ESTIMATING LOADINGS OF EIGHTEEN PERSISTENT TOXICS TO LAKE ONTARIO

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EXECUTIVE SUMMARY

This study is an attempt to update estimate loadings for eighteen persistent toxic chemicals to Lake Ontario from the Niagara River and Canadian-side of the drainage basin. The chemicals studied were those identified as exceeding water column or fish tissue standards, criteria or guidelines in Lake Ontario and/or the Niagara River.

Loadings data for point and nonpoint sources were analyzed and the most current and reliable information available was applied to estimate loadings to the Lake. The loadings data available at this time is fragmentary. It is most reliable and comprehensive for the Niagara River and the industries that discharge directly to surface waters. Information gaps were found in several source categories (e.g. agricultural runoff, spills, groundwater, and tributaries). However, the present loading estimates are an improvement over the original estimates made in 1989 by the Lake Ontario Toxic Committee and should assist decision-makers in the elaboration of toxic loadings reduction strategies.

Based on the available data and the estimation methods described in this report, it is estimated that Lake Ontario receives over 1,500 kg of 18 persistent toxics every day (see Table A). Lead loadings are the largest, representing roughly two-thirds of the total, followed by: arsenic (424 kg/day); tetrachloroethylene (49 kg/day); mercury (8 kg/day); the five PAHs (each between 2 and 3 kg/day); and, PCBs (1.4 kg/day). The remaining 5 organochlorine pesticides and 2 chlorinated organics, all tallied, have loadings of less than 1 kg/day.

The Niagara River dominates all other source categories, representing two-thirds of the total loadings. Other important sources are urban runoff, atmospheric deposition and municipal sewage treatment plants (STPs): rendering, respectively, 13, 9 and 6 percent of the total loadings.

For most of the 18 chemicals, the Niagara River is the major source of loadings with the exception of: toxaphene and octachlorostyrene for which no information is available; and, chlordane which originates mainly from runoff.

Data gaps, uncertainties and accuracy of the loading estimates are discussed in this report and recommendations are proposed to improve the estimates and to integrate loading information.

It is hoped that the loading estimates provided in this report will be updated when new measurements become available using a computer database that was developed in parallel with this study.

TABLE A : LOADING ESTIMATES OF 18 PERSISTENT TOXICS FROM CANADIAN SOURCES AND THE NIAGARA RIVER TO LAKE ONTARIO

LOADINGS IN KILOGRAMS PER DAY												
GROUP CATEGORY	*INDUSTRIAL*			*RUNOFF*		*MUNICIPAL*						
SOURCE CATEGORY **LOTMP Persistent Toxics**	INDUSTRY	SPILLS FROM DOFASCO	NIAGARA R. & GREAT LAKES	URBAN RUNOFF	AGRICULTURAL RUNOFF	COMBINED SEWER OVERFLOW	MUNICIPAL STPs	BYPASSING	WATER FILTRATION PLANTS	ATMOSPHERIC DEPOSITION	TRIBUTARIES (loadings not accounted for in other source categories)	**TOTAL LOAD**
Arsenic	1.625	ND	374.800	3.641	NI	0.342	15.724	0.089	1.237	12.539	13.766	423.763
Benz(a) anthracene	0.220	0.013	2.322	NI	NI	NI	ND	0.012	ND	0.061	NI	2.628
Benzo(b) fluoranthene	0.228	0.012	1.560	NI	NI	NI	ND	0.012	ND	0.160	NI	1.972
Benzo (k) fluoranthene	0.274	0.008	1.641	NI	NI	NI	ND	0.012	ND	0.136	NI	2.071
Benzo (a) pyrene	0.581	0.129	1.518	NI	NI	NI	ND	0.012	ND	0.085	NI	2.325
Chlordane	NI	NI	0.007	0.011	0.011	0.001	0.009	ND	ND	0.010	ND	0.049
Chrysene	0.372	0.011	2.225	NI	NI	NI	ND	0.012	ND	0.112	NI	2.732
DDT	NI	NI	0.082	0.003	0.006	ND	0.007	ND	ND	0.026	0.006	0.130
Dieldrin	NI	NI	0.151	0.002	0.001	NI	ND	ND	ND	0.004	0.005	0.163
Dioxin (2,3,7,8–TCDD)	ND	ND	ND	NI	NI	NI	ND	ND	ND	ND	NI	0
Hexachlorobenzene	0.003	ND	0.114	0.017	NI	0.001	0.001	ND	ND	0.003	ND	0.139
Lead	22.517	ND	624.200	200.137	NI	11.088	69.268	0.328	0.979	130.349	ND	1,058.866
Mercury	0.034	ND	6.165	0.080	NI	0.006	0.243	0.005	0.002	1.555	0.257	8.347
Mirex	NI	NI	0.013	ND	ND	ND	ND	ND	ND	NI	0.017	0.030
Octachlorostyrene	ND	ND	NI	NI	NI	NI	ND	ND	ND	NI	0.004	0.004
PCBs	0.012	ND	0.942	0.227	NI	0.012	0.041	ND	ND	0.116	ND	1.350
Tetrachloroethylene	0.046	NI	46.540	NI	NI	NI	2.501	0.051	ND	NI	NI	49.138
Toxaphene	NI	NI	NI	NI	NI	NI	ND	ND	ND	0.013	ND	0.013
SUM OF 18 TOXICS	25.912	0.173	1,062.280	204.118	0.018	11.4495	87.794	0.533	2.218	145.169	14.055	1,553.719
PERCENT OF TOTAL	1.6%	0%	67.0%	12.9%	0%	0.7%	5.5%	0%	0.14%	9.2%	0.9%	

LEGEND:
ND – less than the detection limit or 1 g/day
NI – No information

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SUMMARY OF LISTS

1. Introduction

1.1 The Lake Ontario Toxics Management Plan (LOTMP)

To address the environmental and health impacts of persistent toxic chemicals in Lake Ontario, four parties (the United States Environmental Protection Agency, Environment Canada, the New York State Department of Environmental Conservation, and the Ontario Ministry of the Environment) signed a declaration of intent to develop a Lake Ontario Toxics Management Plan (LOTMP) on February 4th, 1987.

The goal of the LOTMP is to bring Lake Ontario to a state that provides drinking water and fish which are safe for unlimited human consumption, and allows natural reproduction within the Lake ecosystem of the most sensitive native species, such as the bald eagle, osprey, mink, and river otter[1]. To achieve this goal the LOTMP[1] proposes to reduce toxic inputs through:

(1) existing and developing programs;
(2) special efforts and geographic areas of concern;
(3) lake-wide analysis of pollutant fate; and,
(4) zero discharge.

The effectiveness of these programs cannot be measured until the magnitude of specific sources in relationship to the total Lake loading is known. To effectively control persistent toxics the LOTMP has recognized that their sources and fate in the ecosystem must be known[2].

Accurate loading estimates are required to refine, validate and calibrate mass balance models. Models are being established which relate toxic inputs to concentrations in water, sediment and biota. These models will provide a basis for determining load reduction targets to achieve acceptable concentrations and establish the time period to achieve these.

A substantial database of toxic chemical concentrations in water, sediment and biota have been developed for Lake Ontario[1]. Rather less data is available for estimating toxic chemical loadings from various sources.

Preliminary loading estimates provided by the Lake Ontario Toxics Management Plan[1] indicate that the data gathered and analyzed at that time was insufficient to accurately establish toxic loadings. Of all the source categories, that included industry, tributaries and municipal sources, only the Niagara River estimates were considered reliable. (See Appendix A for the original estimates). Quantitative knowledge of loadings of the 18 persistent toxics were not documented sufficiently to establish loadings.

The four parties made commitments to improve loadings estimates for Lake Ontario through:

- development of a methodology to estimate nonpoint source loadings based upon existing data sources;
- development of chemical-specific data on the loadings from hazardous waste sites along the Niagara River;
- field investigations to improve estimates of radionuclide levels from Canadian sources in the ambient water of the Lake;
- development of estimates of historic Lake loadings;
- field investigations of ambient levels of toxics in the Lake; and,
- collection of improved data on tributary loadings[1].

This report aims to meet the immediate requirement of the LOTMP for developing an updated inventory of toxic chemical loadings from point and nonpoint sources to assist in targeting control actions.

1.2 Purpose and Scope of this report

The purpose of this project was to:

- gather available information on loadings to Lake Ontario for all source categories on the Canadian side;
- estimate loadings for 18 persistent toxics for all point and nonpoint source categories;
- compile this information in a database; and,
- summarize this information in a report.

This report provides:

- a brief review of the categorization of the 18 persistent toxics (Chapter 2 and Appendices B to E for their presence in Lake Ontario, their origins, uses, emission sources, and regulatory status);
- an assessment of the information base for its coverage of the 18 chemicals and its applicability to estimating loads in general (Chapter 3);
- an inventory of the sources of 18 persistent toxics (Chapter 5-17) and estimates of the loadings for each source category; and,
- recommendations for improving loading estimates, integrating load information and developing priorities for reducing toxic chemical loads (Chapter 19).

It is to be recognized that in many cases, loadings are calculated using data that were not collected for that purpose. However, the findings of this report represent the best achievable loadings estimates given the limited time frame and budget allotted to the study. Once better loading measurements are available, it is hoped that these estimates of chemical loads will be refined, using the database created by this project, to provide a more accurate accounting system for persistent toxic chemicals entering Lake Ontario.

The geographic area covered in this report is the same as defined in the LOTMP addressing the toxics problems encountered within the geographic boundary of:

- open waters of the Lake;
- nearshore areas and embayments of the Lake; and
- tributaries, including the Niagara River, that input into the Lake.

In this report, the Niagara River is considered an input to the Lake and no determination of the sources upstream from its mouth at Niagara-on-the-Lake is attempted. The St. Lawrence River is considered the output from the Lake; the sources in this river are, therefore, outside the scope of this report.

The Lake Ontario drainage basin is shown in Figure 1. Briefly, Lake Ontario has a surface area of 19,000 km^2 and a volume of 1,640 km^3, making it the twelfth largest freshwater body on earth[3]. It has a maximum depth of 244 metres. The largest inflow to Lake Ontario is the Niagara River (5,700 m^3/s). Other major tributaries, in decreasing order according to flow are the: Oswego, Trent, Black and Genessee Rivers. Water is retained for approximately 6 years[4] before it is discharged at approximately 7,700 m^3/s via the St. Lawrence River.

This report addresses the sources on the Canadian side of the Lake Ontario basin exclusively (although, the load from atmospheric deposition represents the input for the entire surface of the Lake). It is anticipated that our U.S. colleagues will study the other side of the basin to complete the Lake Ontario loadings database.

FIGURE 1: MAP OF DRAINAGE BASIN

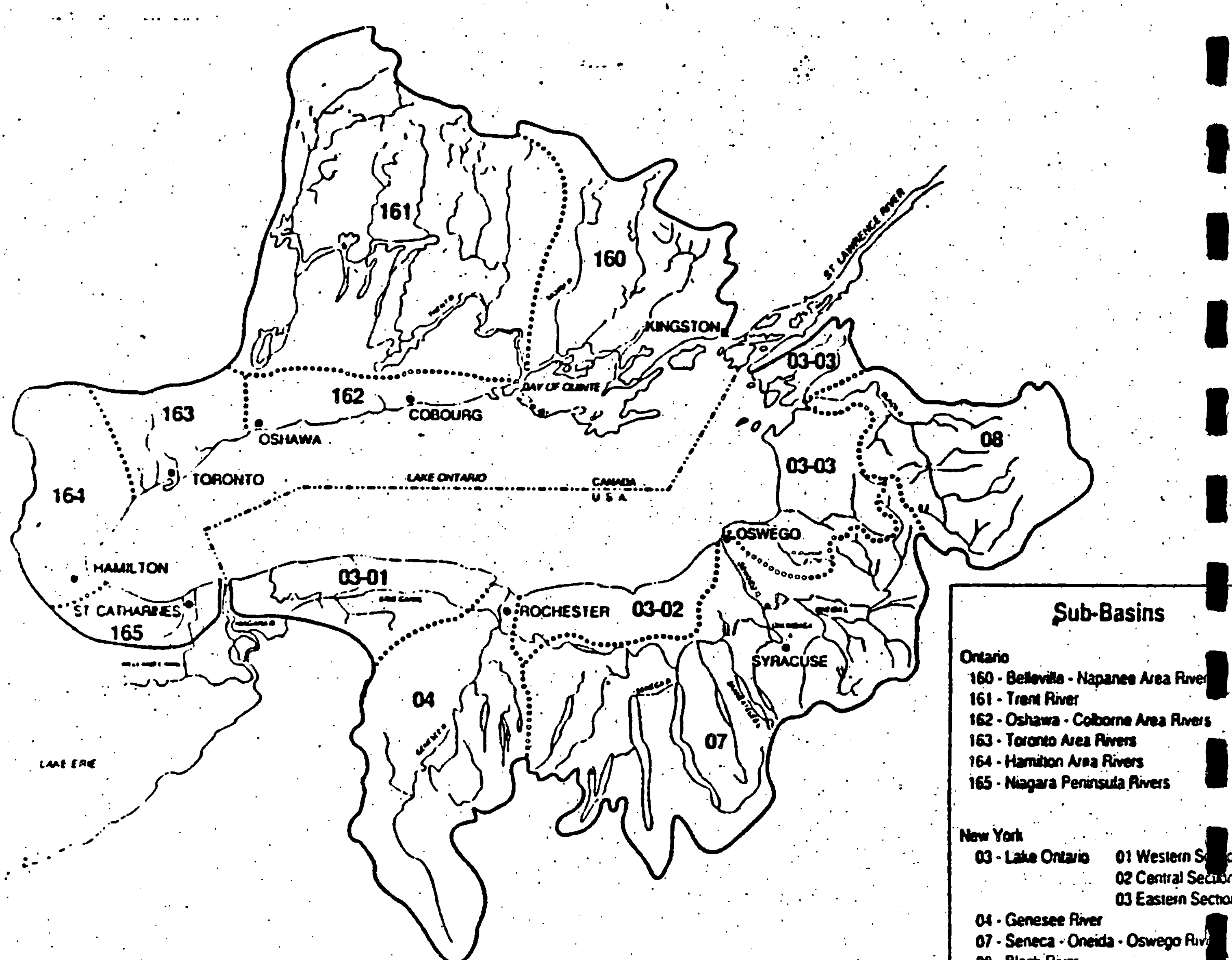


Figure 1-2: Lake Ontario Basin and Major Sub-Basins

SOURCE: Lake Ontario Toxics Committee. 1989. Lake Ontario Toxics Management Plan. Environment Canada, United States Environmental Agency, Ontario Ministry of the Environment, New York State Department of Environmental Conservation.

2. The Priority Toxics being Studied

The eighteen chemicals selected for study were identified as exceeding water column or fish tissue standards, criteria or guidelines in Lake Ontario and/or the Niagara River.

The list of eighteen toxics being studied is presented in Table 2A. It includes:

- Pesticides that have been restricted or banned for more than ten years, including toxaphene which was never used or manufactured in the Great Lakes area;
- A group of five polyaromatic hydrocarbons, as well as the most toxic of dioxins, 2,3,7,8-TCDD - all by-products more often associated with air emissions than water emissions;
- Some chlorinated organics that are not manufactured (PCBs are no longer manufactured and hexachlorobenzene and octachlorostyrene are by-products of manufacturing); and,
- Metals commonly used in manufacturing processes.

These chemicals are toxic, persistent and bioaccumulate. Furthermore, all these chemicals are potential causes of human and/or biotic health problems in the Lake Ontario basin, as indicated by their exceedance of standards/guidelines for levels in fish and/or water designed to safeguard human health and aquatic life. See Appendix B for a summary of the problems associated with toxic chemicals in Lake Ontario.

