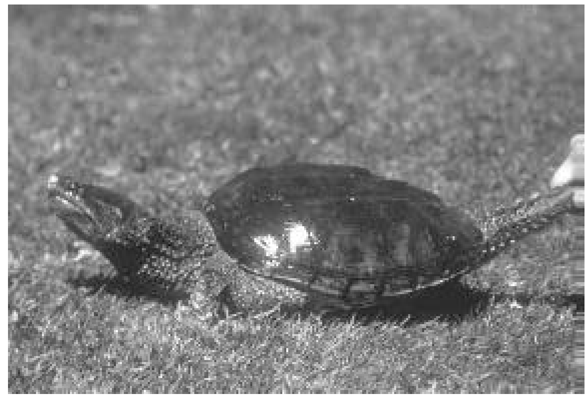
CHAPTER 3 PROBLEM IDENTIFICATION

Significant changes have occurred in the Lake Ontario ecosystem over the last century due to the effects of toxic pollution and habitat loss resulting from the rapid development of the Lake Ontario basin. The extent of these changes was fully realized in the 1960s and 1970s, when Lake Ontario colonial waterbirds experienced nearly total reproductive failures due to high levels of toxic contaminants in the food chain. In 1972, Canada and the United States took actions to ban and control contaminants entering the Great Lakes, and, in 1987, renewed the Great Lakes Water Quality Agreement (GLWQA) with the goal to restore the overall health of the Great Lakes ecosystem. Today, as a result of these actions, levels of toxic contaminants in the Lake Ontario ecosystem have decreased significantly, and colonial waterbird populations have overcome most of the recognized contaminant-induced impacts of 25 years ago (i.e., their eggshells show normal thickness, they are reproducing normally, and most population levels are stable or increasing). However, *bioaccumulative toxics* persist in sediment, water, and biota at levels of concern for some fish species, such as lake trout and salmon, and for higher order predators, such as bald eagles, snapping turtles, mink and otters, and humans.



Snapping Turtle
(National Park Service, Indiana Dunes National Lakeshore)

This chapter summarizes lakewide impairments of beneficial uses in Lake Ontario caused by chemical pollutants and other factors. These impairments are those beneficial uses of the Great Lakes which cannot presently be realized, as laid out in the GLWQA. The same process is being used to identify problems within the other Great Lakes and in Areas of Concern (AOC). Given the rapid environmental changes that have occurred over the last 20 years, emphasis was placed on using the most recent information to identify current problems facing the Lake Ontario ecosystem. Sources and loadings of critical pollutants, as well as other

3.1 Introduction

As defined by the Great Lakes Water Quality Agreement, “impairment of beneficial use(s)” is a change in the chemical, physical, or biological integrity of the Great Lakes System sufficient to cause any of the following:

1. *Restrictions on fish and wildlife consumption*
2. *Tainting of fish and wildlife flavor*
3. *Degradation of fish and wildlife populations*
4. *Fish tumors or other deformities*
5. *Bird or animal deformities or reproductive problems*
6. *Degradation of benthos*
7. *Restrictions on dredging activities*
8. *Eutrophication or undesirable algae*
9. *Restrictions on drinking water consumption, or taste and odor problems*
10. *Closing of beaches*
11. *Degradation of aesthetics*
12. *Added costs to agriculture or industry*
13. *Degradation of phytoplankton and zooplankton populations*
14. *Loss of fish and wildlife habitat*

factors responsible for the identified problems, are summarized in this chapter as well. Local impairments found in Lake Ontario AOCs and other nearshore areas are also discussed.

The GLWQA provides fourteen indicators of beneficial use impairments (identified in the text box on page 25) to help assess the impact of toxic chemicals and other factors on the Great Lakes ecosystem. These indicators provide a systematic way to identify pollutant impacts on the entire ecosystem, ranging from phytoplankton to birds of prey and mammals, including humans.

3.2 Identifying Lakewide Problems and Critical Pollutants

The LaMP process uses a broad range of ecological factors, in addition to regulatory standards, to identify critical pollutants. The GLWQA 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".

In preparing this binational problem assessment, Canada and the United States first independently evaluated 13 of the Lake Ontario beneficial use impairments for those geographic areas within their jurisdictions (Rang *et al.*, 1992; USEPA and NYSDEC, 1994). The agencies proceeded to integrate their separate evaluations into this binational assessment of the status of beneficial use impairments in Lake Ontario. The fourteenth beneficial use impairment, loss of fish and wildlife habitat, was evaluated using Lake Ontario habitat reports compiled by the United States Fish & Wildlife Service (USF&WS) as part of the LaMP evaluation process (Busch *et al.*, 1993) and others (Whillans *et al*., 1992). The LaMP recognizes the importance of appropriate linkages to other natural resource management initiatives such as fishery management plans, lake-level management, wetlands protection, watershed management plans, and control strategies for exotic species.

The beneficial use impairment assessment identifies the lakewide use impairments in Lake Ontario and the toxic substances contributing to these impairments (i.e., those substances for which we have "direct" evidence that they are impairing beneficial uses). It is also important for the Lake Ontario LaMP to consider toxic substances which are **likely** to impair beneficial uses (i.e., there is "indirect" evidence that these chemicals are impairing beneficial uses if they exceed the most stringent U.S. or Canadian standard, criteria, or guideline). The Four Parties reviewed recent fish tissue contaminant concentrations and found mercury concentrations in smallmouth bass and walleye to exceed Ontario's 0.5 parts per million (ppm) guideline for fish consumption throughout the lake. Mercury is responsible for local impairments in Canada. In addition, dieldrin was also found to exceed the most stringent water quality and fish tissue criteria lakewide. Although mercury and dieldrin are not causing lakewide impairments of beneficial uses, these contaminants will be included as LaMP critical pollutants given the lakewide nature of these criteria exceedences.

3.3 Lakewide Beneficial Use Impairments

The following is a summary of the technical basis for the beneficial use impairment assessment and the identification of the chemical, physical, and biological factors contributing to these impairments. A general list of references is provided as Appendix G. Detailed references for information sources are provided in the individual United States and Canadian assessment reports that were used for this evaluation. In the development of the LaMP, the lakewide impairment status (impaired, degraded, insufficient information, or unimpaired) was determined after consideration of the Ecosystem Goals for Lake Ontario (section 1.7) and the preliminary ecosystem objectives. This report does not provide a complete analysis of the biological and physical problems facing the lake because the ecosystem objectives and indicators needed to evaluate these problems are still being developed.

Based on the assessment, four lakewide beneficial use impairments exist that require binational actions:

- Restrictions on fish and wildlife consumption
- Degradation of wildlife populations
- Bird or animal deformities or reproductive problems
- Loss of fish and wildlife habitat

These impairments are also used to identify critical pollutants and biological/physical stressors. PCBs, DDT, dioxins, and mirex are the critical pollutants associated with one or more of these lakewide impairments (Table 3-1). Loss of fish and wildlife habitat is due primarily to physical and biological factors rather than toxic contaminants. All Lake Ontario AOCs, except the Port Hope AOC, also list these four impairments as local concerns. The LaMP process will be coordinated with the development of Remedial Action Plans in these local areas to ensure the development of effective strategies for lakewide critical pollutants and other lakewide issues. Through the LaMP process, other existing programs that address these issues will also be supported and coordinated.

Table 3-1. Summary of Lake Ontario Lakewide Beneficial Use Impairments and Related Critical Pollutants and Other Factors.

Lakewide Impairments	*Impacted Species*	*Lakewide Critical Pollutants & Other Factors*
Restrictions on Fish and Wildlife Consumption	Trout, Salmon, Channel catfish, American eel, Carp, White sucker	PCBs, Dioxins, Mirex
	Walleye, Smallmouth Bass[a]	Mercury[a]
	All waterfowl[b]	PCBs, DDT, Mirex[b]
	Snapping Turtles[b]	PCBs[b]
Degradation of Wildlife Populations	Bald Eagle[c]	PCBs, Dioxin, DDT
	Mink & Otter[c]	PCBs
Bird or Animal Deformities or Reproductive Problems	Bald Eagle[c]	PCBs, Dioxin, DDT
	Mink & Otter[c]	PCBs
Loss of Fish and Wildlife Habitat	A wide range of native fish and wildlife species	Lake Level Management Exotic Species Physical Loss, Modification, and Destruction of Habitat

[a] Canadian advisories only.
[b] U.S. Advisories only.
[c] Indirect evidence only (based on fish tissue levels).
Notes: Dieldrin, although listed as a LaMP critical pollutant, is not associated with an impairment of beneficial use.
"DDT" includes all DDT metabolites; "Dioxin" refers to all dioxins/furans.

3.3.1 Restrictions on Fish and Wildlife Consumption

The Four Parties have agreed that fish and wildlife consumption advisories due to PCBs, dioxins and furans, and mirex are lakewide beneficial use impairments. Most human exposure to many persistent and bioaccumulative contaminants is through eating fish and other aquatic organisms, which far outweighs contaminant exposures related to drinking water, air, or other terrestrial sources. Consumption advisories are developed to help protect people from the potential health impacts associated with long term consumption of contaminated fish and wildlife.

Fish Consumption Advisories

In general, consumption advisories are based on contaminant levels in different species and ages of fish. Both Ontario and New York fish consumption advisories account for the fact that contaminant levels are generally higher in older, larger fish. There are some differences in the fish tissue monitoring processes of the two governments; for example, New York State analyzes entire fillets which include belly-flap and skin (catfish, bullhead, and eels are exceptions since skin is removed before analysis) and Ontario analyzes muscle fillets. These two types of fish samples are not directly comparable. Muscle fillets have lower fat content. Since organochlorine chemicals, such as PCBs and DDT, tend to concentrate in fatty tissue, muscle fillet samples will generally show lower levels of these contaminants than the levels found in the fattier fillets.

Both jurisdictions agree that PCBs, dioxin, DDT, and mirex are responsible for this lakewide impaired beneficial use and require binational actions. Although not responsible for consumption advisories on a lakewide basis, mercury concentrations in larger smallmouth bass and walleye are likely to exceed Ontario's 0.5 ppm criteria for human consumption and will therefore be considered a critical pollutant.

In Ontario, a Sports Fish Contaminant Monitoring Program is administered by the Ministry of the Environment (MOE) and the Ontario Ministry of Natural Resources (MNR). New York State operates a statewide fish tissue monitoring program. USEPA's Great Lakes National Program Office coordinates a fish tissue monitoring effort as part of a long term contaminant trends monitoring project. Fish tissue samples are also collected by the Canadian Department of Fisheries and Oceans (DFO) as part of its long term contaminant trends monitoring program.

In Ontario, sportfish advisories are published every two years in the Guide to Eating Ontario Sport Fish, which includes tables for the Great Lakes. Appendix E provides a detailed breakdown of Lake Ontario advisories as reported in the 1997-98 Guide. Advisories were reported for 19 species: salmon (chinook, coho), trout (rainbow, brown, lake), white bass, yellow and white perch, whitefish, rainbow smelt, freshwater drum, channel catfish, white and redhorse suckers, brown bullhead, American eel, black crappie, gizzard shad, and carp. The contaminants responsible for advisories are PCBs (50%), dioxins and furans (1%), and mirex (27%). The regular evaluation of commercial catches by DFO's fish inspection program has led to some restrictions on the commercial harvest of carp, large walleye, and channel catfish.

The New York State Department of Health issues annual fish consumption advisories for New York State waters which include specific and general advisories for Lake Ontario. NYSDEC collects and analyzes fish for contaminants. "Eat none" advisories are in place for Lake Ontario American eel, channel catfish, carp, lake trout, rainbow trout, chinook salmon, coho salmon over 21 inches, brown trout over 20 inches, and white perch (west of Point Breeze). "Eat no more than one meal per month" advisories are in effect for Lake Ontario white sucker, coho salmon less than 21 inches, brown trout less than 20 inches, and white perch (east of Point Breeze). "Eat no more than one meal per week" advisories are in effect for many Lake Ontario fish species not listed above. In addition, an "Eat none" advisory, which applies to all Lake Ontario fish, is in effect for all women of childbearing age and children under the age of 15. This stringent advisory is designed to protect these sensitive human populations from any increased exposure to toxic contaminants.

In addition to these lakewide consumption advisories caused by organic contaminants, it is worth noting that a considerable number of local advisories exist in Canadian waters due to mercury. Appendix E provides a detailed breakdown of mercury advisories. Mercury advisories were reported for nine species of fish, including walleye, in fourteen locations. Walleye is an important recreational fishery in the eastern end of Lake Ontario. Fish consumption advisories are periodically reconsidered if new information suggests that more restrictive advisories are necessary to fully protect human health or if contaminant levels have dropped below guidelines.

