data were judged to be suitable for the computation of statistical summaries if the detection frequency is at least 50 percent for sample sizes of 25 to 49, and at least 25 percent for sample sizes of 50 or more (Gleit, 1985). Even at sample sizes of 50, the estimated mean and standard deviation can be biased by 50 to 100 percent when there is a low percentage of detected values (Helsel and Hirsch, 1995).

The minimum criteria to characterize contaminant concentrations from point sources can differ somewhat from nonpoint sources such as tributaries. Tributaries are predominately influenced by event-based phenomena and hence the need for more stringent screening criteria to avoid bias. Point sources, on the other hand, are process-based and hence are characterized by relatively constant flows and concentrations. The minimum number of observations needed to characterize concentrations of contaminants discharged from point sources remains 10. However, if data are censored (reported below detection), 25 to 50 percent or more of the observations should be reported above the detection limit. However,

with small data sets, the computation of the MLE can produce unexpected results. Therefore, an MLE based on 50% or more observations above the detection limit would still be preferable.

### Minimum Criteria for Loads

Contaminant loads are computed using two types of data: 1) concentration data and 2) ancillary data such as streamflow, effluent discharge, rainfall, or dryfall. A load is a measure of the rate of transport of a known mass of a contaminant expressed in kilograms or tons per unit of time, either per day or per year. The most desirable situation for computing annual loads is if samples and measurements are taken concurrently each day. Daily loads are computed and summed for the year. The availability of daily values for computation of annual loads is uncommon because of funding constraints on monitoring programs. In the absence of daily values for loads, statistical techniques are available that can make up for limited data. Load estimators based on statistical regressions are techniques commonly used to estimate daily loads from samples collected at less than daily frequencies (Cohn, 1988; 1994; Cohn *et al.*, 1992; Richards, in press).

Load estimators for tributaries and connecting channels require sample data be collected at sufficient frequencies with regard to important variables such as streamflow and season (Cohn, 1994; Richards, in press). Most stream load estimators in use today can accommodate some degree of censored values. The MVUE (Minimum Variance Unbiased Estimator) (Cohn *et al.*, 1992; Cohn, 1994) can be used to compute tributary load estimates when at least 25 percent of the sample data are above the detection limit and when there are 50 or more samples with at least 25 samples collected per year. The AMLE (adjusted maximum likelihood estimator) (Cohn *et al.*, 1992; Cohn, 1994) requires the same sampling frequency with at least 20 samples above the detection limit. Realistically, an estimator technique may perform quite well with anywhere from as few as 30 to as many as 75 or more samples. Many samples are more desirable than few samples. For smaller sample sizes, the percentage of censored data must be kept to a minimum of 50 percent.



For purposes of this report, data sets suitable for the computation of contaminant loads from non-point sources such as tributaries were judged to be best represented by a sample size of at least 50. In addition, concentrations of contaminants should be detected in at least 25 percent of the samples. Samples applicable to the computation of loads should have been collected at or near a daily streamflow gage. The samples also must be collected over a range of low to high streamflows representative of the stream at the sample-collection site.

Referring to the prior discussion on point sources, the minimum number of reported observations needed to compute loads from point sources remains 10. The minimum criteria established to compute loads discharged from point sources were at least 25 percent of the observations above the detection limit.

# **Appendix C:** Background on Environmental Justice

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**Definition of Environmental Justice (U.S. EPA):** 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.

**United States Policy on Environmental Justice:** On February 11, 1994, President Clinton issued Executive Order 12898 ordering every Federal agency to "make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions, the District of Columbia, the Commonwealth of Puerto Rico, and the Commonwealth of Mariana Islands."

**Lake Erie Binational Public Forum Policy Statement on Environmental Justice:** In October of 1997, a majority of the Lake Erie Binational Public Forum voted to adopt the U.S. EPA definition of Environmental Justice, and endorsed the following Environmental Justice policy statement:



The Lake Erie LaMP Binational Public Forum recognizes the inherent value of Lake Erie as a natural environment, and that regardless of race, color, or national origin or economic circumstances:

- any citizen has the right to participate in decisions which affect the environment;
- that no segment of the population of the Lake Erie watershed should suffer disproportionately from adverse human health or environmental effects because of race, color, national origin, or economic circumstances, and should have the opportunity to live in clean, healthy, and sustainable Lake Erie communities;
- that every person of the Lake Erie watershed should have the right to public participation, government accountability, access to the courts, and protection of human health.

The Lake Erie LaMP Binational Public Forum hereby recognizes the following:

1. Executive Order 12898 in the U.S.
2. Environmental Bill of Rights, 1993 (Statutes of Ontario, 1993) in Canada.

# Appendix D: Habitat Projects

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## EXAMPLES OF EXISTING PROJECTS

### 1. BUFFALO RIVER FISH AND WILDLIFE HABITAT RESTORATION, Buffalo, New York

***Project Type:*** restoration, education/outreach
***Project Goals:*** Goals are: 1) to increase area of habitat capable of supporting a healthy diversity and distribution of fish and wildlife communities, with emphasis on self-sustaining native biota; 2) heighten awareness and foster greater appreciation of natural resources; and, 3) enhance recreational opportunities for use of fish and wildlife resources.
***Project Status:*** *complete*
***Narrative:*** The lower reaches of the Buffalo River have deep channels and steep banks that have been reinforced to prevent erosion. In a few shallow areas, submergent and emergent wetlands do exist and have been enhanced to provide spawning and nursery habitat for fish and nesting and resting areas for waterfowl. Periodic dredging to maintain navigation limits the extent of the habitat. For many years the area suffered from industrial and municipal pollution, with no river access for Buffalo city dwellers. Three small areas, now restored, offer people access for wildlife appreciation, education, fishing and canoeing.
***Project Actions:***

- At the Smith Street site, logs were placed underwater offshore to improve aquatic species habitat. A rock reef was enhanced to create a riverine wetland. The shore was planted with native species. Public access includes a fishing overlook, interpretive nature trails and a canoe dock.
- At the Ohio Street site, native vegetation was planted along the shore. Two fishing/ overlook platforms were constructed. A stone dust trail along the river was installed. A canoe launch was constructed.
- At the Bailey Avenue Peninsula site, the shoreline was enhanced with native vegetation. Logs were placed near the shoreline to improve fish habitat. A trail system and interpretive signs were installed.

***Project Partners:*** Erie County Department of Environment and Planning, New York Department of Environmental Conservation.



### 2. CAROLINIAN REFORESTATION - CENTENNIAL PARK, Dunnville, Ontario

***Project Type:*** restoration
***Project Goal:*** To create a woodlot depicting the area's natural heritage and providing wildlife habitat for species found within the Carolinian zone.
***Project Status:*** *complete*
***Narrative:*** Carolinian forest is a feature of southern Ontario that is unique in Canada. With extensive historical clearing of land for development and agriculture, little of this habitat type remains. Efforts to establish Carolinian stands require selection of native tree species. In this demonstration project, 14 species were planted in a heritage grove.
***Project Actions:***

- Dunnville Town Council approved designation of Centennial Park as a heritage grove.
- The Dunnville District Heritage Association and the Dunnville Horticultural Society then procured Carolinian species of trees such as honey locust, sycamore, black gum and pin oak for planting.
- Subsequently, species such as Kentucky coffee tree, butternut, tulip tree and hackberry have been added to the site.

***Project Partners:*** Dunnville District Heritage Association, Dunnville Horticultural Society, community volunteers, Town of Dunnville.
***Additional Details:*** The original project expanded into a Thompson Creek restoration project in Dunnville undertaken by 16 partners, including: Ducks Unlimited, Dunnville

Bioregion Association for Community Planning, Dunnville District Conservation Dinner Committee, Dunnville District Hunters & Anglers, Dunnville District Heritage Association, Dunnville Horticultural Society, Dunnville Secondary School, Environment Canada's Action 21 Community Funding Program, Grand River Conservation Authority, The Grand River Foundation, Haldimand Stewardship Council, Ministry of Natural Resources, Region of Haldimand-Norfolk, Six Nations of the Grand River, Thompson Creek Elementary School, Town of Dunnville and other interested schools and members of the community. A variety of objectives include demonstrating increased biodiversity; promoting understanding of the natural environment; educating private landowners about proper land stewardship practices; and increasing public awareness about the importance of healthy ecosystems.

### 3. CAZENOVIA CREEK HABITAT RESTORATION AND STEWARDSHIP PROJECT, New York

***Project Type:*** restoration, education/outreach
***Project Goal:*** Habitat improvement along streambanks of the Cazenovia Creek watershed.
***Project Status:*** *ongoing*
***Narrative:*** This project will improve up to 2500 feet of streambank within the watershed; re-establish critically impacted habitat for game and fish and other animals; improve nearshore aesthetics; and replace non-native noxious vegetation with native trees and shrubs. It will also seek to create a network of interested community representatives who will conduct project activities and monitor the project and assess the effects on enhancing stream corridor habitats.
***Project Partners:*** Erie County (New York) Department of Environment and Management



### 4. CHAGRIN RIVER WATERSHED, Ohio

***Project Type:*** planning/coordination/collaboration
***Project Goal:*** A framework for model ordinances for riparian protection.
***Project Status:*** *ongoing*
***Narrative:*** This project is developing a general framework for model ordinances for riparian buffers, wetland, and floodplain management.
***Project Partners:*** Chagrin River Watershed Partners, U.S. Environmental Protection Agency.

### 5. CITY OF TRENTON LINKED RIVERFRONT PARKS, Trenton, Michigan

***Project Type:*** restoration, education/outreach
***Project Goals:*** A rehabilitated and enhanced Detroit River shoreline and habitat for fish and wildlife in Trenton, Michigan, and increased public access that links a riverfront park system.
***Project Status:*** *ongoing*
***Narrative:*** Currently, much of the Detroit River shoreline is hardened or has been developed by municipalities and industry, causing significant loss of fish and wildlife habitat. This project will enhance fish and aquatic habitat along the Detroit River as part of a city and park redevelopment project in Trenton, Michigan. Rather than limiting riverbank stabilization to conventional sheet piling, gravel and cobble habitat will be designed and installed to demonstrate the feasibility of creating fish habitat in conjunction with urban park development. This habitat demonstration project is an important aspect of the larger, long-range City of Trenton Linked Riverfront Parks Master Plan. It is an action item that directly seeks to remediate the loss of fish and wildlife habitat and beneficial use impairment identified in the Detroit River Remedial Action Plan.
***Project Actions:***

- Compile a summary report of baseline data on the existing aquatic habitat conditions in the Trenton Channel within the proposed project area.
- Design and install appropriate habitat at identified project sites.
- Disseminate information about the project widely.

***Project Partners:*** City of Trenton, Downtown Development Authority, Michigan Department

of Environmental Quality, Michigan Department of Natural Resources, Michigan Sea Grant, U.S. Geological Survey, U.S. Environmental Protection Agency, Wayne State University.
***Project Needs:*** The project actions will be completed in 3-5 years. Additional monitoring funds will be necessary in the future to measure long-term success of the fish and wildlife habitat restoration part of the project.

### 6. COMMON TERN/PIPING PLOVER HABITAT RESTORATION, SHELDON'S MARSH STATE NATURE PRESERVE, Ohio

***Project Type:*** protection/restoration
***Project Goal:*** To restore and maintain historical nesting habitat for common tern and piping plover on 15 acres of foredune on the barrier beach at Sheldon's Marsh State Nature Preserve.
***Project Status:*** *ongoing*
***Narrative:*** The 460 acre Sheldon's Marsh has one of the last naturally occurring barrier beaches (40 acres) on the south shore of Lake Erie which protects the integrity of an undiked wetland behind it. The barrier beach/marsh complex is heavily used by nesting and migrating waterfowl and shorebirds. Lake sturgeon, an endangered fish species, spawn on the Sheldon's Marsh beach and the U.S. Fish & Wildlife Service Great Lakes Piping Plover Recovery Plan identifies Sheldon's Marsh as ideal habitat. Both common tern and piping plover are impaired due to unmet population objectives per the draft Lake Erie LaMP degradation of wildlife populations and loss of wildlife habitat assessment. Because common tern and piping plover use the same type of habitat, any improvements benefit both species. Stresses to existing habitat include: a) 80,000 people visit Sheldon's each year, making it the third highest visited Nature Preserve in the state; b) vegetative succession on the foredune has eliminated the open, vegetation-free habitat necessary for common tern and piping plover; c) the littoral drift that replenishes the barrier beach has been stopped, resulting in a 1200 foot loss to the beach over the past 20 years.
***Project Actions:***

- Succession has been controlled by removing vegetation from 15 acres of foredune.
- Public access has been limited to 300 yards on either end of the barrier beach between May 1 and September 30 each year to maintain the habitat conditions needed for the sensitive species that use it.
- A U.S. Army Corps of Engineers engineering study is nearly complete and will identify whether construction of the Huron pier has stopped littoral drift which supplies materials for barrier beach replenishment. If so, the Corps will recommend and potentially assist with funding remedial measures to correct this problem and maintain the barrier beach.

***Project Partners:*** Ohio Department of Natural Resources - Divisions of Wildlife, Natural Areas and Preserves and Geo-survey, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service.
***Additional Needs:*** Resources will be needed to continue the first action. For action 3, $6 to 8 million is needed to construct a segmented breakwall and provide sand for beach replenishment. A potential source of this funding is a grant from the U.S. Army Corps of Engineers.

### 7. CONSERVATION FARM PLAN PROGRAM, Ontario

***Project Type:*** restoration
***Project Goal:*** Reduce environmental impacts on agricultural lands.
***Project Status:*** *ongoing*
***Narrative:*** Conservation Farm Plans are prepared for agricultural operators in the Essex region. These plans identify farm specific projects that could be undertaken to reduce environmental impacts (e.g. feedlot drainage improvements) and improve environmental values (e.g. planting buffer strips) in ways that enhance farm production or do not reduce farm production.
***Project Partners:*** Essex Region Conservation Authority
***Project Needs:*** Approximately $18,000 per year.

## 8. CONSERVATION PLANNING IN THE HURON RIVER WATERSHED, Michigan

***Project Type:*** inventory/classification

***Project Goal:*** A complete inventory of the rare species and natural communities of the Huron River watershed.

***Project Status:*** *ongoing*

***Narrative:*** The Huron River watershed is currently the cleanest river in Southeast Michigan. The watershed supports a multi-million dollar fishery, is home to threatened and endangered species, and contains two-thirds of the region's public recreational lands. The Huron River Watershed Council is engaged in several projects aimed at preserving open spaces and wildlife habitat in the Huron River watershed, modeled after the Chicago Wilderness program. This project will fund the habitat inventory components of their ongoing work. The Watershed Council staff will gather existing data regarding open spaces, building on the work done by the Michigan Natural Sources Inventory, National Wetlands Inventory, and other efforts. A "gap analysis" will also be performed to target rare ecosystems or communities. All of the information will be stored as multimedia and geographic information system (GIS) databases. This project will support publicly accessible computer-based tools for evaluating land use options for informed community planning.

***Project Partners:*** Huron River Watershed Council

## 9. CONSERVING ALVAR HABITATS, Ohio

***Project Type***: inventory/assessment, protection

***Project Goal:*** Conservation of rare Lake Erie alvar habitats that support the endemic lakeside daisy forb and leafhopper insect species.

***Project Status:*** *ongoing*



***Narrative:*** Western Lake Erie's Kelleys Island and Marblehead Peninsula are home to an unusual Great Lakes habitat, the alvar. Alvars are landscapes that occur on limestone or dolomite bedrock, have thin soils, and are subject to severe drought and seasonal flooding. They are habitat for rare plants and animals. The western Lake Erie sites are known habitat for four species of leafhoppers: *Chlorotettix spatulatus, Laevicephalus minimus, Polyamia caperata,* and *Chlorotettic fallax.* The Great Lakes endemic lakeside daisy *(Hymenoxis herbacea)* has evolved to survive only in this special environment. Loss of alvar habitat is attributed to quarrying, development, off-road vehicle damage, over-grazing and browsing, non-indigenous invasive species, plant collecting, logging and poor forestry practices, waste dumping, and vandalism. Conservation of this unique but sparse habitat in the Lake Erie basin will preserve plant and animal genetic diversity and help us understand the impacts of climate change on vegetation. The conservation of alvar habitat in Lake Erie is part of the International Alvar Initiative, a project to conserve alvar sites throughout the Great Lakes basin.

***Project Actions:***

- Assess alvar distribution and conservation status.
- Document priority sites for long-term protection.
- Develop a working knowledge of how alvar systems function.
- Develop conservation strategies for protection and stewardship.
- Increase public awareness of alvar importance as habitat.

***Project Partners:*** The International Alvar Working Group includes members from: Agriculture Canada; Bruce Peninsula National Park; Carleton University; Couchiching Conservancy; Federation of Ontario Naturalists; Finger Lakes Community College; McGill University; Michigan Natural Features Inventory; Michigan State University; Nature Conservancy of Canada; New York Natural Heritage Program; Ohio Department of Natural Resources; Ontario Ministry of Natural Resources; Ontario Natural Heritage Information Centre; Shippensburg University; State University College/Geneseo; Essex Region Conservation Authority; State University of New York; The Nature Conservancy; University of Guelph; Wisconsin Natural Heritage Program; and York University. Other partners are the U.S. Fish and Wildlife Service and U.S. EPA.

***Additional Needs:*** The first two bullet items are complete. Project partners are conducting independent research addressing bullet action three. Bullet actions four and five need to be implemented.

### 10. CUMMING'S FARM - MODERN CONSERVATION FARMING, Ontario

***Project Type:*** restoration, education/outreach

***Project Goal:*** Marginal farmland was retired into black walnut and wildlife habitat.

***Project Status:*** *complete*

***Narrative:*** In the agricultural communities of southern Ontario, an educational and influential tool has been developed to demonstrate how various habitat protection and restoration features can be integrated into a working farm. These landowners have established a series of land stewardship activities that blend the natural landscape into a modern farming operation in the Rondeau Bay area of Chatham-Kent.

***Project Actions:***

- Marginal farmland was retired into black walnut and wildlife habitat. Productive portions of the farm were converted into 100% no till soil conservation management systems.
- Eroded areas of the farm were improved through use of grassed waterways and drop inlets.
- This farm is a living example of modern conservation farming with the aim of sustaining the soil resources to maintain crop profitability. It has demonstrated internationally the practicality and value of conservation farming.

***Project Partners:*** National Soil Conservation Program, Land Stewardship I, Land Stewardship II, Landowners John and Peter Cummings, Woodlands Improvement Agreement Program, Ontario Ministry of Natural Resources.

***Additional Details:*** This farm is in the Rondeau Bay area, with the highest potential of anywhere in Ontario for delivery of phosphorus to Lake Erie, so conservation efforts have dramatic effects. Adjacent waters are highly valued waterfowl staging areas, and a neighboring landowner is re-establishing tall grass prairie as upland migratory bird habitat.

***Similar Projects:*** The Essex County Demonstration Farm is operated by the Essex Region Conservation Authority and Essex Soil and Crop Improvement Association in partnership with more than 30 organizations and individuals. The Johnson Farm in Kent County is a Land Conservation Model. The Sinclair-Campbell Ducks Unlimited project demonstrates conservation tillage and a variety of other conservation techniques to reduce impact of soil erosion and run-off into neighboring Big Creek and Long Point marshes.



### 11. CUYAHOGA RIVER RAP URBAN STREAM RESTORATION, Cleveland, Ohio

***Project Type:*** new tool/technology demonstration, restoration, education/outreach

***Project Goals:*** Innovative soil bioengineering techniques for stream and riparian zone restoration will restore fish and wildlife habitat as well as reduce pollutant loadings from urbanized areas within the Cuyahoga River Area of Concern.