To categorize chemicals the Lake Ontario and Niagara River Secretariats established an ad hoc Categorization Committee. The committee reviewed the available water column and fish tissue data in relation to the applicable standards, criteria and guidelines (see Appendix C for standards and guidelines) of the various jurisdictions. Those parameters identified by the review as exceeding standards are provided in Table 2A. This list is currently in the process of being updated.

For the initial review forty-two chemicals had ambient data to allow their categorization: insufficient information was available to categorize the hundreds of other chemicals entering the Lake. Data from point sources, sediment, tributaries and biota were examined to establish evidence of presence in or input to the Lake.

The hazard of each of the eighteen is determined by the chemical's persistence, ability to bioaccumulate, toxicity, carcinogenicity and, levels in the environment (quantity)[5]. These terms are defined and hazard properties of the chemicals are summarized in Appendix D.

Pollutants are released to the environment during industrial production (i.e., emissions, spills), use of this product (pesticide spraying, burning of coal), and a product's final disposal (incineration emissions and evaporation or leaching from landfills). Of the 18 toxics the metals and polyaromatic hydrocarbons are the only chemicals with natural sources. The remaining 10 are considered to originate exclusively from anthropogenic sources. In Appendix E the origins of each of the 18 toxics are reviewed to provide information on: the pathways by which it is likely to enter the lake; and, potential interventions for reducing its loadings.

TABLE 2A: CATEGORIZATION OF "PRIORITY" TOXICS

CHEMICAL	LAKE ONTARIO FISH TISSUE (1)	LAKE ONTARIO WATER COLUMN (1)	CATEGORY (1)	NIAGARA R. WATER (2)	SIGNIFICANT NIAGARA R. SOURCES (3)
ARSENIC	NI	NI	-	A	
BENZ(A)ANTHRACENE	NI	NI	2a	A	X
BENZO(A)PYRENE	NI	NI	2a	A	X
BENZO(B)FLUORANTHENE	NI	NI	2a	A	X
BENZO(K)FLUORANTHENE	NI	NI	2a	A	X
CHLORDANE	A	C	1A	A	
CHRYSENE	NI	NI	2a	A	
DDT & METABOLITES	B	B	1B	A	
DIELDRIN	B	B	1B	A	
2,3,7,8-TCDD	A	D	1A	A	X
HEXACHLOROBENZENE	B	B	1B	A	X
LEAD	NI	C	1C	A	
MERCURY	A	NI	1A	A	X
MIREX	A	NI	A	A	X
OCTACHLOROSTYRENE	B	NI	1B	A	
PCBs (TOTAL)	A	A	1A	A	X
TETRACHLOROETHYLENE	NI	NI	2a	A	X
TOXAPHENE	D	NI	1D	A	

LEGEND FOR TABLE 2A

(1) - The level of a contaminant in fish tissue and the water column in Lake Ontario, where ambient data was available, were compared to the different standards.

1 - AMBIENT DATA AVAILABLE
A - Exceeds enforceable standard
B - Exceeds a more stringent but unenforceable criterion
C - Equal to or less than most stringent criterion
D - Detection limit too high to allow complete categorization
E - No criterion available
2 - AMBIENT DATA NOT AVAILABLE
a - Evidence of presence in or input to the Lake
b - No evidence of presence in or input to the Lake.
NI- No data available after initial review.

(2)- These chemicals exceeded water quality standards, criteria or guidelines at Niagara-on-the-Lake.

(3)- These ten chemicals were identified, based on ambient Niagara River water column data, as having a significant positive differential load (i.e., a positive differential load ≥ 25% of the total load as measured at Niagara-on-the-Lake), or based on the existence of known current Niagara River sources[6]. They are listed for 50% reduction by the Niagara River Toxics Management Plan (NRTMP).

SOURCE: Lake Ontario Toxics Committee. 1989. Lake Ontario Toxics Management Plan. Environment Canada, United States Environmental Agency, Ontario Ministry of the Environment, New York State Department of Environmental Conservation.

NOTE: Although levels of iron and aluminum exceed standards, they were not included in the list of toxics to be studied as: no reliable indicators of toxicity are available (no single number is ideal because of the variety of forms in which these metals are present in ambient waters); and, differentiation between loads of these metals originating from natural and anthropogenic sources is not yet possible[6].

3. The Information Base For Estimating Loadings

3.1 Collection of Data for this Report

The initial data gathering stage relied on a questionnaire (see Appendix F), sent to 70 experts from disciplines that included: groundwater, sediments, atmospheric deposition, tributary monitoring, sewage treatment plants and industrial discharges. This questionnaire had a 70% response rate. As the questionnaire requested the respondents to suggest names of people with expertise or information on chemical loadings to Lake Ontario further sources of information were identified. As a result, over 100 people were interviewed. In this way, most experts and the available monitoring information databases were identified.

Unfortunately, at this time, much of the monitoring and loadings reports are still "in progress", or not released, and so, this study was not able to make use of them. Generally, much of the loading information does not get published and is difficult to access. A few ingenious researchers overcome this difficulty by holding workshops that require researchers to bring their unpublished data and integrate it into a mass-balance model or atmospheric deposition estimate on location.

A further impediment to using "loading information databases" is that information is typically presented in terms of concentrations (e.g., mg/L) and not loads (e.g., kg/day). For example, information on tributary concentrations is available from the Ministry of Environment (MOE) in yearly reports - voluminous texts that provide raw sampling data - or through the Sample Information System (SIS). The flow data must be obtained through a Federal Agency, the Water Survey of Canada. The coding system is different for the two agencies, which complicates matching the water gauge stations with the sampling locations. Creation of a central registry of information would undoubtedly alleviate access problems such as these.

The U.S. Toxic Release Inventory (TRI) is a model that the Canadian Federal and Provincial governments are considering in their attempts to construct a comprehensive toxic emissions (not loadings) inventory[7]. A Canadian counterpart of TRI, the National Pollutants Release Inventory, is presently in the early stages of development.

3.2 Sources of Information Available in Ontario

No comprehensive source of loading data is available, however, many different programs and studies provide information from both point and nonpoint sources. Several sources of information are described in this section. Table 3A presents a summary of the loading-related information available in Ontario.

TABLE 3A: SUMMARY OF INFORMATION AVAILABLE FROM DIFFERENT MONITORING PROGRAMS FOR THE 18 PERSISTENT TOXICS

SOURCE CATEGORY Chemical	SEDIMENT 1	RUNOFF 2	NIAGARA R. 3	ST. LAWRENCE 4	TRIBUTARY 5	MISA INDUSTRIAL 6	STPs 7	TORONTO RAP 8	QUINTE RAP 9	HAMILTON RAP 10	PORT HOPE RAP 11	AIR EMMISSIONS 12	AIR DEPOSITION 13	AES ATMOSHERE 14	MOE ATMOSPHERE 15
Arsenic	X	X	X	X	X	X	X	X	X	X		X	X		X
Benz(a)Anthracene	X		X	X		X	X	X	X			X	X		X
Benzo(b)Fluoranthene			X	X		X	X	X	X			X	X	X	X
Benzo(k)Fluoranthene			X	X		X	X	X	X			X	X	X	X
Benzo(a)Pyrene	X		X	X		X	X	X	X			X	X	X	X
Chlordane	X	X	X	X	X		X	X	X	X			X	X	X
Chrysene	X		X	X		X	X	X	X				X	X	X
DDT	X	X	X	X	X		X	X	X	X			X	X	X
Dieldrin	X	X	X	X	X		X	X					X	X	X
Dioxin (2,3,7,8-TCDD)			X	X		X	X		X			X			X
Hexachlorobenzene	X	X	X	X	X	X	X	X	X	X			X		X
Lead	X	X	X	X	X	X	X	X	X	X	X	X	X		X
Mercury	X	X	X	X	X	X	X	X	X	X	X	X	X		
Mirex	X	X	X	X	X		X	X	X	X			X	X	
Octachlorostyrene	X				X	X		X	X						
PCBs	X	X	X	X	X	X	X	X	X				X	X	X
Tetrachloroethylene			X	X		X	X			X					
Toxaphene													X		

LEGEND:

(1) Persaud, D. et al., 1989.[8]
(2) Schroeter and Associates. 1992.[9]
(3) & (4) Kuntz, K. 1990.[10]
(5) Harangozo, S. 1991.[11]
(6) MOE. 1991.[12]
(7) M.M. Dillon. 1987.[13]
(8) Snodgrass, W. and M. D'Andrea. 1992.[14]
(9) Poulton, D. 1990.[15]
(10) Rogers,K et al. 1988.[16]
(11) Weston, S. Personal Communication.[17]
(12) ORTECH International, 1991.[18]
(13) Eisenreich, S. and Strachan, W. 1992.[19]
(14) Chan, C. and L.H Perkins, 1991.[20]
(15) Reid, N.W. et al. 1990.[21]

3.2.1 Reporting on Direct Dischargers

Sewage treatment plants (STPs) and industries in Ontario that discharge directly into Ontario's lakes and rivers are self-monitored, on a monthly basis, for conventional pollutants such as biological oxygen demand (BOD), phosphorous and suspended solids. The MOE publishes this information in annual reports (e.g. Report on the 1989 Dischargers from Sewage Treatment Plants in Ontario[22] and Report on the 1989 Industrial Direct Discharges in Ontario[23]). Although these reports do not generally contain any loading information for persistent toxics they provide information for the direct discharging industries and STPs on the: average volume of wastewater flow; size of plant; and, wastewater treatment provided. For STPs the number and volume of bypass occurrences are also reported. No information is provided on the large number of industries discharging indirectly into Lake Ontario via municipal sanitary sewers.

From the information in these reports identification of the plants discharging into Lake Ontario was possible.

3.2.2 Overview of Municipal Industrial Strategy Abatement (MISA)

In June 1986, the MOE initiated the Municipal Industrial Strategy for Abatement (MISA) program to control municipal and industrial discharges into surface waters: the stated objective of this program is "virtual elimination of toxic contaminants in municipal and industrial discharges into waterways".

In October, 1986 a federal-provincial task force was established to identify and list the toxic contaminants to be regulated under the MISA program. The Effluent Monitoring Priority Pollutants List (EMPPL)[12] contained 179 chemicals or groups of chemicals that were detected or were potentially present in Ontario municipal and industrial effluents and pose a hazard to the receiving environment. EMPPL outlines a chemical hazard assessment methodology for its on-going development and review. This hazard assessment is based on: a chemical's environmental persistence; potential to bioaccumulate; acute and sub-lethal toxicity to biological organisms including humans; and, potential to exist in effluents discharged to surface waters.

A permanent federal-provincial advisory committee (Priority Substances Advisory Committee) was established to add/delete chemicals as new information becomes available on effects, environmental fate, and exposure.

The MISA program currently includes industries and municipalities that discharge directly into Ontario's waterways, as listed below.

INDUSTRIAL DIRECT DISCHARGERS IN THE FOLLOWING SECTORS:

- Petroleum Refining
- Organic Chemicals Manufacturing
- Iron and Steel
- Mining

- Pulp and Paper
- Inorganic Chemicals
- Metal Casting
- Electric Power Generation
- Industrial Minerals

MUNICIPAL SEWAGE TREATMENT WORKS

In August 1989, approval was given to develop the MISA Municipal Program. This program includes regulations for sewage treatment plants (STPs) and "the Sewer Use Control Program". The ministry is assisting a number of municipalities to adopt and implement a model sewer use by-law, revised in 1988, which limits the concentration of certain toxic chemicals that can be released into the sewer by industry.

Industrial Effluent

Under the MISA program, new regulations have been introduced that require industrial dischargers to monitor their discharges to surface water. The program has developed in the following three stages:

- **the Pre-regulation Stage**, in which government consulted with the regulated sector and carried out preliminary monitoring to obtain data for developing regulations[24];
- **the Effluent Monitoring Stage**, in which regulations were developed for each sector requiring industrial dischargers to monitor their effluents at regular intervals (using specific protocols/procedures for sampling, analyses, quality control and, quality assurance). To date, monitoring regulations for all nine industrial sectors have become law. The parameters and frequency for monitoring and the regulation in-force dates are established. Under this program, monitoring requirements for each industrial sector is specified in two regulations : The General Effluent Monitoring Regulation (Ontario Regulation 695/88)[25], which embodies the technical principles common to all sectors; and, the relevant sector-specific regulation.

  As to the MISA reporting format resulting from this required monitoring, it is sector-specific. Some of the sectors provide monitoring data in the form of two six-month reports, others, 12-month reports. Some sectors provide data in terms of both loadings and concentration; others provide only the concentration and flow data. Some provide only the sum of the industry's average concentration data, others provide the average concentration data from all the discrete sources of an industry.

  The MISA effluent monitoring database provides information for determining loadings. It is:

  - recent (1989-91);
  - on-going - requiring annual analyses for selected chemicals;
  - reliable, as it is subject to a rigorous quality assurance/control program; and,

- comprehensive in that it analyses for both organics and metals, as determined by the effluent monitoring regulation from each sector.

However, MISA monitoring has its limitations for determining loadings of persistent toxics, as it does not analyze all pollutants in each sector. From Table 3B it can be seen that pulp and paper industries are not required to monitor for arsenic and, thermal electric plants are only required to monitor for 3 parameters (not PCBs). Also, within a sector, some streams are monitored and others are not: for example, monitoring of emergency overflows and stormwater from the iron and steel industries are limited to benzo(a)pyrene and lead, although, they most likely also contain other polyaromatic hydrocarbons, as well as, arsenic and hexachlorobenzene. See Appendix G for a listing of the monitoring requirements for the different streams of selected sectors.

The industries discharging directly into Lake Ontario are listed in Table 3C. As well, their location, the sector to which they belong and the availability of MISA report or other monitoring data are listed.

- **the Effluent Limit Stage**, in which regulations will be developed and implemented for each of the industrial and municipal sectors, on a sector-by-sector basis. The ministry will release regulations for each sector specifying:
  - effluent limits; and,
  - a list of water-based persistent toxic substances that must be eliminated from discharges, along with the timetable for elimination.

All persistent toxic contaminants with at least 10 % of samples (at the 95% confidence interval), above the method detection limit described by regulation for that contaminant, will be selected for the purpose of setting limits. All effluents must be non-acutely lethal. Draft regulations will be released for public review in 1992, with regulations for all industrial sectors to be in place by the summer of 1993.

Information on Stormwater

Under MISA effluent limits regulation, dischargers may be required to conduct a stormwater control study and take action to control stormwater if the surface runoff from an outdoor process or non-process area at a site exceeds the best-available-technology (BAT) limits for the process effluent. If required, dischargers will have six months to develop a stormwater control study plan and two years to implement the plan. If stormwater does not exceed BAT limits it may be required to be continuously monitored for the purpose of assessment. The frequency of this monitoring will be determined on a site-by-site basis.