Wildlife Consumption Advisories

Diving ducks, such as mergansers, feed on fish and other aquatic organisms and, as a result, tend to be the most heavily contaminated waterfowl. New York has a statewide advisory recommending that mergansers not be eaten and that the consumption of other types of waterfowl be limited to no more than two meals per month. The New York State Health Department also advises that wild waterfowl skin and fat should be removed before cooking and that stuffing be discarded. The contaminants of concern for Lake Ontario mergansers in New York are PCBs, DDT, and mirex.

Snapping turtles are another example of a high level predator that is near the top of the food chain. Over their relatively long life span, snapping turtles can accumulate significant levels of persistent toxic substances in their fatty tissues. New York's statewide advisory recommends that women of childbearing age, and children under the age of 15, "eat no" snapping turtles, and recommends that others who choose to consume snapping turtles should reduce their exposure by trimming away all fat and discarding the fat, liver, and eggs prior to cooking the meat or preparing the soup. This advisory is based on PCBs, as the primary contaminants of concern. Studies conducted by the Canadian Wildlife Service of Environment Canada have shown contaminant levels in ducks and turtles to be below guidelines. There are no consumption advisories for wildlife species in the Canadian portion of the Lake Ontario basin.

3.3.2 Degradation of Wildlife Populations and Bird or Animal Deformities or Reproduction Problems

The Four Parties have agreed that wildlife consumption advisories and population and reproduction impairments are lakewide impairments caused by PCBs, dioxin equivalents, and DDT. Wildlife used in the evaluation of this beneficial use indicator include mink, otter, bald eagles, colonial water birds, and a variety of fish species. These species were chosen because of historical, documented problems associated with contaminants or other non-chemical stressors. These species are useful indicators of environmental conditions because of their high level of risk due to being at or near the top of the food chain or requiring special habitat in order to reproduce successfully.

There is indirect evidence that bald eagle, mink, and otter populations remain degraded along the Lake Ontario shoreline. Levels of PCBs, dioxins, and DDT and its metabolites in the food chain are thought to be important factors that are limiting the recoveries of these wildlife populations. There is no indication that current levels of contaminants in the open waters are degrading fish populations. The two impairments, degradation of fish and wildlife populations and bird or animal reproduction problems, are addressed together in this section since past declines in some wildlife populations are directly related to contaminant-related reproduction problems.

Bald Eagles

Bald eagle populations began to decline in the early 1900s due to hunting and loss of habitat. In the decades following the introduction of DDT in 1946, contaminant-induced eggshell thinning lowered reproductive success throughout North America, including the Lake Ontario basin. During the 1980s, after DDT and other pesticides were banned, a few successful bald eagle nesting territories were re-established in the Lake Ontario basin. By 1995, bald eagles had recovered to the point that they were moved from the U.S. endangered species list to the threatened species list. There are at least six successful bald eagle nesting territories in the Lake Ontario basin that have fledged more than sixty eaglets since 1980 (Nye, 1979, 1992). Although there are no nesting territories located close to the Lake Ontario shore, it is expected that bald eagles will reoccupy historical shoreline nesting territories as their population steadily expands, provided appropriate nesting habitat is available. In 1992, a survey of the entire Lake Ontario shoreline (both Canadian and U.S. sides) for suitable breeding habitat for bald eagles was conducted by Environment Canada, the Ontario Ministry of Natural Resources, and U.S. bald eagle experts. This information will be available in future LaMP documents.

Bald eagle and young at nest
(Don Simonelli
Michigan Travel Bureau)

There is indirect evidence that bald eagle reproduction in the Lake Ontario basin is impacted by persistent toxic contaminants. Studies of bald eagles nesting on other Great Lakes shorelines suggest that levels of PCBs, dioxins, and DDT in the Lake Ontario food web may cause lowered reproductive success, increased eaglet deformities, and early adult mortality (Best, 1992; Bowerman *et al.,* 1991). This could be a concern as shoreline nesting territories become re-established and the eagles feed on contaminated fish during the nesting and breeding season.

Colonial Waterbirds

Colonial waterbirds have a long history of being used as indicators of contaminant effects on Lake Ontario and throughout the Great Lakes (Gilbertson, 1974; Mineau *et al.,* 1984). More than 25 years ago, Gilbertson (1974, 1975) and Postupalsky (1978) found highly elevated contaminant levels in eggs, severe eggshell thinning, elevated embryonic mortality, high rates of deformities, declining population levels, and total reproductive failure among several species of colonial waterbirds on Lake Ontario. Although many of these conditions have improved substantially, [e.g., concentrations of PCBs, dieldrin, total DDT, mirex, mercury, and dioxins have declined significantly in herring gull eggs and, to a lesser extent, in cormorants and Common and Caspian Terns (Weseloh *et al.*, 1979, 1989; Ewins and Weseloh, 1994; Bishop *et al.*, 1992; Pettit *et al.*, 1994), eggshell thickness has returned to normal (Price and Weseloh, 1986; Ewins and Weseloh, 1994), and population levels have increased (Price and Weseloh, 1986; Blokpoel and Tessier, 1996)], the current status of some of these conditions is unknown and some new issues have arisen (physiological biomarkers, endocrine disruption, genetic deformities) in birds as well as in other classes of wildlife. These issues will be the subject of future studies, the results of which will be considered by the LaMP.

Mink & Otter

As with the bald eagle, there is indirect evidence that suggests reproduction of Lake Ontario mink in nearshore areas is affected by persistent toxic contaminants. Laboratory studies corroborate that levels of PCBs and dioxin-like contaminants in the food chain may limit the natural recovery of both mink and otter populations.

Settlement, trapping, and habitat losses during the eighteenth century are believed to have contributed to major population declines for both species. Prior to these changes, the river otter had one of the largest geographic ranges of any North American mammal and was found in all major U.S. and Canadian waterways.

In the 1960s, reproductive failures of ranch mink that had been fed Great Lakes fish led to the discovery that mink are extremely sensitive to PCBs (Hartsough, 1965; Aulerich and Ringer, 1977). Laboratory experiments have shown that a diet of fish, with PCB or other dioxin-like contaminant levels comparable to those found in some Lake Ontario fish, can completely inhibit mink reproduction. However, the fact that mink are highly opportunistic and may rely on muskrat, rabbits, and mice for the bulk of their diet in some locales makes it difficult to estimate the impact that environmental contaminants are having on the populations of this species. Otters, on the other hand, rely almost exclusively on fish for their diet, but there is little information on the sensitivity and exposure of otters to PCBs and other contaminants.

Information on mink and otter population trends and reproductive rates is extremely limited, which makes it difficult to evaluate their status. Currently, harvest statistics from trappers is the only indicator of population trends. This is a poor indicator as it is influenced by weather, fur prices, disease, and other factors that are not related to health and population status. Field studies of mink and otter populations are extremely labor intensive and not always successful given the secretive nature of these animals. Investigators often need to rely on secondary indicators of presence in an area, such as tracks and scat.

Fish Populations

The loss of several fish species and reductions in native fish populations between the early 1800s and the 1960s are attributed primarily to overfishing, loss of habitat, and the impact of exotic species, such as the sea lamprey and alewife. The loss of some species, such as the blue pike, an important predator, has permanently altered the Lake Ontario ecosystem. The contribution of persistent toxic contaminants to the loss of certain fisheries is unclear because fish populations were already severely degraded by the time that significant levels of contaminants began to be released to the environment. Current levels of contaminants in Lake Ontario do not appear to have a measurable impact on fish reproduction as fish culture facilities obtain eggs from Lake Ontario salmon and trout to support stocking programs. Successful culture of these species in the hatchery environment suggests that they are capable of natural reproduction in the wild. However, a sustained population of lake trout has been difficult to re-establish naturally. This is due to excessive predation by alewife on lake trout eggs and fry; degradation of spawning habitats; unsuitable genetic backgrounds of some stocked fish; excessive harvest; and potential sub-lethal impacts of toxic substances. A possible vitamin deficiency problem impacting lake trout and salmon, due to their reliance on alewife as their principal prey, is also a factor inhibiting the natural reproduction of these fish. With declining nutrient levels and decreasing alewife populations, record numbers of naturally reproduced lake trout yearlings were observed in 1995.

Fishing from shore
(USDA Natural Resources Conservation Service)

Although current levels of toxic contaminants, such as dioxin, are now generally acknowledged to be below toxic levels for lake trout fry, some research suggests that Lake Ontario dioxin concentrations in water and sediment during the 1940s and 1950s may have been sufficiently high to prevent lake trout reproduction. Research is ongoing to recognize and better understand any potential synergistic or additive effects of contaminants on current fish populations.

Populations of walleye, lake whitefish, and burbot are continuing to increase, and there are now several year classes of lake herring. More recently, there have been increasing reports of native fish catches that were thought to be extinct or severely depleted (e.g., deep water sculpin, lake sturgeon, and stickleback). This information suggests that the ecological stage is set for significant recovery of native Lake Ontario fish species barring any major unforeseen changes in the food web.

3.3.3 Loss of Fish and Wildlife Habitat

The Four Parties agree that loss of fish and wildlife habitat is a lakewide impairment caused by artificial lake level management, the introduction of exotic species, and physical loss, modification, or destruction, such as deforestation and damming of tributaries. Binational evaluations are underway to evaluate potential options to mitigate these impacts. An evaluation of recent (1980-1990) habitat conditions did not identify persistent toxic substances as a significant cause of lakewide habitat loss or degradation.

Artificial Lake-Level Management

There is considerable evidence that the management of lake levels has inadvertently reduced the area, quality, and functioning of some Lake Ontario nearshore wetlands. Nearshore wetlands are important to the ecology of the lake because they provide habitat necessary for many species of fish and wildlife to successfully live and reproduce. These wetlands may be unique or of limited quantity in the number and types (diversity) of plants and soil benthic type (i.e., rocks, sand, or silt). Without wetlands of suitable quality and quantity, many species of fish and wildlife would be at risk. There is also significant concern among the citizens living along the shoreline of Lake Ontario that lake level management is causing increased erosion and property loss. High lake levels are associated with accelerated rates of erosion and property loss in areas susceptible to lake-induced erosion.

Lake level management was first recommended to limit flooding and erosion in the Lake Ontario basin and to prevent flooding of major metropolitan areas along the St. Lawrence River, such as Montreal. Lake Ontario level and St. Lawrence River flow regulations are also used to benefit commercial navigation and hydropower production. The International Joint Commission (IJC) was established in 1909 by the Boundary Waters Treaty to serve as an impartial group with jurisdiction over boundary water uses. The IJC consists of three U.S. members appointed by the President of the United States and three Canadian members appointed by the Prime Minister of Canada. Plans to artificially manage Lake Ontario water levels began in 1952 when the IJC issued an Order of Approval to construct hydropower facilities in the international reach of the St. Lawrence River at Cornwall, Ontario and Massena, New York. The hydropower facilities were completed in 1960. The IJC amended its order in 1956 to include regulation criteria designed to reduce the range of lake levels and to protect riparian and other interests downstream in the Province of Quebec. This amended order also established the International St. Lawrence River Board of Control to ensure compliance with provisions of the Orders. The St. Lawrence Board consists of ten members chosen by the IJC for their technical expertise.

Lake levels are currently regulated by Plan 1958-D. This plan sets maximum and minimum flow limitations which change week to week to provide adequate hydropower production and, at the same time, maximize depths for navigation and provide protection against flooding in the St. Lawrence River. Authorization may be requested by the Board to deviate from Plan 1958-D when supplies are greater or less than those upon which the plan was developed. During the development of this plan, environmental and recreational factors were not considered. As recommended by the IJC's Levels Reference Study Board, the St. Lawrence Board has been investigating the possibility of changing the current plan and/or procedures to better address environmental and recreational concerns.

Several environmental issues have been identified in studies completed by the Levels Reference Study Board in 1993. As a result of lake level management, Lake Ontario wetlands are no longer experiencing the same range of periodic high and low water levels. This reduction in range has resulted in some wetlands becoming a monoculture of cattails -- a greatly reduced biodiversity of nearshore areas. In addition, the current four foot range in fluctuation for Lake Ontario is too narrow to preclude cattail overpopulation by modifying the timing of water level highs and lows from their natural cycle. This can have a devastating effect on wetlands, often resulting in too little water for fish and wildlife reproduction purposes, but has provided benefits to recreational and commercial boating.

Further studies, which will take a number of years to complete, are underway to identify possible ways to improve the lake level management scheme, to be more sensitive to environmental needs, as well as public health and economic needs. Regulation of lake levels is difficult because changes in precipitation rates and winter ice cover are unpredictable and limit our ability to manage water levels. Shoreline erosion is a natural occurence caused by the energy present in water at the shoreline. The nature of erosion that may occur is related to the soil type and elevation, wind, current, and water level at the time. Where the energy in the water can be absorbed, erosion will be slow, but where the makeup of the shoreline is unstable, the effects of erosion take place more quickly.