***Project Status:*** *ongoing*

***Narrative:*** The Cuyahoga River suffers from a loss of biodiversity as evidenced in historical data on fish populations documented in the Cuyahoga River Remedial Action Plan. Sampling in the early 1990s showed significant progress toward recovery of aquatic habitat, however, conditions still do not meet the requirements for the state warmwater habitat designation. The greatest stresses to wildlife habitat and impacts to biodiversity are habitat destruction and the alteration of physical processes such as channelization, floodplain development, damming, etc. The consequence is the degraded riparian condition of the watershed including loss of streambank vegetation, loss of buffer zones, and accelerated stream bank erosion. This project is demonstrating effective streambank restoration using innovative soil bioengineering techniques in several communities throughout the Area of Concern. In addition, municipal engineers, planners, local decision makers and landowners are being shown the new technologies and benefits.

***Project Actions:***

- A series of workshops were held to teach local engineers, planners and decision makers to use bioengineering techniques to restore degraded streambanks.
- Demonstration projects were implemented at several sites throughout the Area of Concern.
- A homeowner/backyard stewardship program will be developed and implemented to teach residents about the restoration projects and to convey the importance of protecting the riparian zone.

***Project Partners:*** Biohabitats, Inc., Cuyahoga River Community Planning Organization, City of Cleveland, City of Seven Hills, Cleveland Metroparks, Environmental Design Group, Inc, Metroparks Serving Summit County, Cuyahoga and Summit Soil and Water Conservation Districts, Municipal Engineers Association of Northeast Ohio, Northeast Ohio Areawide Coordinating Agency, Northeast Ohio Four County Planning and Development Organization, Northeast Ohio Regional Sewer District, Ohio Environmental Protection Agency, Natural Resource Conservation Service, Ohio Department of Natural Resources, U.S. Army Corps of Engineers, U.S. EPA, Village of Highland Hills.
***Additional Needs:*** Project action one is completed. Project actions two and three are in progress. Additional funding will be needed for streambank restoration beyond the demonstration phase to restore as much of the Cuyahoga River as possible.

### 12. D'AUBIGNY CREEK RESTORATION, Ontario

***Project Type:*** assessment/research, restoration, monitoring
***Project Goal:*** Watershed rehabilitation to increase stream velocity, stabilize banks and remove barriers to fish movement.
***Project Status:*** *complete*
***Narrative:*** Like many streams in southern Ontario, D'Aubigny Creek was degraded by poor agricultural practices, railways, urban development and beavers, all of which left a heavy accumulation of sediment on the streambed, eroded banks, decreased stream flow and warmed stream temperatures. Extensive rehabilitation has occurred along the entire length of the stream through a community-based partnership. Stream temperatures decreased, sand and silt were flushed from the substrate, water quality has improved and trout are found in a larger portion of the creek.



***Project Actions:***

- A stream assessment showed that the creek's potential for fisheries habitat improvements was excellent due to the existing groundwater resources.
- Pauline Johnson Collegiate Vocational School incorporated the rehabilitation of D'Aubigny Creek into their grade 12 Environmental Studies curriculum.
- Students have removed flow impeding debris from the stream and built bank stabilization structures out of logs.
- 51 tonnes of rock was placed in the stream to build vortex weirs and meander the creek channel.
- Students also planted trees along the stream establishing and expanding buffer strips.
- The Brantford Steelheaders built lunker structures for fish cover, added cobble to the stream, planted trees and removed instream debris.
- The project has also included a comprehensive monitoring program in order to assess changes in the entire creek ecosystem. Habitat assessment, stream temperature, fish population, water quality, stream channel characteristics and flows have been monitored by the Steelheaders and other community partners, since 1990.

***Project Partners:*** Pauline Johnson Collegiate Vocational School, Brantford Steelheaders, Grand River Conservation Authority, Ministry of Natural Resources, Brant Nature Club, Environmental Youth Corps, Brant Waterways, Canada Trust - Friends of the Environment Foundation, Izaak Walton Flyfishers Club (Toronto), Ministry of Natural Resources Community Fisheries Involvement Program.
***Additional Details:*** This creek flows into the Grand River, a major tributary of Lake Erie.
***Similar Projects:*** Stream buffers, streambank stabilization projects, restoration and in-stream improvements have been undertaken in numerous locations across the Lake Erie watershed, particularly in Norfolk County where development and intense agriculture historically degraded conditions.

### 13. DETROIT RIVER CANDIDATE SITES FOR HABITAT PROTECTION AND RESTORATION, Michigan

***Project Type:*** inventory, assessment/research

***Project Goal:*** To inventory and describe the physical characteristics of remaining habitat for fish and wildlife in the Detroit River.

***Project Status:*** *ongoing*

***Narrative:*** Through field surveys and low-altitude aerial photography, remaining habitat for fish and wildlife in the Detroit River will be inventoried. Candidate sites will be placed into two categories: functional habitat to be protected from impairment, and impaired, non-functional, habitat to be restored and enhanced. Green areas not converted to other land uses will be located along the riverfront in Michigan waters and further characterized and investigated using field surveys and conversations with local residents. All candidate sites will be ranked in order of priority. Recommendations for protection and existing restoration measures will be outlined.

***Project Actions:***

- Determine the number, location, and extent of remaining functional and impaired candidate sites of fish and wildlife habitat.
- Characterize the sites' present fish and wildlife resource value and function.
- Evaluate the potential of each site for protection and remediation.
- Prioritize sites in functional and impaired categories for remediation using existing ranking system.

***Project Partners:*** U.S. Fish and Wildlife Service, Ducks Unlimited, Grosse Ile Nature Conservancy and Land Trust, Grosse Ile Conservation Club, Trenton Sportman Club, Downriver Walleye Federation, American Heritage River Initiative, Midwest Natural Resources Group, Waterways for Wildlife Project.

***Additional Needs:*** Funding will be needed to implement restoration of the priority sites.



### 14. DETROIT RIVER LAKE STURGEON PROJECT, Michigan

***Project Type:*** assessment/research, inventory

***Project Goal:*** A comprehensive rehabilitation plan for Detroit River lake sturgeon.

***Project Status:*** *ongoing*

***Narrative:*** Because lake sturgeon live a long time and are bottom feeders, they are a potential indicator species for monitoring tissue contaminant levels and fish habitat. The Detroit River and sediments are heavily contaminated and fish habitat is impaired. Little is known about remnant Detroit River lake sturgeon populations. Understanding lake sturgeon population dynamics, habitat requirements at all life stages, and the dynamics between sturgeon and contaminant levels will provide the basis for a comprehensive plan to rehabilitate lake sturgeon populations. If the lake sturgeon and its habitat can be rehabilitated, the resulting benefit to Detroit River fisheries in general will be a targeted approach to eliminating beneficial use impairments to fish and wildlife habitat.

***Project Actions:***

- Gather lake sturgeon spawning, nursing, feeding, resting and migration information in the Detroit River in order to determine habitat needs.
- Evaluate the physical, chemical, and biological aspects of current or potential lake sturgeon habitat in the Detroit River.
- Research how exposure to contaminated sediments affects sturgeon growth and survival.
- Formulate a restoration plan for lake sturgeon in collaboration with regional fishery management authorities.

***Project Partners:*** U.S. Geological Survey/Biological Resources Division, U.S. Fish and Wildlife Service, Great Lakes Fishery Commission, Michigan Department of Natural Resources, Ontario Ministry of Natural Resources.

***Additional Needs:*** Funding has been secured for initial research for the first action. This will be completed in 2002. Additional funding will be needed for the three other actions.

### 15. DEVELOPMENT OF A CONSERVATION ETHIC IN THE OAK OPENINGS, Ohio

***Project Type***: education/outreach
***Project Goal:*** To increase the awareness of the Toledo public regarding the Oak Openings natural areas.
***Project Status:*** *ongoing*
***Narrative:*** This project will: develop and implement a marketing and outreach campaign which evaluates the awareness and knowledge level of local residents regarding the Oak Openings; develop a professional marketing strategy and campaign to inform and engage local residents as to the importance of the Oak Openings as a unique natural area; implement an Oak Openings marketing campaign; conduct a market evaluation to gauge effectiveness; and, restore two to three small sites as visual examples of the messages disseminated through the marketing campaign.
***Project Partners:*** The Nature Conservancy.

### 16. ESSEX REGION BIODIVERSITY CONSERVATION STRATEGY, Ontario

***Project Type*:** restoration
***Project Goal***: To identify high priority habitat restoration sites for the Essex region, and develop and implement restoration plans for these sites.
***Project Status:*** *ongoing*
***Narrative:*** Through remote sensing and field surveys, remaining fish and wildlife habitats have been identified and mapped for parts of the Essex region's Lake Erie watershed; unmapped areas are presently being mapped. Using known ecological principles, high priority restoration and enhancement opportunities are identified. These opportunities, when implemented, will confer an immediate and significant benefit to the biodiversity and ecosystem health of the local landscape. Once high priority sites are identified, landowner agreements are obtained, restoration plans are developed, and implementation is undertaken.
***Project Actions:***
- Determine the location and extent of remaining fish and wildlife habitats.
- Identify high priority fish and wildlife habitat enhancement opportunities.
- Provide associated recommendations regarding relative priority of habitat types for restoration, habitat targets, etc.

***Project Partners:*** Essex Region Conservation Authority, Environment Canada, Canada Trust Friends of the Environment Foundation, Essex County Stewardship Network, Ontario Ministry of Natural Resources, Ontario Ministry of the Environment, Ducks Unlimited Canada, University of Windsor, Essex County Field Naturalists Club, Citizens Environment Alliance, CAW Windsor Regional Environmental Council, Essex County Federation of Agriculture, Essex County Woodlot Owners Association, Little River Enhancement Group, Project Green, Canadian Wildlife Service, Carolinian Canada, County of Essex, City of Windsor, Town of LaSalle, Town of Amherstburg.
***Additional Needs:*** Funding for ongoing restoration projects at high priority sites.

### 17. FRIENDS OF WATERSHEDS PROGRAM, Ontario

***Project Type:*** restoration, protection, planning/coordination/collaboration, education/outreach
***Project Goal:*** Coordination and support for grassroots watershed groups.
***Project Status:*** *ongoing*
***Narrative:*** The Friends of Watersheds program provides central coordination and support for grassroots Friends of Watersheds groups throughout the Essex region. Volunteer habitat restoration and enhancement projects (e.g. cleanups, tree plantings, etc.) are also undertaken through this program. Funding for the program presently expires early in 2000.
***Project Partners:*** Essex Region Conservation Authority, Friends of Watersheds.
***Project Needs:*** Approximately $52,000 per year.

## 18. GRAND RIVER LOWLANDS TACTICAL PLAN, Ohio

***Project Type:*** protection, restoration, planning/coordination/collaboration

***Project Goal:*** To conserve and enhance wildlife diversity, wetland and riverine habitats, and increase recreational opportunities, utilizing a watershed approach, in the Grand River, Ohio Lowlands.

***Project Status:*** *ongoing*

***Narrative:*** The Grand River Lowlands in Northeast Ohio is a unique ecosystem with relatively undisturbed natural communities. Some of Ohio's highest quality wetlands, an intact riparian corridor, and the highest diversity of fish and mussels of any river of its size in the Lake Erie basin, characterize the ecosystem. Wildlife species abound. State endangered species such as the river otter, eastern massasauga rattlesnake, northern brook lamprey, and Great Lakes crayfish inhabit the lowlands along with neotropical migrant birds and 115 species of nesting birds, 375 species of macroinvertebrates, 18 species of reptiles, and ten species of amphibians. State endangered plant species such as Clifton's wood fern and thin-leaf sedge are also present at the Grand River Wildlife Area. The water quality benefits of the lowlands for aquatic species and for Lake Erie are immense. Development stemming from the Cleveland area is the single largest threat to the habitat and wildlife of the Grand River Lowlands. Protected in part by designations that underscore its uniqueness, such as Ohio Scenic River and Exceptional Warmwater Habitat, the lowlands are the focus of a multi-organizational partnership to protect its natural resources.

***Project Actions:***

- By 2005, the acreage of protected habitat will increase by 50% (approximately 4500 acres) over 1998 statistics.
- By 2005, recreational use will increase by 25% over 1997 statistics from the *Socio-Economic Study of Ohio's Wildlife Areas*.
- By 2005, the protected riparian corridor will increase by 50% (approximately 5 miles) over 1998 statistics.



***Project Partners:*** Ashtabula Metroparks, Ashtabula Soil and Water Conservation District, Cleveland Museum of Natural History, Cooperative Extension Service, Geauga Metroparks, Geauga Soil and Water Conservation District, Headwaters Land Trust, Lake Metroparks, Lake Soil and Water Conservation District, Natural Resource Conservation Service, Ohio Department of Natural Resources, Ohio Environmental Protection Agency, The Nature Conservancy, Trumbull Soil and Water Conservation District, U.S. EPA, Western Reserve RC&D, other individuals, clubs, and local organizations.

***Additional Needs:*** All project actions are in progress. Under each are a number of strategies that will need support in order to meet the year 2005 objectives.

## 19. GREAT LAKES GREENNESS PROJECT

***Project Type:*** monitoring

***Project Goal:*** Analyze land use changes in the Great Lakes basin over three decades.

***Project Status:*** *ongoing*

***Narrative:*** An analysis of three decades of satellite imagery of the Great Lakes basin is resulting in insights into land use changes. Maps will show increases and decreases in farm land, forests, and urban areas as well as trends. Results will be reported at the State of the Lakes Ecosystem Conference (SOLEC) in Fall 2000.

***Project Partners:*** U.S. Environmental Protection Agency.

## 20. HABITAT DEVELOPMENT ON INDUSTRIAL AND PRIVATE PROPERTY: ST. CLAIR RIVER WATERWAYS FOR WILDLIFE PROGRAM, Michigan, Ontario

***Project Type:*** restoration, planning/coordination/collaboration

***Project Goal:*** Ongoing voluntary cooperative habitat enhancement efforts along the St. Clair River by private landowners, particularly industry, to contribute to the long-term health of wildlife habitats and populations.

***Project Status:*** *ongoing*

***Narrative:*** Through the Waterways for Wildlife Program, the Wildlife Habitat Council (WHC) is working with industries and organizations along the St. Clair River to establish an international watershed management plan for the river. The project is designed to promote voluntary, cooperative habitat enhancement efforts initiated by WHC member corporations along the river corridor. These efforts are being used as models to encourage participation from neighboring public and private land managers. The program is focusing on engaging corporate and private landholders to manage their properties to achieve the project objectives as identified by general program participants. One example of a project is the reforestation of the Darcy McKeough Floodway Channel. Project participants are protecting and enhancing habitat along the river, using scarce financial resources more efficiently, contributing to the long-term health and viability of the river, and providing productive habitat for riparian, upland, and prairie-associated wildlife.

***Project Actions:***

- The Wildlife Habitat Council continues to engage industries and organizations along the St. Clair River to participate in managing the river according to an international watershed management plan.
- Projects to implement the plan will focus on accomplishing various habitat and wildlife objectives.



***Project Partners:*** Wildlife Habitat Council, Detroit Edison, Ontario Hydro, Terra International, Consumers Power, Ford Motor Company, and other corporate and conservation groups.

***Additional Needs:*** Both project actions are ongoing with needs for additional partners as well as specific projects.

## 21. LAKE ERIE GRASSLANDS, Ohio

***Project Type:*** restoration

***Project Goal:*** 800 acres of restored native prairie grassland.

***Project Status:*** *ongoing*

***Narrative:*** The project will seed 800 acres of native prairie grasses in Erie, Ottawa, and Sandusky Counties in Ohio. The plantings will be done on properties owned by approximately 50 individuals. The local chapter of Pheasants Forever will provide the seed, labor and equipment to do these planting. An evaluation of the plantings will be done in the fall of 1999 by the Natural Resources Conservation Service, the Ohio Division of Wildlife, and the Chapter to see that adequate stands of these grasses are established. Should these stands not be adequate, they will be re-seeded by the Chapter. This restoration project will reduce soil erosion, improve water quality, increase biodiversity, and improve wildlife habitat (particularly for declining grassland bird species).

***Project Partners:*** Natural Resources Conservation Service, Ohio Department of Natural Resources, Pheasants Forever.

## 22. LONG-TERM NONPOINT POLLUTION ABATEMENT BY A LAKE ERIE MARSH AND ITS IMPLICATIONS FOR WETLAND RESTORATION POLICIES, Ohio

***Project Type:*** assessment/research

***Project Goals:*** To determine the long-term effect of agricultural runoff on the assimilative capacity of two Lake Erie marshes. Target analytes were those that have a negative impact on water quality in the littoral and open water zones of Lake Erie: sediment, carbon, organic matter, nitrogen, phosphorus, and selected pesticides (aldrin, dieldrin, endrin, endrin aldehyde, DDT and metabolites, and three hexachlorobenzene pesticides (HCHs)). To examine the value of wetlands in terms of mitigating the impacts of nonpoint source pollution on downstream habitats, rather than on NPS pollution impacts to the wetland habitat itself.

***Project Status:*** *complete*

***Narrative:*** This project is based on the premise that programs of wetland acquisition and management designed to emphasize water quality benefits of marshes, should be based on long-term information on contaminant assimilation by wetlands. Current land use practices generally divert nonpoint source runoff around marshes via ditches that discharge to Lake Erie. On the basis of scientific research showing how draining agricultural runoff through marshes abates pollution, the Winous Point Shooting Club breached its dikes to allow more runoff to flow through it rather than around it. The sustained ability of wetlands to remove pollutants during many decades is poorly documented. The long-term record of material transfer between water and sediment may be preserved in the sediment stratigraphy. These issues were addressed in a study of two marshes along the southwestern shore of Lake Erie, by analyzing accumulation records of sand-silt-clay, total phosphorus (TP), organic matter, metals and pesticides preserved in four sediment cores. The two marshes, North Marsh (260 ha) and West Marsh (220 ha), have been managed in the same fashion by the Winous Point Shooting Club for the past 150 years, except that the west marsh has been free from runoff since 1978. These wetlands are classified as palustrine emergent marshes and are dominated by persistent emergents, trees and shrubs. Their agricultural watersheds have been in use since the mid-19th century and are poorly drained. Both marshes have been protected by dikes from the high-energy open-lake environment since ca. 1920 and are situated between agricultural land to the north and Muddy Creek Bay to the south. This bay drains into Sandusky Bay and thus into Lake Erie.



***Project Actions:***

- Soil data and land use within the marsh watersheds was obtained from quadrangle maps and digitized for use in a GIS application.
- Two cores were taken from each marsh, core chronology was documented, and chemical analyses of the core were performed.
- Nutrient, organic matter, and sediment accumulation rates were calculated for each marsh.
- Pesticide concentration profiles were generated.

***Results:*** Land use practices in the watershed of either marsh changed little since 1950. There was only slight evidence for separating pre-European agricultural deposits from more recent sediments. Phosphorus accumulation during the last 10 years in the North Marsh more than tripled compared with the accumulation rates during the 1920-1977 interval. The pesticide data from Winous Point showed variations of aldrin, endrin, HCHs, and DDT with depth that can be attributed to agricultural use. High concentrations of HCHs and endrin in West Marsh sediments since the mid-1960s point to a possible airborne source. There appeared to be a delay between pesticide application and deposition in the marshes. The continued ability of the North Marsh to sequester phosphorus from agricultural runoff suggests that marshes can play an important role in removing excess phosphorus over the long term. Marshes may also remove carbon and nitrogen from runoff.

***Project Partners:*** Winous Point Shooting Club, J.F. Gottgens, A.L. Spongberg, and B.E. Muller, University of Toledo.

***Additional Needs:*** Although this project is complete, some future needs were identified. Only those that apply to the LaMP habitat restoration context are included. Long-term, real-time research on nutrient and contaminant budgets in Laurentian marshes, linking sedimentary signals to a record of concentrations of target analytes in inflows and outflows, is needed. Pesticides that have been banned appear to still be entering the marsh. Therefore,

continued monitoring for these compounds is recommended. Although the project results make the anecdotal observation that the use of these marshes to trap phosphorus from runoff does not seem to impact the use of these marshes by waterfowl and wildlife, this was not specifically studied in this project. The LaMP would benefit from knowing if any of the pollutants, not just phosphorus, trapped in these wetlands are adversely impacting wildlife from the perspectives of use, reproduction, and/or bioaccumulation.