TABLE 3B: SUMMARY OF MISA MONITORING REQUIREMENTS FOR THE INDUSTRIAL SECTORS FOR 18 PERSISTENT TOXICS

INDUSTRIAL SECTOR / Chemicals	PULP & PAPER	INDUSTRIAL MINERALS	PETROLEUM	INORGANIC CHEMICALS	METAL CASTING	IRON & STEEL	MINING	ELECTRIC NUCLEAR	ELECTRIC THERMAL	ORGANIC CHEMICALS
Arsenic		X	X	X	X	X	X	X	X	X
Benz(a)anthracene	X	X	X	X		X	X	X		X
Benzo(b)fluoranthene	X	X	X	X		X	X	X		X
Benzo(k)fluoranthene	X	X	X	X		X	X	X		X
Benzo(a)pyrene	X	X	X	X		X	X	X		X
Chlordane										
Chrysene	X	X	X	X	X	X	X	X		X
DDT										
Dieldrin										
Dioxin (2,3,7,8-TCDD)	X	X	X			X	X	X		X
Hexachlorobenzene	X	X	X	X		X	X	X		X
Lead	X	X	X	X	X	X	X	X	X	X
Mercury	X	X	X	X	X	X	X	X	X	X
Mirex										
Octachlorostyrene	X		X	X		X	X	X		X
PCBs	X	X	X	X	X	X	X	X		X
Tetrachloroethylene	X	X	X	X		X	X	X		X
Toxaphene										

SOURCES : SEE APPENDIX G.

TABLE 3C: SUMMARY OF THE MONITORING INFORMATION FOR ALL ONTARIO INDUSTRIES DISCHARGING DIRECTLY TO LAKE ONTARIO

NO.	SOURCE	INDUSTRIAL SECTOR	MISA REPORT AVAILABLE	OTHER MONITORING
1	Petro-Canada, Mississauaga	Petroleum	Yes	
2	Petro-Canada, Oakville	Petroleum	Yes	
3	Celanese Canada Inc., Ernestown	Organic Chemicals	Yes	
4	Dupont Kingston Township	Organic Chemicals	Yes	
5	G.E. Plastics Ltd., Coubourg	Organic Chemicals	Yes	
6	BLT Resins, Division of Bakelite*	Organic Chemicals (CLOSED-1991)	No	MOE.(1992)[26]
7	Kimberly Clark, St. Catherines	Pulp & Paper	Yes	
8	Beaver Wood Fibre Co., Thorold	Pulp & Paper	Yes	
9	Domtar Fine Papers, St. Catherines	Pulp & Paper	Yes	
10	Domtar Packaging, Trenton	Pulp & Paper	Yes	
11	Noranda Forest, Thorold	Pulp & Paper	Yes	
12	Quebec & Ontario Paper Co., Thorold	Pulp & Paper	Yes	
13	Strathacona Paper Co, Twp of Camden E.	Pulp & Paper	Yes	
14	Trent Valley Paperboard, Glen Miller	Pulp & Paper	Yes	
15	General Motors, St. Catherines	Metal Casting	Yes	Canviro(1989)[27]
16	Canada Pipe Company, Hamilton	Metal Casting	Yes	
17	Chrysler Canada, Etobicoke*	Metal Casting	Yes	
18	Stelco Page Hersey Works, Welland Canal	Metal Fabricating	No	No
19	Dofasco, Hamilton	Iron & Steel	Yes	
20	Stelco, Hamilton	Iron & Steel	Yes	
21	Lasco, Whitby	Iron & Steel	Yes	
22	Exolon-Esk, Thorold	Inorganic Chemicals	Yes	
23	Columbian Chemicals, Hamilton	Inorganic Chemicals	Yes	
24	Essoroc, Picton	Industrial Minerals	Yes	
25	Lafarge Canada, Bath	Industrial Minerals	Yes	
26	Cameco, Port Granby	Metal Mining, Smelting, Refining	Yes	Acres.(1991)[28]
27	Cameco, Port Hope	Metal Mining, Smelting, Refining	Yes	Acres. (1991)[28]
28	Cameco, Welcome	Metal Mining, Smelting, Refining	Yes	Acres. (1991)[28]
29	Ontario Hydro TGS, Lakeview, Toronto	Electrical Power Generation	Aug. 92	
30	Ontario Hydro NPGS - Pickering Plant A	Electrical Power Generation	Aug. 92	Acres. (1991)[28]
31	Ontario Hydro NPGS - Pickering Plant B	Electric Power Generation	Aug. 92	Acres. (1991)[28]
32	Ontario Hydro- Lennox TGS, Bath	Electrical Power Generation	Aug. 92	
33	Ontario Hydro NPGS- Darlington	Electric Power Generation	Aug. 92	Acres. (1991)[28]
34	Ontario Hydro TGS- R.L. Hearn	Electric Power Generation	Aug. 92	
35	Campbell's Wellington Mushroom Farm,	Miscellaneous: Food & Beverage	No	No
36	Canadian Canners Ltd., St. Davids	Miscellaneous: Food & Beverage	No	No
37	Orenco (Ontario Rendering), Dundas	Miscellaneous: Food & Beverage	No	No
38	Canadian Vegetable Oil	Miscellaneous: Food & Beverage	No	No
39	Redpath Sugar	Miscellaneous: Food & Beverage	No	No
40	St. Lawrence Starch Company	Miscellaneous: Food & Beverage	No	No
41	Canada Malting Company	Miscellaneous: Food & Beverage	No	No
42	Victory Soya Mills	Miscellaneous: Food & Beverage	No	No
43	Tend-R-Fresh Division, Dundas	Miscellaneous: Food & Beverage	No	No
44	Domtar Wood Preserving, Trenton	Miscellaneous: Wood Preserver	No	Brown, P.[29]

LEGEND:
Yes - MISA report available
Date - MISA report in progress to be completed on this date.
No - MISA report not required for this industry.

Municipal Sewage Treatment Plants (STPs)

The MISA Thirty-seven Municipal Water Pollution Control Plants: Pilot Monitoring Study[30] provides the geometric mean concentrations for influent and effluent of 17 plants in the Lake Ontario Basin for 18 metals and 151 organic compounds. Another version of this report is in progress and will provide arithmetic mean concentrations for this same 1987 monitoring data. Modelling, carried out by Shroeter and Associates, in the report Loadings of Toxic Contaminants from Urban Nonpoint Sources to the Great Lakes from Ontario Communities[9] extrapolates the MISA monitoring information for 37 STPs on the Canadian-side of the Great Lakes (not just Lake Ontario) to furnish a loading estimate for the entire Lake Ontario Basin (Canadian-side) from STPs and combined sewer overflow. Also, the 37 STP study provides limited information as to the industrial sectors discharging to STPs, as outlined in appendix J.

Another study, MISA Municipal Demonstration Project: Sewer-use Control[31] is monitoring STPs industrial sewer-use for metals in 5 municipalities, including two municipalities (5 STPs), in the Lake Ontario Basin. One other study has been conducted by MISA for a STP entitled Toronto Main STP MISA Pilot Site Study Component Report: Water Quality[32] which includes monitoring data for 18 metals and 151 organic compounds.

In summary the "MISA program for STPs" does not provide on-going monitoring of STPs or industries discharging into STPs for persistent toxics. The data from MISA studies, thus far, provides only monitoring data for a fraction of the STPs (representing 87% of the flow) in Lake Ontario and very little data on industries discharging into STPs. This 1987 monitoring data is becoming out-of-date.

3.2.3 Initiatives (other than MISA) to Monitor STPs and Industries

Other than MISA, monitoring data for STPs is sparse. The municipal sector is insufficient to fill the information gap for STP loadings; only a few municipalities have monitored their effluent for metals and/or organics. See section 3.2.7. The Remedial Action Plan (RAP) programs intitiated monitoring for persistent toxics for 4 STPs in Metropolitan Toronto and 6 in the Bay of Quinte area for the Bay of Quinte RAP. See Table 3D and section 3.2.6 for a list of municipal STP monitoring. Repeated studies by MISA and municipalities may be duplicating efforts.

Regarding industry the runoff discharged by Domtar Wood Preserving was contained in a recent, not yet published, Environment Canada report[29]. Beyond the records listed in Table 3C there exists only a small and fragmentary information base, derived from Remedial Action Plan (RAP) initiatives, and limited, for the most part, to metals.

TABLE 3D: SUMMARY OF THE MONITORING INFORMATION FOR ALL MUNICIPAL SEWAGE TREATMENT PLANTS (STPs) DISCHARGING TO LAKE ONTARIO

	NAME OF MUNICIPAL STP	STUDY		MUNICIPAL STP	STUDY
1	Bath, Presquile Bay		31	Mississauga, Lakeview	(1)
2	Belleville STP	(3)	32	Napanee STP	(3)
3	Batawa STP, Trent R.		33	Newcastle,Port Darlington(Graham Cr.)	(4)
4	Bricroft		34	Niagara-on-the-Lake	(1)
5	Bobcaygeon		35	Oakville (South-East)	(1)
6	Brighton		36	Oakville (South-West)	
7	Burlington (Skyway)	(1)	37	Oshawa (Harmony Cr.)	(4)
8	Campbellford,Trent R.		38	Peterborough, Otonabee R.	(1)
9	Coubourg STP #1 and #2	(2)	39	Pickering, Duffin Cr. (York-Durham)	(1)
10	Coldwater		40	Picton STP	(3)
11	Deseronto STP	(3)	41	Port Hope	
12	Dysart		42	Scugog, Lake Scugog	
13	Dundas, Cootes Parad.	(2)	43	Smith	
14	Ernestown,Collius Cr.		44	Stirling, Rawden Cr.	
15	Ernestown, Millhaven Cr.		45	St.Catherines, Port Dalhousie	(5)
16	Frankford, Trent R.	(3)	46	St.Catherines, Port Weller	(5)
17	Fenelon Falls		47	Toronto, Highland Cr.	(1),(6)
18	Grimsby	(1)	48	Toronto, Humber	(1),(6)
19	Halton Hills, Black Cr.		49	Toronto, Main	(1),(6),(7)
20	Halton Hills, Silver Cr.		50	Toronto, North	(1),(6)
21	Hamilton, Redhill Cr.	(1),(2)	51	Trenton STP	(3)
22	Hastings, Trent R.		52	Tweed, Moira R.	
23	Havelock, Plato Cr.		53	Warkworth, Mill Cr.	
24	Kingston Twp.	(1)	54	Watertown, Grindstone Creek, Hamilton	(2)
25	Kingston STP	(1)	55	Wellington	
26	Lindsay, Scugog R.	(1)	56	Whitby, Corbett Cr.	(4)
27	Madoc, Moira R.		57	Whitby, Pringle Cr.	(1)
28	Marmora, Crowe R.				
29	Milton, Oakville Cr.				
30	Missisauga, Clarkson	(1)			

-NOTES--
(1) Canviro (1988).[30] - analyzed for entire 18 persistent toxics.
(2) Leclair B. (personal communication).[31] - analyzed for metals only.
(3) Poulton (1990).[16] - analyzed for metals and 96 organics
(4) Durham Region (1990).[33] - analyzed for lead and arsenic (unpublished).
(5) Canviro Consultants (1989)[34]- analyzed for lead and mercury.
(6) ZENON Environmental Inc. (1990)[35] analyzed for 150 organics(15 of list of 18).
(7) Poulton, D. and Beak (1991)[32] - analyzed for entire 18 persistent toxics.

3.2.4 Inventory of Waste Sites

An inventory of the active and closed waste disposal sites in Ontario has been chronicled since 1985-86. The most current report was published in June, 1991. For each site, information is provided on:
- waste types;
- site locations; and,
- year of closure, in the case of closed sites.

A listing of the industrial sites producing and using coal tar and related tars in Ontario and closed municipal coal gasification plant sites is also provided in the report, Waste Disposal Site Inventory[36].

No estimates are available for leachate generation, flux or loadings from waste sites. The regional offices of MOE have information on the quantity and quality of leachate in various files that are not readily accessible and could not be obtained for this report.

3.2.5 MOE Generator Registration Program

Generators are legally required to register their waste with the MOE and provide accurate and complete descriptions of waste quantities/types for manifests under Ontario Regulation 309 . The information collected by the MOE through this registration process has been compiled and computerized. This information provides the most complete record of the treatment of hazardous and liquid industrial waste in the province and contains information about the disposal of waste for persistent toxics both on-site and off-site.

The report, Ontario Waste Management Corporation Environmental Assessment, Volume 1: The OWMC Undertaking[37] released data from the MOE Generator Registration Program which describes the types of wastes being generated and their place of disposal. As well as being useful for estimating loadings from waste sites the database provides information on companies producing hazardous materials and loadings to STPs. Although this program represents the largest database of industrial emissions it is uncertain how it can assist with estimating loadings to Lake Ontario and so its information was not used in this report.

3.2.6 Remedial Action Plans (RAPs)

Remedial Action Plans (RAPs) attempt to embody a comprehensive ecosystem approach to restore and protect beneficial uses in areas with significant pollution problems (areas of concern). Each RAP is designed to identify pollution problems and then resolve them by indicating the specific actions required to be taken and who has responsibility for taking this action. The 1987 revised Great Lakes Water Quality Agreement (GLWQA) requires that the public be consulted in all actions undertaken pursuant to RAPs. In a Plan consideration must be given to:

- municipal and industrial wastewater treatment;

- hazardous waste management;
- nonpoint source pollution control(such as urban and agricultural runoff and groundwater);
- fisheries and wildlife management;
- dredging and harbour maintenance;
- land use planning; and,
- recreation.

The Great Lakes Water Quality Board identified four areas of concern on the Canadian-side of Lake Ontario in its 1985 report to the IJC. In each of these areas, one or more of the GLWQA's general or specific objectives were not being met which has caused or is likely to cause impairment of beneficial uses. These four "areas of concern" are:

- Metropolitan Toronto;
- Bay of Quinte;
- Hamilton Harbour; and,
- Port Hope.

The Niagara River was also identified as a binational "area of concern". Three "areas of concern" on the American-side of Lake Ontario were identified.

The reports, resulting from these RAPs, generally provide monitoring data for conventional parameters and metals. Additionally, Bay of Quinte and Metro Toronto RAPs have completed studies that monitored a number of organics.

Metro Toronto RAP

The Metro Toronto RAP team has initiated a number of studies, most of which are presently in progress. The historical database for Metro Toronto tributaries was considered inadequate to estimate contaminant loads and so the RAP team initiated studies to quantify pollutant loads. Their first effort produced a report Measurement of Pollutant Loadings from Tributaries Discharging to Lake Ontario - Metro Toronto Waterfront[38] which is the result of a weekly sampling program for heavy metals and trace organics over a year. The study yielded predominately results below the detection limit. Another project entitled Assessment of Tributary Loadings to the Metro Toronto Waterfront is underway: six tributaries (the Rouge River, Highland Creek, the Don River, the Humber River, Mimico Creek and Etobicoke Creek) are being sampled using 100 litre large volume samples for trace organics and 20 litre samples for metals over a one year period.

Furthermore, a deficiency in data, for contaminant loadings from storm sewers and combined sewer overflows was recognized, resulting in the initiation of the following four studies:

- Two Toronto Waterfront Wet Weather Outfall Study ([1] City of Toronto, 1990 and [2] City of Etobicoke and Scarborough, 1989), in which priority outfalls are monitored for 16 metals and 50 organics;
- Dry Weather Discharges to the Metropolitan Toronto Waterfront[14], in which sewer outfalls, 4 STPs (Humber, Main, Lakeview, and Highland) and, 3 water filtration plants

(R.L Clark, R.C. Harris and S.J. Horgan) are monitored for 16 metals and 50 organics; and,

- Toronto Waterfront Wet Weather Outfall Study - Phase 3: Assessment of the Seasonal Variability in Outfall Loadings, in which 2 outfalls are monitored for 16 metals and 50 organics.

The dry weather study was completed in time to use the information on water filtration plants to calculate loadings of toxics to Lake Ontario.

Bay of Quinte RAP

In 1988 the Bay of Quinte RAP team initiated a survey of toxic contaminants which furnished loading information for the RAP report 1988 Toxic Contaminants Survey[16]. In this survey, monitoring of 11 heavy metals and 96 organic contaminants levels was conducted for:

- 6 STPs;
- 4 industries;
- 5 tributary mouths (Trent R., Moira R., Salmon R., Napanee R., Picton Marsh Cr.);
- surface water at a number of "in Bay" stations; and,
- Bay of Quinte sediments.