Erosion of certain areas of Lake Ontario's shoreline is a natural process that will inevitably occur.

Exotic Species

It is difficult to assess the interactions between newly introduced exotic species, naturalized exotic species, and native species. This evaluation is further complicated by other chemical and physical changes that are taking place in the basin. It is clear, however, that exotic species are having a significant impact on the Lake Ontario ecosystem.

The Lake Ontario ecosystem has endured several waves of invasions of exotic species. Some of these species, such as the sea lamprey, have clearly had a negative impact on native species. In fact, sea lamprey predation on lake trout is recognized as one factor that contributed to the demise of that species. The United States-Canadian Great Lakes Fishery Commission was established primarily to control the sea lamprey. Through its efforts, the observed rate of lake trout woundings or mortalities by sea lamprey is now sufficiently low to allow achievement of other fishery management objectives. Currently, with the continuation of control efforts, the sea lamprey is not considered a major limiting factor for the recovery of native fish.

Who controls and manages exotic species?

- ***Great Lakes Fishery Commission***
- ***United States & Canadian Coast Guards***
- ***Ontario Ministry of Natural Resources***
- ***Canadian Department of Fisheries and Oceans***
- ***New York State Department of Environmental Conservation***
- ***U.S. Federal Aquatic Nuisance Species Task Force***
- ***U.S. Fish and Wildlife Service***
- ***U.S. Sea Grant***

Unlike the sea lamprey, other exotic species have become important components of the Lake Ontario food chain. These species include smelt and alewife, which are now the dominant forage fish. More recently invading exotic species that have potentially significant adverse impacts on the ecosystem include zebra mussels, ruffe, round goby, blueback herring, and the spiny water flea. Although the ruffe, round goby, and blueback herring are now present in the Great Lakes basin, they have not yet reached Lake Ontario. The potential for the round goby and blueback herring to reach Lake Ontario in the near future is considered to be fairly high.

Zebra and quagga mussels have altered the Lake Ontario ecosystem by redirecting nutrients flowing through the system from the pelagic to the benthic food web. This shunting of energy to the benthic food web can reduce productivity in the open lake. Although these changes may resemble natural historical conditions, they are having a negative impact on the naturalized open lake forage fish (alewife and smelt) and predators that are dependent upon those species as a food source. Zebra mussels appear to increase the *bioaccumulation* of toxic chemicals into food chains and decrease *macroinvertebrate* prey of whitefish and slimy sculpin. They also negatively impact beach use, and they appear responsible for declines in native clam populations. In addition, there are increased maintenance costs associated with keeping drinking water and cooling water intakes free of these mussels. Zebra mussels do have some positive effects, including improved water clarity; the development of mussel shell bottoms favorable to certain macroinvertebrates; increases in native benthic forage fish; and increased survival in young native lake trout, lake whitefish, and potentially lake herring.

It is exceedingly difficult and costly to control exotic species after they have been introduced to an ecosystem, so control programs have concentrated on preventing new introductions and inhibiting the spread of existing species. An important component of these control programs is the regulation that requires ocean-going ships to exchange their ballast water at sea before entering the St. Lawrence Seaway. This requirement seeks to ensure that any exotic species present in the ballast water will not be released into the Great Lakes. It is believed that zebra mussels, the round goby, and the ruffe were all introduced to the Lakes in this way.

The United States and Canadian Coast Guards are working to limit the introduction of non-indigenous species through transoceanic shipping. In addition to the ballast water exchange requirement, chemical treatment measures may be necessary to deal with any organisms that may be left in the tanks after ballast water exchange.

Physical Loss or Destruction of Habitat

The early colonists began to alter the seasonal flows of Lake Ontario tributaries by clearing land. As the land was cleared, water temperatures began to rise, siltation increased, and aquatic vegetation (which provides cover for young fish) was lost. Further, the damming of Lake Ontario tributaries and streams impeded migration of salmon and other native species to their spawning and nursery grounds. The combined impacts of all these factors were devastating to nearshore, tributary, and wetland habitats.

Wetlands provide vital habitat to many species of Lake Ontario's wildlife. It has been estimated that about 50 percent of Lake Ontario's original wetlands throughout the watershed has been lost. Along the intensively urbanized coastlines, 60 to 90 percent of wetlands has been lost. These losses are a result of the multiple effects associated with urban development and human alterations, such as draining wetlands to establish agricultural land, marina construction, dyking, dredging, and disturbances by public utilities. Natural processes, such as erosion, water level fluctuations, succession, storms, and accretion, contribute to the loss of wetlands as well.

Wetland being filled

Currently, approximately 80,000 acres of Lake Ontario's wetlands remain. The largest expanses are located in the eastern portion, along the coastline of Presqui'ile Bay's Provincial Park in Ontario and in Mexico Bay in New York. The pressures of urban and agricultural development continue to threaten wetlands as the public wishes to locate along the lakeshore, have larger marinas in river mouths, achieve more efficient stormwater removal from streets and properties, or till marginal wetlands in the watershed during dry years. Major government initiatives, including education and regulatory controls, have done much to reduce or prevent the loss of wetlands. More than 20 percent of Lake Ontario's wetlands are fully protected (parks) while additional areas are subject to a variety of municipal, state/provincial, or federal rules, regulations, acts, or programs. Stemming continued losses of wetlands requires action at the most efficient level of organization, and opportunities to protect, restore, or replace these valuable habitats need to be explored.

3.4 Insufficient Information for Lakewide Assessment but Impaired in Areas of Concern

3.4.1 Degradation of Benthos

The term "benthos" refers to the wide range of organisms that live in direct contact with the lake bottom sediments. Benthic organisms are an important food source for fish and other aquatic organisms. As the benthic community is in direct contact with the sediment, it can be a major route for transfer of contaminants to higher trophic levels. All of the Lake Ontario AOCs, which generally have higher levels of sediment contamination than the open water areas, have either listed degraded benthic communities as an impaired use or are in the process of evaluating this issue.

There is currently insufficient information on the nature of macrobenthic communities throughout the lake, including the open water basins, to make a determination on the status of this impairment. This impairment will be evaluated through the LaMP process once sufficient information has been collected and analyzed. A recent investigation collected detailed information on macrobenthic communities from more than 40 locations throughout the lake. This information is currently being evaluated and a follow-up investigation is in progress. In addition to identifying potential impacts of toxic chemicals on benthic communities, information will be collected on the relative extent and density of zebra mussels. Zebra mussels have the potential to degrade native populations of benthic organisms lakewide and warrant special consideration.

Changes within the benthic community are related to the dramatic changes in nutrient levels and fish community structure that occurred between the 1950s and the present. These impacts may have overshadowed any past or present lakewide impacts from toxic contaminants. Although sediment contamination, both organic and inorganic, throughout Lake Ontario has been well documented, not enough is known about the role of physical habitat, predation, or nutrient levels on benthic community structures and populations to isolate the effects of sediment contamination on these organisms.

Quantitative surveys of Lake Ontario benthic communities did not begin until the 1960s (with the exception of one survey in 1922) (Nalepa, 1991). Generally Lake Ontario's open water benthic communities are dominated by small crustaceans (*Diporeia* spp.) and worms (*Stylodrillus heringianus*). Healthy populations of these organisms are considered to be indicators of good environmental quality since they require cold, well oxygenated waters and are pollution intolerant. *Diporeia* spp. is an effective bioaccumulator of organic contaminants and an important food source for Lake Ontario slimy sculpin, smelt, and alewives. Studies of *Diporeia* tissue contaminants show levels of PCBs, DDE, and hexachlorobenzene at much higher levels than the surrounding sediment concentrations; bioaccumulation factors for PCBs were found to range from nine to nineteen in western Lake Ontario. No studies have been specifically designed to assess the long term sub-lethal effects of contaminant levels on benthic communities.

3.4.2 Degradation of Phytoplankton and Zooplankton Populations

Phytoplankton are microscopic forms of aquatic plants, including algae and diatoms, and are at the base of the aquatic food chain. Zooplankton are small aquatic animals that feed on phytoplankton or other zooplankton. Zooplankton are an important food for plankton-eating fish, such as alewife and smelt.

The potential effects of toxic substances on the health and reproduction of phytoplankton and zooplankton are not well understood. Declining phosphorus levels, changes in fish populations, and exotic species may have obscured any impacts that contaminants might have had on these populations. No lakewide studies of plankton were conducted before the loss of major fisheries in the 1920s, the onset of lakewide eutrophication in the 1940s, and toxic pollution in the 1950s (Christie and Thomas, 1981; Stoermer *et al.,* 1975). The first detailed studies of Lake Ontario phytoplankton and zooplankton were conducted in the 1970s; however, these studies were primarily concerned with defining plankton species distributions and productivity and were not designed to evaluate potential contaminant impacts. More research is required to determine if contaminants are having a negative impact on phytoplankton and zooplankton in Lake Ontario.

Recent studies suggest that Lake Ontario phytoplankton community structures are shifting in response to lakewide phosphorus reduction programs and zebra mussel invasion, and total biomass is decreasing for the same reason (Wolin *et al*., 1991 and Makarewicz, 1993). The zooplankton community has changed since the early 1970s, in response to grazing by exotic species (alewife), and the mid-July to mid-October biomass declined by approximately 50 percent in response to both decreasing phytoplankton biomass and intense grazing by plankton-eating fishes.

Monitoring efforts in the U.S. and Canada are developing a better understanding of Lake Ontario phytoplankton and zooplankton populations. A comprehensive offshore biomonitoring program (Bioindex project) has been conducted by the Canadian Department of Fisheries and Oceans, from 1981 to the present at a mid-lake station, and from 1981 to 1995 at an eastern basin station. The U.S. Lake Ontario Bioindex program, a cooperative research program carried out by the New York State Department of Environmental Conservation, Cornell University, and the U.S. Fish & Wildlife Service, has monitored 35 stations throughout the lake since 1995. In addition, USEPA's Lake Guardian research vessel has monitored eight stations since 1986. MOE has conducted a monitoring program of phytoplankton and related trophic and chemical parameters at six municipal water treatment plant intakes in Lake Ontario since the late 1960s. Phytoplankton composition (to genus) and biomass data are available on a weekly basis and chemical data have been available since 1976. These programs have collected seasonal data on physical and chemical parameters as well as a comprehensive set of data on phytoplankton and zooplankton biomass, species composition, and production. The analysis of these data will consider contaminants as just one of a suite of factors that impact on the impairment of this beneficial use. A detailed report on the findings of these studies will be summarized in future LaMP documents.

3.5 Localized Impairments in Areas of Concern and Other Nearshore Areas

In addition to lakewide impairments, a number of other problems are found in some localized nearshore areas and embayments. This is not surprising as industrial and municipal contamination can become concentrated at the mouths of rivers or harbors. The IJC has identified seven specific geographic AOCs on Lake Ontario (see page 3 for a map of these sites). Remedial Action Plans (RAPs) serve as the primary mechanism for addressing these localized contaminant problems and other issues unrelated to lakewide impairments. Additional nearshore problems beyond the specific AOCs are being addressed through a variety of other environmental management programs. Table 3-2 summarizes the status of these beneficial use impairments. A list of contacts for specific RAPs is provided in Appendix D for those who would like to obtain more detailed information on the status of impairments in AOCs and actions underway to address these problems.

Table 3-2. Summary of Beneficial Use Impairments in Six Lake Ontario Areas of Concern (AOC) and Other Nearshore Areas. Another AOC, the Eighteenmile Creek in the U.S., is in the process of completing its beneficial use impairment assessment.

Indicators of Beneficial Use Impairments	Lakewide Status	Rochester Embayment	Oswego Harbor	Hamilton Harbour	Metro Toronto	Port Hope	Bay of Quinte	Other Nearshore Areas
1. Restrictions on Fish & Wildlife Consumption	X	X	X	X	X		X	X
2. Tainting of Fish & Wildlife Flavor		?						
3. Degradation of Fish or Wildlife Populations	X	X	X	X	X		X	
4. Fish Tumors or Other Deformities		?		X	?		?	Several locations on north shore
5. Bird or Animal Deformities or Reproductive Problems	X	X	X	?	?			
6. Degradation of Benthos	?	?	X	X	X		X	
7. Restrictions on Dredging Activities				X	X	X	X	Several small bays and harbours
8. Eutrophication or Undesirable Algae		X	X	X	X		X	Tributary mouths, harbors, and embayments
9-A. Restrictions on Drinking Water Consumption								
9-B. Drinking Water Taste & Odor Problems		X					X	
10. Beach Closings		X		R	X		X	X
11. Degradation of Aesthetics		X		X	X		X	
12. Added Costs to Agriculture or Industry		X						
13. Degradation of Phytoplankton & Zooplankton Populations	?	?	?	?	?		X	
14. Loss of Fish & Wildlife Habitat	X	X	X	X	X		X	

X - impairment identified ? insufficient information R - beneficial use restored

3.5.1 Fish Tumors

Fish tumors are more common in some species of nearshore fish, such as brown bullheads and white suckers, than others; however, it is very difficult to determine what the o atural tumor incidence rate is for particular location (Hayes *et al*., 1990). Relatively high levels of tumors can be found in fish from both clean and polluted water bodies. For example, skin and liver tumors have been documented in fish taken from relatively pristine drinking water reservoirs in New York and Pennsylvania, where no elevated levels of carcinogens [such as polycyclic aromatic hydrocarbons (PAHs)] have been detected in sediments or water (Bowser *et al.*, 1991). This fact complicates the process of selecting a control or background site to which the incidence of fish tumors in a contaminated area can be compared. Viruses, genetic differences, and naturally occurring carcinogens, in addition to chemical contaminants, are thought to have a role in fish tumor development.