### 23. MANAGING AGRICULTURAL DRAINS TO ACCOMMODATE WILDLIFE - JAMES BERRY DRAIN PROJECT, Ontario

***Project Type:*** restoration, monitoring

***Project Goal:*** To provide an opportunity to incorporate the needs of fish and wildlife into drain design and maintenance.

***Project Status:*** *complete*

***Narrative:*** Agricultural drains are integral features of much of southwestern Ontario's farmlands. This Norfolk County demonstration project incorporates habitat-enhancing methods of maintaining or improving a drainage outlet, while reducing or minimizing costs. Fish and wildlife habitat features are enhanced and protected by buffer strips and rock chutes for bank erosion control. The drain is a warm water fishery that supports spawning pike. The site provided an opportunity to monitor the effectiveness of the buffer strips and investigate different maintenance techniques.

***Project Actions:***

- An Engineer's report under the Drainage Act identified a number of unique features for this six kilometre drain emptying into Big Creek Marsh (Class 1 wetland).
- The report included 9 metre wide continuous buffer strips, sediment basins, a retention pond with a water control structure, and a fish bypass.
- The performance of the retention pond in reducing sediment delivery to an adjacent 10 acre marsh was evaluated.
- The use of the buffers by wildlife species and waterfowl was also monitored.



***Project Partners:*** Ontario Soil and Crop Improvement Association, Canadian Wildlife Service, Township of Norfolk, Long Point Region Conservation Authority, Ministry of Natural Resources, Long Point Bird Observatory, Wetlands/Woodlands/Wildlife Program - Canada/Ontario Agriculture Green Plan of Agriculture and Agri-Food Canada in co-operation with the Ontario Ministry of Agriculture, Food and Rural Affairs, National Soil Conservation Program, Murray Marsh Club.

***Additional Details:*** This project is enhanced by neighbouring projects. An adjacent area features conservation tillage, and has had warm-season native grasses sown for wildlife habitat. To the west, another project includes a 3500' grassed waterway with two rock chutes and a series of catch basins installed in an agricultural field to intercept surface water flow. An outlet for the basin is provided by underground tile extending the full length of the waterway. To the east, a project undertakes upland restoration using native trees, shrubs, wildflowers and grasses. An existing 10-acre wetland is enhanced to create hemi-marsh conditions providing nesting habitats for water birds and staging habitat for waterfowl.

***Similar Projects:*** Across Lake Erie's Ontario watershed, a number of projects similar to the above have been completed. In Kent County on the Rondeau Bay watershed, the John Clark Drain, an eroding watercourse in a cattle pasture, was successfully rehabilitated. The watercourse was regraded, eroding slopes were stabilized with a live-staked armoured mattress system, willow fascines installed at bases of eroded areas with red-osier dogwood brushlayer upslope. Vortex weirs were placed in-stream; all exposed soils were re-seeded with a mix including annual grasses and Canada wild rye. There have been at least six similar drain modifications completed in Essex County, four in Norfolk, and others in Elgin, Oxford and Kent Counties.

### 24. MARSH MONITORING PROGRAM, Long Point, Ontario

***Project Type:*** monitoring, assessment/research, education/outreach

***Project Goals:*** To provide baseline information on the population status of Great Lakes marsh birds and calling amphibians and assess their habitat requirements and in so doing contribute to evaluations that lead to the recovery of Areas of Concern.

***Project Status:*** *ongoing*

***Narrative:*** The Marsh Monitoring Program began in 1995 to: provide information about coastal and inland marsh birds and amphibians; contribute to the evaluation of highly degraded coastal and Great Lakes Areas of Concern; improve understanding of the habitat associations of wetland birds and amphibians; and involve skilled and motivated citizens in monitoring and conserving their local wetlands. Marsh birds and amphibians are significant components of coastal wetland ecosystems. Many may be locally or regionally in decline because of habitat degradation. With the help of volunteers from all over the basin, surveys of marsh birds and calling amphibians, as well as habitats, are taking place annually. The surveys are conducted using standardized protocols. Data is analyzed and conveyed to citizens binationally through a website, public presentations, and articles in newspapers and magazines. Since the Marsh Monitoring Program has established credible monitoring protocols, it will be responsible for reporting on two Great Lakes basin indicators of health at the binational State of the Great Lakes Ecosystem Conferences (SOLEC).

***Project Actions:***

- Solicit and train volunteers from areas of concern all over the Great Lakes basin to properly monitor marsh birds and/or calling amphibians.
- With volunteers, plot survey routes in each of the areas of concern.
- Collect survey data and maintain over the long term in order to measure trends.
- Analyze marsh bird and calling amphibian data to determine abundance and diversity in Great Lakes basin area of concern wetlands.
- Communicate results of the data analysis back to the volunteers and to resource managers.

***Project Partners:*** Bird Studies Canada, Environment Canada, Great Lakes Protection Fund, U.S. Environmental Protection Agency, volunteers from around the Great Lakes basin.

***Additional Needs:*** This long-term ongoing project needs consistent funding. For assisting the LaMP in setting management goals and measuring progress toward restoration of beneficial uses, it would help to establish consistent representative sites for monitoring.



### 25. MIGRATORY BIRD HABITAT – BIRD STUDIES CANADA HEADQUARTERS, Ontario

***Project Type:*** restoration

***Project Goal:*** To enhance an exisiting 10-acre wetland, creating hemi-marsh conditions which provide nesting habitats for water birds and staging habitat for waterfowl.

***Project Status:*** *complete*

***Narrative:*** This property is in the Dedrich Creek watershed, where other land uses include a golf course and a cemetery, making this a unique opportunity for naturalizing part of a tributary of the Long Point Inner Bay.

***Project Actions:***

- An extensive management plan for the property phased out agricultural fields.
- Water levels are manipulated when possible to provide exposed substrate in the upper end of the wetland during spring and late summer shorebird migration.
- Annual aquatic plants provide feeding opportunities for waterfowl and other birds in the fall.
- The manipulation of water levels also improves vegetation diversity and interspersion.
- Plantings of native trees, shrubs and grasses focus on interspersion among vegetation types and creation of dispersion corridors for migrant land birds.

***Project Partners:*** Bird Studies Canada, Norfolk Field Naturalists, Ontario Heritage Foundation, Nature Conservancy of Canada, Long Point Region Conservation Authority, Ministry of Natural Resources, Environment Canada, Norfolk Land Stewardship Council, Ducks Unlimited.

***Additional Details:*** The wetland perimeter will be enhanced by upland restoration using native trees, shrubs, wildflowers and grasses.
***Similar Projects:*** Wetland enhancement projects, typically including tree plantings and wild rice establishment, are undertaken in a number of locations in the watershed, including campgrounds and sportsmen's clubs.

### 26. NEARSHORE HABITAT PRIORITIES FOR MIGRATORY SONGBIRDS, New York

***Project Type:*** inventory, assessment/research, new tool/technology demonstration
***Project Goal:*** Maps that identify key migratory songbird concentrations in nearshore habitats along the eastern Lake Erie and Lake Ontario shorelines. These maps will help determine habitat conservation priorities.
***Project Status:*** *ongoing*
***Narrative:*** Because the Great Lakes are barriers to migrating songbirds, nearshore habitats function as stopover areas. Not all shoreline stopover areas are of equal importance. Furthermore, stopover areas frequented by a great number of songbirds may not be of high quality, offering little in the way of energy replenishment. Using a remote sensing technique called Doppler radar, concentrations of songbirds along eastern Lake Erie and Lake Ontario are being identified. Subsequent to identification, songbirds will be captured to determine stopover length and the quality of the habitat as it relates to energy replenishment. The high quality habitats will be identified, prioritized and the information disseminated to be used for conservation planning. Planning efforts will be better able to target areas where beneficial uses are impaired.
***Project Actions:***
- Inventory migratory bird concentration areas in nearshore habitats.
- Assess stopover length and the changes in the condition of birds in different shoreline types.
- Incorporate information into regional conservation plans.

***Project Partners:*** SUNY-College of Environmental Science and Forestry, Braddock Bay Bird Observatory, Genesee Land Trust, SUNY-Brockport, Clemson University, Bird Studies Canada, New York State Department of Environmental Conservation.
***Additional Needs:*** The first two actions are in progress and expected to be completed in 2002. Additional resources will be needed to disseminate the information and incorporate it into regional conservation plans.

### 27. OJIBWAY PRAIRIES AND SAVANNAHS, Windsor, Ontario

***Project Type:*** protection, education/outreach
***Project Goal:*** Protection of the fragile prairie and savannah ecosystems and resident rare plant and animals populations while providing public access.
***Project Status:*** *ongoing*
***Narrative:*** The greatest challenge facing the Ojibway Prairie and Savannah Complex is changing the public's perception of nature by providing access to natural areas, while protecting fragile and globally rare plants and animals. Intensive human activities in and around the park have put stress on rare prairie and savannah habitats and consequently on the wildlife dependent on them. Public relations and education programs aimed at local residents have brought people to the complex to explore and learn about the diversity of plant and animal life that is thriving in this urban area. Neighbors are participating in naturalist field trips, bird-watching tours, and seasonal festivals, all designed to offer opportunities to learn about how ecosystems function and contribute to the health of the greater Lake Erie watershed.
***Project Actions:***
- Continue to manage Ojibway Prairie and Savannah Complex for its biodiverse plant and animal populations and to maintain the functioning of these rare ecosystems.
- Offer opportunities for the public to take part in nature-oriented activities.

***Project Partners:*** Ojibway Nature Centre and Complex, Windsor Department of Parks and Recreation, Ontario Ministry of Natural Resources.

***Projects Needs:*** Both project actions are ongoing and long-term and will require continued funds to maintain operations.

### 28. PENN SOIL RIPARIAN CORRIDORS, Pennsylvania

***Project Type:*** restoration
***Project Goal:*** Restored Lake Erie watershed tributaries that contribute to the health of native wildlife species and the lake itself.
***Project Status:*** *ongoing*
***Narrative:*** One of the major agricultural enterprises within the Lake Erie drainage basin is dairying. Stream watering for livestock is an age-old practice for area farmers. This direct access of the cows to the streams provides the opportunity for direct discharge of manure and soil erosion from the banks of the streams. The consequences are pollution of the waterway and the destruction of the ecosystem, including 20% of Pennsylvania's rare and endangered plant species, along the stream and tributaries leading to Presque Isle Bay and Lake Erie. Through landowner contact, progress is being made in restoring riparian corridors leading to Lake Erie. Using fencing, cattle are being kept from streams. Streambanks are then being replanted with native species. The result is habitat for a variety of wildlife species, including songbirds and waterfowl.
***Project Actions:***
- Fencing to exclude cattle from streams will be installed at selected sites pending landowner involvement.
- Degraded ecosystems within the Lake Erie watershed will be restored, including the reestablishment of indigenous plants along the riparian corridors of the tributaries to Lake Erie.

***Project Partners:*** Crawford Conservation District, Erie Conservation District, Natural Resource Conservation Service, Penn Soil RC&D, U.S. Environmental Protection Agency.
***Additional Needs:*** The above two action items are pilots. Additional resources will be needed to carry out the fencing and the restoration on additional sites.



### 29. PLANT COMMUNITY SURVEY OF OHIO'S LAKE ERIE DRAINAGE, Ohio

***Project Type:*** inventory
***Project Goal:*** Identification of plant communities in the Lake Erie drainage of Ohio in order to better set priorities to protect habitat for rare plants.
***Project Status:*** *complete*
***Project Narrative:*** Prior to this project, the classification of plant communities in the Lake Erie drainage of Ohio was incomplete or preliminary. Most natural communities have been transformed by timbering, agriculture, and urban and industrial development, leaving few known high quality areas for the state's rare plants. This complete survey of plant communities is helping resource managers to set priorities for habitat protection that will benefit Ohio's rare plants.
***Project Actions:***
- Review all plant community records.
- Conduct plant community surveys to document additional sites.
- Rank plant communities to assess their conservation priority as rare plant habitat.

***Project Partners:*** Ohio Division of Natural Areas and Preserves, The Nature Conservancy Great Lakes Program.

### 30. PORTAGE RIVER WATERSHED IMPROVEMENT PROJECT, Ohio

***Project Type:*** restoration
***Project Goal:*** Improved water quality along the Portage River.
***Project Status:*** *ongoing*
***Narrative:*** A $300,000 grant was given to the Toledo Metropolitan Council of Governments to provide incentives to landowners to install filter strips to prevent erosion along the Portage River. Water quality is expected to improve as a result.
***Project Partners:*** Toledo Metropolitan Council of Governments, Ohio Environmental Protection Agency, Portage River Basin Council.

### 31. RE-ESTABLISHING THE FRESHWATER UNIONID POPULATION OF METZGER MARSH, Ohio

***Project Type:*** restoration
***Project Goal:*** The re-establishment of a viable native clam community in Metzger Marsh.
***Project Status:*** *ongoing*
***Narrative:*** One of the most devastating ecological problems resulting from the invasion of the non-indigenous zebra mussel has been the virtual elimination of native unionid clams. A large population of native clams was discovered in Metzger Marsh in 1996 after dewatering to replace an eroded dike. During dewatering, the clams were removed and placed in aquaria. Further field observations and laboratory experiments showed that warm summer water temperatures and soft, silt-clay sediments common to wetlands trigger complete burrowing of the clams. This provides spatial separation that discourages the zebra mussels from infesting and serves as a physical cleansing mechanism to remove any encrusted zebra mussels. Recent surveys failed to find any live unionids outside of the marsh in the littoral zone of western Lake Erie. This project is returning the 21 species of native clams to Metzger Marsh with access to Lake Erie. Wetlands such as Metzger Marsh may provide a refugia for maintaining native clam stocks in waters colonized by zebra mussels.



***Project Actions:***
- The adult clams originally collected before dewatering were measured and tagged in order to monitor their rate of survival.
- Growth rates of young native clams were monitored and will be compared to that of clams released back into the marsh.
- Reproductive capability will be monitored for at least two years after reintroduction to the marsh.
- Successful recruitment of juveniles into the marsh will be monitored.

***Project Partners:*** U.S. Geological Service, Biological Resources Division
***Additional Needs:*** The original project will be completed in 2000; however, additional monitoring for long-term success will be needed for several years.

### 32. RESTORATION OF HABITAT AT PRESQUE ISLE, Pennsylvania

***Project Type:*** restoration
***Project Goal:*** The wetlands and dunes of Presque Isle will be restored to support healthy bird, amphibian and insect populations.
***Project Status:*** *ongoing*
***Narrative:*** Presque Isle's 3200 acres of wetlands and dunes have been impacted by a variety of invasive plant species including tree of heaven, European white birch, Japanese bittersweet, hairy willow herb, Japanese bush honeysuckle, purple loosestrife, Eurasian watermilfoil, reed canary grass, *Phragmites*, curly pondweed, narrow-leaved cattails, and hybrid cattails. The invasions have turned species-rich habitats into monocultures or habitats for just a few species that crowd out native species. The result is a diminishment or fragmentation of healthy habitats for native wildlife. Eliminating non-indigenous invasive species from Presque Isle is restoring and enhancing wetland and dune habitat for native bird, amphibian and insect populations, and preventing further loss of wildlife habitat.
***Project Actions:***
- Draft a plan that addresses control techniques for management units on Presque Isle.

- Use a variety of eradication techniques such as burning, cutting, hand removal, and herbicides to eliminate non-indigenous invasive species from wetland and dune habitats.
- Monitor the effects of eradication techniques on native plant species.
- Monitor the effects of healthier wetland and dune habitats on bird, amphibian and insect populations.

***Project Partners:*** Presque Isle Partnership, Pennsylvania Department of Conservation and Natural Resources, Mercyhurst College, Cleveland Museum of Natural History, Penn State University.

***Additional Needs:*** A plan (Action 1) is in place and eradication at specific sites (Action 2) has occurred. Additional funds are needed to completely eradicate non-indigenous invasive species throughout Presque Isle and monitor the effects on native plant species and on bird, amphibian and insect populations (Actions 3 and 4).

### 33. RESTORING AN ENDANGERED SPECIES TO MIDWEST OAK OPENINGS, Toledo, Ohio

***Project Type:*** restoration, new tool/technology demonstration, education/outreach

***Project Goals:*** Sufficient habitat to reintroduce the endangered Karner blue butterfly, extirpated from the Toledo, Ohio area since 1989.

***Project Status:*** *ongoing*

***Narrative:*** The Karner blue butterfly was extirpated from Toledo, Ohio in 1989 because of the loss of its primary habitat, oak openings. Oak openings are globally imperiled communities that support a diversity of plants and animals. Even more significant, loss of oak openings has contributed to soil erosion and the resulting sedimentation of the Maumee River. In order to restore the integrity of remaining parcels of oak openings at various sites in the region, restoration has been initiated on more than 300 acres. Intensive land management will restore critical habitat components for the Karner blue butterfly. Reintroduction is expected by the year 2000. In addition to the Karner blue, the habitat is important for the frosted elfin and Persius dusky wing butterflies, both state endangered species. A targeted education outreach program is also being developed to promote stewardship of public lands in the Toledo area.



***Project Actions:***

- Using the latest ecological restoration technologies, more than 300 acres will be intensively managed, including invasive species removal, prescribed burning, and planting and seeding.
- Baseline community plots will be monitored for critical Karner blue habitat components and release sites selected.
- The Karner blue butterfly will be released and monitored as part of the endangered species plan.

***Project Partners:*** Toledo Metroparks, The Nature Conservancy, Ohio Department of Natural Resources, University of Toledo, Bowling Green State University, U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency.

***Additional Needs:*** Actions 1 and 2 are in progress. Monitoring of Karner blue for success after release and continued management of restored sites will require additional funds.

### 34. SPRINGFIELD TOWNSHIP NATIVE VEGETATION ENHANCEMENT PROJECT, Michigan

***Project Type:*** planning/coordination/collaboration

***Project Goal:*** To revise Springfield Township standards and ordinances so that native vegetation plantings are encouraged in planning for development.

***Project Status:*** *ongoing*

***Narrative:*** This is a habitat project in Springfield Township, Michigan. Springfield Township will work in five areas: 1) develop education materials about the project and the benefits of using native vegetation, and provide a system for information dissemination to developers, builders, landscape designers, suppliers and homeowners; 2) analyze existing Township standards and ordinances for possible conflicts with native vegetation enhancement goals;

3)develop proposed revisions to standards and ordinances that encourage integration of native vegetation into design and development practices, such as stormwater management; 4) develop proposed guidelines for the protection and re-use of existing native vegetation on sites being developed; and 5) develop a database of native plants appropriate for use in the Township and identify sources for these plants.
***Project Partners:*** Springfield Township, Oakland County, Michigan.

### 35. ST.CLAIR RIVER LAKEPLAIN PRAIRIE AND OAK SAVANNA ECOSYSTEM RESTORATION, Michigan

***Project Type:*** inventory/classification**,** planning/coordination/collaboration**,** restoration
***Project Goal:*** Restored lakeplain prairies and oak openings within the St. Clair River delta and the Algonac Area.
***Project Status:*** *ongoing*
***Narrative:*** The lakeplain prairies and oak openings within the St. Clair River delta and Algonac area are globally imperiled coastal communities. Less than 0.6 percent of Michigan's original lakeplain prairie and oak savanna communities remain. Several sites, including St. Clair Flats Game Area, Algonac State Park, and Dickinson and Harsens Islands, harbor state-endangered or threatened species (11 plants, 7 animals), and the federally threatened eastern prairie fringed orchid. This is one of the best opportunities for restoration of these community types. Restoration will benefit habitats closely associated with globally rare species particularly along the shoreline.
***Project Actions:***

- An inventory and monitoring plan for the natural areas of St. Clair Flats Game Area, Algonac State Park, and Dickinson and Harsens Islands is complete.
- Baseline inventories for plants and insects are being conducted.
- Restoration activities, including invasive species control and controlled burning, will begin once inventories are complete.
- Public education and volunteer stewardship training will be needed to accomplish restoration goals and raise public awareness of the resources.

***Project Partners:*** Michigan Natural Heritage Program, Southeast Michigan Planning Council of Governments, Michigan Waterways for Wildlife Council.
***Additional Needs:*** Additional resources are needed for stewardship training and material for public outreach.