Further, research has been carried out which:

- estimated agricultural loadings of phosphorous. The Analysis of Agricultural Diffuse Source Loadings to the Bay of Quinte[39] provides an estimate of the magnitude of agricultural diffuse source phosphorus loadings to the Bay of Quinte along with an evaluation of the effectiveness and on-farm costs of diffuse source control measures;
- determined the potential for landfills in the Bay of Quinte watershed to leach chemicals to the bay. Landfill leachate concentrations were determined for a number of chemicals (none of the 18 toxics discussed in this report) and minimum and maximum leachate generation was estimated[40]; and,
- analyzed the fate of three toxic contaminants- arsenic, PCBs, and pentachlorophenol- by a mass balance model in A Mass Balance Model of the Fate of Toxic Substances in the Bay of Quinte[41].

Information from the RAP reports assisted in calculating loadings for STPs in this report.

Hamilton Harbour RAP

In the Draft Remedial Action Plan for Hamilton Harbour (December, 1991)[42] loadings to the harbour of a few toxic chemicals (zinc, phenols, total polyaromatic hydrocarbons, lead, cyanide, iron, copper and chromium) were calculated. It was MOE loadings data that were used. The following sources were considered in the loadings:

- Lake Ontario;

- Burlington STP;
- Combined Sewer Overflows;
- Urban Runoff;
- Stelco;
- Creeks;
- Dofasco;
- Cootes Paradise; and,
- Hamilton STP.

According to the RAP report, suspended sediment data was collected in 1988 and 1990 by MOE at major point sources and by National Water Research Institute (NWRI) at sediment traps at three locations throughout the harbour. These findings are, presently, being used to develop an enhanced suspended sediment mass balance model for the harbour.

The loading estimates from the Hamilton Harbour RAP report were not used in this report as the information it provides was found elsewhere.

Port Hope RAP

The focus of this RAP is radioactivity and so, does not provide any information on the 18 toxic persistent chemicals.

3.2.7 Municipal Initiatives

A few municipalities have undertaken sampling of the STPs in their jurisdiction, as follows:

- Metropolitan Toronto monitored four STPs (Main, Humber, Highland Creek and North Toronto) by obtaining one composite sample of the influent and effluent for 150 organic parameters ove. a 72 hour period (15 of the list of 18 were analyzed)[35];
- Durham region enroled MOE to analyze three STPs (Harmony, Corbett Cr., and Graham Cr.) for metals (e.g. lead and arsenic)[33]; and,
- St. Catherines analyzed two municipal STPs (Port Darlington and Port Weller) for metals (lead and mercury)[34].

Further, St. Catherines Area Pollution Control Plan (SCAPCP) initiated monitoring of conventional parameters and metals (e.g. lead and mercury) to identify the relative importance of pollutant sources, and magnitude of pollutant inputs[34]. Included in the pollutant sources assessed by SCAPCP were:

- Dry Weather Seepage;
- Stormwater runoff;
- Direct Industrial Discharges;
- Bypasses and Combined Sewer Overflows; and,
- Municipal STPs.

3.2.8 Occurrence Reporting Information System (Spills)

The Occurrence Reporting Information System[43], operated by the MOE Spills Action Centre, provides a summary every year for Lake Ontario that details the total amount spilled of petroleum products, and hazardous materials and solutions. The MOE computer database provides more information including:

- estimates of the volume spilled;
- description of the spill; and,
- identification of the source of the spill.

The computer database is not organized by basins and so all records must be sifted through. This exercise was carried out for this report but no system is presently in place that provides this information. Refer to Appendix G, Table G1 for a summary of the spills generated from the computer database. Loading estimates for spills can be derived from the volumes of spills reported in Occurrence Reporting Information System (ORIS) and typical concentration data. In this report loading calculations were carried out for Dofasco, the source of the largest number and volume of spills. MISA provides loadings for a limited number of parameters (benzo(a)pyrene and lead) for Stelco's emergency overflow.

3.2.9 Urban Runoff

Since the late 1970's, the National Water Research Institute (NWRI) in Burlington has been engaged in investigations in the composition of urban runoff. The mean concentrations of 50 chemicals in stormwater and street sediment were determined in a 1989 field program conducted in 12 urban centres in southern Ontario. Nine of the eighteen toxics were analyzed (the metals, a few pesticides and PCBs- see Table 3A). Annual loadings of toxic chemicals in urban runoff from the study area were estimated within an order of magnitude using:

- mean concentrations; and,
- computed runoff volumes and sediment yie!ds

These estimates appear in Annual Loadings of Toxic Contaminants in Urban Runoff from the Canadian Great Lakes Basin[44]. They do not include possible contributions from combined sewer overflows or illicit point source discharges into storm sewers.

In Loadings of Toxic Contaminants from Urban Nonpoint Sources to the Great Lakes from Ontario Communities[9] Schroeter uses the URBLOAD program to provide estimates for the total urban runoff loadings. Estimates are considered, by the author of the report, to be accurate within the range of ± 50 to 80%. This lcading information accounts for all areas on the Canadian-side of the Great Lakes Basin with:

- urban populations greater than 10,000; and,
- populations in the range 5,000-10,000 with densities greater than 4 persons/hectare.

For areas meeting this criteria, it considers runoff from residential, industrial and commercial areas but not open spaces.

Quantity/quality simulation modelling of urban runoff loadings had been done by the: City of Toronto; City of Scarborough; and, Borough of East York. Urban runoff pollutant loadings were extracted from these studies to develop the Schroeter estimates. For all other urban areas, Schroeter used derived probability models to estimate stormwater runoff volumes and loading.

3.2.10 Agricultural Runoff

No determination of concentrations or loadings of any of the eighteen toxics for agricultural or open spaces has been made. To obtain agricultural loading values the author of this report applied an agricultural runoff estimation method using the concentrations of four pesticides in urban runoff.

For estimating loadings of currently used pesticides, the Survey of Pesticide Use in Ontario[45] is potentially a very useful information base. The survey has been carried out every five years in Ontario, since 1973, to identify and quantify the active ingredients of all pesticides used for field crops; fruit crops; vegetable crops; and, roadside spraying (the 1988 survey did not include roadside spraying).

Pesticide-use at the drainage basin level was estimated from the survey results for the Counties (or portion of Counties) in the drainage basin. The total quantity (Q) of the active ingredient of a particular pesticide was calculated by the following method:

$$Q = A \times R$$

A = crop area treated in a County
R = application of active ingredient per area (ie, 1 kg/hectare) for that County from the survey findings.

This survey provides no assistance with estimating loadings of banned/restricted pesticides. None of the five pesticides being studied, were applied to crops from 1973 to 1988 according to the survey. However, methoxychlor, of which DDT is a photolytic product, is listed; approximately 5 kilograms of the active ingredient in methoxychlor was used in the Lake Ontario basin in 1988 and 280 kg in 1983.

3.2.11 The Niagara River

Since 1984, ambient water and suspended solids samples have been collected at the head (Fort Erie) and mouth (at Niagara-on-the-Lake, one mile upstream of Lake Ontario) of the Niagara River. Monitoring for at least 74 chemicals (16 of 18 toxics- see Table 3A) is carried out to determine inputs:

- to the Niagara River from the eastern basin of Lake Erie; and,
- from the River into Lake Ontario.

Once per week composite samples of suspended solids and water are collected continuously over a 24 hour period. Also, grab samples are taken of centrifuged water (for chlorophenol analysis) and, whole water (for volatile organics and trace metal analysis). A delay of 15 to 18 hours between sample collection at Fort Erie and Niagara-on-the-Lake was introduced to account for the time required for water to travel the length of the river.

The program is operated by Environment Canada for the Niagara River Toxics Management Plan (NRTMP) and uses sampling and analytical methods which have been agreed to by the four parties to NRTMP. Mean station concentrations and loads, with 90% confidence intervals, are calculated for all chemicals with three or more measured values above the practical detection limit (PDL). Annual reports are produced, the latest is entitled Joint Evaluation of Upstream/Downstream Niagara River Monitoring Data for the Period April 1988 to March 1989[10].

Differences between upstream/downstream loads are calculated for water and suspended solid phases and its statistical significance is reported.

3.2.12 Exit Load from Lake Ontario

Exit loads from Lake Ontario via the St. Lawrence River are monitored by Environment Canada at the Wolfe Island Station. The station, located on the south shore of the Island on Banford point, has been operational since 1976 but sampling for organics did not start until 1982. Once per week composite samples of suspended solids and water are collected continuously over a 24 hour period and grab samples are taken of centrifuged water for chlorophenol analysis and whole water (not centrifuged) for analysis of volatile organics and trace metals (16 of 18 persistent toxics - see Table 3A)[46]. All sampling and analyses procedures are consistent with those detailed in the Niagara River Protocol document.

Annual reports of exit loads for Lake Ontario are not available, however, the average concentrations and loads with 90% confidence intervals can be obtained, on request, from Hans Biberhofer, Inland Waters Directorate, Environment Canada, Burlington.

Although the exit load from Lake Ontario is provided in this report it is not included in the loading matrix ; the St. Lawrence is not within the geographical scope of the LOTMP.

3.2.13 Tributary Monitoring Program

Raw water concentrations from the tributary monitoring program are published in separate reports for each MOE region (Water Quality Data Ontario Lakes and Streams 1987 [1] Southeastern ,[2] West Central and [3] Central Region[11]). Current information can be obtained from the Sampling Information System (SIS) program on disc or printout. Loadings can be determined from these reports and the flow data from the Water Survey of Canada, Environment Canada. See Table

3E for a listing of the monitoring and water gauge locations and, size of the drainage basin. The following tributaries are not gauged: Brookside, Picton, Rattray, and, Sawguin Creeks.

The program monitors metals for most of the more than 40 Canadian tributaries entering Lake Ontario using various monitoring schedules. Eight tributaries are part of an enhanced tributary monitoring network (Credit River, Don River, Etobicoke Creek, Humber River, Redhill Creek, Trent River, Twelve Mile Creek, and, Welland Canal). These tributaries are also analyzed for a number of organic chemicals (chlordane, DDT and metabolites, dieldrin, hexachlorobenzene, mirex, octachlorostyrene, polychlorinated biphenyls, and toxaphene).

Since there are no computed loading estimates available, an estimate of loadings from all tributaries with gauges was accomplished in this report. Unfortunately, the concentrations observed are predominately "censored" (Statician's term for data that is below the detection limit, to indicate that the unknown numerical value has been proscribed by the limitations of the measurement process). After 4.5 years of sampling and a hundred samples, not one organic parameter had three samples above the detection limit (see Table 14D).

TABLE 3E: SUMMARY OF TRIBUTARY WATER QUALITY MONITORING AND FLOW GAUGING STATIONS DISCHARGING DIRECTLY UPSTREAM OF LAKE ONTARIO

TRIBUTARIES	LOCATION	WATER GAUGE CODE	DRAINAGE AREA (Km^2)
Bowmanville Cr.	West Beach Road, Bowmanville.	02HD006	82.9
Bronte Cr.	Highway 2, Bronte	02HB011	235
Brookside Cr.	Highway 2, 1.5 Miles East of Brookside.	NA	
Bloomfield Cr.	Church Street,Bloomfield.	02HE001	13.9
Carruther Cr.	First Road East of Ajax Town Line.	02HC100	
Cobourg Brook	Park South of Fourth St.	02HD103	
Colbourne Cr.	Bridge in Lakeport.	02HD102	
Consecon Cr.	Mill Dam.	02HE002	114
Credit River	Southern Dam of Orangeville Reservoir.	02HB002	795
Don River	Pottery Road.	02HC024	316
Duffins Cr.	Baseline Road, 1 Mile West of Ajax.	02HC049	249
Etobicoke Cr.	Highway 2, Long Branch.	02HC030	204
Farewell Cr..	Wentworth Str. Oshawa.	02HD014	204
Gage Cr.	Highway 2, 1 Mile East of Port Hope.	02HD104	
Ganaraska R.	Peter St. Port Hope.	02HD003	67.3
Graham Cr.	First Cr., Newcastle.	02HD105	
Grindstone Cr.	Highway 2, Bayview, Hamilton Harbour.	02HB012	82.6
Highland Cr.	Highland Cr. Park, West Hill.	02HCO13	88.1
Humber River	Lakeshore Road.	02HC003	800

TABLE 3E: **SUMMARY OF TRIBUTARY WATER QUALITY MONITORING AND FLOW GAUGING STATIONS DIRECTLY UPSTREAM OF LAKE ONTARIO (continued)**

TRIBUTARIES	LOCATION	WATER GAUGE CODE	DRAINAGE AREA (Km^2)
Lynde Cr.	Baseline Rd, Whitby Township.	02HC018	106
Millhaven Cr.	First. Concession Rd. South of Odessa.	02HM006	150
Mimico Cr.	Highway 2, Mimico.	02HC033	70.6
Moira River	Footbridge North of Highway 2, Belleville.	02HL005	2,620
Napanee River	Downstream from River Rd, Napanee.	02HM001	694
Oakville Cr.	Simcoe Str. South, Oshawa.	02HB005	95.6
Oshawa Cr.	Simcoe Str. South, Oshawa.	02HD008	95.8
Picton Cr.	Conservation Area Pound.	NA	
Pringle Cr.	Watson Cr., Whitby.	02HD014	
Proctors Cr.	Road to Highway 33, Brighton.	02HD100	
Rattray Cr.	Meadow Wood Rd, Clarkson.	NA	
Redhill Cr.	Mountainbrook Blvd, Hamilton Albion Falls.	02HB107	
Rouge River	Box Grove, Town of Markham.	02HC022	186
Salmon River	Dundas St., Shannonville.	02HM003	891
Sawguin Cr.	County Rd. 28.	NA	
Shelter Valley Br.	Concession Road South of Grafton.	02HD010	64.8
Smithfield Cr.	County Road 64 near Lovett.	02HD109	
Spencer Cr.	Cootes Road, Dundas.	02HB010	
Trent River	New Highway 2 Bridge, Trenton.	02HK004	12,000
Twenty Mile Cr.	First Concession Rd down from Smith STP.	02HA006	293
Welland Ship Canal	Weir downstream from Lakeshore Rd.	02HA019	
Wilmot Cr.	Highway 2, 2 Miles West of Newcastle.	02HD009	82.6
Wilton Cr.	Company Road 8, 1 Mile West of Chambers.	02HM004	112

LEGEND

NA: not available - tributary is not gauged.

3.2.14 Atmospheric Deposition

Atmospheric deposition to the Great Lakes was first estimated at a 1986 workshop held by Strachan and Eisenreich (1989) and documented in their report, The Summary Report of the Workshop on Great Lakes Atmospheric Deposition[47]. At that time loading estimates were possible for only a few chemicals (i.e., PCBs, DDT, Benzo(a)pyrene and lead). Insufficient data on atmospheric concentrations did not permit estimating loadings for other chemicals. Since the 1986 workshop, a binational Integrated Atmospheric Deposition Network (IADN) has been put in place. Concentrations of the organics and metals in air (from both the gaseous and particulate phase) and rain/snow are now measured at several Canadian and American master and satellite stations, with the participation of both Government and University scientists.