The presence of tumors in Lake Ontario fish was first noted in the early 1900s before persistent toxic contaminants became a problem in the lake. Liver tumors were first identified in wild fish in the 1960s. However, a temporal correlation between any change in the incidence of fish tumors and the onset of the severe environmental contamination problems of the 1960s cannot be firmly established because the first detailed studies of fish tumors in Lake Ontario were not conducted until the 1970s.

A 1996 collection of spawning walleye in the Salmon River, a tributary of the Bay of Quinte, found that the frequency of liver tumors increased with the age of the fish and was more prevalent (87.5%) in female walleye greater than 14 years of age. The frequency-age relationship is comparable to previous walleye collections in the St. Lawrence River. The tumors are non-invasive and it is possible that the tumors are a naturally occurring phenomenon in old walleye. However, before any interpretation of probable cause can be made, it will be necessary to determine the rates of liver tumors in similarly aged walleye from other more pristine habitats.

Contaminant-related fish tumors would be expected to be most prominent in Lake Ontario AOCs where there are generally higher contaminant levels than in open water areas. To date, Hamilton Harbour is the only Lake Ontario AOC which lists this impairment. The Oswego Harbor AOC recently completed a fish tumor study that found no impairment. The Metro Toronto, Bay of Quinte, and Eighteenmile Creek AOCs have each indicated that additional information is necessary to fully evaluate the status of this impairment**.** As there are few reports of tumors in open water fish, fish tumors are not considered to be a lakewide impairment. The lakewide status of this impairment will need to be periodically evaluated as new information is developed on the incidence of tumors in open water fish as well as the role of contaminants and other factors involved in fish tumor development.

3.5.2 Restrictions on Dredging Activities

Localized areas of sediments with elevated levels of persistent toxic contaminants are found in some Lake Ontario harbors and river mouths. Periodic dredging of these sediments is necessary to maintain shipping and small craft channels. This beneficial use impairment is not considered to be a lakewide impairment because dredging restrictions do not pertain directly to open water areas; however, this impairment is a concern in a number of localized nearshore areas and AOCs.

Criteria that are used to assess dredging activities are not based on whether or not dredging should take place, but rather the mode of dredged material disposal. There are five main ways to dispose of dredged sediments. Clean, uncontaminated sediments can either be placed on beaches or reused along shorelines as fill. The other three methods of disposal, offshore, upland, and confined, are based on the degree of contamination of the sediments. The most highly contaminated sediments require confined disposal in special contaminated sediment facilities. Less contaminated sediments can be stored in landfills or disposed in deep offshore waters.

Dredging

The Canadian Department of Public Works maintains the register for Canadian dredging data. The register records location of dredging, volume of sediments dredged, disposal methods, and chemical analysis data. Information on dredging activities was registered from 1975 until a few years ago when navigational dredging activities declined in the region. From 1980 to 1985, PCBs exceeded the “marginally polluted level” at Hamilton, Toronto, Oshawa, Whitby, and Point Traverse. Dredging was undertaken from 1985 to 1991 at Grimsby, Whitby, Trenton, Kingston, and four times in Oshawa. Based on Ontario’s sediment quality guidelines (1992), PCBs exceeded the “severely polluted level” at Oshawa in 1985, the “slightly polluted level” in 1986, and the “marginally polluted level” in 1991. In 1991, the dredged material was disposed in a closed harbor disposal cell. The Hamilton Harbour, Metro Toronto, Port Hope, and Bay of Quinte AOCs all identify dredging restrictions as an impairment. In addition to organic pollutants, sediment concentrations of heavy metals and conventional parameters, such as nitrogen, phosphorus, and oil and grease, have also been identified as a concern in a number of nearshore areas.

In the United States, the Army Corps of Engineers (USACE) oversees and approves dredging projects in coordination with USEPA. There are currently no restrictions on dredging or dredged material disposal activities in the U.S. waters of Lake Ontario due to contaminated sediments. Sediment dredged from major Lake Ontario harbors meets USEPA and USACE guidelines for open water disposal. No dredging restrictions were identified by the RAPs for Rochester Embayment or Oswego Harbor. The only U.S. dredging restriction applies to the type of dredging methods that can be used on the Genesee River. In response to local concerns regarding excessive turbidity levels, dredging techniques that cause excessive turbidity in the river are not allowed. Critical pollutants are not a cause of these limitations.

In February 1998, USEPA and USACE finalized the Inland Testing Manual, which lays out stringent testing protocols for dredged material disposal in inland waters. Over the next 12 to 18 months, USEPA and USACE will work with their partners to develop a regional manual to implement the national testing protocol in the New York State portions of Lakes Ontario and Erie. The status of this beneficial use could change if future dredging projects encounter sediments that exceed these new, more stringent testing requirements.

3.5.3 Eutrophication or Undesirable Algae

Eutrophication is a process in lakes that is characterized by an overload of nutrients. It is often accompanied by algal blooms, low oxygen concentrations, and changes in food web composition and dynamics. In Lake Ontario, persistent eutrophication and undesirable algae are no longer causes of lakewide problems. The elimination of eutrophication problems in Lake Ontario during the 1950s and 1960s is largely due to the success of the binational phosphorus reduction programs and improvements in wastewater treatment plants throughout the entire Great Lakes basin. In the summer of 1993, the average Lake Ontario total phosphorus level was 9.7 ug/L, near the GLWQA objective of 10 ug/L for open lake spring conditions (IJC, 1980 and Thomas *et al.,* 1980).

In the 1950s and 1960s, algal blooms and fish die-offs occurred throughout Lake Erie and Lake Ontario, raising concerns about the environmental impacts of excessively high phosphorus levels. In an attempt to remedy this problem, the GLWQA set a target load of 7,000 metric tonnes of phosphorus per year. To measure the success of the reduction programs, additional targets were set: phosphorus concentration (10 ug/L), chlorophyll *a* (2.6 ug/L), and water clarity (5.3 m in open waters).

In response to the phosphorus control programs, open lake phosphorus concentrations declined from a peak of about 25 ug/L in 1971 to the 10 ug/L guideline in 1985. By 1991, Lake Ontario phosphorus levels were well below the guideline. In addition, since the early 1980s, water clarity has increased by 20 percent, photosynthesis has declined approximately 18 percent, and late summer zooplankton production has declined by 50 percent. All of these are positive changes reflecting an overall shift of the lake back towards its original condition of low nutrient levels.

Although significant progress has been made in reducing eutrophication problems in nearshore areas, this is still a concern in local areas. Each of the Lake Ontario AOCs, with the exception of Port Hope, has identified eutrophication as a local impairment. In New York State, Braddock Bay, Irondequoit Bay, Sodus Bay, East Bay, Port Bay, Little Sodus Bay, Chaumont Bay, and Mud Bay are showing signs of eutrophication. Nutrients from agricultural runoff and on-site waste disposal systems (septic systems) are the most frequently identified sources of the problem. County level environmental planning efforts are providing the lead on controlling these localized eutrophication problems in the U.S.

In conclusion, it appears that eutrophication is no longer a problem in offshore waters. This is largely due to the success of the binational phosphorus reduction programs and improvements in wastewater treatment plants throughout the entire Great Lakes basin. Although substantial improvements have been made in the nearshore areas, eutrophication may still be a significant issue in some local areas.

3.5.4 Restrictions on Drinking Water Consumption, or Taste and Odor Problems

Regular monitoring of the quality of water supplies drawn from Lake Ontario shows that water quality meets or exceeds public health standards for drinking supplies. Open lake surveillance monitoring conducted as part of Canadian and United States research efforts also confirms the high quality of Lake Ontario water.

The largest category of consumer complaints about drinking water, worldwide, is taste and odor problems (AWWA, 1987). Changes in the taste of drinking water may indicate possible contamination of the raw water supply, treatment inadequacies, or contamination of the distribution system. Although there are standards for some parameters that may cause taste and odor problems, such as phenolic compounds, there is considerable variation among consumers as to what is acceptable. Aesthetically acceptable drinking water supplies should not have an offensive taste or smell.

Although there are no drinking water restrictions on the use of Lake Ontario water, some nearshore areas, such as Rochester and the Bay of Quinte, report occasional taste and odor problems. Lake Ontario water suppliers most commonly receive consumer complaints regarding an "earthy" or "musty" taste and odors. Studies conducted by Lake Ontario water suppliers have shown that these problems are related to naturally occurring chemicals, such as geosmin (trans, trans-1,10-dimethyl-9-decalol) and methylisoborneol (MIB), produced by decaying blue-green algae and bacteria. Using chlorine to clear water supply intakes of zebra mussels may also stimulate the production of these taste and odor-causing chemicals. Geosmin and MIB can cause taste and odor problems for sensitive individuals at levels as low as one part per trillion (ppt), well below the detection limits of the analytical equipment currently available to water authorities (2 to 3 ppt). Once identified, taste and odor problems can be eliminated at water treatment plants by the use of powdered activated carbon or potassium permangenate.

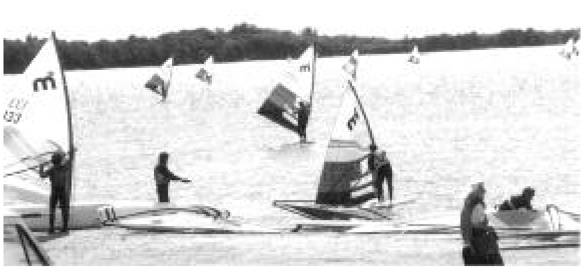
Taste and odor problems are more common during algal blooms. Additionally, storm events precipitate these problems by breaking up mats of the green algae Cladophora from their rocky substrate in nearshore areas. Floating mats of Cladophora located in warm shallow water are ideal habitats for blue-green algae and bacteria growth. The presence of these floating mats contributes to taste and odor problems. Localized eutrophication problems in some nearshore areas may also contribute to taste and odor problems.

In summary, taste and odor problems are considered to be a locally impaired beneficial use in some areas. The causes, however, are poorly understood. Naturally occurring algae, eutrophic conditions, and zebra mussel controls may all be important contributing factors.

3.5.5 Beach Closings

Beach closings are restricted largely to shorelines near major metropolitan centers or the mouths of streams and rivers. These closings follow storm events when bacteria-rich surface water runoff is flushed into nearshore areas via streams, rivers, and combined sewer overflows (CSOs). In some instances beaches may be closed based on the potential for high bacteria levels to develop following storm and rain events. Beaches are also closed for aesthetic reasons, such as the presence of algal blooms, dead fish, or garbage. Given the localized nature of beach closings and their absence along much of the Lake Ontario shoreline, they are not a considered lakewide problem.

In Ontario, beaches are closed when bacterial (E. coli) levels exceed 100 organisms/100mL. During recent years (1995 to 1997) beach closings have continued in heavily urbanized areas in the western part of the basin due to storm events, but are less frequent in the central and eastern regions. Examples of ongoing problems include the beaches of the Bay of Quinte, Toronto, Burlington, Hamilton, Niagara, Pt. Dalhouse, and St. Catherines. Upgrading stormwater controls through the installation



Windsurfers enjoying the beach

of collection tanks so stormwater from CSOs can be treated in Toronto and Hamilton should reduce beach closings in these areas.

The only U.S. beach with recent closings is Ontario Beach within the Rochester AOC. These closings have been posted due to rain events, storm runoff, excessive algae, waves greater than four feet, or visibility less than one-half meter. Ontario Beach is routinely closed as a precaution during storm and rain events because these conditions have the potential to cause high bacteria levels along the beach shore. Ontario Beach summer fecal coliform levels have been well below the state's action level of 200 fecal coliforms/100mL. The implementation of a combined sewer overflow abatement program resulted in significant decreases in fecal coliform levels in the Genesee River and adjacent shoreline areas. Actions are also underway to address stormwater problems that impact other areas of the Rochester Embayment.