### 36. TOUSSAINT RIVER IMPROVEMENT INCENTIVE PROGRAM, Ohio

***Project Type:*** restoration
***Project Goal:*** Improve the health of the Toussaint River by instituting conservation practices.
***Project Status:*** *ongoing*
***Narrative:*** This program offers financial incentives to install filter strips, set aside floodplain lands, and use conservation tillage practices to improve the health of the river by reducing sediment runoff and creating wildlife habitat.
***Project Partners:*** Maumee RAP, U.S. Environmental Protection Agency.

### 37. URBAN DYNAMICS OF LAND USE CHANGE AND SHORELINE DEVELOPMENT ALONG THE DETROIT RIVER, Michigan, Ontario

***Project Type:*** assessment/research, inventory/classification, education/outreach
***Project Goal:*** Measure historic and landscape changes and predict ecological and natural resource impacts of proposed projects in master plans already approved by jurisdictions along the Detroit River.
***Project Status:*** *ongoing*
***Narrative:*** Geographic analysis combines an understanding of the demographic, economic, social, and geographic history of a region with the quantitative assessment of the spatial patterns, trends and rates of land use change. While goals of this program emphasize present-day environmental issues and local concerns, the historical component is crucial to

understand how the modern urban environment evolved. By combining the analysis of urban land use change with historical and geographic information, an **urban biography** can be derived that integrates temporal layers of geographic information with the pace, patterns, and extent of the urbanization process. The resulting interpretation integrates factors that drive, enable, shape, constrain, and sustain specific land use practices and patterns, such as urban sprawl.

***Project Actions:***

- Document rates of changes in wetlands, farmlands, forests, and lakeplain prairie resulting from transformation of the natural landscape into an urban environment in the Detroit-Windsor corridor.
- Assess losses of fish habitat over time caused by changes in the channels of the Detroit River, including increased water depth and cross-sectional area, as a result of numerous navigation projects that deepened the river, armored the shoreline, and altered shallow, gradually-sloping, littoral areas.
- Educate the public about the influences of human immigrations, water level fluctuations, intensity of international trade, drainage laws, ship building, industrialization, wetland protection by private and public agencies, and modern transportation on land use changes, landscape morphology, and shoreline development.

***Project Partners:*** U.S. Geological Survey, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, International Joint Commission, Southeast Michigan Council of Governments, City of Detroit, City of Windsor, Essex Region Conservation Authority, Ontario Ministry of Natural Resources, Canada Fisheries and Oceans, Michigan Department of Natural Resources, Central Michigan University, Grosse Ile Township, Greater Detroit American Heritage Rivers.

## PRELIMINARY LIST OF PROPOSED PROJECTS

### 1. AQUATIC RENEWAL PROGRAM/COMMUNITY RIVER KEEPERS, Ontario

***Project Type:*** planning/coordination/collaboration, restoration, education/outreach
***Project Goal:*** A community-based rehabilitation initiative of restoration projects undertaken through voluntary action with funding and support and technical advice from dedicated staff.
***Project Status:*** *proposed*
***Narrative:*** The current demand for community groups to work on a "backyard resource" is huge. Agencies and public groups cannot meet the demand and interest in this type of effort. The public wants to be involved in local projects to improve water quality and build a sense of environmental and community responsibility. Previous efforts have been tremendously successful in developing local stewardship of these precious resources and a passion for working together for a common interest. Funding would be put into a coordinated, prioritized program to accommodate the level of interest. Areas where plans for watercourses or sub-watersheds are currently waiting to be implemented or have restoration initiatives begun would have the highest priority. The need to service this interest goes beyond the urban fringes of the middle Grand River and will continue to grow as the public realizes that technical advisors and funding are available.
***Project Partners:*** Grand River Conservation Authority.
***Project Needs:*** $150,000 for each of five years.

### 2. ATLAS OF BIODIVERSITY OF SOUTHEAST MICHIGAN WATERSHEDS: LAKE HURON TO LAKE ERIE CORRIDOR



***Project Type:*** inventory/classification, assessment/research, education/outreach
***Project Goal:*** To demonstrate the local and global significance of the biodiversity of the Lake Huron-Lake Erie corridor. To promote a broad-based understanding of the significance of the region's biodiversity.
***Project Status:*** *Proposed*
***Narrative:*** The Atlas will be a compendium of information about the ecology and geology of the watersheds of the St. Clair River, Lake St. Clair, and the Detroit River. It will explain the geology of the area and delve into the various plant communities, including wetlands, prairies, woodlands, and riparian and upland zones. It will describe pre-European settlement vegetation, give examples of those remnant plant communities still existing, and outline steps we can take to protect and restore the resource for the future. It will highlight how these areas serve as important habitat for wildlife, and describe how they are an essential convergence point for hundreds of thousands of waterfowl during their migration along both the Atlantic and Mississippi flyways.
***Project Actions:***

- Identify, survey, describe, and map existing vegetative features along the Huron/Erie corridor and Lake St. Clair.
- Describe the geology of the watersheds.
- Describe pre-European settlement vegetative conditions, and identify the remnants of these communities.
- Highlight and explain the importance of this region as a major migration flyway.
- Produce an atlas that will be widely distributed to the public.

***Project Partners:*** Wildlife Habitat Council, DTE Energy, U.S. Environmental Protection Agency, Michigan Department of Natural Resources, Michigan Natural Features Inventory, Greater Detroit American Heritage River Initiative, St. Clair River RAP, Clinton River RAP, Lampten Stewardship Network, City of Detroit, Great Lakes Commission, Environment Canada, Ontario Ministry of the Environment, Essex Region Conservation Authority.

### 3. ASSESSMENT OF MERCURY CONTAMINATION ON ENDOCRINE DISRUPTION AND REPRODUTION POTENTIAL OF LAKE TROUT, New York

***Project Type:*** assessment/research, inventory, restoration

***Project Goal:*** Identification of cause and effect relationship between mercury contamination and reproductive impairment.

***Project Status:*** *proposed*

***Narrative:*** One of the major environmental problems in the Great Lakes ecosystem is the potential ecological and human health impacts of chemicals that disrupt the endocrine system and the immune system through chemical messengers known as hormones. The endocrine system is a network of glands and organs regulating many biological functions, including growth, metabolism and reproduction. Chemicals that elicit endocrine-disrupting effects in animals include a wide range of organic compounds and pesticides. Although significant progress has been made in the rehabilitation of fish communities in the Great Lakes in the past 25 years, fishery management agencies have been stocking lake trout into the Great Lakes for several decades with little success. Lack of sustained natural reproduction of lake trout and other salmonids highlight the need for further rehabilitation. Several factors, including bioaccumulation of contaminants in these fishes have been suspected to be responsible for their lack of natural reproduction. Mercury is a potential endocrine disruptor in fish and is responsible for lakewide impairments in Erie. The proposed study will focus on the endocrine-disrupting effects of mercury, and the results will be used to develop a model to help fishery managers predict reproductive potential of lake trout in Lake Erie based on the fish's mercury burden. The results of the proposed study can also be used to refine the beneficial use impairment assessments in the Lake Erie LaMP.

***Project Actions:***

- Investigate the effect of methyl mercury on reproductive hormones (testosterone and estrogen) and reproductive success of lake trout used by the U.S. Fish and Wildlife Service and New York State Department of Environmental Conservation to stock Lake Erie.
- Determine habitats in Lake Erie where lake trout populations will be most at risk of mercury contamination.
- Develop an empirical model to predict reproductive success of lake trout exposed to mercury contamination in Lake Erie.

***Project Partners:*** U.S. Fish and Wildlife Service, New York State Department of Environmental Conservation, Pennsylvania Fish and Boat Commission, U.S. Geological Survey, and Buffalo State College.

***Project Needs:*** Funding needed to accomplish project actions.



### 4. CALEDONIA FISHWAY IMPROVEMENTS, Ontario

***Project Type:*** restoration

***Project Goal:*** To replace a fishway located at the Caledonia Dam on the Grand River in order to improve passage of the fish community over this barrier.

***Project Status:*** *proposed*

***Narrative:*** The final design for this project has been completed and will emphasize the provision of passage for non-jumping fish species such as walleye, bass, pike, mooneye, crappie and various forage species. The Grand River Fisheries Management Plan indicated barriers to fish migration played a significant role in limiting fish production particularly in the lower Grand River and ultimately in Lake Erie. Fish needed access to high quality habitat upstream as far as Brantford but could not negotiate the fishways at the Caledonia Dam. Thus far, more than $50,000 has been invested in biological investigations and engineering design to develop the best available fishway. Cost estimates range from $400,000 to $500,000 and corporate sponsors are actively being sought to participate in this venture. Ontario Ministry of Natural Resources has committed significant funds to the building of this fishway if partner funds can be secured.

***Project Partners:*** Grand River Conservation Authority, Ontario Ministry of Natural Resources.

***Project Needs:*** $150,000 in the year 2000.

## 5. DETROIT RIVER ECOLOGICAL RISK ASSESSMENT

***Project Type:*** assessment/research, inventory/classification
***Project Goal:*** A completed ecological risk assessment of the Detroit River.
***Project Status:*** *proposed*
***Narrative:*** The initial focus of this project would be to conduct an ecological risk assessment of the entire Detroit River with an objective of evaluating the environmental and human health impacts of pollutants in the river. Cleanup actions are often triggered by human health standards, which differ from toxicity standards for benthic communities. Currently, there is no mechanism in place to address lower levels of contaminants in sediments under traditional federal regulatory authorities, so damage must be evaluated on a case-by-case basis using risk assessment tools. In order to move toward delisting degradation of benthos as an use impairment, a risk assessment is necessary to evaluate and establish authority over impaired areas that are below existing regulatory levels. This project would evaluate the entire river in order to understand the dynamics of the system and associated problems.
***Project Partners:*** U.S. Environmental Protection Agency, Environment Canada, U.S. Army Corps of Engineers, Great Lakes Institute for Environmental Research, U.S. Geological Survey, U.S. Fish and Wildlife Service, Michigan Department of Natural Resources, Ontario Ministry of Natural Resources.

## 6. DETROIT RIVER GIS AND OUTREACH MAPPING PROJECT

***Project Type:*** inventory, assessment/research, education/outreach
***Project Goal:*** To provide an easy, reliable, cost-effective, and accessible mechanism for distribution of a wide variety of standardized and geo-referenced data sets to stakeholders for spatial data analysis and thematic mapping purposes.



***Project Status:*** *proposed*
***Narrative:*** The Lake Huron/Lake Erie corridor is comprised of the St. Clair, Lake St. Clair, and Detroit River. The rivers are Areas of Concern (AOCs). In 1996, the third priority recommendation of the Detroit River RAP report was to develop a geographic information system (GIS) for the St. Clair/Detroit River AOCs. It was recognized that timely access to accurate spatial data in a GIS is a key tool for efficient and cost-effective decision making. Addressing the information needs outlined in the RAPs with a comprehensive GIS will greatly assist the environmental restoration goals of the Lake Erie LaMP. Along with addressing LaMP goals, GIS analysis and mapping would be instrumental in spills planning, the binational Lake Huron/Erie corridor monitoring strategy, habitat and biodiversity location mapping, and the Greater America Heritage Rivers historic features mapping. Available data sets on commercial, industrial, and environmental information, as well as habitat, cultural, transportation, hydrologic, and physical landform features would also be assembled and disseminated. The tool will provide a solid foundation for inter-agency spatial data sharing and collaboration across the region.
***Project Actions:***

- Develop and distribute a survey to United States and Canadian agencies responsible for AOC and Lake St. Clair remediation and habitat restoration efforts. The survey would evaluate data availability, cost of procurement, data needs and presentation standards required to assist stakeholders with Huron/Lake Erie corridor projects.
- Develop data processing and presentation protocols based on the survey.
- Process data and design customized mapping tools for standard mapping presentations.
- Distribute standardized data layers and mapping tools on CD-ROM media to stakeholder agencies.
- Disseminate information and mapping tools to the general public via Internet from a website and server located at Eastern Michigan University CEITA lab.

***Project Partners:*** Eastern Michigan University, U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, Michigan Department of Environmental Quality, National Oceanographic and Atmospheric Administration (NOAA), U.S. Geological Survey, Great Lakes Commission, Southeast Michigan Council of Governments, University of Windsor-GLIER, Environment Canada, Ontario Ministry of the Environment, Essex Region Conservation Authority.

### 7. DETROIT RIVER SOFT SHORELINE PROJECT

***Project Type:*** restoration, education/outreach
***Project Goal:*** To re-engineer the Detroit River and Belle Isle with soft shorelines to provide fish spawning habitat.
***Project Status:*** *proposed*
***Narrative:*** A Natural Resource Conservation Service staff person is needed to work in the Detroit metro area, particularly on Belle Isle, to offer assistance in re-engineering the shoreline. Currently, much of the shoreline is hardened, having little value as fish habitat. Re-engineering the shoreline to include soft shoreline would expand fish spawning habitat.
***Project Partners:*** Natural Resource Conservation Service, Detroit American Heritage Rivers, City of Detroit.

### 8. EPHEMERAL WETLAND CONFERENCE

***Project Type:*** education/outreach
***Project Goal:*** Hold a conference that brings together ephemeral wetland and amphibian experts to compile information on the decline of ephemeral wetlands in the area and the effect on amphibian populations.
***Project Status:*** *proposed*
***Narrative:*** Ephemeral wetlands are critical ecosystems throughout the Great Lakes and the Midwest. Loss of these wetlands is contributing to an overall decline in amphibians. This conference would bring together ephemeral wetland and amphibian experts to share information and disseminate this information to a wider audience, thus laying the foundation for protection and restoration work.
***Partners:*** U.S. Environmental Protection Agency, other federal and state agencies.



### 9. ESTIMATION OF LAKE TROUT MORTALITY FOLLOWING STOCKING IN LAKE ERIE, Pennsylvania, New York and Ontario

***Project Type:*** restoration, monitoring, planning/coordination/collaboration
***Project Goal:*** Restore a naturally reproducing lake trout population in the eastern basin of Lake Erie that will eventually yield an annual harvestable surplus.
***Project Status:*** *proposed*
***Narrative:*** The current lake trout restoration effort in Lake Erie began in 1976. Several strains of lake trout are raised to yearlings at the U. S. Fish and Wildlife Service Allegheny National Fish Hatchery. The U.S. Fish and Wildlife Service and the New York State Department of Environmental Conservation stock the yearlings at several locations in the lake. Assessments of the lake trout population have shown a decline in juvenile lake trout abundance since 1994 in Lake Erie. These observations have resulted in questions about the post-stocking survival of the hatchery reared fish. Is this due to changes in the quality of the stocked fish or have changes in the lake resulted in lower survival during the first year? Factors that may be responsible for post stocking lake trout mortality include stress due to transport and stocking, change in water quality, predation, and availability of food for the stocked fish. The stresses with stocking include transport in aerated truck tanks for several hours, release through hoses into the water, and changes in water chemistry. It is likely that any mortality from stocking would occur within a few days. The purpose of this study is to get a more accurate measure of the mortality associated with the stress of stocking the yearling lake trout. Holding the fish in net pens will eliminate increased risk of mortality due to predation on potentially stressed fish. Keeping the fish for a short period will rule out lack of food as a cause of mortality. Measurement of water chemistry parameters may identify potential causes of mortality.
***Project Actions:***

- Stock yearling lake trout following standard stocking protocol into several net pens and monitor mortality for a 48 hour period before releasing into the lake.
- Conduct study for two to three years and include strain and site differences.
- Develop a model to predict stocking mortality and stocking density needed to produce and maintain a naturally reproducing lake trout population.

***Project Partners:*** U.S. Fish and Wildlife Service, New York Department of Environmental Conservation, Pennsylvania Fish and Boat Commission, U.S. Geological Survey/Biological Resources Division, Ontario Ministry of Natural Resources.
***Additional Needs:*** Funds are needed to increase the number of replicates and include assessment of each strain stocked in Lake Erie.

### 10. HIBERNATION, SEASONAL ACTIVITY, MOVEMENT PATTERNS AND FORAGING BEHAVIOR OF ADULT LAKE ERIE WATER SNAKES *(Nerodia sipedon insularum)*, Lake Erie Islands, Ohio

***Project Type:*** habitat assessment/inventory/classification
***Project Goals:*** 1) Locate and characterize hibernation sites used by adult Lake Erie water snakes on Kelleys, South Bass, Middle Bass, and North Bass Islands. This information is lacking and is needed for effective recovery plan development. 2) Characterize seasonal activity patterns of adult Lake Erie water snakes, especially the time of entry into and emergence from hibernation. This period of the life cycle may represent a time of increased vulnerability to human disturbance and natural enemies. 3) Characterize movement patterns of adult Lake Erie water snakes throughout the active season. Although previous data suggest that Lake Erie water snakes are fairly site specific, occasional documentation of snakes moving between islands and study sites occurs. In addition, many marked snakes are never recaptured, pointing to a need for more complete understanding of adult movement patterns. Once this data is obtained it will allow determination of the required habitat size needed to effectively protect the Lake Erie water snake. 4) Characterize the foraging behavior of adult Lake Erie water snakes. Although diet composition data are available, less is known about foraging locations and the length and frequency of foraging bouts. Boat traffic and other human activities may have an impact on the snakes that forage in the nearshore waters of Lake Erie. 5) Locate and characterize sites used by pregnant female snakes when giving birth.



***Project Status:*** *proposed*
***Narrative:*** The Lake Erie water snake is one of many wildlife species classified as impaired in the Lake Erie LaMP wildlife assessment. On August 30, 1999, the U.S. Fish and Wildlife Service listed the Lake Erie water snake as threatened under the Endangered Species Act. A species is designated as threatened if it is likely to become in danger of extinction within the foreseeable future throughout all or a significant portion of its range. Recent data show that the number of snakes per kilometer of shoreline has declined dramatically at key study sites - by 75% on North Bass Island and by 81% on Middle Bass Island. The current estimate for the U.S. population ranges from 1,520 to 2,030 adults. The Lake Erie water snake is primarily limited to 22 islands and rock outcroppings in western Lake Erie that are more than 1 mile from the Ohio and Canadian mainland. There are relatively few Lake Erie water snakes on the mainland and they often interbreed with other snake in these situations. Stated another way, 95% of the Lake Erie water snake population is currently restricted to an area with a diameter of less than 20 km (25 miles). The Lake Erie water snake uses habitat composed of shorelines that are rocky or contain limestone/dolomite shelves and ledges for sunning and shelter. The population suffers from three problems: 1) declines in population density, 2) current reproduction and survival rates appear insufficient to allow the population to increase to levels higher than existing vulnerable threshholds, and 3) low population densities and insular distribution make it vulnerable to extinction or extirpation. This project is designed to answer research questions so that a recovery plan can be developed.
***Project Actions:***

- Radio transmitters will be implanted in 20 adult males and 25 adult females, which will allow tracking for a 2-year period. The females will be captured while pregnant and maintained in captivity until they give birth. Then the transmitters will be implanted and they will be released.
- Throughout the course of this study, non-telemetered snakes will be captured, marked with subcutaneous PIT tags, measured, and released to provide updated census data. This includes the young born to the above-mentioned females.

***Project Partners:*** *Potentially* U.S. Fish and Wildlife Service, Northern Illinois University,

Ohio Department of Natural Resources - Divisions of Wildlife and Parks and Recreation, The Ohio State University - F. T. Stone Laboratory, and Ohio Sea Grant. Discussions with all potential project partners have not occurred due to current lack of funding.
***Project Needs:*** 1) Project Funding of approximately $130,000 is needed over a 5-year period ($50,000 for each of the first 2 years, and $10,000 for each of the remaining 3 years). The major expenses include radio transmitters and tracking equipment, PIT tags, and other field equipment, travel, and personnel costs for the people tracking the snakes. 2) Linking Research - The Lake Erie LaMP Animal Deformities or Reproductive Problems Assessment indicates that Lake Erie water snake is exposed to considerable PCB levels in its diet from western Lake Erie. A Canadian study of biological effects of PCB exposure in Lake Erie water snakes at Pelee Island is underway. Because the proposed study of U.S. Lake Erie water snakes calls for handling many snakes, it may present a potential opportunity to expand research about PCB exposure effects into the U.S. population. 3) If desired, a subset of the Lake Erie water snakes born to the females in captivity could be used to repopulate Green and West Sister Islands.

