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.

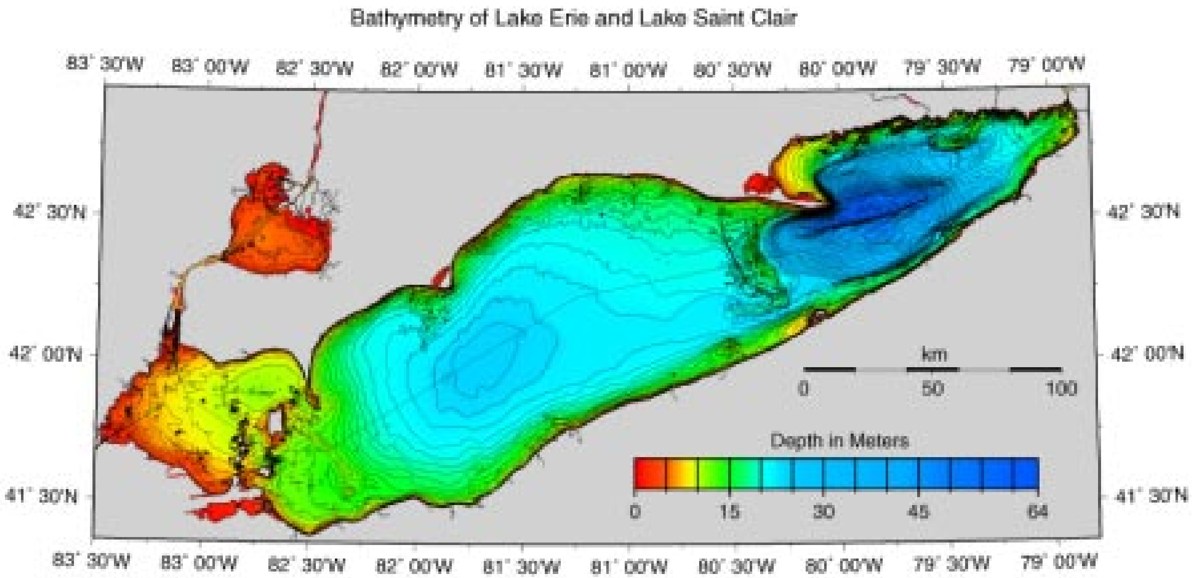
Lake Erie is naturally divided into three basins (Figure 2.1). The western basin is very shallow with an average depth of 7.4 metres (24 ft.) and a maximum depth of only 19 metres (62 ft.). The central basin is quite uniform in depth, with the average depth being 18.3 metres (60 ft.) and a maximum depth 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.)

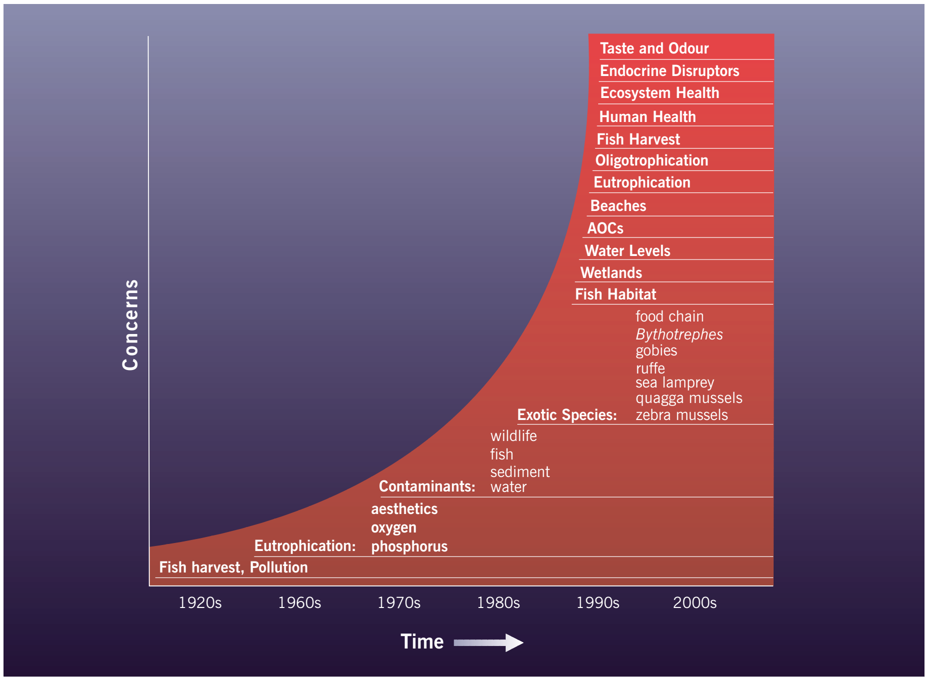
Of all the Great Lakes, Lake Erie is exposed to the greatest stress from urbanization, industrialization and agriculture. Reflecting the fact that the Lake Erie basin supports the largest population, it surpasses all the other Great Lakes in the amount of effluent received from sewage treatment plants (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