3.5.6 Degradation of Aesthetics

There are currently no aesthetic problems in the open waters of Lake Ontario. This is attributed to the elimination of widespread eutrophication problems and the restoration of water clarity. However, some Lake Ontario AOCs have identified this impairment. Evaluating aesthetic problems is subjective, often based on individual value judgments. Localized aesthetic problems along Lake Ontario shorelines include algal blooms, dead fish, debris, odor, silty water, improper disposal of boat sewage wastes, and litter problems at parks and scenic highway stops.

On the U.S. side, the Rochester AOC lists silt, odors related to alewife dieoffs, and decaying algae as aesthetic problems. A recent water quality survey conducted at the Oswego Harbor AOC indicates that this beneficial use is not impaired.

On the Canadian side, the Metro Toronto RAP lists debris and litter, turbidity in the vicinity of tributary mouths and landfilling operations, and weed growth along shorelines as aesthetic problems. In addition, the Royal Commission for Toronto's Waterfront noted the continued loss of Toronto area historical buildings and landscapes and the lack of adequate public access to the lake as aesthetic concerns. The Bay of Quinte RAP identified algal blooms as the primary cause of aesthetic concerns. Major causes of aesthetic impairment in Hamilton Harbour include oil sheens, objectionable turbidity, floating scum, debris, putrid matter, and reduced water clarity in shallow areas.

3.5.7 Added Costs to Agriculture or Industry

This is not a lakewide impairment as Lake Ontario waters do not require any additional treatment costs prior to agricultural or industrial use. The Rochester Embayment AOC is the only Lake Ontario AOC to identify this impairment, based on the additional maintenance costs associated with the physical removal of zebra mussels from water intake pipes.

Many industries and municipalities adjacent to Lake Ontario are experiencing zebra mussel infestation in their water intakes. The main treatment for this problem is to use various chlorine compounds, together with other chemicals such as calcium permangenate, to kill the mussels -- an ongoing maintenance cost.

3.6 Unimpaired Beneficial Uses

Tainting of Fish and Wildlife Flavor

The contamination of surface waters by certain types of organic contaminants, such as the class of chemicals known as phenols, can taint fish and wildlife flavor. During the 1950s, 1960s, and 1970s, levels of phenols near the mouth of the Niagara River often exceeded standards designed to prevent tainting of fish and wildlife flavor. Since that time, improvements in wastewater treatment systems have dramatically reduced the amounts of these substances being discharged to surface waters. Today, levels of phenols are well below levels of concern.

There are no existing reports that indicate tainting of fish and wildlife flavor is a concern for the open waters of Lake Ontario. Neither is this potential impairment identified as a problem in any nearshore areas of the lake. Evaluating this type of impairment is difficult given the very subjective nature of taste. Studies have shown that fish consumers cannot consistently detect the difference between tainted and non-tainted fish. The length of time and preservation methods used before cooking fish can also contribute to taste problems.

3.7 Pollutants to be Addressed Through the LaMP

As discussed in the previous section, there is direct and indirect evidence that PCBs, DDT and its metabolites, mirex, and dioxins/furans are impairing beneficial uses in Lake Ontario.[1,2]

[1]Heptachlor and heptachlor epoxide have been removed from the list of critical pollutants since the April 1997 draft based on new information summarized in Appendix B.

[2]Dieldrin, although it exceeds criteria on a lakewide basis, is no longer believed to be the cause of bald eagle reproduction problems, as explained in Appendix B.

It is also important for the Lake Ontario LaMP to consider toxic substances that are **likely** to impair beneficial uses. In this case, there is no direct evidence that a substance contributes to use impairments, but there is indirect evidence if a chemical exceeds U.S. or Canadian standards, criteria, or guidelines. A review of recent fish tissue contaminant concentrations identified mercury as a lakewide contaminant of concern because mercury concentrations in larger smallmouth bass and walleye are likely to exceed Ontario's 0.5 parts per million guideline for fish consumption throughout the lake. Although there are no U.S. or Canadian consumption advisories for eating smallmouth bass and walleye on a lakewide basis, the data are sufficient to identify mercury as a critical pollutant as part of the LaMP pollutant reduction strategy. As with mercury, dieldrin is not linked to a lakewide impairment but dieldrin concentrations exceed the most stringent criteria for both water and fish tissue. Given the lakewide nature of these exceedences of the most stringent criteria, dieldrin is also included in the list of LaMP critical pollutants.

Previous LOTMP reports had also identified three other contaminants as exceeding standards and criteria: octachlorostyrene (OCS), chlordane, and hexachlorobenzene (HCB). A review of current information showed that none of these contaminants persist as a lakewide issue. OCS, chlordane, and HCB are well below applicable water quality criteria, as described in Appendix B.

The critical pollutants that have been identified as impairing uses in Lake Ontario are persistent, bioaccumulative toxic substances: they remain in the water, sediment, and biota for long periods of time and they accumulate in aquatic organisms to levels that are harmful to human health. It is the intent of the Four Parties to prevent the development of additional lakewide use impairments that may be caused by other persistent, bioaccumulative toxics entering the lake. Therefore, the LaMP will identify actions that will address the critical pollutants identified above as well as the broader class of chemicals known as persistent, bioaccumulative toxics.

***Lakewide Critical Pollutants* are bioaccumulative and persistent toxic substances that are known or suspected to be responsible for lakewide impairments of beneficial uses: PCBs, DDT & its metabolites, mirex, dioxins/ furans, mercury, and dieldrin. These substances will be the focus of the Lake Ontario LaMP source reduction activities.**

Lake Ontario lakewide critical pollutants all resist natural breakdown processes and can bioaccumulate in living organisms. Given these properties, these contaminants will persist in the environment long after most sources of these contaminants have been eliminated or controlled. Improvements in laboratory analytical techniques now allow us to detect most of these contaminants at extremely low levels in air, water, soil, and biota samples.

Strategies to reduce or eliminate critical pollutant inputs need to be based on an understanding of how and where these chemicals were used or are produced and disposed so that their sources can be located and controlled. We also need to understand the various physical and chemical pathways by which these contaminants move through the ecosystem to be able to determine the appropriate control strategy and to predict the time needed to restore impairments. The following discussion provides a brief overview of the six lakewide critical pollutants and some preliminary contaminant loadings information.

This preliminary attempt to develop estimates of critical pollutants entering the lake identified a number of data gaps. Examples of the types of data gaps to be considered as part of future LaMP efforts include: 1) insufficient data to estimate critical pollutant loadings for many tributaries; 2) limited data on atmospheric loadings of critical pollutants throughout the basin; and 3) the amount of critical pollutants being effectively removed from the system due to burial in the deep basins of the lake.

3.8 Sources and Loadings of Critical Pollutants

3.8.1 Sources of Critical Pollutant Loadings Information

It is extremely difficult to estimate critical pollutant loadings entering Lake Ontario via rivers, precipitation, sewage treatment plants, waste sites, agricultural areas, and other sources. The levels of contaminants entering the lake from these sources are constantly changing in response to many known and unknown factors. As a result, loadings data are often limited and rely on numerous assumptions. Although quantitative loadings information may be difficult to obtain, qualitative indicators provided by the environmental monitoring of water, sediment, and aquatic organisms can often provide sufficient information to identify those contaminant sources that need to be controlled. Improving the database on sources and loadings of critical pollutants is a high priority, as is determining effective ways to virtually eliminate these critical pollutants from Lake Ontario.

Table 3-3 presents four major categories of critical pollutant loadings estimates based on the best data currently available:

1. loadings from sources outside the Lake Ontario basin;
2. loadings from sources inside the Lake Ontario basin;
3. atmospheric loadings; and
4. releases from Lake Ontario to the St. Lawrence River and *volatilization* to the atmosphere.

These are very preliminary estimates and are subject to significant changes as monitoring and loading calculation techniques improve. The data are drawn from a number of information sources and monitoring programs which often use different criteria, methods, and loading calculation methods. These estimates indicate that the volume of some contaminants leaving the lake, such as PCBs and DDT, may be greater than the amount coming in. One explanation for this may be that contaminants are slowly being released from sediments already present in the Lake Ontario system.

Table 3-3. Preliminary Estimates of Lake Ontario Critical Pollutant Loadings Information

	Loadings from Sources Outside the Lake Ontario Basin (Kg/yr)			Loadings from Water Discharges within the Lake Ontario Basin (Kg/yr)				Atmospheric Loadings (Kg/yr)	Amounts Leaving Lake Ontario (Kg/yr)			Net Change (Kg/yr)
	Other Great Lakes	Niagara River Basin	Total	Point and Non-point via Tributaries	Direct Point Source Discharges		Total		via St. Lawrence River	Volatilization to Atmosphere	Total	
					U.S.	Can.						
PCBs	302	138	440	97	0.02	?/ND	97	64	411	440	851	-250
Total DDT	96	ND	96	16	1.5	?/ND	17.5	16	1.8	141	143	-13.5
Mirex	ND	1.8	1.8	0.9	?/ND	?/ND	0.9	ND	0.7	?	0.7	2.0
Dieldrin	43	ND	43	5	4.3	?/ND	9.3	13	43	320	363	-297.7
Dioxins	ND	ND	ND	NQ	?/ND	?/ND	?/ND	0.005	?	?	?	?

? = no information available   ND = not detected/not measurable   NQ = present but not quantified

NOTE: Loading estimates for mercury could not be completed in time for this report but will be addressed in future LaMP reports.

<u>Data Sources</u>:

Other Great Lakes

Joint Evaluation of Upstream-Downstream Niagara River Monitoring Data, 1992-93, Prepared by Data Interpretation Group, River Monitoring Committee, January 1995. (Loadings measured at the head of the Niagara River at Fort Erie)

Niagara River Basin

Joint Evaluation of Upstream-Downstream Niagara River Monitoring Data, 1992-93, Prepared by Data Interpretation Group, River Monitoring Committee, January 1995. (Difference between loadings measured at Fort Erie and Niagara-on-the Lake).

Atmospheric

Estimating Atmospheric Deposition of Toxic Substances to the Great Lakes, An Update, Eisenreich, S.J. & W.M.J. Strachan, Workshop proceedings, Canada Centre for Inland Waters, Burlington, Ontario, January 31 - February 2, 1992. June 1992. (deposition and volatilization of PCBs, DDT, mirex, dieldrin)
Atmospheric Deposition of toxic chemicals to the Great Lakes: A review of data through 1994. Hoff *et al.*, 1996, Atmospheric Environment Vol. 30, No. 20 pp 3305-3527.

Contaminant Loads leaving via St. Lawrence River

Concentrations and loadings of trace organic compounds measured in the St. Lawrence River Headwaters at Wolfe Island 1989-1993.
Prepared by J. Biberhofer, Environment Canada, Environmental Conservation Branch, Ontario Region, Ecosystem Health Division, Report No: EHD\ECB-OR\95-03\I, August 1994.

One of the challenges of the LaMP is to understand the state of Lake Ontario as it exists today and how it may change in the near future and over the long term. Concentrations of toxic substances in water, sediment, fish, and wildlife respond at different rates to changes in loadings and changes in biological or physical conditions. Programs in place today which have already reduced critical pollutant loadings may not have an impact on environmental levels for decades, particularly in fish and wildlife. This time lag must be considered when evaluating data which were often collected several years before being reported and which reflect loadings which occurred many more years before data collection. Organisms accumulate chemicals or metals that have been in the ecosystem for long periods of time, either in sediment or in organisms which are lower on the food chain. Estimating if current programs will eventually resolve some of these ecosystem issues and over what time frame is an important step in understanding what additional measures are necessary to accelerate the cleanup of Lake Ontario.

CSS Limnos
(Environment Canada, National Water Research Institute, Technical Operations)

Long term water quality monitoring programs are conducted by Environment Canada at Fort Erie and Niagara-on-the-Lake (at both ends of the Niagara River), and at Wolfe Island at the head of the St. Lawrence River. These programs use similar sampling and analytical methods. The data provide a good estimate of the critical pollutant loadings that originate from upstream Great Lakes basins, those that originate in the Niagara River basin, and the volume of critical pollutants that leaves Lake Ontario via the St. Lawrence River.

Estimates of atmospheric loadings of critical pollutants to Lake Ontario were developed by the International Atmospheric Deposition Network. Estimates for the amounts of critical pollutants volatilizing to the atmosphere were also provided. Volatilization may be a significant process by which critical pollutants are leaving the Lake Ontario system. Estimating atmospheric deposition is difficult, and these estimates contain a significant degree of uncertainty.

For the purposes of this report, the amounts of critical pollutants entering Lake Ontario via all Lake Ontario basin tributaries were based on representative point and non-point sources within each tributary's watershed. The 22 tributaries with the highest flow rates were included in this review (see Table 3-4). Quantitative and qualitative monitoring techniques, as well as biological monitoring results, were used to estimate loadings or the relative presence or absence of critical pollutants within each tributary watershed.