### 11. HILLMAN MARSH MUDFLAT RESTORATION, Ontario

***Project Type:*** restoration
***Project Goal:*** Create and manage mudflat habitats for migratory bird species in Point Pelee National Park and Hillman Marsh Conservation Area.
***Project Status:*** *proposed*
***Narrative:*** Point Pelee National Park and Hillman Marsh Conservation Area are important stopover sites for migratory bird species on the Mississippi Flyway. While marsh habitat is abundant at Hillman, mudflat habitat is under-represented both at the Conservation Area and regionally. The restoration project will involve the creation of managed mudflat habitats through elevation modifications and water level controls to create one of the premier mudflat habitats in the Mississippi Flyway portion of the Great Lakes basin.
***Project Partners:*** Essex Region Conservation Authority.
***Additional Needs:*** Cost for this project is $250,000.



### 12. LAKEWIDE COORDINATED LOWER TROPHIC LEVEL ASSESSMENT IN LAKE ERIE, Ontario, New York, Pennsylvania, Ohio, and Michigan

***Project Type****:* monitoring, planning/coordination/collaboration
***Project Goal****:* Provide a standardized lakewide database describing lower trophic levels.
***Project Status****: proposed*
***Narrative****:* Ecosystem change associated with zebra and quagga mussels, and phosphorus control has substantially altered the productive potential of the Lake. The amount of food at the base of Lake Erie's food web, as measured by phytoplankton production and chlorophyll *a*, has declined 49-90% since 1991 and may now be limiting the production of important fish species. Understanding the effects of changes in the environment and the food web, and their respective influences on the composition and productivity of the fish community are imperative for the sustainable management of fisheries in Lake Erie and elsewhere. This long-term, lakewide database describing lower trophic levels will be an invaluable resource to managers and researchers in modelling the Lake Erie ecosystem. Recognizing the extent of ecosystem change, and linking it to fisheries production will enable managers to seek conservative actions to ensure the fisheries remain sustainable in light of changing environmental conditions. The present paucity of information collected in a standardized and lakewide fashion limits our present ability to adaptively manage the resource during this period of transition. The coordinated, interagency approach, including the maintenance of a centralized database will ensure all information is available to all interested parties through the Forage Task Group report presented annually to the Great Lakes Fishery Commission. Sample processing will be coordinated through a minimum number of contractors to ensure consistency. Preliminary work was conducted in 1999.
***Project Actions:***
- Identified approximately 20 stations scattered throughout the lake.

- Collection of samples annually from May through September by each participating agency.
- Laboratory analysis of phosphorus, chlorophyll *a*, phytoplankton and zooplankton identification and biomass calculation, and benthic invertebrates.
- Maintenance of a centralized database. All information will be available to all interested parties through the Forage Task Group annual report.

***Project Partners:*** Ohio Department of Natural Resources, Michigan Department of Natural Resources, U.S. Fish and Wildlife Service, New York State Department of Environmental Conservation, Pennsylvania Fish and Boat Commission, U.S. Geological Survey/Biological Resources Division, Ontario Ministry of Natural Resources.

***Additional Needs****:* Although each participating agency will support the field collection of samples, a long-term source of funding is still needed for laboratory analysis.

### 13. LAND STEWARDSHIP INCENTIVE PROGRAM, Ontario

***Project Type:*** restoration

***Project Goal:*** Provide technical support and financial incentives for land stewardship activities which would address water quality and fish habitat degradation problems throughout the Grand River, Ontario watershed.

***Project Status:*** *proposed*

***Narrative:*** The intention of this proposed project is to reverse water quality and habitat losses due to nonpoint sources of sediment and nutrients. These improvements would be carried out through a coordinated program of streambank buffer development, instream rehabilitation, wetland creation, livestock access restriction, tree planting and education packages. The priority would be to undertake projects where impacts are the greatest and the potential for improvement is the highest, i.e. the main river and tributaries of the Nith River, Conestoga River and Grand River upstream of Belwood Reservoir. The incentive program would complement the Region of Waterloo/GRCA Rural Water Quality Program that is currently funding $1.5 million over five years within the municipality. This project would target areas where these funds are not available.

***Project Partners:*** Grand River Conservation Authority

***Project Needs:*** Funding to initiate and sustain the project.

### 14. ONTARIO CONSERVATION RESERVE PROGRAM, Ontario

***Project Type:*** restoration

***Project Goal:*** Improved water quality and reduction in soil erosion.

***Project Status:*** *proposed*

***Narrative:*** This project would implement a pilot program on a watershed basis that mimics the Conservation Reserve Program available in the United States. Cultivated land adjacent to watercourses and wetlands would be targeted for retirement into a permanent grass cover or for reforestation. An expanded program would be implemented across southern agricultural Ontario. Objectives would be to reduce soil erosion, improve water quality and fish and wildlife habitat.

***Project Partners (potential):*** Ducks Unlimited Canada, Ontario Federation of Anglers and Hunters, Trout Unlimited, National Wild Turkey Federation, Ruffed Grouse Society, Wildlife Habitat Canada, Ontario Stewardship, Ontario Soil and Crop Improvement Association, Conservation Ontario.

***Project Needs:*** Resources necessary to implement this project.

### 15. PHRAGMITES CONTROL ON LONG POINT, Ontario

***Project Type:*** restoration, assessment/research, monitoring
***Project Goal:*** Control invasive *Phragmites australis* in Long Point wetlands.
***Project Status:*** *proposed*
***Narrative:*** *Phragmites australis* (common reed grass) is threatening coastal wetlands throughout the lower Great Lakes. Further research, monitoring, and control is warranted. Long Point in Ontario is a good potential study site.
***Project Partners:*** Bird Studies Canada
***Project Needs:*** Resources to initiate a research, restoration, and monitoring program at Long Point.

### 16. ROUND GOBY AS A VECTOR OF CONTAMINANTS FOR SELECTED LAKE ERIE LITTORAL-ZONE PISCIVORES

***Project Type****:* monitoring, assessment/research
***Project Goal****:* Estimate bioaccumulation of contaminant levels in selected littoral-zone piscivores that feed on the round goby.
***Project Status****: proposed*
***Narrative:*** In 1990, the round goby (*Neogobius melanostomus*) was first discovered in North America in the St. Clair River near Windsor, Ontario. Since then, the range of this non-indigenous benthic fish species has grown to include all five of the Great Lakes, as well as several tributaries within the Great Lakes watershed. Currently, the largest population of round goby within the basin can be found in Lake Erie, as a result of both introduction dynamics and the large amount of ideal habitat that the lake has to offer. Within the past 5 years, catch-per-unit-effort data from various state, federal, and provincial fishery surveys have shown a steady increase in round goby numbers. In addition, the detected range of the goby within the lake has consistently grown, demonstrating the ability of this species to rapidly colonize large portions of nearshore habitat. Recent investigations have shown that dreissenids (zebra and quagga mussels) comprise approximately 70 to 90% of the diet of adult round goby in Lake Erie. Because of this high reliance upon dreissenids, it is believed that goby may become recipients of contaminants (e.g. PCBs) previously isolated within dreissenid tissue. Over time, goby tissue may contain a significant contaminant burden as a result of biomagnification. Previous research has demonstrated the possibility that round goby consumption can cause increases in the PCB tissue levels of some predators. Lake Erie fishery surveys have shown that several fish species are becoming increasingly reliant upon round goby as a forage base. Because of this predator-prey interaction, larger, relatively long-lived piscivores may experience heightened contaminant burdens as a result of biomagnification, and potentially impair piscivore reproduction in the lake.
***Project Actions:***
- Assess the contaminant levels of round goby and selected piscivores.
- Analyze contaminant burden data for spatial and temporal heterogeneity.
- Assess diets of piscivores to determine proportion of round goby in diets.
- Develop a predator/prey model based on data collected during field surveys.
- Develop contaminant burden predictive model for round goby and selected piscivores.

***Project Needs:*** Funding needed to accomplish project actions.

### 17. RURAL NONPOINT SOURCE POLLUTION REMEDIATION PROGRAM, Ontario

***Project Type:*** restoration
***Project Goal:*** Improve water quality and reduce loading to Lake Erie.
***Project Status:*** *proposed*
***Narrative:*** Presently, Environment Canada funds the Rural Nonpoint Source Program for the Detroit River and Muddy Creek watersheds. The balance of the region is not able to access incentive grant funds under this program to undertake riparian planting projects, implement sediment and erosion control projects (e.g. rock chute installation), purchase no-till planters, or upgrade faulty septic systems in high priority areas. The project would expand the Rural Nonpoint Source Program to the Lake St. Clair and Lake Erie watershed

to improve rural water quality and loadings to the Great Lakes.
***Project Partners:*** Essex Region Conservation Authority
***Project Needs:*** Approximately $130,000 per year.

### 18. WESTERN LAKE ERIE WATERSHED CONSERVATION RESERVE ENHANCEMENT PROGRAM, Ohio

***Project Type:*** restoration
***Project Goal:*** To improve water quality in the Lake Erie watershed of Ohio.
***Project Status:*** *proposed*
***Narrative:*** The Ohio Conservation Reserve Program would like to commit environmentally sensitive land to the conservation reserve program in order to improve water quality. Riparian buffers, filter strips, and windbreaks would be installed. Wildlife habitat and wetlands would be protected and restored. Other best management practices would be instituted.
***Project Partners:*** Ohio Conservation Reserve Enhancement Program, Ohio Department of Natural Resources.

### 19. NATURAL RESOURCE DAMAGE ASSESSMENT FOR ASHTABULA RIVER RAP, Ohio

***Project Type*:** restoration, planning/coordination/collaboration
***Project Goal***: To atone for years of chemical stress on the aquatic community in the river and to restore habitat lost in the Ashtabula River AOC.
***Project Status***: *in the planning stages*
***Narrative***: As part of the Ashtabula River RAP, implementation of habitat restoration projects is being discussed. There are several areas in the river where habitat improvement can be accomplished now. There are other areas where habitat restoration cannot be done until the contaminated sediments have been dredged from the river. This won't be completed until 2005. The federal and state natural resource trustees are in the process of negotiating with the responsible parties for further habitat preservation and restoration in and near the Ashtabula River and Harbor.
***Project Partners***: Ashtabula River RAP, Ashtabula River Partnership, U.S. Fish and Wildlife Service, Ohio Environmental Protection Agency, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency.

# **Appendix E:** PCB Action Descriptions

# Appendix E: PCB Action Descriptions

**Monitoring Trends of Selected PCB Congeners and Pesticides in Great Lakes Predator Fish Collected during 1994-1997.** US Geological Survey, Biological Resources Division, Great Lakes Science Center (USGS/BRD/GLSC):
This agreement will provide information on the concentration of toxic organic contaminants in lake trout and walleye that have been collected for the Open Lake Trend Monitoring element (Element 1) of the Great Lakes Fish Contaminant Monitoring Program. Composites of whole fish will be analyzed for PCB congeners, toxaphene homologs, pesticides, and other contaminants as listed in the 1996 USGS/EPA Cooperative Agreement and in the Request for Proposal (RFP) from EPA/GLNPO dated April 9, 1997. The project will complement trend analyses performed in previous years in the Great Lakes Fish Contaminant Monitoring Program. This agreement will also provide information on the concentration of toxic organic contaminants in coho salmon that have been collected for the Game Fish Fillet Monitoring element (Element 2) of the Great Lakes Fish Contaminant Monitoring Program. Skin-on fillets will be analyzed for the same contaminants identified above for Element 1 of the Fish Monitoring Program. This part of the project will provide information regarding potential human exposure to contaminants through consumption of popular sport species, as well as complement trend analyses performed for top predator species with shorter exposures than lake trout. In addition to information collected for the Great Lakes Fish Contaminant Monitoring Program, this agreement will provide for the analyses of a small number of fish samples from Mariupol, Ukraine. Whole fish will be analyzed for the same contaminants identified above for the Great Lakes Fish Contaminant Monitoring Program. The results will provide information for a joint U.S. EPA and University of Illinois at Chicago project concerning environmental pollutants and the health status of children living in Mariupol. Project Period: 9/20/97 to 12/30/99.



**Cook County (Illinois) PCB and Mercury Clean Sweep**: The waste collection component of the Cook County (Illinois) PCB and Mercury Clean Sweep pilot program began in October 1999 with a pickup of light ballasts containing PCBs, fluorescent lamps, lights and batteries from a park district in Cook County. This collection event was preceded by a mailing of brochures announcing and describing the Clean Sweep program to approximately 6,000 potentially participating businesses, organizations, and associations in the county. A web site was established (www.erc.uic.edu/cleansweep) containing a description of the program and information on PCBs and mercury, and a hotline number (1-888-SWEEP-22) was established for potential participants. The program provides PCB and mercury recycling or waste disposal at reduced costs until the end of 1999 for small businesses and local governments in Cook County, Illinois.

**PCB Reduction Commitment Letter:** The PCB Workgroup drafted a letter for signature by senior Environment Canada and U.S.EPA officials seeking commitments from targeted organizations to reduce their remaining PCBs. U.S.EPA Region 5's Regional Administrator sent letters to the three major automobile manufacturers in the U.S. (DaimlerChrysler, Ford, and General Motors) and to five major steel producers with facilities in the Great Lakes basin (Bethlehem Steel, Ispat Inland, LTV Steel, National Steel, and U.S. Steel). All three automobile manufacturers responded and committed to not only meet the PCB reduction challenge, but go beyond it in terms of the amount of PCBs reduced and/or when the company would eliminate all of its PCB equipment. Ispat Inland committed to reduce high level PCBs in electrical equipment by 95% by 2006. They also committed to continue a program to eliminate PCBs that are present in hydraulic systems in their plants. The letters to the steel producers were sent in late October, so not all of them have had time to respond as of this update. Environment Canada also sent PCB reduction commitment letters to six corporations in the automotive and iron/steel sectors. A response has been received from DaimlerChrysler indicating that they have met the Canadian PCB challenge. Responses from other corporations are also expected soon.

**PCB Sources and Regulations Report:** A re-draft of the PCB Sources and Regulations Background report, which covers Steps 1 & 2 of the Four-Step Analytical Process, was completed and posted on the BNS web site for public review. Comments on the report are due December 30, 1999. This report includes updated information regarding changes to U.S. PCB regulations, and new PCB data. The Step 1 & 2 report was also updated to include PCB sources and regulations in Canada.

**U.S. PCB Transformer Registrations:** The new PCB Transformer Registration Database shows that there are 18,714 transformers registered and in-use in the U.S., containing a total of 108,625,659 pounds of PCBs. The 1994 baseline of 200,000 estimated transformers containing high-level PCBs is higher than the reported 1998 database total. Although reductions of PCB transformers have occurred since 1994, the reductions alone may not account for the difference between the 1994 baseline and the number of transformers in the registration database. While the database provides the best existing and current information on the number of PCB transformers remaining in use, it has not been thoroughly quality controlled. In addition, the figures do not include registrations submitted after the initial development of the database and they do not include PCB transformers which were not registered. The PCB workgroup will evaluate the differences between the 1994 baseline and the 1998 database.

**Ottawa River Hot Spot Delineation and Risk Assessment:** Grant to the Toledo Metropolitan Area Council of Governments (on behalf of the Maumee RAP). Project period from 10/15/99 to 10/15/01. The purpose of this project is to support a sediment study and risk assessment on the Ottawa River, part of the Maumee Area of Concern. The project will allow for the collection of additional sediment cores, which will help to determine where the hot spots are. It will also make use of previously collected data to assess risk. Both of these activities will aid in developing priorities for future remediation.



**U.S. EPA's Office of Water has developed a Clean Water Action Plan.** The Plan identifies nonpoint sources including atmospheric deposition as the most important remaining threat to water quality. Since U.S. EPA's existing programs do not focus on control of these nonpoint sources, the action plan emphasizes innovative approaches like consensus building among stakeholders at the local and watershed level for project efforts. Atmospheric deposition is among the prominent nonpoint sources addressed by the plan. A commitment toward inter-agency cooperation on understanding the risks of atmospheric deposition of nitrogen compounds and other toxic pollutants upon water bodies and integrating air deposition into TMDL determinations are also highlighted.

**Sediment Assessment and Remediation Support:** U.S. Army Corps of Engineers - Great Lakes and Ohio River Division: This amendment to the existing interagency agreement augments the existing funds for procuring the support of the U.S. Army Corps of Engineers in the collection and analysis of sediment samples, review of feasibility studies and remediation design plans, and other technical support for sediment assessment and remediation studies. This agreement allows for the integration and coordination of U.S.EPA and USACE activities and provides the U.S.EPA with access to USACE's vast technical experience in dealing with sediments on an "as needed" basis. Project Period: 12/01/98 to 9/30/00.

**Fisheaters Family Health Study at Rouge River**, Julie Wirth, PhD and Wilfried Karmaus, MD, Dept. Epidemiology. Michigan State University, May 28,1999.
A large body of evidence derived from wildlife and experimental animal studies has demonstrated adverse effects of organochlorine contaminants, including PCBs, on a variety of health outcomes. However, in humans the findings are less consistent. Since PCBs tend to persist and bioaccumulate in various tissues, they have the potential to damage and/or interfere with the normal functioning of developmental, reproductive, neurological and immunological processes in exposed humans and animals. The most significant threat to human health from these compounds probably comes from their potential to impair

reproductive capacity and fetal health. Since these compounds can cross the placenta and the yolk sac, their ability to affect developmental processes in the embryo and fetus is of great concern. Additional exposure to the offspring can occur through their presence in the mother's milk.

The Fisheaters Family Health Project (funded by the Agency for Toxic Substances and Disease Registry) is assessing the effects of PCB exposure via consuming sport-caught Great Lakes fish on human reproductive measures. Sport-caught fish from the Great Lakes have been shown to have relatively high levels of PCBs as well as other environmental contaminants. The main goal of this project is to assess markers of reproductive health in two Michigan cohorts exposed either *directly* through consumption of sport-caught Great Lakes fish, or *indirectly* through *in utero* exposure. The cohort from which participants are recruited is the Department of Natural Resources database of men and women with Michigan fishing licenses. After over two years of recruiting we have very few participants from the Detroit area. In the process of contacting potential participants via our telephone recruiting scheme, we have been informed by respondents that a substantial number of people, especially people of color, fish in the Rouge River, which is highly contaminated with a variety of chemicals including PCBs. We have also been told that some of the anglers are subsistence fishers meaning that they eat their catch, not just occasionally, but as a major food source. Based on this information, it is likely that these anglers and any family members sharing the catch are at greatly increased risk for exposure to PCBs via consuming their catch. Thus, we expect a higher frequency of adverse health effects in this group.

In order to assess the risk to these men, women and their families, we would like to contact them and explain our project. The context for this exchange will be community centers, local churches, or possibly fishing sites on the river. If the anglers are willing, we would then administer a short questionnaire on their general health, reproductive health and fish eating habits, including the species they catch, where they catch them, how the fish are prepared and how much they eat. We would also like to obtain a blood sample from which to determine their serum PCB and reproductive hormone levels (for men: testosterone, luteinizing hormone and follicle stimulating hormone; for women, estradiol). Protocols to measure outcomes (questionnaires, blood collection and PCB and hormone analysis) are already in place for use in the Fisheaters Family Health Project. By using these venues to approach a population at risk for increased PCB exposure, we hope to make the local communities aware of the possible health risks as well as the benefits involved in eating sport-caught Great Lakes fish so that the individuals can make informed decisions. We also hope to stimulate involvement in local and state efforts at remediation.



**Toledo Metropolitan Area Council of Governments:** Ottawa River Hot Spot Delineation and Risk Assessment: The purpose of this project is to support a sediment study and risk assessment on the Ottawa River, part of the Maumee River Area of Concern. The activities will aid in developing priorities for future remediation. Project Period: 10/15/99 to 10/15/01.Funded by U.S. EPA-GLNPO.