Eisenrich and Strachan (1992) held another workshop January 31, 1992 to February 2, 1992 which culminated in the report Estimating Atmospheric Deposition of Toxic Substances to the Great Lakes: An Update (Draft)[19]. At the workshop, Canadian and American scientists selected air and rain concentrations representative of the entire Great Lakes region for 40 compounds by reviewing annual average concentrations available for the various stations. From these concentrations, aerosol deposition and precipitation loads were determined for each of the Great Lakes for a large suite of organochlorine compounds, heavily used herbicides (i.e., alachlor and atrazine), PAHs, and trace metals (i.e., mercury, lead, cadmium, and arsenic). The estimates in this report were considered to be the best for atmospheric deposition available at present and so were used for atmospheric loadings estimates in this report.

Other Initiatives

The Inland Waters Directorate (IWD) of Environment Canada has formed a network of precipitation stations on the Great Lakes. Rain and snow samples are collected at 16 stations for inorganic analysis and at 8 stations for organic analysis. Eight stations are located in the Lake Ontario basin. Concentration levels and loadings have not yet been published.

The Atmospheric Environmental Service of Environment Canada is doing research on atmospheric transport and deposition of toxics in Southern Ontario. Recent data published by Hoff et al. (1991) provide average concentrations for vapour-phase[48] polychlorinated biphenyls (PCBs) and organohalogen pesticides from July 1988 to September 1989 for a site located on Manitoulin Island.

The Air Resources Branch of the Ontario Ministry of the Environment established a toxics deposition network in 1987 to monitor for PCBs, chlorinated pesticides, trace metals and PCDD/PCDFs in air and precipitation (thirteen of eighteen persistent toxics - See Table 3A). Monitoring sites are located at four rural shoreline sites around the Great Lakes. Only one site is located in the Lake Ontario basin at Point Petre.

An urban site on the Toronto Islands and an inland site at Dorset were also established to analyze for dioxins and dibenzofurans. The monitoring site on the Toronto Islands was specifically requested to meet the needs of the Metro Toronto RAP to estimate deposition to the Toronto Waterfront area. This site allows comparison of the levels found in urban and rural locations[21]. Data is compiled into annual reports that provide concentrations in precipitation. No loadings estimates are provided. The most current concentration data from this network can be found in Reid et al. (1991)[49].

Data from the initiatives mentioned above were not used directly in the air deposition loadings in this report, but were considered in the estimates of Eisenreich and Strachan (1992) which were used here.

3.2.15 Toxic Atmospheric Emissions

Toxic chemical emission factors are available in ORTECH International (1991). The report was commissioned by Environment Canada (DOE)[18] to fulfil the Great Lakes Water Quality Agreement Annex 15 requirements of developing a toxic chemical inventory of source emissions that may impact on Great Lakes water quality. Emission factors were consolidated and developed on a sector basis for the following toxic chemical classes: dioxins (PCDDs), furans (PCDFs), PCBs, polyaromatic hydrocarbons (PAHs), chlorobenzenes, chlorophenols, and specific trace metals. The Residual Discharge Information System (RDIS) files, developed by DOE, were used to compile emission of the most common air pollutants.

The most thoroughly characterized emissions are the electric power generation sources and specific incineration sectors (i.e., municipal refuse, sewage sludge and industrial waste incineration). The data was useful only as preliminary estimates. In this report the data was used to determine the origin of pollutants (see Appendix E, Table E1).

3.2.16 Sediments

In 1983, the Ontario Ministry of the Environment initiated the In-Place Pollutants Program to obtain information on the physical and chemical characteristics of surficial sediment and the levels of contaminants in representative species of benthic invertebrates in selected areas of the Great Lakes[8]. Fourteen locations with a total of 56 monitoring stations were sampled in Lake Ontario in 1983. This program does not provide loading estimates to the water from this sector.

However, loadings from the resuspension of sediments have been estimated through modelling efforts for a few chemicals, i.e., PCBs, lead, benzo(a)pyrene and mirex[50, 51, 52]. These estimates were not applied to the findings in this report as they are considered very uncertain. Also modelling efforts show sediments to provide a net sink, rather than a loading source, for Lake Ontario.

3.3. Organizing and Integrating the Information on Loadings into a Computer Database

Over the past five years, measurements of chemical concentrations in municipal STP plant effluents, industrial discharges, tributaries and other sources to the Lake Ontario basin have been made as part of the numerous programs mentioned in this chapter. Unfortunately, most of these programs are not specifically designed to provide accurate loading estimates. Often sampling and analytical protocols are variable (see Table 3F to compare the variation in detection limits amongst the various programs). Another drawback is that the data are retained by the agencies which initiated the programs allowing limited accessibility. There is no single comprehensive loadings database for Lake Ontario.

This lack of integration of different monitoring programs provides the impetus to create a computerized database that would include the parameters discussed above. This database provides a means to ensure the timely availability of data and its manipulation. If researchers were required to input a summary of loadings/concentrations into this standard, computerized format on an annual basis, data would be more readily accessible and comparable. This database would facilitate the updating of loading estimates to Lake Ontario when new information becomes available. Eventually the information could be integrated spatially into a Geographic Information System.

3.3.1 Description of the Computer Database

Loading data from many reports/databases/programs were entered and stored in the database management system DBase 4. The format is provided in Table 3G. An example of a report form is provided on the following page. The information is organized by outfall, source category and report (title and author).

DBase allows the information to be restructured to prepare different reports to make various types of analysis and answer queries. These features enable complex multi-table reports to be constructed.

TABLE 3F : PRACTICAL DETECTION LIMITS OF MONITORING PROGRAMS FOR (1) URBAN RUNOFF, (2) STPS, (3) INDUSTRIES, (4) TRIBUTARIES, (5) RAPS, AND (6) NIAGARA AND ST. LAWRENCE RIVERS

PROGRAM #	1		2	3	4	5	6		
	SS ng/g	W ng/L	WW ng/L	WW ng/L	WW ng/L	WW ng/L	WW ng/L	SS ng/g	W ng/L
Arsenic	50	100	5,000	5,000	1,000	1,000	0.1	*	*
Benz(a)anthracene	*	*	*	500	*	1	*	270	0.26
Benzo(b)fluoranthene	*	*	*	700	*	1	*	430	0.50
Benzo(k)fluoranthene	*	*	*	700	*	1	*	420	0.49
Benzo(a)pyrene	*	*	*	600	*	1	*	350	0.46
Alpha-Chlordane	4	0.4	2	*	2	0.2	*	0.84	0.07
Gamma-Chlordane	4	0.4	2	*	2	0.2	*	0.56	0.04
Chrysene	*	*	*	300	*	1	*	490	0.57
p,p'-DDE	4	0.4	1	*	5	0.1	*	2.0	0.20
o,p'-DDT	4	0.4	5	*	5	0.5	*	2.5	0.26
p,p'-DDT	4	0.4	5	*	5	0.5	*	2.7	0.28
p,p'-DDD	4	0.4	5	*	5	0.5	*	2.2	0.22
Dieldrin	4	0.4	2	*	2	0.5	*	1.2	0.18
Dioxin (2,3,7,8-TCDD)	*	*	1	0.02	*	*	*	*	0.02
Hexachlorobenzene	4	0.4	1	10	1	0.1	*	2.3	0.07
Lead	500	1,000	30,000	30,000	5,000	10,000	0.2	*	*
Mercury	100	50	10	100	20	10	0.02	*	**
Mirex	0.4	0.4	5	*	5	0.5	*	1.6	0.11
Octachlorostyrene	*	*	50	100	1	0.1	*		
PCBs	90	9	20	100	20	1	*	28	3.3
Tetrachloroethylene	*	*	1	1,100	*	0.001	0.35	*	*
Toxaphene	*	*	40	*	500	*	*		

LEGEND :
SS - limits for sediment samples or suspended sediment(ng/g)
W - limits for filtered water (ng/L)
WW - limits for whole water (ng/L)
* - not analyzed for
1. Detection Limits for Stormwater samples (Marsalek and Schroeter, 1988)[44].
2. MISA Conventional Detection Limits for STPs (Poulton, 1991)[15].
3. Regulation Method Detection Limits from MISA for Industrial Effluents (Government of Ontario, 1989)[25].
4. Tributary Monitoring Program (Enhanced and Regular) (Hazarangozo, 1991)[11].
5. Toronto RAP-Dry/wet weather and tributary studies (Snodgrass and D'Andrea, 1992)[14].
6. Niagara R. and St. Lawrence River Monitoring (Kuntz, 1990)[10].

Not listed in the table are detection limits for air. AES has reported minimum detection limits of 0.04-0.1 pg m^{-3} for PCB congeners and most organochlorines in air[48]. MOE has reported detection limits of 0.4 ug/l for arsenic, 1 ug/l for lead, and 0.05 ng/l for chlorinated pesticides in rain and 0.02 ug/filter for arsenic, 0.05 ug/filter for lead and 0.1 ng/m^3 for chlorinated pesticides in air[49].

TABLE 3G: LEGEND FOR DATABASE OF LAKE ONTARIO LOADINGS

****

OUTFALL :	Discrete point that was monitored.
GEOGRAPHIC LOCATION:	City or area of study, e.g., Lake Ontario basin, Hamilton Harbour, Toronto.
SOURCE CATEGORY:	Atmospheric Deposition, Groundwater, Industrial Discharge, Model, Nonpointsources, Outlet - St. Lawrence, Inlet - Niagara River, Agricultural Runoff, Urban Runoff, Wet weather seepage, Dry Weather Seepage, Spills, Sediment, Tributary, or Sewage Treatment Plant.
LATITUDE & LONGITUDE:	## ## ##

Data provided for each priority chemical:

SAMPLE NUMBER:	Number of Samples analyzed.
NUMBER DETECTED:	Number of samples detected above Method Detection Limit.
DETECTION LIMITS:	Practical Detection Limit when listed or otherwise the Method Detection Limit.
UNITS:	Units concentration expressed in.
MEAN CONCENTRATION:	Mean Concentration
STANDARD DEVIATION:	Standard Deviation from Mean Concentration
MAXIMUM LOAD:	The load (kg/day) when samples below the detection limit (censored data) are given the value of the detection limit. If this information is not available, the 90% confidence interval is substituted if available (noted in treatment of censored data).
MINIMUM LOAD:	The load (kg/day) when all censored data is given the value of zero. If this information is not available, the 90% confidence interval is substituted if available (noted in treatment of censored data).
LOAD:	The load (kg/day) that could be obtained from the data available. Preferably a value between the maximum and minimum load was chosen i.e., censored data/2 or /10, or if not available the maximum load. Often just the minimum load was available.
CENSORED DATA:	The value applied to censored data to calculate the mean concentration and loading estimate.
FLOW:	Flow volume used to obtain loading from concentration (m^3/day).
DATE OF MONITORING:	Year monitoring was conducted.

ANY INFORMATION IN THE REPORTS PERTAINING TO THE FOLLOWING WAS LISTED:
- SAMPLING/ANALYSIS PROTOCOLS
- QUALITY CONTROL MEASURES
- CONCENTRATION INFORMATION
- BIBLIOGRAPHIC AND CONTACT INFORMATION (SEE EXAMPLE 1 ON FOLLOWING PAGE).

FIGURE 2: EXAMPLE OF FORM GENERATED BY INFORMATION BASE FOR TOXIC CHEMICAL LOADING TO LAKE ONTARIO

OUTFALL: LASCO -Plant Effluent: 0100 pond
GEOGRAPHIC LOCATION: Whitby
SOURCE CATEGORY: Industrial Discharge- Iron & Steel
LATITUDE: 435043 LONGITUDE : 785422

CHEMICAL NAME	SAMPLE NUMBER	NUMBER DETECT	DETECT LIMITS	UNITS	CONC.	STD DEV.	MAX. LOAD	MIN. LOAD	LOAD (kg/day)
Arsenic									
B(a)A									
B(a)P									
B(b)F									
B(k)F									
Chrysene									
Chlordane									
DDT									
Dieldrin									
Dioxin									
HCB									
Lead	157	91		mg/L	0.052	0.075	0.374	0.333	0.3470
Mercury									
Mirex									
Octachl									
PCBs									
Tetracl									
Toxaphene									

FLOW: 6765.751 m3/day
TREATMENT OF NON-DETECTS: Non-detects treated as dl/10.
DATE OF MONITORING DATA:

FURTHER INFORMATION

SAMPLING/ANALYSIS PROTOCOLS: MISA Protocols
QUALITY CONTROL MEASURES: MISA QA/QC plan
CONCENTRATION INFO. IN REPORT:
LOADING INFORMATION:

BIBLIOGRAPHICAL AND CONTACT INFORMATION

REPORT: MISA Monitoring for the Iron & Steel Sector
INVESTIGATION TYPE: Program MISA-6 mos.report
STUDY/LAST REPORT DATE: 09/01/91
SPONSORED BY: MISA, MCE
WRITTEN BY: Yousry Hamdy
CONTACT NAME: Yousry Hamdy
AGENCY: MISA, MOE
ADDRESS: 1 St. Clair Avenue West, 7th Floor,
Toronto, Ontario M4V 1K6
PHONE NUMBER: (416)323-4821

LEGEND:
B(a)P - Benzo (a) pyrene
B(a)A - Benzo(a)anthracene
B(b)F - Benzo (b) fluoranthene
B(k)F - Benzo(k)fluoranthene
Tetracl - Tetrachloroethylene
Octachl - Octachlorostryene
HCB - Hexachlorobenzene

Note: Limited information was available in many studies, in which case the column was left blank.

4. Source Categories

The sources of toxic chemicals were identified by the Virtual Elimination Task Force [53] [54]. These categories are typically divided into point sources and nonpoint sources. Point source pollution refers to discharges from municipal sewage treatment plants (STPs) or industrial facilities, usually conveyed to receiving water by means of a pipe[55]. The point source definition also applies to the following:

- storm overflows from discharges to STPs i.e., bypasses, combined sewer overflows (CSOs);
- spills and site runoff from industry;
- seepage from specific waste sites; and,
- spills from vessels on the Great Lakes.

Nonpoint source pollution refers to contamination originating from diffuse and hard to identify sources[56] and includes:

- urban runoff;
- non-urban (agricultural and resource extraction) runoff;
- atmospheric deposition;
- resuspension of sediments; and,
- groundwater seepage.

Tributaries provide a pathway for pollutants to enter the lake from the point and nonpoint sources, as mentioned above, in its drainage basin.

For the purpose of this report, the sources have been organized in different categories, as follows:

- Industrial point sources(Chapter 5);
- Backwash from water filtration plants (Chapter 6)
- Municipal point sources (Chapter 7);
- Combined sewer overflow (CSO) and bypassing (Chapter 8);
- Spills (Chapter 9);
- Urban runoff (Chapter 10);
- Agricultural runoff (Chapter 11);
- Niagara River- the entrance load (Chapter 12);
- St. Lawrence River - the exit load (Chapter 13);
- Tributaries(other than Niagara and St. Lawrence)(Chapter 14);
- Groundwater seepage (Chapter 15);
- Atmospheric deposition (Chapter 16); and,
- Sediment resuspension (Chapter 17).

5. Industrial Point Sources

Forty-four (44) Canadian industries discharge effluent and/or stormwater directly into Lake Ontario and its tributaries. Map 2 provides the locations of these industries. These industries include:

- three organic manufacturers (excluding BLT Resins which has ceased operations but may have site runoff);
- two petroleum refineries;
- two inorganic chemical manufacturers;
- three metal casting operations;
- three iron and steel industries;
- one metal fabricating industry;
- eight pulp and paper industries;
- three thermal and three nuclear generating plants;
- two industrial mineral plants;
- three metal mining and refining plants;
- nine food and beverage processors; and,
- one wood preserving plant.