Table 3-4. Estimates of Atmospheric, Point, and Non-point Source Contaminant Loadings Entering Lake Ontario via Tributaries (Kg/yr)

Source	Country	PCBs (Kg/yr)	Total DDT (Kg/yr)	Dioxins Furans (g/yr)	Dieldrin (Kg/yr)	Mirex (Kg/yr)
Burlington Canal	Canada	2.8(1)\ ¥ (8,10)	¥ (8)	¥ (10)	?	ND ¥(8)
Credit River	Canada	¥ (8)	¥ (8)	?	?	ND ¥ (8)
Don River	Canada	1.1 (3)	0.5(3)	¥ (10)	1.3 (3)	?
Duffins Creek	Canada	¥ (8)	¥ (8)	?	?	?
Humber River	Canada	1.7(3)\ ¥ (8)	0.4(3)\¥ (8)	?	0.1 (3)	ND ¥ (8)
Moira River	Canada	?	?	?	?	?
Napanee River	Canada	?	?	¥ (7)	?	?
Oakville Creek	Canada	¥ (8)	¥ (8)	?	?	?
Salmon River	Canada	?	?	?	?	?
Trent River	Canada	¥ (4)	?	¥ (7,10)	?	?
Twelve Mile Creek	Canada	¥ (8)	¥ (8)	¥ (7)	?	ND ¥ (8)
Welland Ship Canal	Canada	¥ (8)	¥ (8)	¥ (7)	?	¥ (8)
Atmospheric	Canada & US	64 (2)	16 (2)	?	13 (2)	?
Niagara River & upstream Great Lakes	Canada & US	440 (9)	96 (9)	ND* (9)	43 (9)	1.8 (9)
Black River	US	52.2 (5)	0.02 (5)	¥ (7)	1.1 (5)	¥ (5)
Eighteenmile Creek	US	7.3 (5)	0.01 (5)	¥ (5)	0.1 (5)	0.01 (5)
Genesee River	US	14.2 (5)	0.03 (5)	¥ (5)	1.7 (5)	0.03 (5)
Irondequoit Creek	US	0.003 (5)	0.002 (5)	¥ (5)	0.002 (5)	?
Johnson Creek	US	¥ (6)	¥ (6)	¥ (6)	?	?
Northrup Creek	US	?	?	?	?	?
Oak Orchard Creek	US	¥ (5)	¥ (5)	¥ (5)	¥ (5)	¥ (5)
Oswego River	US	17.1	1.5	¥ (5)	1.2 (5)	0.9 (5)
Sandy Creek	US	1.01 (5)	?	?	?	?
Wine Creek	US	0.001 (5)	ND (5)	?	ND	?

References
-1 Fox *et al.*, 1996
-2 Hoff *et al.*, 1996
-3 D'Andrea and Anderton, 1996
-4 Poulton, 1990
-5 Litten, 1996
-6 Estabrooks *et al.*, 1994
-7 MOE, MISA, 1994
-8 MOE Spottail Shiner data
-9 Niagara River upstream/downstream program, 1995
-10 Canviro Consultants, 1988

? No information available for compound
¥ Detected in qualitative monitoring programs or in effluent of facilities discharging to tributary.
ND Not detected
* 2,3,7,8 TCDD

The location of point sources (Figure 3-1) and loadings information (Tables 3-5 and 3-6) are presented for those that discharge directly to the lake. Point sources that discharge to tributaries are included in tributary loading estimates. Jurisdictional differences confound these point source loadings estimates. New York State requires dischargers whose wastewater is known or suspected to contain significant levels of critical pollutants (principally sewage treatment plants) to monitor for those contaminants. There is no current data on Ontario point sources as no Ontario industrial point source discharged the critical pollutants in sufficient quantities to require regulation under MISA. Information on CSOs, stormwater, and other non-point sources may be included in future assessments.

To get copies of the TRI, call the Pollution Prevention Unit at NYSDEC, Sitansu Ghosh (518-457-2553). To get copies of the NPRI, contact the NPRI office in EC's Ontario Region at 416-739-5890 or access it on the internet at http://www.ec.gc.ca/pdb/npri.htmi.)

Information on releases to the environment of critical pollutants and other contaminants is available to the public in publications developed and released on a regular basis by governmental agencies. For sources in the U.S., the annual Toxics Release Inventory (TRI) summarizes on an annual basis the emissions of approximately 650 pollutants from facilities nationwide. For sources in Canada, the National Pollutant Release Inventory (NPRI) provides information on the onsite releases to air, water, and land; on transfers offsite in waste; and on the three R's (recover, reuse, and recycle) of 176 substances. The NPRI is the only legislated nationwide publicly accessible inventory of pollutant releases and transfers in Canada.

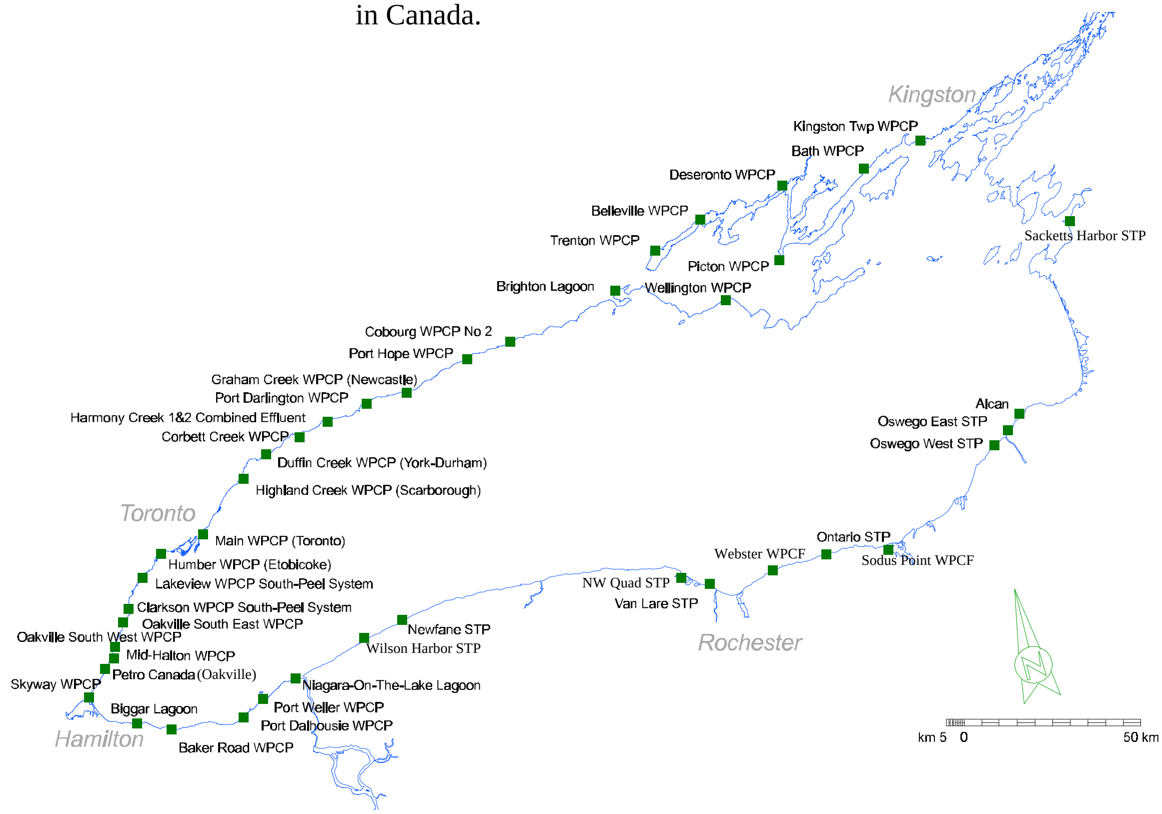


Figure 3-1. Point Sources Directly Discharging to Lake Ontario
[STP - *Sewage Treatment Plant*; WPCF - *Water Pollution Control Facility*; WPCP - *Water Pollution Control Plant*]

Table 3-5. Preliminary Estimate of Lakewide Critical Pollutants Entering Lake Ontario via Direct Discharges in the U.S. (1989-1995).

Point Sources	Country	Discharge Flow (1000 m^3 per day)	PCBs (Kg/yr)	Total DDT (Kg/yr)	Dioxins/ Furans* (g/yr)	Dieldrin (Kg/yr)	Mirex (Kg/yr)
Alcan	US	32.2	0.02	ND	ND	ND	?
Newfane STP	US	5.6	ND	ND	ND	ND	ND
NW Quad STP	US	62	ND	ND	ND	ND	ND
Ontario STP	US	2.3	ND	ND	ND	ND	ND
Oswego East STP	US	11	ND	ND	ND	ND	ND
Oswego West STP	US	15.1	ND	1.5	ND	ND	ND
Sacketts Harbor STP	US	0.02	?	?	?	?	?
Sodus Point WPCF	US	0.02	?	?	?	?	?
Van Lare STP	US	401	ND	ND	?	4.3	?
Webster WPCF	US	28.0	ND	ND	ND	ND	ND
Wilson Harbor STP	US	0.01	?	?	?	?	?

WPCF = Water Pollution Control Facility
STP = Sewage Treatment Plant
* = dioxin/furan loadings reported in grams per year
? = No information available
ND = Not detected

Data Sources: New York State SPDES program
Litten, NYSDEC 1996

Note: Estimates are based on standard monitoring performed by the POTW operators as well as non-standard research methods used by NYSDEC investigators that can detect lower levels of contaminants than standard methodologies. As a result, contaminants reported to be "not detected" by standard analytical methods might be "detected" if non-standard research methods are used. Therefore, the details of a specific POTW's operation, flow rate, and the analytical methods used need to be carefully considered before the significance of a reported "non-detect" can be completely understood.

Note: This table only includes the more significant wastewater point source dischargers. Discharges related to power generation plants and small dischargers are not included in this table. A more complete review of these dischargers will be performed as part of future LaMP activities.

Table 3-6. Preliminary Estimate of Lakewide Critical Pollutants Entering Lake Ontario via Direct Discharges in Canada (1989-1995).

Point Sources	Country	Discharge Flow (1000 m^3 per day)	PCBs (Kg/yr)	Total DDT (Kg/yr)	Dioxins/ Furans* (g/yr)	Dieldrin (Kg/yr)	Mirex (Kg/yr)
Baker Road WPCP (Grimsby)	Canada	14.7	ND	ND	ND	ND	ND
Bath WPCP	Canada	1.2	?	?	?	?	?
Belleville WPCP	Canada	30.5	?	?	?	?	?
Biggar Lagoon	Canada	1.1	?	?	?	?	?
Brighton Lagoon	Canada	2.6	?	?	?	?	?
Clarkson WPCP (Mississauga)	Canada	99.6	ND	ND	ND	ND	ND
Cobourg WPCP No 1	Canada	9.9	?	?	?	?	?
Cobourg WPCP No 2	Canada	5.8	?	?	?	?	?
Corbett Creek WPCP (Oshawa)	Canada	34.9	?	?	?	?	?
Deseronto WPCP	Canada	1.4	?	?	?	?	?
Duffins Creek WPCP (Pickering)	Canada	237.6	ND	ND	ND	ND	ND
Graham Creek WPCP (Newcastle)	Canada	2.04	?	?	?	?	?
Harmony Creek 1&2 (Oshawa)	Canada	52.8	?	?	?	?	?
Highland Creek WPCP (Scarborough)	Canada	160.2	ND	ND	ND	ND	ND
Humber WPCP (Etobicoke)	Canada	337.7	ND	ND	ND	ND	ND
Kingston Twp WPCP	Canada	22.1	ND	ND	ND	ND	ND
Lakeview WPCP (Mississauga)	Canada	268.4	ND	ND	ND	ND	ND
Main WPCP (Toronto)	Canada	680.1	ND	ND	ND	ND	ND
Mid-Halton WPCP	Canada	11.4	?	?	?	?	?
Niagara-On-The-Lake Lagoon	Canada	4.02	ND	ND	ND	ND	ND
Oakville South East WPCP	Canada	72.4	ND	ND	ND	ND	ND
Oakville South West WPCP	Canada	33.1	?	?	?	?	?
Petro Canada Ltd (Oakville)	Canada	?	?	?	?	?	?
Petro Canada Ltd (Mississauga)	Canada	9.5	?	?	ND	?	?
Picton WPCP	Canada	3.7	?	?	?	?	?
Port Dalhousie WPCP	Canada	72.3	?	?	?	?	?
Port Darlington WPCP	Canada	8.3	?	?	?	?	?
Port Hope WPCP	Canada	5.5	?	?	?	?	?
Port Weller WPCP	Canada	49.3	?	?	?	?	?
Skyway WPCP (Burlington)	Canada	76.5	?	?	?	?	?
Trenton WPCP	Canada	12.4	?	?	?	?	?
Wellington WPCP	Canada	0.5	?	?	?	?	?