# **Appendix F:** Mercury Action Descriptions

# Appendix F: Mercury Action Descriptions

### General U.S. EPA Efforts

The U.S. EPA has committed FY 2000 funds to support mercury research in a number of priority areas including transport, transformation and fate; and human health and wildlife effects of methylmercury. These research activities are aimed at reducing the uncertainties currently limiting the Agency's ability to assess and manage mercury and methylmercury risks. A particular target of research will be collection and analysis of information on mercury emissions and control options for coal-fired utilities in order to support OAR's mandate for a regulatory determination on mercury controls for utilities by December 15, 2000.

Current national efforts are focused in a number of areas by EPA offices. Among these are the Mercury Total Maximum Daily Loading (TMDL) pilot project at Devil's Lake, Wisconsin by EPA's Office of Air Quality Planning and Standards (OAQPS). This program seeks to support the states in establishing total maximum daily loadings for specific water bodies which have trouble meeting water quality standards through point source controls. In some cases, TMDLs attempt to quantify atmospheric deposition and the sources responsible for it to implement appropriate control measures and reduce pollutant inputs to a watershed.

U.S. EPA's Office of Research and Development (ORD) has just released its Mercury Research Strategy, which outlines an intra-agency effort to define and address the scientific questions of greatest concern through coordinated research program. The key fate and transport questions the strategy seeks to address are how much methylmercury in fish is contributed by U.S. sources relative to other natural and global sources; and how much and over what time period will levels of methylmercury in fish in the U.S. decrease as the result of reductions made by U.S. sources (Delta Institute).

EPA's Office of Water has developed a Clean Water Action Plan. The Plan identifies nonpoint sources including atmospheric deposition as the most important remaining threat to water quality. Since EPA's existing programs don't focus on control of these nonpoint sources, the action plan emphasizes innovative approaches like consensus building among stakeholders at the local and watershed level for project efforts. Atmospheric deposition is among the prominent nonpoint sources addressed by the plan. A commitment toward inter-agency cooperation on understanding the risks of atmospheric deposition of nitrogen compounds and other toxic pollutants upon water bodies and integrating air deposition into TMDL determinations are also highlighted.

Mercury emissions from coal-fired utilities remain a primary focus of EPA research efforts and potential regulation. EPA's Office of Air Quality Planning and Standards has an ongoing study of speciated mercury emissions from a small subset of coal-fired boiler units to glean additional information on which to make a decision whether to regulate these critical sources.

## Lake Erie Specific

### *Pollution Reduction*

#### Erie County, Department of Environment and Planning: Mercury Pollution Prevention in Health Care Initiative

Erie County, in partnership with the Western New York Healthcare Association (WNYHA) and the Buffalo Sewer Authority (BSA), will solicit participa tion from a minimum of four area hospitals to develop, implement, and measure the success of mercury pollution prevention and reduction strategies tailored to the specific needs of each facility. The proposed work entails: promoting the U.S. EPA/American Hospital Association Memorandum of Understanding; a preliminary assessment of mercury use within each facility; technical expertise and guidance on source identification and reduction strategies; establishment of training and education programs; determination of total mercury reduction achieved; presentation of the four facilities efforts as case studies to remaining Erie County healthcare facilities; and the dissemination of program results and information throughout the Great Lakes basin. Project Period: 10/1/99 to 9/30/01

#### The P$^3$ERIE Partnership GLNPO Grant (Pennsylvania)

The P$^3$ERIE partnership has successfully worked on practical projects and educational efforts throughout the grant period. P$^3$ERIE's successes have gained media attention and the P$^3$ERIE partners are pleased with project results and positive spin-offs from the project. P$^3$ERIE's partnership efforts have had the following results:



- Approximately 1975 pounds of mercury collected and recycled.
- Approximately 10,000 pounds of pesticides collected and disposed including 350 pounds of DDT, 500 pounds of toxaphene, 275 pounds of chlordane, and 215 pounds of aldrin/dieldrin.
- Collecting mercury from 14 schools and removing approximately 160 varying sized containers of extremely hazardous chemicals including mercuric compounds from 14 school laboratories.
- The largest hospital in northwest Pennsylvania virtually eliminating mercury from its facility and becoming the first mercury free facility in northwest Pennsylvania and perhaps throughout the state.
- Six hospitals beginning or expediting mercury reduction programs.
- International Paper Erie Mill, the largest wastewater discharger to the City of Erie wastewater treatment plant, completed a mercury audit of its facility, removed approximately 180 pounds of elemental mercury, and did not detect any mercury in wastewater streams.
- Publication of two brochures concerning mercury pollution prevention. P$^3$ ERIE distributed approximately 11,000 copies of the brochure for the general public and 2,900 copies of the brochure for businesses. The brochures are also available on the Internet.
- Sponsoring six workshops on energy efficiency, mercury reduction, and pollution prevention attended by over 280 people from businesses, health care facilities, local government, and educational institutions.
- Initiating an effort for the Pennsylvania Department of Environmental Protection to assist the Pennsylvania Dental Association with the development of hazardous material management guidelines for dental practices.
- Coverage on 24 TV news segments, an appearance on a local TV business show, an appearance on five radio talk shows, and other radio news coverage, newspaper coverage and TV/radio public service announcements.
- Participating in over 20 group outreach efforts to schools, civic organizations, and professional associations and at community events such as Earth Day and Discover Presque Isle Day.

- Receiving two prestigious environmental awards.
- Establishment of a community wide, locally managed pollution prevention partnership.
- Helping foster a positive relationship between the Pennsylvania Department of Environmental Protection and the public, local government, institutions, and businesses.

The management of $P^3$ERIE was transferred from OPPCA to local control in September 1999. Gannon University will be managing the partnership. Gannon's role will be to bridge the partnership from federal and state funding and state management to local management and financial sustainability. On November 16, 1999, $P^3$ERIE held a facilitated meeting to determine if the partnership should seek non-profit status and to determine the partnership's goals and future projects.

### Michigan Department of Agriculture: Michigan Mercury Manometer Disposal

Mercury manometer gauges used on dairy farms will be replaced with non-mercury gauges. This will reduce the potential for spilling mercury into the environment. Mercury gauges will also be collected from inactive dairy farms. This work will be done at little or no cost to the farmer. All manometers collected will be stored by the dairy service provider until a Department of Agriculture employee collects them and brings them to the nearest Michigan Clean Sweep Disposal site. Project Period: 10/1/99 to 9/30/00

### Michigan Department of Agriculture: Michigan Clean Sweep

This Clean Sweep program shall remove and dispose of old, unwanted, suspended, or canceled pesticides from the agriculture community, industry, and homeowners in Michigan at no fee to the end-user. During annual collection programs, pesticides on the Level I BNS-targeted substances, Level II BNS Toxics, and pesticides of concern for the Lake Michigan, Erie, and Superior LaMP are collected and removed from the environment, demonstrating an ongoing need to provide disposal options to household, private, and commercial participants. Some of the pesticides removed include Dieldrin/Aldrin, Mercury, DDT, Lindane, Chlordane, and others, including numerous "unknown" chemicals returned without labeling or original containers. Project Period: 10/1/99 to 9/30/00



### Ontario Ministry of the Environment Projects

1. On January 24, 2000, the Ministry of the Environment announced new provincial emission limits (caps) plus a monitoring and reporting program for the power generating industry in Ontario, including the two facilities (Lambton, Nanticoke) located in the Lake Erie basin. Mandatory reporting of broad range of emissions (including mercury) to the Ministry will be instituted as of May 2000. The lower emission limits (caps) for Nox and SO2 could result in reduced mercury emissions from 1999 levels. For details see http://www.ene.gov.on.ca/envision/news/00600mb.html

2. The Ontario Ministry of the Environment is working to set new emissions performance standards for mercury emissions from the coal-fired power plants including those located in the Lake Erie basin (Lambton, Nanticoke). These Canada-wide standards are being set in conjunction with the other Provinces, the Territories and the Federal Government. These standards will also address and be integrated with reduced emissions in acid gases, smog precursors and particulate matter, as well as considering Canada's committment to Kyoto. For details see http://www.ccme.ca/3e_priorities/3ea_harmonization/3ea2_cws/3ea2.html

3. New (draft) emissions standards have recently been announced (November 1999) by the Ontario Ministry of the Environment that would affect several point sources of mercury in the Lake Erie basin. These Canada-wide standards have been developed in cooperation with the other Provinces, Territories and the Federal government. Once implemented (dates proposed range from 2003 to 2006) these standards will reduce mercury emissions

from the dozen medical waste incinerators and one hazardous waste incinerator located in the basin.

4. As of early 2000, Federal, Provincial and Territorial environment departments are investigating the releases of mercury to the environment from various commercial products and some forms of wastes. A focus on dental amalgam, fluorescent lamps and sewage sludge that is land-applied is expected to result in Canada-wide standards in late 2000. Dental amalgam discharges to sewers, and sludge application to agricultural soils appear to not be causing harm directly, but may be resulting in increased mercury levels in Lake Erie fish and wildlife.

5. The Ontario Ministry of the Environment along with Environment Canada have been working with the Ontario Dental Association to develop a best management practices (BMPs) document for dentists, scheduled for completion in May 2000. Adoption of BMPs by Ontario dentists (use of amalgam traps) can reduce mercury releases to the sewers and hence to Lake Erie. In addition a recent survey of some Ontario hospitals indicated that most have substantially reduced or even eliminated their use of mercury containing materials (sphygnomanometers, fixatives, stains, disinfectants, thermometers) so that their releases to sewers (and incinerators) has been substantially reduced.

***Information Based***

**State University of New York at Buffalo: A Mercury Screening Model for Lake St. Clair**



This grant will support the development of a model for the transport and fate of mercury in Lake St. Clair, where mercury is a well-documented problem. This model will simulate mercury sources, water and sediment concentrations, and fish bioaccumulation in Lake St. Clair. It will be used to evaluate trends, direct research needs, and provide guidance to Great Lakes managers. The model that results from this project will eventually be of use throughout the Great Lakes basin. Project Period: 09/1/99 to 2/28/01.

**Delta Institute: Creation and Dissemination of Targeted Fish Advisory Materials and a Forum Website in Cooperation with the Lake Erie Binational Public Forum**

The goal of this project is to open doors of communication. The first part of the project continues the work of the Lake Erie Binational Public Forum's Environmental Justice Task Group in creating and making available an easy-to-read and culturally sensitive fish advisory brochure. The advisory work will alert at-risk families, both low-income and minority, in the Lake Erie Basin to the dangers of contaminated fish consumption and will also provide positive alternatives for cooking, cleaning and selecting fish in order to decrease risk. Educational materials will be designed to be specific to local areas and communities. An effective dissemination strategy, with on-going outreach efforts, will be key to the success of this project.

**Ohio EPA: Mercury Reduction Fact Sheets**

The Office of Pollution Prevention will develop two fact sheets that focus on ways to reduce mercury and/or other persistent, bioaccumulative and toxic chemicals in hazardous waste. Fact sheets will be distributed to industry, service companies and the general public in Ohio, and to pollution prevention programs in other Great Lakes states.

### *Sediments*

#### Gannon University: 3-D Mapping of Contaminants in Presque Isle Bay Sediments

This grant will support the collection of sediment samples in Presque Isle Bay, Pennsylvania. The assessment will include the collection and analysis of sediment cores and surficial samples from 10 locations. Samples will be analyzed for chemical contaminants, biological toxicity, and benthic community structure. Results will be used in making sediment management decisions for the Presque Isle Bay sediments. Project Period: 9/30/99 to 9/29/01.

## Basin-wide or Multiple Basins

### *Pollution Reduction*

#### Michigan Mercury Pollution Prevention Task Force

The Michigan Mercury Pollution Prevention task force, which first convened in August 1994, has been active in many mercury pollution prevention activities throughout Michigan. Significant accomplishments include: 1) a household hazardous waste collection program in 22 counties sponsored by the Michigan Department of Environmental Quality (MDEQ), resulting in the collection of 200 pounds of mercury; 2) distribution of 16,000 copies of the "Merc Concern" brochure throughout Michigan; 3) development of a mercury pollution prevention web page at http://www.deq.state.mi.us/ead/p2sect/mercury; and, 4) distribution of mercury outreach materials to science teachers (Delta Institute).



#### Detroit Water and Sewerage Department (DWSD) PCB/Mercury Minimization Program

Consistent with its ongoing efforts to work with its customers to pilot pollution prevention programs, the DWSD has undertaken a number of special programs to effectively control mercury in hospitals, dental practices, industrial laundries, laboratories, and households. DWSD has initiated an Atmospheric Deposition Study, made revisions to its Local Limits Ordinance, and established an Education Outreach Program for the general public. The program helps identify current uses of mercury, identify and coordinate and/or encourage proper disposal practices, and evaluate the effectiveness of voluntary activities to date. In one project under this program, the DWSD developed and coordinated a six-month Bulk Mercury Collection Program in cooperation with the Michigan Dental Association, the National Wildlife Federation, the Michigan Department of Environmental Quality, and the U.S. EPA. More than 400 dentists took advantage of the program, contributing about 1,350 pounds of raw mercury.

#### Great Lakes United, Inc.: Clean Production Project for Basin Communities

Great Lakes United, Inc. (GLU) will continue its support and represent the interests of coalition members, work with member groups to support and develop a Great Lakes "clean car campaign", and promote dioxin and mercury reduction from medical waste disposal. Project Period: 10/1/99 to 9/30/00

#### U.S. Navy, Great Lakes Naval Station, Naval Dental Research Institute: Mercury Removal from the Dental-Unit Waste Stream

The interagency agreement provides funds to the Naval Dental Research Institute to examine the mercury removal from the dental-unit wastewater stream. Dental mercury is concentrated in fresh-and salt-water food chains, and both mono and dimethylmercury can be produced in bottom sediments by non-enzymatic methylation. Project Period: 9/1/99 to 8/31/00. The project shall:

1) Educate practioners as to the importance of reducing heavy metal contamination from their dental-unit wastewater streams;

2) Provide an electronic resource where practioners can locate sources, materials, supplies, and help in removing heavy metals from the waste stream;
3) Establish a cadre of qualified personnel to speak to dental professionals on the subject of amalgam hazards, collection, and recycling; and
4) Install, test, and evaluate pretreatment systems for both large and small dental treatment facilities.

### The Delta Institute: Sector Based Pollution Prevention

Through this project, the Delta Institute will focus on achieving toxics reductions through commitments from private and public sector owned and operated energy production units. There are three separate components to this project. The first is to engage selected industrial sectors in pollution prevention initiatives through increased use of energy efficiency and conservation technologies for boilers. The second is to determine the incentives for and barriers to investments in energy efficiency technologies and conservation practices. The final component involves development of a method to quantify the reduction of persistent bioaccumulative toxics from energy efficiency and conservation technologies and practices. Project Period: 9/1/99 to 9/30/00.

### National Wildlife Federation: Local & Sector-based Pollution Prevention in the Binational Strategy

Through this project, the National Wildlife Federation will focus on 1) building on existing efforts to implement pollution prevention, by way of sector-based strategies; and 2) coordinated Environmental Non-Governmental Organization participation in the Binational Toxics Strategy. Project Period: 10/1/99 to 9/30/00.



### Ohio EPA Mercury Reduction Strategy

A pollution prevention strategy will be developed to identify, coordinate and prioritize existing and future efforts to reduce mercury in hazardous waste streams, TRI releases and other discharges to the environment. This effort will focus on hazardous waste generators and facilities, TRI releases and others in the Great Lakes basin portion of Ohio. Information from U.S. EPA and other states, including the U.S. EPA Action Plan for Mercury, will be reviewed to develop a strategy that will complement existing efforts. As part of this effort, hazardous waste annual reports, RCRIS, TRI releases and other data from 1997 will be analyzed to determine the sources, generation and management of mercury within the Great Lakes basin portion of Ohio.

## Basin-wide or Multiple Basins

***Information Based***

### University of Wisconsin: Mercury Education Program for Schools

This project will focus on developing, adapting, and disseminating high-quality mercury related educational materials for schools. The focus will be on reducing the use of mercury in the school, in students' homes, and in the communities of participating schools throughout the Great Lakes Basin. Project Period: 10/1/99 to 9/30/00.

### Indiana University: Deposition of Toxic Organic Compounds to the Great Lakes: The Integrated Atmospheric Deposition Network

This agreement will provide funds for the sixth year of operation and maintenance of the Integrated Atmospheric Deposition Network (IADN) by Indiana University. The IADN is a binational network made up of five sites, one per Great Lake. Twice a month atmospheric samples of rain, vapor, and particles are taken and analyzed for pesticides and other organics.

The results are used to calculate loadings of these substances to the Great Lakes. Project Period: 1/22/99 to 1/22/00

### Environment Canada: Integrated Atmospheric Deposition Network Quality Assurance and Quality Control Program

The Great Lakes National Program Office (GLNPO) is collaborating with Environment Canada to implement the binational Integrated Atmospheric Depo sition Network (IADN) as mandated by Annex 15 of the Great Lakes Water Quality Agreement and Section 112(m) of the Clean Air Act. Both agencies reconfirmed their joint support of this binational partnership in the second phase of IADN, which began in 1998 with the signing of a six-year implementation plan by Dave Ullrich and John Mills. The subject cooperative agreement contributes to this binational partnership by matching Canadian support for the implementation of the IADN Quality Assurance and Quality Control (QA/QC) program. This program benefits the public and the Great Lakes States by providing quality controlled data to determine loadings of air toxics to the Great Lakes, for use in identification of sources of air toxics and to target reduction activities at the local level. Project Period: 10/ 1/99 to 9/30/01

### U.S. Army Corps of Engineers - Great Lakes and Ohio River Division: Sediment Assessment and Remediation Support

This amendment to the existing interagency agreement augments the existing funds for procuring the support of the U.S. Army Corps of Engineers in the collection and analysis of sediment samples, review of feasibility studies and remediation design plans, and other technical support for sediment assessment and remediation studies. This agreement allows for the integration and coordination of U.S. EPA and USACE activities and provides the U.S. EPA with access to USACE's vast technical experience in dealing with sediments on an "as needed" basis. Project Period: 12/01/98 to 9/30/00.



### U.S. Army Corps of Engineers, Great Lakes and Ohio River Division: Contaminated Sediment Management, Amendment, "CDF White Paper"

This agreement will enhance the understanding and management of contaminated sediments in the Great Lakes by producing a report investigating the use, monitoring, and environmental impacts of using Confined Disposal Facilities (CDFs) to manage contaminated sediments. The report shall be a detailed summary of the status of CDFs on the Great Lakes constructed and operated by the Corps, including information about the purpose of the CDFs, the types of designs and operations applied, the state of knowledge on their environmental performance and impacts, and the net environmental effects of CDFs on the Great Lakes. The majority of the report will be extracted from a number of existing reports, white papers and documents developed by and for the Corps and EPA. This project is envisioned to provide a consolidated report summarizing information contained in existing documents into one concise and consistent report. Project Period: 10/01/98 to 9/30/00.

### Sustainable Fisheries Foundation: Development of a Guidance Manual to Support the Assessment of Contaminated Sediments in the Great Lakes Basin

This grant will support the development of a guidance manual for assessing and making remediation decisions regarding contaminated sediments. The manual will include a focused review of relevant literature and develop an ecosystem-based framework for assessing and managing contaminated sediments that is consistent with the International Joint Commission guidance on ecosystem management. The manual will be reviewed and published as an EPA-GLNPO document. Project Period: 9/30/99 to 12/31/00.

### Ohio Healthy Hospital Pollution Prevention Initiative

Medical waste incinerators are the fourth largest known releasers of mercury to the environment, constituting approximately ten percent of all emissions sources. Hospitals are also responsible for producing one percent of the total municipal solid waste in the entire country, and a variety of hospital equipment is known to contain mercury. To complement the memorandum of understanding signed between U.S. EPA and the American Hospital Association, Ohio is working with the Ohio Hospital Association (OHA) to reduce the generation of hospital waste, including mercury, that hospitals commonly have in thermometers, blood pressure monitors and other equipment. A formal agreement between the two organizations was signed in 1999. As part of the agreement, Ohio EPA and OHA agree to create and implement programs to:

- Virtually eliminate mercury-containing waste from the health care industry's waste stream.
- Reduce the total volume of waste created by the industry.
- Educate health care professionals on pollution prevention activities they can implement.
- Reduce the amount of chemicals used by the industry.
- Monitor the industry's progress in implementing pollution prevention initiatives over time.