5.1 Description of Industrial Source Categories

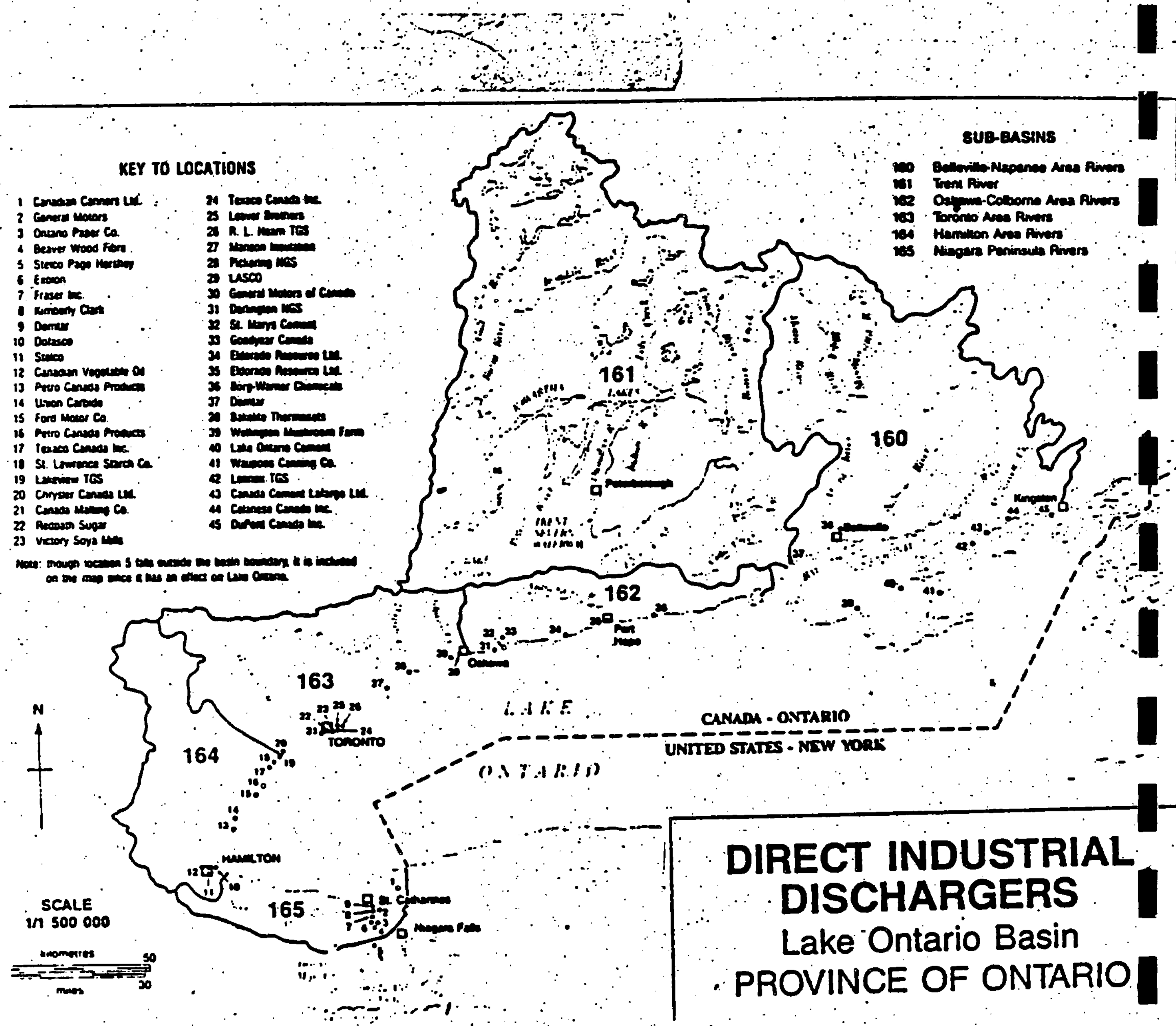
In this section industrial information is organized according to MISA industrial sectors (See section 3.2.2 for an overview of MISA and Table 3C for the MISA sectors applying to specific industries). The information provided, in this section, includes: the size of the industry; what and how much it produces; and, its wastewater treatment.

The substances released by industry are often by-products of the materials/processes it uses, e.g., the industries using significant quantities of coal (i.e., Electrical Generating Stations, and the Iron and Steel industries) will likely release the coal contaminants - PAHs, arsenic and lead and iron and steel, and metal casting/fabricating industries will likely discharge metals. The magnitude of loadings from a specific industry is proportional to its scale of operation, and effectiveness of its in-plant controls /waste-water treatment applied.

According to the Report on the 1989 Industrial Direct Discharges in Ontario[23] all effluent from the direct dischargers undergoes some wastewater treatment (although not cooling water and site runoff in some cases). Some plants mention recycling of wastewater, however, generally in-plant controls are either not mentioned or not available..

Knowledge of the wastewater treatment and production processes are not generally available for the much larger number of industries that discharge indirectly to Lake Ontario (through STPs).

MAP 2: THE LOCATION OF INDUSTRIAL POINT SOURCES



SOURCE: Lake Ontario Toxics Committee. 1989. Lake Ontario Toxics Management Plan. Environment Canada, United States Environmental Agency, Ontario Ministry of the Environment, New York State Department of Environmental Conservation.

Organic Chemical Manufacturing Sector

Organic chemical manufacturing involves using chemicals derived from petroleum and natural gas. A small portion of organic compounds are derived from coal.

LIST 5A: SUMMARY OF INDUSTRIES IN THE ORGANIC CHEMICALS SECTOR DISCHARGING DIRECTLY TO LAKE ONTARIO

SITES	PRODUCTION	WASTE WATER TREATMENT
Celanese Canada Inc. Millhaven. (800 employees)	Manufactures staple fibre and industrial yarn by polymerization of ethylene glycol and terephthalic acid.	Treats process and sanitary wastewater through the use of activated sludge treatment.
Dupont Canada Inc. Kingston site. (1500 employees)	Reacts adipic acid and hexamethlyenediamine to form a synthetic-nylon (Nylon 66). It is extruded into filaments and cast into flakes or pellets.	Routes process wastes with sanitary wastes for trickling filter pretreatment prior to discharge to the Kingston Township Sanitary treatment plant. An environmental concern has been the small on-going loss of Dowtherm A (biphenyl /diphenyl ether heat transfer fluid).
GE Plastics Canada LTD. Normar plant, Cobourg.	Reacts acrylonitrile, styrene and polybutadiene latex with peroxide initiators to produce ABS resins and intermediate latex. A subsequent operation compounds dry resins with a variety of pigments and additives to produce coloured pellets.	Treats wastewater by both primary and secondary treatment. Process effluents from both the resins and compounding areas are screened and passed through two equalization ponds with a neutralization pit in between.

*Closed plant, with potential for contributing site runoff. No monitoring data available at present.

BLT Specialty Resins, Division of Bakelite Thermosets Inc. Belleville. (140 employees)	Ceased operations March 31, 1991. Produced phenol & formaldehyde resins. Formaldehyde oxidised from methanol on-site & hexamethylene tetramine produced from ammonia and formaldehyde on-site.	Site runoff. Decommissioning: hydrogeological survey under review by MOE.

See Table 5A for loading estimates from this sector. Dupont, which discharges 26 g/day of tetrachloroethylene, is the only plant in this sector that appears to discharge any of the 18 persistent toxics.

TABLE 5A: LOADINGS OF 18 PERSISTENT TOXICS TO LAKE ONTARIO FROM THE ORGANIC CHEMICAL SECTOR

	LOADS IN KG/DAY			
	Celanese	Dupont	G.E. Plastics	TOTAL
Arsenic	ND	ND	ND	ND
Benz(a) anthracene	ND	ND	ND	ND
Benzo (b) fluoranthene	ND	ND	ND	ND
Benzo (k) fluoranthene	ND	ND	ND	ND
Benzo (a) pyrene	ND	ND	ND	ND
Chlordane	NI	NI	NI	NI
Chrysene	ND	ND	ND	ND
DDT & metabolites	NI	NI	NI	NI
Dieldrin	NI	NI	NI	NI
Dioxin (2,3,7,8 -TCDD)	ND	ND	ND	ND
Hexachlorobenzene	ND	ND	ND	ND
Lead	ND	ND	ND	ND
Mercury	ND	ND	ND	ND
Mirex/photomirex	NI	NI	NI	NI
Octachlorostyrene	ND	ND	ND	ND
PCBs	ND	ND	ND	ND
Tetrachloroethylene	ND	0.026	ND	0.026
Toxaphene	NI	NI	NI	NI

LEGEND: ND - less than detection limit
NI - no information

SOURCE: Ministry of the Environment (MOE). 1992. MISA - Six-Month Monitoring Data Report: Organic Chemical Manufacturing Sector (October 1, 1989 to March 31, 1990). Queen's Printer, Toronto.[57]

Petroleum Refining Sector

Industries in the petroleum refining sector involve processes that rearrange the structure of hydrocarbon molecules, but do not involve the addition of other substances (such as chlorine) to feed stocks to create entirely dissimilar derivatives.

List 5B: SUMMARY OF INDUSTRIES IN THE PETROLEUM REFINING SECTOR DISCHARGING DIRECTLY TO LAKE ONTARIO

SITES	PRODUCTION	WASTEWATER
Petro-Canada, Mississauga	Converts crude oil into a wide range of petroleum products.	Treats process, ballast and storm water to primary treatment, filtration on dual media and secondary treatment (activated sludge) before discharge.
Petro-Canada, Oakville	Converts crude oil into a wide range of petroleum products.	Treats process water and some storm water to both primary and secondary (activated sludge) treatment.

See Table 5B for loading estimates from this sector. Lead and arsenic are discharged by both plants. PCBs are discharged solely by the Oakville plant.

Inorganic Chemical Sector

Inorganic chemicals are usually derived from materials of mineral origin. Depending on the products manufactured wastewater generated may contain a number of persistent toxics, including metals and phenols, as well as organic contaminants from cleaning solvents and degreasers used in plant maintenance operations and in the laboratories.

LIST 5C: SUMMARY OF INDUSTRIES IN THE INORGANIC CHEMICAL SECTOR DISCHARGING DIRECTLY TO LAKE ONTARIO

SITES	PRODUCTION	WASTEWATERS
Columbian Chemicals Canada Inc. Hamilton. (110 employees)	Produces carbon black by the furnace process for use in the production of automotive tires, inks, paint pigments and carbon paper.	Discharges from two storm water outlets into Windermere Bay after passing through a series of make-shift sand filters. There are no process or combined effluent discharges. Contaminated water from the process area is collected in a sump and recycled.
Exolon-Esk Company of Canada. Thorold. (100 employees)	Manufactures abrasive products, such as aluminum oxide, silicon carbide and ferrosilicon by fusing bauxite ore with coke.	Discharges furnace cooling water which contains high total suspended solids and organics to a sedimentation pond, and then to Beaverdam Pond.

The MISA twelve month monitoring data shows that neither inorganic chemical industry discharges as much as 1 g/day of the 18 persistent toxics and so a loadings table for this category is not included.

TABLE 5B: LOADINGS OF 18 PERSISTENT TOXICS TO LAKE ONTARIO FROM THE PETROLEUM SECTOR

	LOADS IN KG/DAY		TOTAL LOAD
	Petro Canada Oakville	Petro Canada Miss.	
Arsenic	0.079	0.059	0.138
Benz(a) anthracene	ND	ND	ND
Benzo (b) fluoranthene	ND	ND	ND
Benzo (k) fluoranthene	ND	ND	ND
Benzo (a) pyrene	ND	ND	ND
Chlordane	NI	NI	NI
Chrysene	ND	ND	ND
DDT & metabolites	NI	NI	NI
Dieldrin	NI	NI	NI
Dioxin (2,3,7,8 -TCDD)	ND	ND	ND
Hexachlorobenzene	ND	ND	ND
Lead	0.010	0.197	0.207
Mercury	ND	ND	ND
Mirex/photomirex	NI	NI	NI
Octachlorostyrene	ND	ND	ND
PCBs	0.012	ND	0.012
Tetrachloroethylene	ND	ND	ND
Toxaphene	NI	NI	NI

LEGEND: ND - less than detection limit
NI - no information.

SOURCES: **(loadings calculated from averaging flow and concentration data in the first 6 month and second 6 month report by S. Thompson)**(1) Ministry of the Environment (MOE). 1991. MISA - Preliminary Report on the First Six Months of Process Effluent Monitoring in the MISA Petroleum Refining Sector. Queen's Printer for Ontario, Toronto.[58] (2) Ministry of the Environment (MOE). 1990. MISA - Second Report on the Monitoring Data for the Petroleum Refining Sector (June 1 to Nov. 30, 1989). Queen's Printer for Ontario, Toronto.[59]

Metal casting sector

The metal casting sector includes those industries that manufacture metallic objects by cooling molten metal in a mold or die. This broad definition, includes:

- ferrous casters;
- non-ferrous caster;
- die casters; and,
- foundries.

LIST 5D: SUMMARY OF INDUSTRIES IN THE METAL CASTING SECTOR DISCHARGING DIRECTLY TO LAKE ONTARIO

SITES	PRODUCTION	WASTEWATERS
Chrysler Canada, Etobicoke (450 employees)	Produces aluminum automotive castings such as pistons, master brake cylinders and various engine and transmission system components. Production capacity is 13,012 metric tonnes of aluminum.	Discharges cooling water and storm sewer overflow directly to surface water and indirectly discharges process effluent to Lake Ontario via an STP. Process effluent is from several sources including an oil separator, overflow from an impregnation rinse process, blowdown from any or all of three steam boilers, air compressor cooling water and blowdown from the cooling (permanent-mold millwater) system which cools molds and master brake cylinder castings. The storm sewer receives overflow from a 2,200 gallon capacity tank, which is part of the diecast millwater system necessary for cooling dies, furnace door frames and hydraulic oil heat exchangers. Cooling water which cools two of the air compressors is also directed to the storm sewer which goes to a nearby creek, which goes into Lake Ontario.
General Motors of Canada Ltd. St. Catherines. (2,500 employees)	Processes scrap metal and iron metal and coke into iron and cast as engine parts. Approx. 313,000 tonnes of iron is poured and more than 700,000 engines are produced annually.	Discharges are treated in a suspended solids treatment plant by chemical flocculation and gravity sedimentation. Alum and anionic polyelectrolyte are added upstream of two parallel clarifiers to aid in suspended solids removal. Combined discharge flows to the Welland Canal through a natural drainage area and a lagoon.
Canada Pipe Co. Ltd., Hamilton (270 employees)	Produces pipes from raw materials in foundry.	Discharges effluent from cupola scrubber to surface water after treatment.

See Table 5C for loadings from this sector. All industries discharge lead - General Motors (GM) contributing the highest load. In addition, the Canada Pipe Company discharges arsenic and mercury. The MISA preregulation monitoring of GM indicates that GM may discharge PCBs, arsenic and mercury (see Appendix K), in contrast to the MISA regulation monitoring. Loadings derived from the MISA regulation monitoring and not preregulation data were used in the final loadings matrix, as with 3 samples the pre-monitoring data is not considered reliable.