WPCP = Water Pollution Control Plant — Data Source: Ontario Ministry of the Environment
STP = Sewage Treatment Plant
* = dioxin/furan loadings reported in grams per year
? = No information available
ND = Not detected

Note: This table only includes the more significant wastewater point source dischargers. Discharges related to power generation plants and small dischargers are not included in this table. A more complete review of these dischargers will be performed as part of future LaMP activities.

3.8.2 Polychlorinated Biphenyls

Polychlorinated biphenyls (PCBs) were manufactured between 1929 and 1977. PCBs were considered an important industrial safety product for conditions where high heat or powerful electric currents posed explosive and fire hazards. For example, PCB oil-filled electric switches eliminated electric sparking problems that could trigger explosions at petroleum refineries. PCB oils were used in electrical transformers as a non-flammable electrical insulating fluid. PCBs were also used as industrial lubricating oils to replace earlier types of hydraulic oils that could more easily catch fire under conditions of high pressure and temperature.

The production of PCBs was halted following the discovery that PCBs released into the environment were bioaccumulating to levels of concern in a wide range of organisms. The hazards posed by PCBs were discovered in the 1960s when ranch mink, that had been fed a diet of Great Lakes fish, experienced reproductive failures. The investigations that followed determined that Great Lakes fish were contaminated with PCBs at levels that warranted human fish consumption advisories. Since that time, production of PCBs in North America has been banned, and the use of PCBs is being systematically eliminated. In Canada, old electrical transformers and other equipment that contain PCBs are being stockpiled until they can be safely destroyed. In the U.S., old transformers and equipment containing PCBs must be properly disposed within one year.

Levels of PCBs in the environment have decreased in response to the banning and phasing out of the various uses of PCBs. PCBs are identified as a LaMP critical pollutant because levels of PCBs in Lake Ontario fish and wildlife continue to exceed human health standards and because PCB levels in the Lake Ontario food chain may pose health and reproduction problems for bald eagles, mink, and otter.

The majority of these estimated PCB loadings to Lake Ontario originate outside the Lake Ontario basin (see Figure 3-2). The upstream Great Lakes basins contribute the largest amount (302 kg/yr), followed by the Niagara River basin (138 kg/yr). Within the Lake Ontario basin, point and non-point sources contribute approximately 100 kg/yr, 80 percent of which enters the Lake via streams and rivers. Atmospheric loadings contribute 64 kg/yr directly to the lake surface. Some of the tributary loadings are no doubt due to atmospheric deposition within the watershed. When the loss of PCBs from the Lake basin via volatilization (440 kg/yr) and the St. Lawrence River (411 kg/yr) is considered, the total amount of PCBs within Lake Ontario appears to be decreasing at a rate of 250 kg/yr, only to be transferred downstream, downwind, or buried in the bottom sediments.

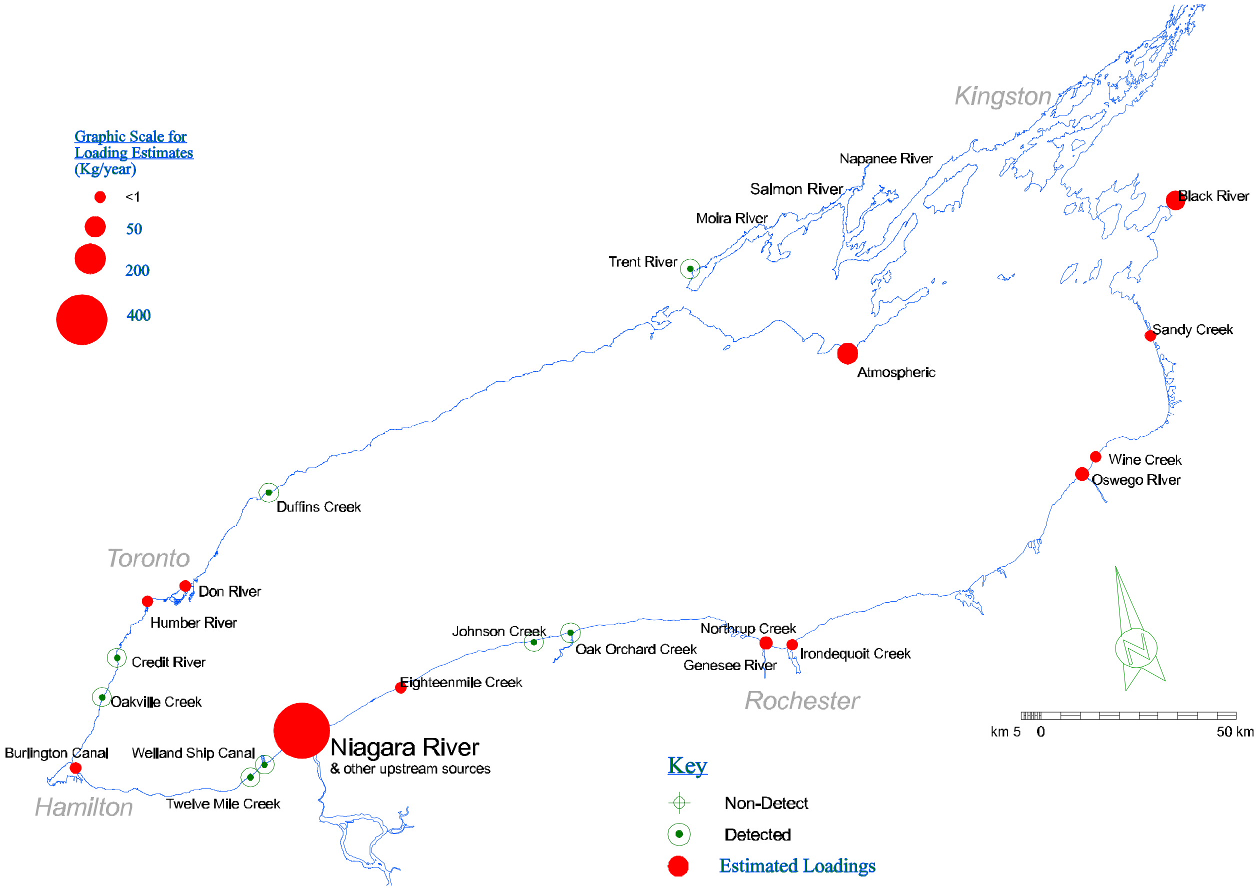


Figure 3-2. Summary of Non-point Source Loadings Information for PCBs (1990-1995).

3.8.3 DDT and Its Metabolites

The development of the pesticide DDT in the 1940s was considered a major breakthrough in the battle against diseases, such as malaria, and in controlling crop pests. Highly effective and cheap to produce, DDT was the most widely used pesticide in North America and other countries from 1946 to 1972. Agricultural use of DDT has since been banned in North America following the discovery that DDT and its breakdown products were causing widespread reproductive failures in eagles and other wildlife species. Although DDT continues to be used in other parts of the world, levels of DDT in the North American environment have decreased significantly since this pesticide was banned, and species impacted by DDT, such as the bald eagle, are recovering. DDT and its metabolites are identified as LaMP critical pollutants because they are responsible for wildlife consumption advisories and are identified as a potential problem contaminant for bald eagles once they re-establish their shoreline nesting territories.

The upper Great Lakes are the largest source of DDT and its metabolites to the Lake Ontario basin (96 kg/yr) (see Figure 3-3). Atmospheric deposition and sources within the Lake Ontario basin contribute approximately 33.5 kg/yr combined. Much of the tributary loadings likely consist of atmospheric fallout in the watershed given the banning of these materials from use in the watershed. The Niagara River Basin does not appear to be a significant source of DDT. Approximately 143 kg/yr of DDT leave Lake Ontario via volatilization to the atmosphere (141 kg/yr) and the St. Lawrence River (2 kg/yr), for a net loss from Lake Ontario of approximately 13 kg/yr.

3.8.4 Mirex (Dechlorane)

The discovery of elevated levels of mirex in Lake Ontario fish during the 1960s triggered lakewide fish consumption advisories. Investigations determined that most of the mirex originated from a chemical production facility on the Niagara River. Use and production of mirex, also known as dechlorane, are now banned in North America. Mirex is identified as a LaMP critical pollutant because levels in some Lake Ontario fish continue to exceed human health standards; a number of fish consumption advisories exist. Although mirex is most widely known for its use as a pesticide, approximately 75 percent of the mirex produced was used as a flame retardant in a variety of industrial, manufacturing, and military

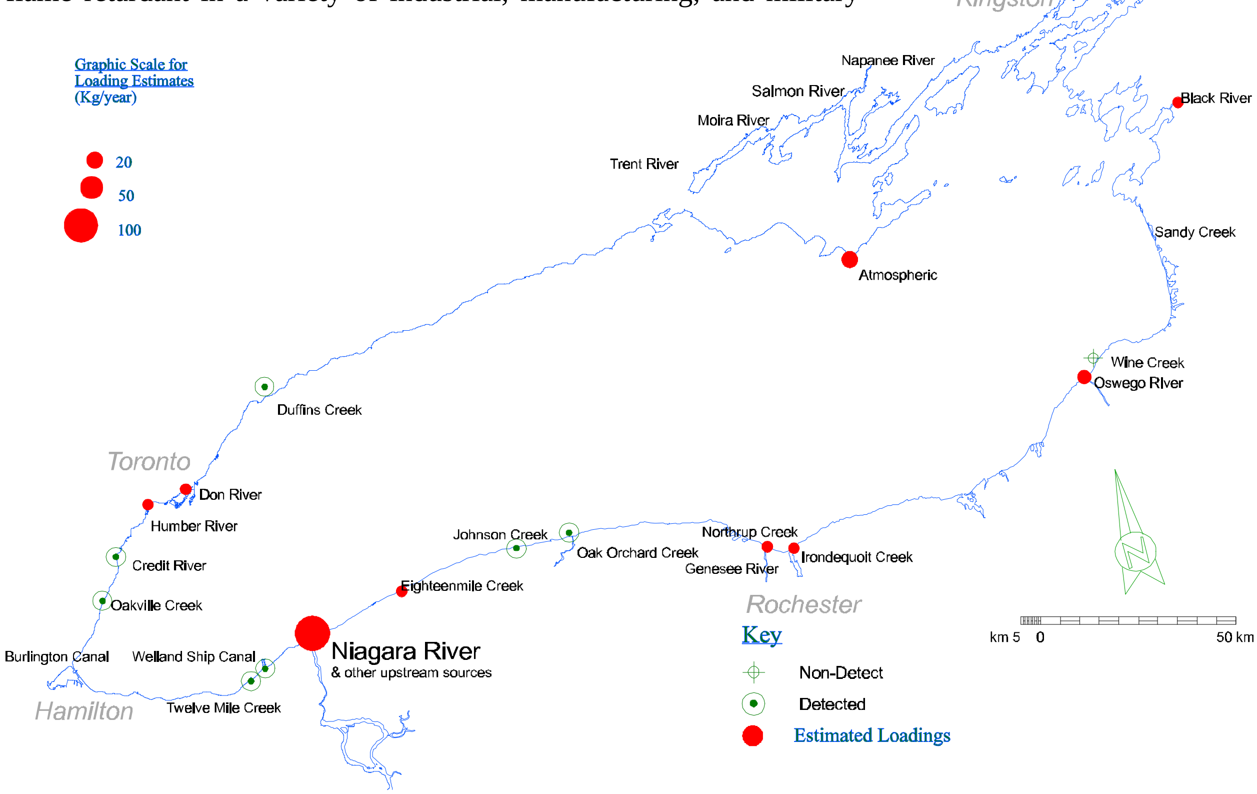


Figure 3-3. Summary of Non-point Source Loadings Information for Total DDT (1990-1995).

applications. Available sales records suggest that more than 50,000 pounds of mirex were used for industrial and manufacturing flame retardant purposes in the Lake Ontario basin. More than 75,000 pounds of mirex were used as a flame retardant in other Great Lakes basins.

Most of the mirex entering Lake Ontario originates in the Niagara River basin (1.8 kg/yr) and an additional 0.9 kg/yr enters via the Oswego River (Figure 3-4). Approximately 0.7 kg/yr of mirex leaves Lake Ontario via the St. Lawrence River. No reliable estimates of atmospheric deposition or volatilization are available at this time.