### Elemental Mercury Collection and Reclamation Program

This program is ongoing in northwest Ohio and collects uncontaminated elemental mercury waste. The program was initiated primarily to prevent children or others from spreading mercury found at improper disposal areas around and contaminating their homes, schools and work areas. See: http:/www.epa.state.oh.us/dist/nwdo/er/mercury.htm



### Implementation Efforts Under the Detroit River RAP

**1. Contaminated Sediments -** The Contaminated Sediments Action Team (COSAT) has been very active in several different ways. COSAT is staffed by a group of volunteers of widely divergent backgrounds and experiences, and all appropriately suited to the tasks ahead. The team has formulated a mission statement that outlines its ambitions, and which reads as follows:

> *The Contaminated Sediments Action Team (COSAT) is a partnership of Detroit River Remedial Action Teams, and local, State, and Federal initiatives to restore, maintain, and enhance beneficial uses of the Detroit River. COSAT will serve as a catalyst to public and stakeholder participation in the sediment remedial process, and will support expeditious and responsible contaminated sediment management.*
>
> Contaminated sediment remedial efforts are arguably one of the newest areas of environmental clean-up. Most previous efforts in pollution elimination have taken place on land or in air, or else have focused on stopping contamination from entering the water for land or air. We now are focusing on areas in our Detroit River that are still repositories of contaminants, which have typically "settled out" downstream of known pollution sources.
>
> COSAT has met several times, and we are actively increasing our knowledge base and coordinating information exchange with numerous key players in the contaminated sediments arena. This includes Canadian researchers, as well as private, academic, state, and federal stakeholders. We goal is to offer a knowledge base to be used to help facilitate sediment remediation efforts.

**Project Description** - The first project anticipated to be accomplished in the Detroit River will be the removal of approximately 50,000 cubic years of sediment downstream of a former steel mill in the Trenton Channel of the River. The area is known as "Black Lagoon." This project is slated to begin in the fall of 2000. It is being managed by MDEQ and USACE.

**Next Steps** - COSAT will need to continue to encourage research and innovation technology to maintain and expand their aggregate skill base, and to systematically evaluate and

efficiently implement any ingredient that will benefit sediment removal technology. COSAT strives to develop into a recognized and trusted resource to various Federal, state, and local governments, as well as to private industry, academia, and interested and concerned individuals. COSAT intends to serve as a focal point to other groups with similar interests to maximize an entire concerted effort.

**2. Non-point Source Pollution** - In 1999, the Detroit River Remedial Action Plan (DRRAP) Non-point Source Action Team was formed to facilitate a reduction of contaminants to the Detroit River. The mission statement of this team is stated as:

> *The goal of the Non-point source pollution team is to stop or reduce further contamination of sediments in the Detroit River from non-point sources by identifying and eliminating those pollution sources.*

This mission statement was adopted to provide a clear and concise agenda that is consistent with the 104 recommendations of the 1996 Detroit River RAP report. Communities are taking a watershed approach to program administration when dealing with non-point source pollution. Urban stormwater, soil erosion spills, remediation sites, and house hold hazardous waste has been identified as the major contributors to non-point source pollution. Federal, State, and Local levels of government have adopted a watershed strategy to combat elusive non-point source pollution. The National Pollutant Discharge Elimination System (NPDES) Phase II regulation is an example of the awareness being brought to water quality issues from stormwater in urban communities. Wayne County and The City of Detroit are in the process of adopting ordinances that protect the quality of stormwater entering the watershed.



**Project Outlook** - The Non-Point Source Action Team has identified two major tasks, which are both multifaceted and pertinent to the implementation of the RAP recommendations: the introduction of Best Management Practices (BMPs) to potential non-point source pollution contributors; and the assembly of data for a watershed wide Geographic Information System (GIS).

The Non-point source and Pollution Prevention action teams have identified the following industries to facilitate the implementation of BMPs: construction sites; junkyards/ scrapyards; golf courses; and river-front industries

There are a variety of industries located along the Detroit River front, these properties have been identified as sensitive areas and will receive special attention.

The identification of potential release sources is instrumental in the proper management of a watershed. The ability to identify and locate these potential sources will aid in developing a pro-active watershed management system to address non-point source pollution. The protection of critical watershed areas is one of the most effective means of preventing pollution in the Detroit River. Below is a list data that will be used to develop the watershed management system.

- Aboveground Storage Tanks (AST)
- Underground Storage Tanks (UST)
- Spill Prevention Control and Countermeasure Plans (SPCC)
- Toxic Release Inventory (TRI)
- Hazardous Waste Hauler Truck Routes

**Next Steps** - The Non-Point Source Action Team recognizes areas that overlap with various action teams. Pollution Prevention and Land Use are the two main action teams the Non-Point Source Action Team expects to overlap with most. Dual participation in various projects will be instrumental in successfully implementing RAP recommendations. Sankor'e Marine High School, a downtown river-front high school, is assisting with Detroit River water quality monitoring or wherever they can participate in the remedial action process. Industries along the river front are interested in developing programs, with the assistance of the Detroit River Remedial Action Plan, to assist in non-point source pollution reduction.

**3. Pollution Prevention** - The 1996 Detroit River RAP report recommended expansion and enhancement of pollution prevention programs. Since that time, progress has been made through both regulatory and voluntary measures. In 1999, the Detroit River RAP Pollution Prevention Action Team was formed to lead and coordinate the implementation of pollution prevention projects at the local level. The team has formulated a mission statement that reads:

*To restore and maintain the integrity of the Detroit River ecosystem to a standard that will provide a safe, clean, self-sustaining environment by leading and coordinating pollution prevention projects, as well as supporting other River stakeholders with pollution prevention efforts.*

Several regulatory programs have benefited from the integration of pollution prevention procedures. The NPDES industrial storm water permitting program requires permitted facilities to define, implement and monitor controls to prevent storm water contamination. Under this program, each permitted facility develops a site-specific pollution prevention plan for storm water runoff to surface waters.

Consistent with the Great Lakes Water Quality Guidance, Michigan's water quality rules now require development of a pollutant minimization program by NPDES permittees in certain circumstances. When a water quality-based effluent limit (WQBEL) for a toxic substance is established below the level of quantification, the permitted facility must develop and conduct a pollutant minimization program for that substance. As part of NPDES permit renewals, these pollutant minimization programs are being implemented for potential sources of mercury.

Voluntary pollution prevention efforts are advocated under Michigan's Pollution Prevention Strategy. Partnership programs encourage and recognize facilities making public commitments to pollution prevention. Voluntary pollution prevention programs with Detroit River stakeholder participation include:



- Michigan Business Pollution Prevention Partnership,
- Clean Corporate Citizens,
- Green Lights Program,
- Mercury Pollution Prevention in Michigan,
- Michigan Great Printers Project,
- Michigan Automotive Pollution Prevention Project,
- Michigan Turfgrass Environmental Stewardship Program, and
- Retired Engineers Technical Assistance Program (RETAP).

**Project Description** - The Pollution Prevention Action Team identified six initial projects for implementation. Each of these projects promotes voluntary participation in pollution prevention activities. Several collaborative efforts are also under consideration by the Team:

- Promote pollution prevention outreach and goals within metal finishing sector.
- Provide recommendations for water use/reuse opportunities in non-contact cooling water applications.
- Initiate a pollution prevention program for marinas along the Detroit River.
- Implement region-wide recycling and disposal program for household hazardous waste.
- Expand PCB minimization program.
- Expand hospital mercury reduction project to other medical/clinical facilities.

**Next Steps** - Opportunities exist to expand voluntary pollution prevention programs within several commercial and industrial sectors, as well as residential areas. The Pollution Prevention Action Team will take a lead role to advance many of these programs, and support other River stakeholders' implementation of others.

The adoption of pollution prevention concepts in regulatory programs could also be further expanded in several areas. Examples include: storm water pollution prevention plan development by indirect/CSO system dischargers and pollution prevention advocacy by enforcement field staff, among others. These efforts are being led by Michigan Dept. of Environmental Quality as part of their regulatory integration plan.

**4. Monitoring and Evaluation** - The 1996 Detroit RAP report recommends monitoring and evaluation of progress towards RAP goals. In 1999, the Detroit River RAP Monitoring and Evaluation Action Team was formed to lead and coordinate monitoring efforts. This action team is one that cuts across most of the RAP issues, since evaluation of RAP efforts coordinated by the other action teams may be done by programs coordinated by the Monitoring and Evaluation Action Team.

**Project Description** - Several efforts are underway that complement RAP monitoring goals. MDEQ has ongoing water, fish, and sediment sampling programs. MDEQ, USGS, and the US Army Corps of Engineers are developing a flow model for source water assessment. This model will be a valuable tool for evaluating the utility of monitoring strategies and results. Michigan Department of Community Health (MDCH) and local health departments provide on-going monitoring at beaches throughout the state.

**Next Steps** - The membership of the action team will be expanded to include individuals with expertise in evaluating biological and sediment issues. Once membership is expanded, a permanent chair will be selected.

The Monitoring and Evaluation Action teams will meet with each of the other action teams to determine the need for monitoring applicable to each team.

Ongoing river monitoring efforts are to be identified by the Team to acknowledge the activity, determine what monitoring needs the project fulfills, determine if the team can add value to the effort, recommend alternatives to enhance the project. The team may also identify specific monitoring projects and sources of funding sought for their implementation.

The team will strive to make available monitoring results available to the public in an understandable format, preferably via the Internet.

# **Appendix G:** Background of the U.S. EPA Total Maximum Daily Loads (TMDL) Process

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### U.S. EPA TMDL Process

U.S. EPA is taking steps to achieve cleaner waters by revising the Total Maximum Daily Load (TMDL) program under the U.S. Clean Water Act. A TMDL is a framework for restoring impaired waters that follows three basic steps:

1. Calculation of the maximum amount of a pollutant that a waterbody can take in and still meet water quality standards;
2. An assessment of current loadings from all sources; and
3. A distribution of the amount calculated in #1 among the pollutant's sources, with an appropriate margin of safety.

Section 303(d) of the Clean Water Act (CWA) and U.S. EPA's implementing regulations at 40 CFR ‘130 and 40 CFR ‘132describe the statutory and regulatory requirements for approvable TMDLs. Using this framework, states, territories, and authorized tribes develop tailored restoration plans for each waterbody that they have identified as impaired, as well as for each pollutant of concern. The minimum components of a TMDL include the following:

- Description of waterbody, pollutant of concern, pollutant sources and priority ranking
- Description of TMDL endpoints - applicable water quality standards or numeric water quality targets
- Loading capacity - amount of loading that a waterbody can receive without violating water quality standards
- Load allocations (LAs)
- Wasteload allocations (WLAs)
- Margin of safety (MOS)
- Seasonal variation
- Monitoring plan for TMDLs developed under the phased approach
- Contribution of pollutant from sediments, where appropriate
- Implementation plans (recommended under current policy)
- Reasonable assurances of implementation
- Public participation
- Submittal letter

The U.S. EPA TMDL process is undergoing significant revision in the year 2000. New regulations have been proposed that will change what is required under both the Section 303(d) lists and for TMDLs. Any strategy developed linking the U.S. EPA TMDL process and the LaMP will be adjusted to follow the new regulations as they are finalized.

### Relationship of the U.S. EPA TMDL process to the Lake Erie LaMP

A TMDL Strategy for Lake Erie is in the process of being discussed and planned. There are key issues to be resolved prior to developing a Lake Erie TMDL Strategy, including identifying those pollutants for which a TMDL is appropriate. The TMDL Strategy will not be designed to take the place of a LaMP now or in the future. A TMDL is one of the many tools that the LaMPs will discuss regarding how the Great Lakes will be managed. The TMDL and the load reduction aspect of the LaMP processes are similar, but there are several key distinctions between the processes.

1. TMDLs focus on adjusting loadings to achieve water quality standards. LaMPs have a broader focus that includes water quality as one of several possible environmental stressors and water quality standards as one of the several endpoints.

2. TMDLs are for the U.S. only. The Lake Erie LaMP is a joint U.S. - Canadian process.
3. TMDLs are a regulatory process. LaMPs may use regulations but, overall, have tended to be voluntary and partnership-based.

In summary, the U.S. EPA TMDL process and the LaMP process are intended to contribute to achieving the common objective of restoring the Lake Erie ecosystem. However, a TMDL defines ecosystem protection more narrowly through the application of water quality standards, and places greater emphasis on understanding the relationship between pollutant load and achievement of the standard. In contrast, the LaMP defines ecosystem protection and restoration more broadly and places greater emphasis on pollution control planning and developing implementation targets.

## Issues to Be Resolved

Several key issues need to be resolved for developing a U.S. EPA TMDL for Lake Erie to complement the Lake Erie LaMP and vice versa.

**Issue 1:** Agreement on the waterbodies and pollutants for which a TMDL is appropriate, and agreement on the roles and responsibilities associated with each of these areas: tributaries, nearshore waters, open waters of the lake.

**Issue 2:** Encouraging consistency in impaired waterbody, or Clean Water Act 303(d), listing procedures among the states.

**Issue 3:** Would partitioning the lake into segments be easier and more efficient to address with U.S. EPA TMDLs?



**Issue 4:** Maintaining consistency in endpoint determinations (water quality standards) among the states and U.S. EPA.

**Issue 5:** Integration with other Programs.

**Issue 6:** Clarify the relationship between LaMP restoration and protection goals and U.S. EPA TMDL endpoints (water quality standards).

**Issue 7:** Options for addressing air deposition of U.S. EPA TMDL pollutants.

**Issue 8:** Approaches for determining margin of safety when addressing fish consumption advisories.

## Next Steps in the U.S. EPA TMDL Development Process

This document is only the first step in the process to develop a U.S. EPA TMDL Strategy for Lake Erie. These are the next steps in the process:

- Gather comments on this strategy planning document.
- Convene Agency Representatives in the fall of 2000 to begin discussions on: a) Strategy Issues Section; b) plans for information meeting; c) plans for stakeholder meetings; d) clarify resources needs and availability; and, e) possible formation of workgroups.
- Convene an information meeting early in 2001 to review the preliminary results of the Devil's Lake Mercury Pilot Study, following release of U.S. EPA Headquarter's TMDL Guidance.
- Convene a series of stakeholder meetings and/or workshops to inform the development of a draft Lake Erie U.S. EPA TMDL Strategy.

# **Appendix H:** Human Health Resources and References

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**Internet Information Resources and Further Reading Regarding Lake Erie Human Health Issues**

## 1. General Internet Resources and Readings

***United States***

US Environmental Protection Home Page
http://www.epa.gov/

U.S. EPA Great Lakes National Program Office
http://www.epa.gov/glnpo

U.S. EPA Region 5
http://www.epa.gov/

U.S. Center for Disease Control
http://www.cdc.gov/

U.S. Agency for Toxic Substances Disease Registry
http://www.atsdr.cdc.gov/

U.S. ATSDR Great Lakes Health Effects Program
http://www.atsdr.cdc.goc/grlakes.html

***States***

New York Department of Health

Pennsylvania Department of Health

Ohio Department of Health

Michigan Department of Community Health

***Canada***

Health Canada General Home Page
http://www.hc-sc.gc.ca/

Health Canada, Environmental Health Program Home Page
http://www.hc-sc.gc.ca/ehp/ehd/

***Province***

Ontario Ministry of Health
http://www.gov.on.ca/health/index.html

***Readings***

Health Canada, 1997. *State of Knowledge Report on Environmental Contaminants and Human Health in the Great Lakes basin.*

International Joint Commission. *Revised Great Lakes Water Quality Agreement of 1978 as Amended by Protocol Signed November 18, 1987.* Reprint February, 1994.

U.S. EPA and Government of Canada, 1995. *The Great Lakes: An Environmental Atlas and Resource Book.*

Johnson, B.L., H.E. Hicks, D.E. Jones, W. Cibulas, A. Wargo and C. T. De Rosa. 1998. Public Health Implications on Persistent Toxic Substances in the Great Lakes and St. Lawrence Basins. *Journal of Great Lakes Research*. 24(2): 698-722.

## 2. Internet Resources and Further Readings for Air

***Canada***

Air Pollution Health Effects Research Program in its Environmental Health Directorate
http://www.hc-sc.gc.ca/ehp/ehd/bch/air_quality.htm

Health Canada/Santé Canada. *Outdoor Air and Your Health: A summary of Research Related to the Health Effects of Outdoor Air Pollution in the Great Lakes Basin. / L'atmosphère et votre santé: Résumé de la recherche relative aux effets sur la santé de la pollution atmosphérique dans le bassin des Grands Lacs.* (Bilingual/bilingue). Great Lakes Health Effects Program/Le programme <Les Grands Lacs: Impact sur la santé>, March/Mars 1996.



***United States***

EPA Office of Air and Radiation
http://www.epa.gov/oar/oarhome.html

U.S. EPA Health Effects Notebook for Hazardous Air Pollutants
http://www.epa.gov/ttn/uatw/hapindex.html

OSHA Indoor Air page:
http://www.osha-slc.gov/SLTC/indoorairquality/index.html

## 3. Internet Resources and Further Readings for Drinking Water

BUIA Technical Report #11 - Drinking Water Consumption Restrictions and Taste or Odor Problems -
http://www.epa.gov/glnpo/lakeerie/buia/lamp11.pdf

***Canada***

Health Canada, 1999. Drinking Water Quality home page, at web site
http://www.hc-sc.gc.ca/ehp/ehd/bch/water_quality.htm

Ontario Ministry of the Environment, Drinking Water Surveillance Program. This web site provides executive summaries describing the performance of municipal water treatment facilities monitored under DWSP, for the years 1996-97.
http://www.ene.gov.on.ca/envision/dwsp/index96_97.htm

***United States***

U.S. EPA Office of Ground Water and Drinking Water Home Page
http://www.epa.gov/safewater/about.html

http://www.epa.gov/OGWDW/wot/appa.html
http://www.epa.gov/ogwdwooo/hfacts.html

U.S. EPA, "How Safe is my Drinking Water?" Office of Ground Water and Drinking Water http://www.epa.gov/OGWDW/wot/howsafe.html

U.S. EPA, Current Drinking Water Standards - National Primary and Secondary Drinking Water Regulations. Office of Groundwater and Drinking Water web site at http://www.epa.gov/OGWDW/wot/appa.html

U.S. EPA, Consumer Confidence Reports. Fact Sheet. At web site http://www.epa.gov/safewater/ccr/ccrfact.html

USFDA, Food Borne Pathogenic Microorganisms and Natural Toxins Handbook Web Page http://vm.cfsan.fda.gov/~mow/chap24.html

US Center for Disease Control. Cryptosporidiosis Fact Sheet. http://www.cdc.gov/ncidod/diseases/crypto/cryptos.htm

**Readings**

Wisconsin Department of Natural Resources, 1998. "Cryptosporidium: A Risk to our Drinking Water." Fact Sheet. Available on WDNR web site at http://www.dnr.state.wi.us/org/water/dwg/Crypto.htm#what steps. Revised June 1, 1998.

Health Canada, 1993. *The Undiluted Truth about Drinking Water.*

Health Canada, 1995. *Great Lakes Water and Your Health: A summary of AGreat Lakes Basin Cancer Risk Assessment: A Case-control Study of Cancers of the Bladder, Colon and Rectum.*

Health Canada, 1998b. *Health Canada Drinking Water Guidelines*. It's Your Health Fact Sheet Series, May 27, 1997.