TABLE 5C: LOADINGS OF 18 PERSISTENT TOXICS TO LAKE ONTARIO FROM THE METAL CASTING SECTOR

Chemical	LOADINGS IN KG/DAY			
	Canada Pipe Company	Chrysler	General Motors	TOTAL
Arsenic	0.003	ND	ND	0.003
B(a)A	NI	NI	NI	NI
B(b)F	NI	NI	NI	NI
B(k)F	NI	NI	NI	NI
B(a)P	NI	NI	NI	NI
Chlordane	NI	NI	NI	NI
Chrysene	NI	NI	NI	NI
DDT	NI	NI	NI	NI
Dieldrin	NI	NI	NI	NI
Dioxin (2,3,7,8-TCDD)	ND	ND	ND	ND
Hexachlorobenzene	NI	NI	NI	NI
Lead	1.446	0.032	4.371	5.849
Mercury	0.00018	NI	NI	0.00018
Mirex	NI	NI	NI	NI
Octachlorostyrene	NI	NI	NI	NI
PCBs	ND	ND	ND	ND
Tetrachloroethylene	NI	NI	NI	NI
Toxaphene	NI	NI	NI	NI

LEGEND: NI - no information
ND - less than the detection limit

SOURCE: Ministry of the Environment (MOE). 1992. MISA Twelve Month Monitoring Data Report: Metal Casting Sector (Period Covered May 01, 1990 to April 30, 1991). Queen's Printer for Ontario, Toronto[60]

Iron and Steel Sector

In the basic iron and steelmaking process, coal is converted to coke which is then combined with iron ore and limestone in blast furnaces to produce iron. The iron is then converted into steel in either basic oxygen or electric arc furnaces. Following these steelmaking operations, the steel is subjected to a variety of hot and cold forming and finishing operations. These operations produce products of various shapes and sizes, and impart desired mechanical and surface characteristics.

LIST 5E: SUMMARY OF INDUSTRIES IN THE IRON AND STEEL SECTOR DISCHARGING DIRECTLY TO LAKE ONTARIO

SITES	PRODUCTION	WASTEWATERS
Dofasco Inc. Hamilton.	Conducts all phases of steel production having: 246 Coke ovens; 4 Blast furnaces; and, numerous rolling mills.	Treats wastewater by: recycling, clarification, filtration, oil recovery, ion exchange and biological treatment.
Stelco Inc., Hilton Works. Hamilton.	Conducts all phases of iron and steel production: coke making, ironmaking, steelmaking and rolling.	Treats wastewater by: recycling, clarification, filtration, oil recovery and ion exchange.
Lasco Inc. (Lake Ontario Steel Company) Whitby. (1100 employees)	Produces low carbon steel grade products. Production: 660,000 tonnes (1987).	Treats wastewaters using scale pits, filters and oil skimming systems before discharge. Cooling water is recirculated.

See Table 5D for loading estimates from this sector. Dofasco and Stelco discharge significant quantities of metals and PAHs. LASCO appears to only discharge lead. Monitoring of emergency overflow and storm sewer was only done for lead and benzo(a)pyrene. The discharge of the other chemicals from these wastestreams is unknown.

Metal Fabricating sector

In this sector metal is subjected to a variety of hot and cold forming and finishing operations. These operations produce products of various shapes and sizes, and impart desired mechanical and surface characteristics.

LIST 5F: SUMMARY OF INDUSTRIES IN THE METAL FABRICATING SECTOR DISCHARGING DIRECTLY TO LAKE ONTARIO

SITES	PRODUCTION	WASTEWATERS
Stelco Inc. Page Hersey Works. Welland.	Fabricates & finishes metal and plastic products. Small diameter seamless pipes are made from steel billets.	Discharges continuously through a diffuser which contains iron particles, suspended solids, oil and grease. DISCHARGE TYPE: continuous through a diffuser.

No monitoring data is available for persistent toxics in the metal fabricating sector and so no loading estimates could be provided.

TABLE 5D : LOADING OF 18 PERSISTENT TOXICS TO LAKE ONTARIO FROM THE IRON & STEEL SECTOR

	Loadings in Kilograms per day						
INDUSTRY	LASCO PROCESS	LASCO STORM SEWER	STELCO PROCESS	STELCO EMERGENCY OVERFLOW	DOFASCO PROCESS	DOFASCO STORM SEWER	TOTAL (PROCESS + OTHER)
Arsenic	ND	NI	1.218	NI	0.266	NI	1.484
Benz(a) anthracene	ND	NI	0.036	NI	0.184	NI	0.220
Benzo(b)fluoranthene	ND	NI	0.048	NI	0.180	NI	0.228
Benzo(k)fluoranthene	ND	NI	0.065	NI	0.209	NI	0.274
Benzo(a)pyrene	ND	ND	0.261	0.001	0.256	0.061	0.579
Chrysene	ND	NI	0.150	NI	0.222	NI	0.372
DDT	NI	NI	NI	NI	NI	NI	NI
Dieldrin	NI	NI	NI	NI	NI	NI	NI
Dioxin (2,3,7,8-TCDD)	ND	NI	ND	NI	ND	NI	ND
Hexachlorobenzene	ND	NI	0.001	NI	0.002	NI	0.003
Lead	0.347	0.313	5.358	0.099	10.051	.222	16.39
Mercury	ND	NI	ND	NI	0.031	NI	0.031
Mirex	NI	NI	NI	NI	NI	NI	NI
Octachlorostyrene	ND	NI	ND	NI	ND	NI	ND
PCBs	ND	NI	ND	NI	ND	NI	ND
Tetrachloroethylene	ND	NI	ND	NI	ND	NI	ND
Toxaphene	NI	NI	NI	NI	NI	NI	NI

LEGEND: ND - Less than the detection limit.
NI - No information.

SOURCE: Ministry of the Environment (MOE). 1991. MISA - 12 Month Report for the First Year of Monitoring in the Iron and Steel Sector. Queen's Printer, Toronto[61].

Pulp and paper sector

Industries (mills) in the Pulp and Paper sector manufacture a wide range of product including: newsprint; bleached kraft market pulps; groundwood specialty papers; fine papers; linerboard; corrugating medium; paperboard; and, tissue products.

LIST 5G : SUMMARY OF INDUSTRIES IN THE PULP AND PAPER SECTOR DISCHARGING DIRECTLY TO LAKE ONTARIO

SITES	PRODUCTION	WASTEWATERS
Beaver Wood Fibre Co. Ltd., Thorold. (160 employees)	Manufactures paperboard from pulp and clean wastepaper. Production: 273 tonnes/day.	Discharges effluent to the Old Welland Canal after undergoing primary treatment consisting of a clarifier and emergency spill pond.
Domtar Inc., Fine Papers Division, St.Catherines. (500 employees)	Converts pulp and clean waste paper into paper products. Production: 200 tonnes/day.	Discharges mill effluent to the Old Welland Canal after undergoing primary treatment consisting of a clarifier.
Domtar Inc., Containerboard Div. Trenton. (140 employees)	Converts hardwood chips into pulp by a sodium carbonate cook. Production: 282 tonnes/day of corrugated medium.	Discharges effluent to the Trent River. 130 tonnes/day of waste pulping liquors are collected and sold for use as road dust suppressant. Some wastewater is recycled.
Fraser Inc., Thorold. (625 employees)	Deinks recycled waste paper and pulps to produce fine papers. Production: 270 tonnes/day.	Discharges effluent to the Old Welland Canal after primary treatment consisting of a clarifier. Effluent from the deinking plant is treated through a high-rate biological oxidation system.
Kimberly Clark of Canada Ltd, Huntsville. (200 employees)	Converts pulp into personal paper products. Production: 97 tonnes/day.	Discharges practically zero effluent. Conventional and tertiary effluent treatment is used.
Quebec & Ontario Paper Company Ltd., Thorold. (1150 employees)	Produces newsprint. Three pulping processes (thermal-mechanical and chemi-mechanical) are applied to debarked logs. Newspaper pulp is also deinked. Production:900 tonnes/day.	Discharges effluent to the Old Welland Canal. A high rate biological treatment system utilizing oxygen treats the wastes from the deinking operations, which then undergo primary treatment by two clarifiers.
Strathcona Paper Company, Strathcona. (160 employees)	Processes waste paper and board. Production: 165 tonnes/day of box board.	Discharges effluent to Napanee River after primary effluent treatment in 5 settling ponds, and secondary treatment consisting of 2 aerated lagoons..
Paperboard Industries Corp., Trent Valley Paperboard Mills Div. Trenton. (279 employees)	Produces paperboard from waste paper and board. Production: 250 tonnes/day	Discharges effluent to the Trent River after undergoing primary treatment consisting of a clarifier.

See Table 5E for loading estimates from this sector. All mills, except Domtar Trenton, discharge lead. Four of the plants discharge tetrachloroethylene and two discharge benzo(a)pyrene. Domtar Trenton is the only plant that discharges as much as 1 g/day of mercury.

TABLE 5E : LOADINGS OF 18 PERSISTENT TOXICS TO LAKE ONTARIO FROM THE PULP & PAPER SECTOR

	LOAD IN KG/DAY								
	NORANDA FOREST	QUEBEC & ONTARIO	STRATH-ACONA	TRENT VALLEY	BEAVER	KIMBERLY CLARK	DOMTAR ST. CATS.	DOMTAR TRENTON	TOTAL
Arsenic	NI	NI	NI	NI	NI	NI	NI	NI	NI
Benz(a) anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(b) fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(k) fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a) pyrene	ND	ND	0.001	ND	0.001	ND	ND	ND	0.002
Chlordane	NI	NI	NI	NI	NI	NI	NI	NI	NI
Chrysene	ND	ND	ND	ND	ND	ND	ND	ND	ND
DDT & metabolites	NI	NI	NI	NI	NI	NI	NI	NI	NI
Dieldrin	NI	NI	NI	NI	NI	NI	NI	NI	NI
Dioxin (2,3,7,8 -TCDD)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachloro-benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead	0.124	0.066	0.007	0.054	0.026	0.016	0.029	ND	0.323
Mercury	0.000	0.000	ND	ND	ND	ND	ND	0.001	0.002
Mirex/ photomirex	NI	NI	NI	NI	NI	NI	NI	NI	NI
Octachloro-styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCBs	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloro-ethylene	0.006	ND	ND	ND	0.001	0.011	0.002	ND	0.020
Toxaphene	NI	NI	NI	NI	NI	NI	NI	NI	NI

LEGEND:	ND - Less than detection limit NI - No information.

SOURCE: (average concentrations and flow for first 6 months and second 6 months which were then averaged by S. Thompson); (1) Ministry of the Environment(MOE). 1991. MISA - Preliminary Report on the First Six Months of Process Effluent Monitoring in the MISA Pulp and Paper Sector (Jan. 1 to June 30, 1990). Queen's Printer, Toronto[62]. (2) Ministry of the Environment(MOE). 1991. MISA - Second Report on the Process Effluent Monitoring in the MISA Pulp and Paper Sector (July 1 to December 31, 1990). Queen's Printer, Toronto.[63]

Electrical Power Generation Sector

Electricity can be generated from falling water and, thermal energy produced by burning fossil-fuel and, nuclear fission.

Thermal generating stations (TGS) produce high-pressure steam that is then used to rotate turbines which drive generators producing electricity. Nuclear-powered thermal generating stations (NGS) use natural uranium dioxide in pellet form as fuel, whereby fission (splitting) generates atoms to heat high-purity demineralized boiler water to produce steam. All commercial nuclear-powered generating units in Ontario are of the CANDU design.

LIST 5H: SUMMARY OF THERMAL GENERATING STATIONS DISCHARGING DIRECTLY TO LAKE ONTARIO

SITE	FUEL & CAPACITY	WASTEWATER	EFFLUENT TREATMENT
Lakeview TGS, Toronto.	Coal (medium sulphur and bitumous) 2,400 MW.	Both conventional and persistent toxic contaminants, have been found in wastewaters from thermal generating station by DOE[64] and EPA.	Discharges once-through cooling water continuously Treatment includes: settling pond; filtration; neutralization; oily water separators; and, recycling.
Lennox TGS, Bath.	Oil (low-sulphur residual or crude). 2,240 MW.	The streams of major concern are: - coal pile effluent (for metals, such as arsenic and lead, and organic compounds); - wet ash handling systems (for metals, organics); - boiler blowdown, (for metals and unconsumed boiler treatment chemicals); and,	Discharges once-through condenser cooling water continuously and storm water. Effluent treatment includes : dissolves air flotation, oily water separation, API type separators on yard drainage, neutralization.
R.L. Hearn TGS, Toronto.	Natural gas. 1,200 MW.	-water treatment plant wastes. Furthermore, drain systems may release suspended solids, oil/grease and spilled chemicals and stormwater runoff may contain coal residues.	Closed the plant ie.,"Mothballed", but equipment is maintained and stored operational (still have potential to discharge pollutants through storm water runoff).

LIST 5I: SUMMARY OF NUCLEAR POWERED GENERATING STATIONS DISCHARGING DIRECTLY TO LAKE ONTARIO

SITE	CAPACITY/ FUEL	WASTEWATER	EFFLUENT TREATMENT
Darlington NGS.	3,524 MW (future). Uranium oxide.	Similar to that of TGS. See above. An estimated 99% of the radioactivity of heavy water is recycled back into the reactor. Leakage is collected and returned to the reactor after cleaning.	Discharges continuous, once-through condenser cooling water. Treatment of sanitary and industrial wastes (pipe-cleaning rinse tank effluent) with rotating biological contactors designed to treat sanitary sewage.
Pickering NGS-A.	3,524 MW. Uranium oxide.		Discharges once-through condenser cooling water continuously. Effluent treatment includes: neutralization, RLWMS Tanks, Oily water separators.
Pickering NGS-B.	2,064 MW. Uranium oxide.		Discharges once-through condenser cooling water. Effluent treatment includes: Neutralization; RLWMS Tanks; Oily water separators.

No loading estimates are available as the MISA data for this sector has not yet been released.

Industrial Minerals Sector

Industrial minerals are non-fuel minerals and rocks which are mined, processed and used for purposes other than their metal content (with the exception of magnesium).

LIST 5J: SUMMARY OF PLANTS IN THE INDUSTRIAL MINERALS SECTOR DISCHARGING DIRECTLY TO LAKE ONTARIO

SITES	PRODUCTION	WASTEWATERS
Essroc Inc. Picton	Manufactures cement.	Treats effluent containing suspended solids and total phosphorus typical of domestic sewage in a mechanical treatment plant.
LaFarge Inc. Bath	Manufactures cement.	Treats effluent in sewage lagoon containing suspended solids and total phosphorus typical of domestic sewage.

The MISA twelve month monitoring data shows that both industrial mineral plants discharge less than 1 g/day of the 18 persistent toxics[65].

Metal Mining, Smelting, Refining Sector

Metal mines and salt mines are found in this sector. These metal mines include mines for: copper; lead; zinc; nickel; gold; iron; salt; silver; and, uranium.

LIST 5K: SUMMARY OF INDUSTRIES IN THE METAL MINING, SMELTING, REFINING SECTOR DISCHARGING DIRECTLY TO LAKE ONTARIO

SITES	PRODUCTION	WASTEWATERS
Cameco. Port Granby.	Leachate is collected and chemically treated.	Collects leachate in two ponds and chemically treats it to remove radium. Precipitated radium is settled out in ponds and the treated effluent is discharged to Lake Ontario.
Cameco. Port Hope.	Uranium trioxide is converted to a fuel for use by nuclear industry.	Does not treat cooling water which may contain fluorides, uranium, ammonia plus nitrate.
Cameco. Welcome Waste Site.	Functions as a waste site. Leachate is collected and chemically treated.	Precipitates out contaminants in the effluent.

The MISA twelve month monitoring data shows that all sites discharge less than 1 g/day of the 18 persistent toxics and so a loadings table for this category is not included[66].

Miscellaneous Sector: Food & Beverage

Food and beverage industries are involved in some stage of the production of food or beverages.