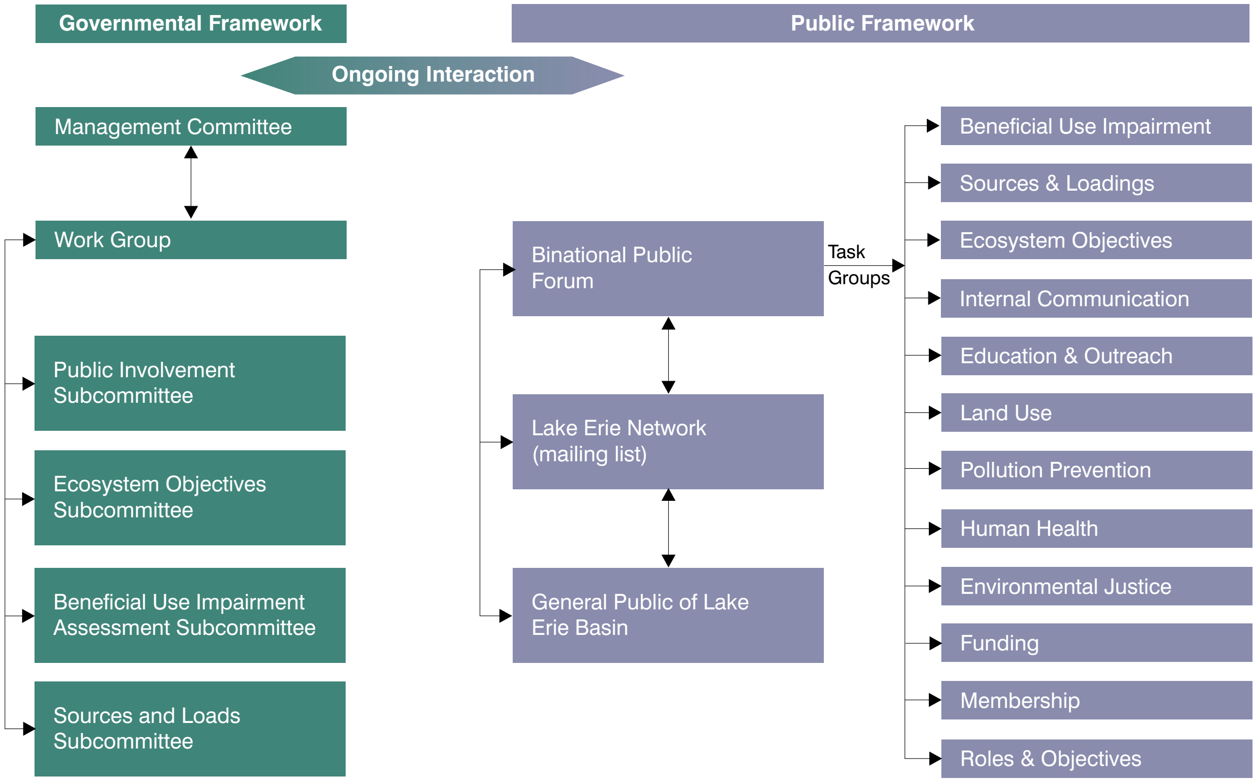
- Agency for Toxic Substances and Disease Registry
- Michigan Department of Environmental Quality
- Michigan Department of Natural Resources
- Natural Resource Conservation Service
- New York State Department of Environmental Conservation
- Ohio Department of Natural Resources
- Ohio Environmental Protection 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.

2.3 References

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