## 4. Internet Resources and Further Readings for Recreational Water

BUIA Technical Report #12 - Recreational Water Quality Impairments (Bacterial Levels and Beach Postings)
http://www.epa.gov/glnpo/lakeerie/buia/beachpt1.pdf
http://www.epa.gov/glnpo/lakeerie/buia/beachpt2.pdf
http://www.epa.gov/glnpo/lakeerie/buia/beachpt3.pdf

***Canada***

Health Canada, 1999. *It's Your Health: Recreational Water Quality.* http://www.hc-sc.gc.ca/ehp/ehd/catalogue/general/iyh/recwater.htm

***United States***

U.S. EPA, Office of Water, *EPA's BEACH Watch Program, 1999 Update* http://www.epa.gov/OST/beaches/update.html

U.S. EPA BEACH Watch Program Homepage http://www.epa.gov/OST/beaches/

U.S. EPA Office of Water, BEACH Watch Program Homepage. http://www.epa.gov/OST/beaches/

U.S. EPA Office of Water, BEACH Watch Program. Local Beach Health Information.
http://www.epa.gov/OST/beaches/local/

Natural Resources Defense Council (NRDC). *Testing the Waters - 1999 - A Guide to Water Quality at Vacation Beaches*
http://www.igc.org/nrdc/nrdcpro/ttw/titinx.html

## 5. Internet Resources and Further Readings for Fish/Food Consumption

BUIA Technical Report #2 - Restrictions of Fish and Wildlife Consumption
http://www.epa.gov/glnpo/lakeerie/buia/lamp2.pdf

***Canada (Ontario)***
Ontario Ministry of the Environment. Guide To Eating Ontario Sport Fish 1999 - 2000
http://www.ene.gov.on.ca/envision/guide/index.htm

***United States***
U.S. EPA Fish Consumption Advisory Information
http://www.epa.gov/OST/fish/

***States***
Michigan Department of Community Health. Michigan Fish Advisory
http://www.mdch.state.mi.us/pha/fish/index.htm



New York Department of Environmental Control. NY Fish Advisory
http://www.dec.state.ny.us/website/outdoors/foe4chad.html

Ohio Department of Natural Resources. Ohio Fish Advisory
http://www.dnr.state.oh.us/odnr/wildlife/fishing/fishregs/fsh14.html

Pennsylvania Department of Environmental Protection. Pennsylvania Fish Advisory
http://www.dep.state.pa.us/dep/deputate/polycomm/update/up968-9.htm#fish

## 6. Internet Resources and Further Readings for Health Effects Information

ATSDR's Toxicological Profiles
http://www.atsdr.cdc.gov/toxpro2.html

ATSDR HAZDAT Database: Hazardous Materials and their Human Health Effects
http://atsdr1.atsdr.cdc.gov:8080/hazdat.html

ATSDR, Public Health Implications of Exposure to Polychlorinated Biphenyls (PCBs)
http://www.atsdr.cdc.gov/DT/pcb007.html

U.S. EPA Mercury Study Report to Congress
http://www.epa.gov/ttn/oarpg/t3/reports/volume5.pdf

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ATSDR (Agency for Toxic Substances and Disease Registry). 1999b. *Mercury Fact Sheet*. Atlanta, Georgia . U.S. Department of Health and Human Services.

ATSDR (Agency for Toxic Substances and Disease Registry). 1998. *Polychlorinated Biphenyls Toxicological Profile* (updated draft). Atlanta, Georgia: U.S. Department of Health and Human Services.

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Anderson, H.A., Amrhein, J.F., Shubat, P., Hesse, J. 1993. *Protocol for a Uniform Great Lakes Sport Fish Advisory*. Great Lakes Sport Fish Advisory Task Force.

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# Glossary and Acronyms

# Glossary

**alewife** - a small silver-colored fish that is not native to Lake Erie.

**alvar** - rare landscape on glaciated horizontal limestone or dolomite bedrock along the Lake Erie shoreline. They are at their southernmost range on the Marblehead peninsula and Kelleys Island. Historically there were more, but have since been destroyed, primarily by quarrying. Alvars are populated by drought-resistant calcium-loving plant species (combination of boreal and prairie species) which are maintained in an open state by drought, wave action and ice formation. These factors retard soil accumulation and the growth of woody species.

**ambient** - surrounding; usually in reference to existing environmental conditions. For example, ambient water quality would refer to the current water quality conditions in the lake.

**anoxia** - a condition where dissolved oxygen in the water column is totally depleted.

**anthropogenic** - of man-made origin, not occurring naturally.

**areas of concern** - specific areas of 42 tributaries to the Great Lakes where degraded environmental conditions have created an impairment to human or ecological beneficial use of the water body.



**Binational Executive Committee** - group of senior managers from the Parties (U.S. EPA and Environment Canada) and other federal, state and provincial agencies which oversees the implementation of activities by the Parties to meet the goals of the Great Lakes Water Quality Agreement.

**beneficial uses** - uses of Lake Erie that are valued by society, such as water quality that is suitable for fishing, drinking, swimming, agricultural, and industrial uses; healthy fish and wildlife populations which support a broad range of subsistence, sport, and commercial uses; and aesthetics.

**benthos** - bottom-dwelling organisms.

**bioaccumulation** - the process whereby a contaminant increases in an organism over time in relation to the amount consumed in food or absorbed from the surrounding environment.

**biomagnification** - a cumulative increase in the concentration of a persistent substance in successively higher trophic levels of the food chain.

**burrowing mayflies** - bottom-dwelling burrowing mayfly larvae *(Hexagenia)* are indicators of high water quality. In the 1950s, mayflies were wiped out in Lake Erie due to poor water quality. Low numbers of mayflies are an indicator of low amounts of dissolved oxygen. Also called Canadian soldiers, June bugs, fish flies.

***Bythotrephes*** - a cladoceran, or water flea. *Bythotrephes longimanus*, the spiny water flea, is a non-indigenous invasive species with a barbed tail spine that competes with fish for zooplankton. The tail spine makes it unattractive to other predators and it has flourished.

**carcinogen** - a substance that causes cancer.

***Cercopagis*** - a cladoceran related to *Bythotrephes*, which is a zooplankton predator. It is another non-indigenous invasive species poised to enter Lake Erie.

***Ceriodaphnia*** - type of *cladoceran*. Helpful in bioassay studies to determine chemical water quality standards for National Pollutant Discharge Elimination System (NPDES) permits.

**chemical contaminants** - naturally occurring, anthropogenic or synthetic chemicals.

**chlordane** - chemical used as a pesticide until banned by the U.S. in 1983 (except for use in controlling underground termites). Chlordane can accumulate in fish and wildlife tissue and is suspected to be a carcinogen.

**chlorophyll *a*** - the pigment that makes plants and algae green. Measurement of chlorophyll *a* is used to determine the quantity of algae in the water.

**cladocerans/copepods** - zooplankton that together make up a major component of the zooplanktonic community. They live in the water column and eat phytoplankton, serving as a link between plants and fish.

***Cladophora*** - a long filamentous type of green algae that attaches to hard surfaces, particularly near the shoreline. Abundant growth is an indicator of phosphorous enrichment.

**confined disposal facility** - a facility built specifically for the disposal of dredged sediment. Often referred to by the acronym CDF.



**critical pollutants** - substances that persist in Lake Erie waters and bioaccumulate in organisms living in or near the lake at levels that cause or are likely to cause impairment of beneficial uses.

***Diporeia*** - an amphipod that is an important food source for whitefish, lake trout and smelt, has declined dramatically in the eastern basin due to impacts from the quagga mussel.

**diatoms** - group of microscopic algae that have rigid cell walls composed of silica. They are an important part of the food chain.

**dioxins** - chemical byproducts of incineration and some industrial processes that use chlorine. Dioxins can accumulate in fish and wildlife and are suspected human carcinogens.

**dissolved oxygen** - the amount of oxygen measured in the water.

***Echinogammarus*** - an exotic amphipod that has replaced *Gammarus fasciatus*, another exotic, in many regions in Lake Erie.

**ecosystem** - the complex of a living community and its physical and chemical environment, functioning together as a unit in nature, with some inherent stability.

**ecosystem approach** - a comprehensive and holistic approach to understanding and anticipating ecological change, assessing the full range of consequences, and developing appropriate management responses. It integrates water quality management and natural resources management.

**ecosystem indicators** - measures of progress towards meeting ecosystem objectives. Indicators can range in type from administrative measures of activities such as number of

permits issued, to environmental measures such as water chemistry or fish populations.

**ecosystem objectives** - statements describing the desired conditions within an ecosystem to be attained and maintained (such as: *clean drinking water*). These statements can include specific descriptions of the desired state of the biological, chemical, and physical components of the ecosystem.

**embayment** - an area of water protected by land forming a bay such as Maumee Bay.

**environmental contaminants** - substances foreign to a natural system or present at unnatural concentrations. They may be chemicals, bacteria or viruses, or the products of radioactivity. Some contaminants are created by human activities while others are the result of natural processes.

**environmental stressors** - factors which cause, or have the potential to cause, impairments of beneficial uses of Lake Erie. These factors include chemical, physical, or biological influences on the Lake Erie ecosystem, as well as management practices.

**eutrophic** - the state of a well-nourished, productive lake that typically exhibits low levels of dissolved oxygen.

**eutrophication** - the process by which a lake becomes rich in dissolved nutrients and deficient in oxygen, occurring either as a natural stage in lake maturation or artificially induced by human activities such as the addition of fertilizers and organic wastes from runoff.



**exposure** - any contact between a substance and an individual who has touched, breathed or swallowed it.

**exposure pathways** - the pathway a contaminant may take to reach humans or other living organisms, and includes drinking water, recreational water and fish/food consumption.

**exposure routes** - The three major routes that chemical and microbial pollutants enter the human body are by ingestion (water, food, soil), inhalation (airborne), and dermal contact (skin exposure).

**food web** - the process by which organisms in higher trophic levels gain energy by consuming organisms at lower trophic levels. Humans are at the highest level of many food webs.

**forage fish** - fish species utilized as principal food sources for major sport and commercial fishes.

**fostering** - practice of removing an unhatched egg from one nest, hatching it artificially, and placing the chick in a new nest (referred in LaMP 2000 in regard to bald eagles).

***Gammarus fasciatus*** - a non-indigenous invasive amphipod.

**Great Lakes Water Quality Agreement** - an agreement signed by the United States and Canada to restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes Basin ecosystem.

**guideline** - a recommended limit for a substance or an agent intended to protect human health or the environment that is not legally enforceable (Health Canada, 1998).

**hacking** - practice of raising animals in captivity, acclimating them to natural conditions and then releasing them into the wild (referred to in LaMP 2000 in regard to bald eagles).

***Hexagenia*** - see burrowing mayfly.

**human health** - "a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity" (World Health Organization, 1984).

**hypolimnion** - the cooler, lower most layer of water in a thermally stratified lake.

**International Joint Commission** - commission established by the Boundary Waters Treaty of 1909, consisting of representatives from both the United States and Canada. The Commission's role is to oversee activities common to the borders of the two countries, including water quality in the Great Lakes.

**keystone species** - a species that has the ability to structure food webs.

**lake effect zone** - the area within the tributary where the water of Lake Erie and the river are mixed. This is typically the point at which the tributary reaches lake level. The size of the lake effect zone for every river is different and also varies with rising and falling lake levels. The following is the approximate distance, in miles, of the lake effect zone for each Ohio tributary to Lake Erie: Ottawa River 6.8; Maumee River 14.8; Crane Creek 2.9; Turtle Creek 5.6; Toussaint River 10.0; Portage River 15.7; Muddy Creek 5.2; Sandusky River 15.4; Huron River 4.6; Old Woman Creek 1.3; Vermilion River 1.5; Black River 4.1; Rocky River 0.5; Cuyahoga River 4.5; Chagrin River 0.9; Grand River 3.3; Ashtabula River 1.8; and Conneaut Creek 1.2.

**lead** - a heavy metal that may be hazardous to health if breathed or swallowed. Lead may bioaccumulate in fish and wildlife.



***Leptodiaptomus sicilis*** - type of *copepod*.

***Limnocalanus macrurus*** - large calanoid native to Lake Erie that has declined due to smelt.

**loadings** - the amount of pollutants being discharged or deposited into the lake.

**macroinvertebrates** - animals without backbones (invertebrates) that are large enough to be seen with the naked eye. Examples of macroinvertebrates include: crayfish, snails, clams, aquatic worms, leeches, and the larval and nymph stages of many insects, including dragonflies, mosquitoes, and mayflies.

**macrophyte** - plants of lakes, streams and wetlands that are visible with the naked eye.

**mercury** - a heavy metal that is a neurotoxin and harmful if inhaled or ingested at sufficiently high concentrations. Mercury readily bioaccumulates in all aquatic organisms.

**mesotrophic** - the trophic state of a lake that is in between eutrophic and oligotrophic.

**microbial contaminant** - micro-organisms (e.g. bacteria, viruses, and protozoa such as *cryptosporidium*) that can cause disease.

**microcystin** - a naturally-occurring, potent liver toxin produced by the algae *Microcystis*.

***Microcystis*** - a blue-green algae that causes algae blooms under eutrophic, high phosphorus conditions. It can be toxic to aquatic life and humans if ingested in sufficient quantities due to the presence of microcystin.

***Mysis relicta*** - freshwater shrimp found primarily in the Great Lakes. A primary food source of lake trout.

**natural land** - undisturbed, naturally occurring landscapes. Habitat.

**neurotoxin** - a substance that is known or suspected to impact the nervous system.

**nitrogen to phosphorus ratio** - nitrogen and phosphorus are both nutrients. The ratio that exists between the two can affect the composition or community of algal species in the water column.

**non-indigenous species** - species that are not native to an area. They could be exotics that originate in a foreign country, or tranplants into a region to which they are not native, but is still within their country of origin.

**oligotrophic** - the state of a poorly-nourished, unproductive lake that is commonly oxygen rich and low in turbidity.

**omnivorous fish** - fish, such as carp, that eat both plants and animals and are tolerant of poor water conditions.

**pelagia** - biological community existing in the open waters. Includes organisms floating in the water column or at the surface, as well as free-swimming organism.

**persistent bioaccumulative toxic chemicals** - chemicals that do not breakdown easily, persist in the environment, and bioaccumulate in plant, animal and human tissues.

**piscivores** - fish eating fish.



**planktivores** - plankton feeding fish.

**pollutants of concern** - in addition to the critical pollutants designated by the Lake Erie LaMP, a second, more comprehensive list of pollutants called pollutants of concern has been developed. For more information on this list, see Section 5.2 of this LaMP document.

**polychlorinated biphenyls** - A group of toxic, highly persistent and bioaccumulative chemicals used in transformers and capacitors (PCBs). A Lake Erie LaMP critical pollutant for priority action.

**polynuclear aromatic hydrocarbon** - A petroleum or coal combustion by-product often associated with elevated levels of tumors in fish (PAH).

**public health agencies** - for Lake Erie, includes the State Departments of Health for Michigan, New York, Ohio, and Pennsylvania; the Ontario Ministry of Health (provincial); Health Canada (federal); U.S. Agency for Toxic Substances and Diseases Registry (ATSDR, federal); U.S. Centers for Disease Control (federal); Public Health Units (municipalities in Ontario); Public Health Departments (state counties).

**phytoplankton** - plant microorganisms that float in the water, such as certain algae.

**remedial action plan** - (RAP) a plan developed and implemented to protect and restore beneficial uses in Great Lakes areas of concern, as required under the Great Lakes Water Quality Agreement.

**secchi disk** - a black and white patterned disk lowered into the water column to measure water clarity.

**sentinel species** - a species used as an indicator of overall environmental conditions, particularly contaminants. For example, mayflies (*hexagenia*) and bald eagles.

**soluble reactive phosphorus** - the part of total phosphorus that bioavailable.

**standard** - a legally enforceable limit for a substance or an agent intended to protect human health or the environment. Exceeding the standard could result in unacceptable harm.

**total phosphorus** - the total concentration of phosphorus found in the water.

**toxicological profiles** - fact sheets prepared by the U.S. Agency for Toxic Substances and Disease Registry (ATSDR), "for hazardous substances which are most commonly found at facilities on the CERCLA National Priorities List and which pose the most significant potential threat to human health, as determined by ATSDR and the Environmental Protection Agency" (U.S. Department of Health and Human Services, 1992).

**toxic substance** - a substance which can cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological or reproductive malfunctions or physical deformities in any organism or its offspring, or which can become poisonous after concentration in the food chain or in combination with other substances (IJC, 1987).

**trophic** - having to do with various nutritional levels of the food chain.

**trophic guilds** - groups of organisms that are similar in their nutritional requirements and feeding habits, such as planktivores, piscivores, omnivores, etc.

**weight of evidence approach** - the weight of evidence approach considers all high-quality scientific data (i.e. the overall evidence) on adverse health effects from wildlife studies, experimental animal studies, and human studies in combination, toward hazard identification and in weighing the actual and potential adverse health effects of environmental contamination in human populations.

**zooplankton** - animal microorganisms that float in the water.

# Acronyms

**AOC** - area of concern
**ANS** - aquatic nuisance species
**ATSDR** - U.S. Agency for Toxic Substances and Disease Registry
**BEC** - Binational Executive Committee
**BTS** - Great Lakes Binational Toxics Strategy: Canada - United States Strategy for the Virtual Elimination of Persistent Toxic Substances in the Great Lakes
**BUI** - beneficial use impairment
**BUIA** - beneficial use impairment assessment
**CDF** - confined disposal facility
**CERCLA** - Comprehensive Environmental Response, Compensation, and Liability Act
**CRP** - Conservation Reserve Program
**CREP** - Conservation Reserve Enhancement Program
**CSO** - Combined sewer overflow
**EC** - Environment Canada
**ECA** - ecosystem alternative
**EJ** - environmental justice
**EOSC** - ecosystem objectives subcommittee
**FCGO** - fish community goals and objectives as developed by the Lake Erie Committee of the Great Lakes Fishery Commission
**FCM** - fuzzy cognitive map model
**FIELDS** - fully-integrated environmental locational decision support system
**GLFC** - Great Lakes Fishery Commission
**GLI** - Great Lakes initiative (Great Lakes water quality guidance - U.S.)
**GLSLB** - Great Lakes St. Lawrence Basin project (Canada)
**GLWQA** - Great Lakes Water Quality Agreement
**IADN** - Integrated atmospheric deposition network
**IJC** - International Joint Commission
**IPCC** - Intergovernmental Panel on Climate Change
**LaMP** - Lakewide Management Plan
**LEC** - Lake Erie Committee of the Great Lakes Fishery Commission
**LEMP** - Lake Erie at the Millennium Plan
**LOEC** - lowest observable effect level
**MAC** - maximum acceptable concentration (used for Canadian guidelines)
**MCL** - maximum concentration limit (used for U.S. standards and guidelines)
**MDEQ** - Michigan Department of Environmental Quality
**MDNR** - Michigan Department of Natural Resources
**NAWMP** - North American Waterfowl Management Plan
**NAWQA** - National Water Quality Assessment Program
**NIS** - non-indigenous invasive species
**NOAA** - National Oceanic and Atmospheric Administration
**NPDES** - National Pollutant Discharge Elimination System
**NPRI** - National pollutant release inventory (Canada)
**NRDC** - Natural Resources Defense Council
**NSERC** - Natural Sciences and Engineering Research Council
**NSI** - national sediment inventory (U.S.)
**NWRI** - National Water Research Institute (Canada)
**NYDEC** - New York Department of Environmental Conservation
**ODNR** - Ohio Department of Natural Resources
**OEPA** - Ohio Environmental Protection Agency
**OSI** - Ohio sediment inventory

**PAH** - polynuclear aromatic hydrocarbon
**PBT** - persistent, bioaccumulative toxic chemicals
**PCB** - polychlorinated biphenyl
**RAP** - remedial action plan
**SOLEC** - State of the Lakes Ecosystem Conference
**SSO** - Separate/sanitary sewer overflow
**STAR** - Science to Achieve Results grant program of U.S. EPA Office of Research and Development
**STP** - sewage treatment plant
**TMDL** - total maximum daily loads
**TRI** - toxics release inventory
**U.S. EPA** - United States Environmental Protection Agency
**USGS** - United States Geological Survey
**WHO** - World Health Organization