3.8.5 Dioxins and Furans

Dioxins and furans are a group of unwanted chemical by-products that are created by a variety of chemical and combustion processes. Laboratory studies have shown some wildlife species to be extremely sensitive to the toxic effects of these contaminants. The potential impacts of the very low levels of these contaminants found in Lake Ontario fish, wildlife, and humans are poorly understood. Therefore, health standards for these

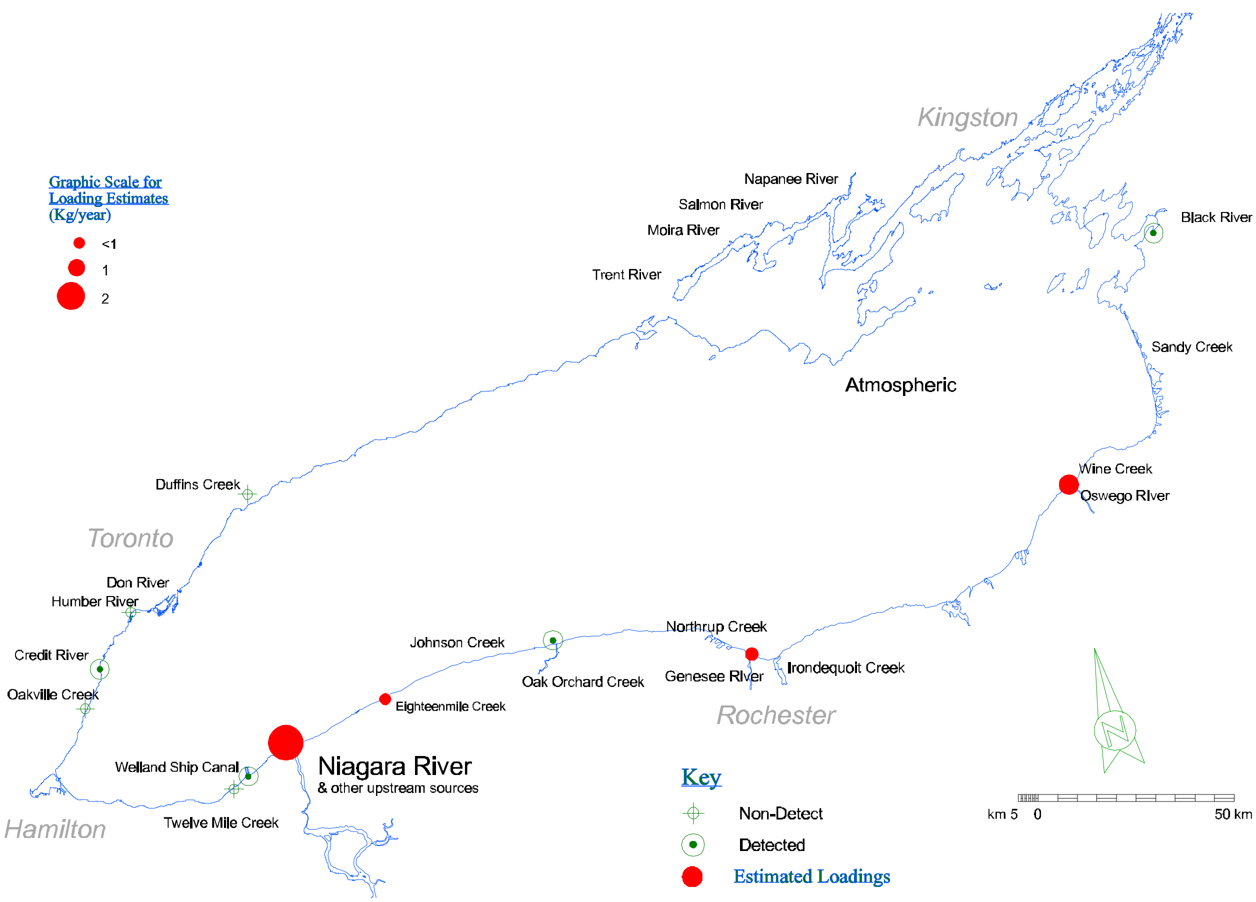


Figure 3-4. Summary of Non-point Source Loadings Information for Mirex (1990-1995).

contaminants have been set very low. Steps have been taken to control and limit those processes that produce high levels of dioxins and furans, resulting in a significant decrease in environmental levels of these chemicals over the last two decades. Some of the processes that can produce dioxins and furans include the use of internal combustion engines, incinerators, and a variety of other chemical processes, which are part of our modern way of life and may be difficult to eliminate altogether. Forest fires and wood burning stoves also produce low levels of dioxins and furans.

Dioxins and furans are identified as LaMP critical pollutants because levels of these contaminants exceed human health standards in some Lake Ontario fish and because these chemicals may limit the full recovery of the Lake Ontario bald eagle, mink, and otter populations by reducing the overall fitness and reproductive health of these species.

Dioxins and furans exist at very low levels in the environment and, as a result, are difficult and costly to detect and accurately quantify. The Niagara River upstream-downstream program monitors exclusively for 2,3,7,8 TCDD (dioxin) and 2,3,7,8 TCDF (furan), the most toxic forms of these compounds; none have been detected. Despite this analytical limitation, data from other media (mussels, spottail shiners, and sediment cores) indicate that there are several sources of both dioxins and furans in the Niagara River and that the River is a source of these pollutants to Lake Ontario. Atmospheric deposition appears to be the largest known source of dioxins/furans, contributing approximately 5 grams per year. Dioxins and furans have been detected in a number of Lake Ontario tributaries using qualitative water and biological sampling methods. No reliable estimates are available for the volume of dioxins/furans that may be leaving the lake via volatilization to the atmosphere.

3.8.6 Mercury

Mercury is a naturally occurring metal, which is found in small amounts in most soils and rocks. Although mercury is best known for its use in thermometers and medical and dental products, it is also used in batteries and in the production of various synthetic materials such as urethane foam. Historically, mercury was added to paints as an anti-mildew agent. Some uses of mercury have now been banned. Loading estimates for mercury could not be completed in time for this report since it was identified as a critical pollutant late in the Stage 1 development process, but it will be included and addressed in future LaMP reports.

3.8.7 Dieldrin

Dieldrin is a formerly used pesticide that is now banned from use in the Lake Ontario basin and throughout North America. Aldrin, another formerly used pesticide, transforms into dieldrin through natural breakdown processes. Dieldrin is identified as a LaMP critical pollutant because dieldrin concentrations in water and fish tissue exceed the U.S. Great Lakes Water Quality Initiative (GLI) criteria throughout the lake. The GLI criterion for water is 0.0000065 parts per billion and Lake Ontario water averages 0.17 parts per billion. The corresponding GLI fish tissue criterion is 0.0025 parts per million. Most Lake Ontario fish clearly exceed this criterion as dieldrin is detectable at concentrations ranging from approximately 0.005 to 0.030 parts per million. Although the GLI criteria are being exceeded, dieldrin concentrations in the environment have been steadily declining. Between 1985 and 1995, dieldrin concentrations in the lake have declined from 0.35 to 0.17 parts per billion based on information collected through Niagara River and Wolfe Island monitoring programs.

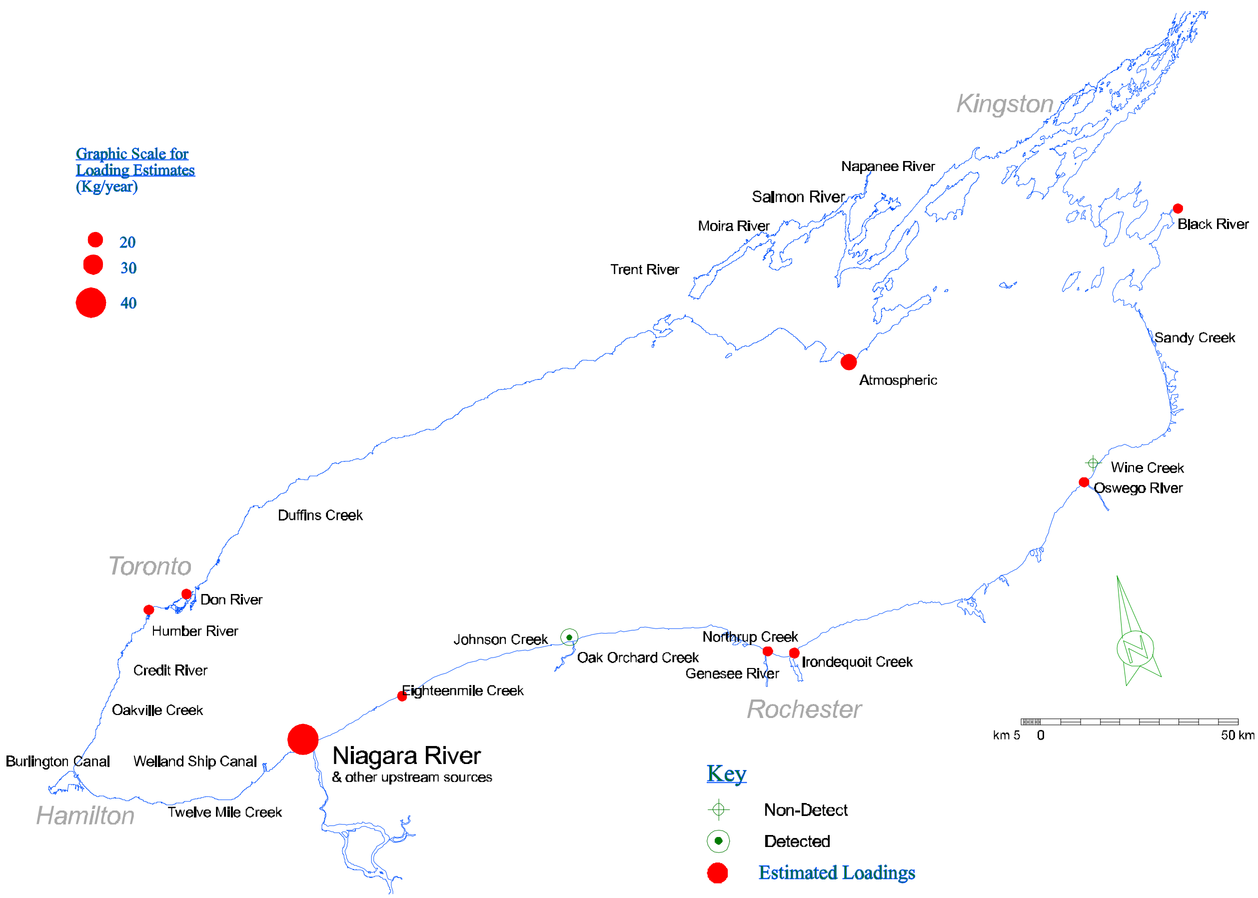


Figure 3-5. Summary of Non-point Source Loadings Information for Dieldrin (1989-1995).

The upper Great Lakes are the largest source of dieldrin to the Lake Ontario basin (43 kg/yr). Atmospheric deposition and point and non-point sources within the Lake Ontario basin are approximately equal (13 kg/yr and 9 kg/yr) (see Figure 3-5). Estimates for the rate of loss of dieldrin in Lake Ontario due to volatilization (320 kg/yr) and the St. Lawrence River (43 kg/yr) suggest that the volume of dieldrin in the lake is decreasing at a rate of 298 kg/yr.

3.9 Summary

In this chapter, the Four Parties have identified the lakewide and local beneficial use impairments of Lake Ontario. The four lakewide beneficial use impairments have been identified as:

- Restrictions on fish and wildlife consumption
- Degradation of wildlife populations
- Bird or animal deformities or reproductive problems
- Loss of fish and wildlife habitat

The lakewide critical pollutants that have been identified as impairing or likely to impair these beneficial uses include PCBs, DDT and its metabolites, dioxins/furans, mirex, mercury, and dieldrin. Exotic species, lake level management, and the physical loss, modification, and destruction of habitat have been identified as the biological and physical factors contributing to lakewide use impairments.

The Four Parties plan to prioritize source reduction efforts to address the most significant contributors of critical pollutants to Lake Ontario. Based on the limited loadings data available, it appears that a significant load of critical pollutants to the lake originates outside the Lake Ontario basin. The upstream Great Lakes basin contributes the majority of the estimated loadings of PCBs (440 kg/yr), DDT and its metabolites (96 kg/yr), and dieldrin (43 kg/yr). Attention must also be focused on the Niagara River, since most of the mirex entering Lake Ontario originates in the Niagara River basin (1.8 kg/yr) and it also contributes to the load of other critical pollutants into the lake. Atmospheric deposition is a source of critical pollutants and appears to be the largest known source of dioxins/furans, contributing approximately 5 grams per year.

The LaMP will also seek to address the inputs of critical pollutants from water discharges within the Lake Ontario basin, including point sources discharged directly to the lake and point and non-point discharges into tributaries to the lake.

The local use impairments identified in this chapter are best addressed on a local level through the development and implementation of Remedial Action Plans and other local management efforts. Through the LaMP, the Four Parties seek to restore the lakewide beneficial uses of the lake by reducing the input of critical pollutants and persistent, bioaccumulative toxics to the lake and by addressing the biological and physical factors identified above. The Four Parties will also work to improve the database on sources and loadings of critical pollutants and other factors causing these impairments.