LIST 5L: SUMMARY OF INDUSTRIES IN THE MISCELLANEOUS SECTOR (FOOD AND BEVERAGES) DISCHARGING DIRECTLY TO LAKE ONTARIO

SITES	PRODUCTION	WASTEWATERS
Campbell's Wellington Mushroom Farm. Hallowell Twp.	Grows mushrooms.	Treats effluent with a mechanical plant having effluent filtration, followed by a polishing lagoon.
Canadian Canners Ltd. St.Davids.	Processes food.	Treats effluent in a facultative lagoon.
Orenco (Ontario Rendering). Dundas.	Processes animal waste to produce tallow and meat meal.	Treats effluent in a conventional sewage treatment plant with polishing lagoon,
Tend-R-Fresh Division. Dundas/Flamborough Twp.	Processes chickens.	Treats effluent by aeration, chemical treatment filters, and dissolved air flotation.
NOTE: No information for: Victory Soya Mills, Canada Malting Co., and Redpath Sugar.		

No loading estimates are available for this sector as this sector has not been included in the MISA program for monitoring. No persistent toxics loadings are expected.

Miscellaneous Sector: Wood Preservers

Wood preserving industries produce a substance to inhibit the decay of wood.

LIST 5M: SUMMARY OF INDUSTRIES IN THE MISCELLANEOUS SECTOR (WOOD PRESERVING) DISCHARGING DIRECTLY TO LAKE ONTARIO

SITE	PRODUCTION	WASTEWATERS
Domtar Wood Preserving. Trenton.	Wood Preserver producing creosote and oil for hardwood railway ties and oil and pentachlorophenol for utility poles.	Treats stormwater in a dissolved air floatation clarifier with polymer addition and activated carbon filters. Process wastewater is treated by a Rayex treatment system using ultraviolet light/ozone enhanced oxidation.

No loads above 1 g/day were reported (Brown, P. personal communication)[29] for the 18 persistent toxics. Site runoff was found to contain a number of other furans and dioxins.

5.2 Loading Calculations

Loadings were calculated from the flow and concentration data in the MISA reports (where the loadings were not already calculated in the reports) using the following equations:

$$L = F \times C$$

F - Average flow for industry (m^3/day).
C - Average concentration of chemical in effluent (kg/m^3).
L - Loadings of chemical in industrial effluent (kg/day)

In sectors where two six month reports were produced two loadings estimates (kg/day) were calculated, summed and divided by two. See tables 5A to 5E for the loadings from each discrete industry in a sector. The loads from the different industries in a sector were summed together to obtain a load for the industrial sector, as shown by the equation below:

$$S = L_1 + L_2 + L_3 + L_n$$

S - load from sector (kg/day).
$L_{1 \text{ to } n}$ - loads from each industry in the sector(kg/day).

In turn the loads from the industrial sectors where summed, as shown by the equation below:

$$T = S_1 + S_2 + S_3 + S_n$$

T - total load from all sectors (kg/day).
$S_{1 \text{ to } n}$ - loads from each sector (kg/day).

Total loadings from all sectors represent the sum of the loadings of 27 of the 44 industries that discharge into Lake Ontario. The information almost exclusively consists of MISA data from the six and twelve month reports noted on loadings tables:
- Petroleum Refining Sector (average of 6 and 12 month report);
- Organic Chemical Sector (6 month report);
- Inorganic Chemicals Sector (12 month report);
- Metal Casting Sector (12 month report);
- Pulp and Paper Sector (average of 6 and 12 month report);
- Iron and Steel Sector (12 month report);
- Industrial Minerals Sector (12 month report); and,
- Metal Mining Sector (12 month report).

Other than the MISA data, unpublished results from a study of site runoff at Domtar Woodpreserving, conducted by Environment Canada (Brown, Personal communication)[29] were used to estimate loadings. The sectors with no loadings data are the electrical generation, food and beverage and, metal fabricating.

Treatment of Censored data

The censored data was treated in different ways by different sectors, assuming the value of:

- zero by the Petroleum and Pulp and Paper sectors;
- the method detection limit divided by 10 by the Iron and Steel, Inorganic Chemical, Metal Mining, and Industrial Minerals sectors; and,
- the method detection limit by the Organic Chemical and Metal Casting sectors and Domtar Wood Preserving.

Note: Only parameters with one sample (or more) above the detection limit were reported in the MISA monitoring reports and assigned a value (other than zero).

Accuracy of Flow

Flows from the final effluent streams are required to have an accuracy of ± 20% or better by the General Effluent Monitoring Regulation (Ontario Regulation 695/88). A higher degree of accuracy is usually obtained as primary measuring devices, when properly installed and operated within their operating range, are accurate to ± 5%. Secondary devices are capable of an accuracy of ± 7% actual flow[25].

Flows of cooling water, storage site effluent, and waste disposal site effluent are measured or estimated at the time of sampling. The use of water balance calculations and pumping rates to estimate flow measurements is permitted, provided that they are capable of accuracies of ± 20% the actual flow rate. Due to the general flatness and lack of stormwater collection systems at some plant sites, stormwater flow measurements are difficult to estimate with any certainty.

Flows from emergency overflow events are required to be estimated. There are no requirements for flow measurement accuracy: the discharger is simply required to submit a description of the methods used and the associated accuracy.

Overall Accuracy

With an accuracy exceeding 20% (assume 10%) for flow measurements and 10% for mean concentrations, loading estimates are considered to have an accuracy of greater than ±30% (assume 20%). The recommended method detection limits are relatively high which can censor appreciable concentrations increasing the uncertainty of the loadings result.

The Environment Canada wood preservation study is considered to be less accurate than the MISA monitoring data based on the lower number of samples obtained (8) and the low frequency of detection.

TABLE 5F: SUMMARY OF LOADINGS TO LAKE ONTARIO FROM DIRECT DISCHARGING INDUSTRIES

SECTOR	IRON & STEEL	ORGANIC CHEMICAL	PETRO	DOMTAR WOOD PR.	METAL CASTING	PULP & PAPER	TOTAL
	kg/day						
Arsenic	1.484	ND	0.138	ND	0.003	NI	1.625
Benz(a) anthracene	0.220	ND	ND	ND	NI	ND	0.220
Benzo(b) fluoranthene	0.228	ND	ND	ND	NI	ND	0.228
Benzo (k) fluoranthene	0.274	ND	ND	ND	NI	ND	0.274
Benzo (a) pyrene	0.579	ND	ND	ND	NI	0.002	0.581
Chlordane	NI	NI	NI	NI	NI	NI	NI
Chrysene	0.372	ND	0.000	ND	NI	ND	0.372
DDT	NI	NI	NI	NI	NI	ND	NI
Dieldrin	NI	NI	NI	NI	NI	NI	NI
Dioxin (2,3,7,8-TCDD)	ND	ND	ND	ND	ND	ND	ND
Hexachlorobenzene	0.003	ND	ND	ND	NI	ND	0.003
Lead	16.390	ND	0.207	ND	5.597	0.323	22.517
Mercury	0.031	ND	0.000	ND	0.000	0.002	0.034
Mirex	NI	NI	NI	NI	NI	NI	NI
Octachlorostyrene	ND	ND	0.000	ND	NI	ND	ND
PCBs	ND	ND	0.012	ND	ND	ND	0.012
Tetrachloroethylene	ND	0.026	ND	ND	NI	0.020	0.046
Toxaphene	NI	NI	NI	NI	NI	NI	NI

LEGEND: ND: less than the detection limit
NI: no information

NOTE: Inorganic Chemicals, Industrial Minerals, Metal and Mining sectors do not discharge any of 18 persistent toxics at levels above 1 gram/day.

SOURCE: Summary of Tables 5A to 5E in this report.

5.3 Discussion of Industrial Loadings

According to information available at this time, the iron and steel industry is by far the largest discharger of metals and polyaromatic hydrocarbons (PAHs). The only other sector discharging PAHs is the pulp and paper sector. Metals are also discharged by the metal casting, petroleum, and pulp and paper sectors.

In the Iron and Steel Sector, Dofasco discharges 67% of the PAHs and 62% of the metals. Stelco discharges approximately one-third of the PAHs and metals. LASCO discharges less than 1 g/day of the different PAHs studied and only 4% of the metals. See Table 5C.

No industries discharge significant quantities of 2,3,7,8-TCDD, although it was found in the chemical industry at measurable,but minute, quantities. Many industries discharge a number of other furans and dioxins.

No industries were monitored for the banned/restricted pesticides. Of the chlorinated organics, tetrachloroethylene was measured in the effluent of Dupont and four pulp and paper industry manufacturers (see Table 5a and 5f). Hexachlorobenzene is discharged in small quantities by one iron and steel plant.

The 27 industries that have reported monitoring data, at present, are the priority sectors and are considered to comprise the bulk of loadings from industry. Reports for the other sectors are not available at this time. Therefore the loadings for the industrial category do not, at this stage, include 17 industries from the Electrical Power Generation and Miscellaneous Industries (food and beverage and metal fabricating sectors).

Loadings for the Electrical Power Generation sector are presently being compiled and it is hoped that these loadings will be added to the final loadings estimate when available.

6. Water Filtration Plants

Water filtration plants filter large quantities of lake water for drinking water and public use. The backwash from reversing the flow to clean the filters can contribute measurable quantities of persistent toxics to the Lake due to the high volume of water filtered.

Loading Calculations

Loadings from water filtration plants in the Metropolitan Toronto area are provided in Beak and Theil (1991)[67]. The loads from the three plants (R.L. Clark, R.C. Harris and S.J. Horgan - formerly called Easterly) were summed to provide a total load. These three water filtration plants serve 58%[68] of the Canadian population in the Lake Ontario basin that use filtration plant water (Loewen, personal communication) to estimate the load from water filtration plants for the basin the following calculation was performed:

$$T = (L_1 + L_2 + L_3) \times (0.58)^{-1}$$

L_1- R.C. Harris Load (kg/day)
L_2- R. L Clark Load (kg/day)
L_3- S.J. Horgan Load (kg/day)

The loads for backwash from the 3 water filtration plants were calculated using regression analysis to determine censored data where more than three samples were detected. Where less than 3 samples were detected half the detection limit was used for the value of censored data.

The frequency of detection of metals was high compared to that of organics. As a result the metal loading estimates are expected to be more accurate than the organics. 7 to 9 samples were generally taken (except for hexachlorobenzene, for which 31 samples were taken).

Loadings could only be computed for metals (See Table 6A). The organics, although detected, provide loadings well below 1 g/day. The loadings from the backwash of R.L Clark and R.C. Harris are similar, while those from S.J. Horgan are 6 to 10 times smaller. This can be attributed to two factors:

- S.J. Horgan has a flow volume of 455,000 m^3 compared to 659,000 m^3 for R.L Clark and 1,000,000 m^3 for R.C. Harris; and,
- S.J. Horgan pumps the "sludge" to the STP after decanting backwash while other plants discharge to the lake.

TABLE 6A : LOADINGS OF 18 PERSISTENT TOXIC CHEMICALS TO LAKE ONTARIO FROM WATER FILTRATION PLANTS

Chemicals	Loads in kg/day				Total Extrapolated for Lake Ontario (*)
	R.L Clark	R.C. Harris	S.J. Horgan	Total for 3 WFPs	
Arsenic	.353	.363	.003	.719	1.237
Benz(a)anthracene	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	ND	ND	ND	ND	ND
Benzo(k)fluoranthene	ND	ND	ND	ND	ND
Benzo(a)pyrene	ND	ND	ND	ND	ND
Chlordane	.000005	.000003	.000011	.000019	0
Chrysene	ND	ND	ND	ND	ND
DDT and metabolites	ND	ND	ND	ND	ND
Dieldrin	.000002	.000004	.000001	.000007	0
Dioxin (2,3,7,8,-TCDD)	ND	ND	ND	ND	ND
Hexachlorobenzene	.000011	.000026	.000002	.000039	0
Lead	.296	.237	.0359	.5689	.979
Mercury	.0005	.0006	.00002	.0011	.002
Mirex	ND	ND	ND	ND	ND
Octachlorostyrene	ND	ND	ND	ND	ND
PCBs	ND	ND	ND	ND	ND
Tetrachloroethylene	.0000705	ND	ND	.000071	0
Toxaphene	ND	ND	ND	ND	ND

LEGEND: ND - less than detection limit
* - total for the Canadian-side of the Lake Ontario basin rounded to 3 digits.

SOURCE: Beak Consultants Limited and Paul Theil Associates Limited. 1991. Study of 1989 Dry Weather Discharges to the Metropolitan Toronto Waterfront. Report submitted to Metropolitan Toronto and Region Remedial Action Plan and Ministry of Environment.

7. Sewage Treatment Plants

Fifty-seven sewage treatment plants (STPs) discharge into the Lake Ontario basin from the Canadian-side (see Map 3 for the major Municipal dischargers and Table 3D for the list of STPs).

Pollutants discharged by industry, commercial activities and residences to STPs can gain entry to Lake Ontario by: overflowing the sewer system capacity to the receiving water; leaking into the groundwater from the sewer system; volatilizing into the atmosphere; and, passing through to the watercourse[13].

Industrial discharges to sanitary sewers are regulated by municipal sewer-use by-laws for some toxic pollutants. Persistent toxics in the discharges of STPs are not specifically regulated[13].

STPs may have primary, secondary or tertiary treatment capabilities. See table 7A for a description of the treatment each STP provides, as described in the Report on the 1989 Discharges from Sewage Treatment Plants in Ontario Plants[22]. Most (98%) of the total flow to STPs receives a minimum of secondary treatment. Secondary treatment refers to biological treatment, through the use of activated sludge containing bacteria that degrade waste. Tertiary treatment refers to chemical treatment in addition to secondary treatment. The remaining 2% of the sewage flow in the Lake Ontario Basin, undergoes only primary treatment i.e., physical treatment processes, such as settling ponds.

STPs are designed to remove the conventional pollutants contained in domestic wastes, such as organic matter, suspended solids and phosphorous. The Report to Congress on the Discharge of Hazardous Wastes to Publicly Owned Treatment Works[69] states that, while the removal rates for conventional pollutants are high in secondary STPs, the removal rates for toxic contaminants vary. At secondary STPs operating at peak efficiency, 62% of all pollutants received are biodegraded. The remainder consisting mainly of persistent toxics, are: volatilized in the collection system or at the treatment plants (14%); removed to sludge (16%); or, passed through to the watercourse (8%)[69]. For systems not operating at peak efficiency, only 43% of the pollutants received are considered to be biodegraded. The remainder consisting mainly of persistent toxics, are: volatilized (25%); removed to sludge (14%); and, passed through to the watercourse (18%)[69].

Loading Calculations

Some monitoring of persistent toxics has been carried out for 31 of the 57 STPs discharging into Lake Ontario. The complete list of 18 persistent toxics was monitored at 17 STPs (representing 87% of the flow), as reported by Canviro Consultants (1988)[30]. Relatively high detection limits were used in this study (see Table 3G for the detection limits). A list of the other studies that conducted monitoring for STPs are provided in Table 3D.

The loads were calculated from the flow and concentration data in the different reports, as shown below:

$L = F \times C$

L - Load for chemical in STP (kg/day)
F - Annual average flow for STP (m^3/day).
C - Average concentration for chemical in samples for STP(kg/m^3).

The loads from the different STPs were summed together to obtain a load for all the STPs monitored in the basin, as shown by the equation below:

$S = L_1 + L_2 + L_3 + L_n$

S - load from all STPs monitored (kg/day).
$L_{1 \text{ to } n}$ - loads from each STP monitored(kg/day).

See Table 7B for individual plant loads and the sum of all the STPs with monitoring data.

Due to the fact that the monitoring data represents only a fraction of the STP flow to the Lake Ontario Basin, the full load (assuming loads are proportional to flow) was estimated by the equation below:

$R = F \times S$

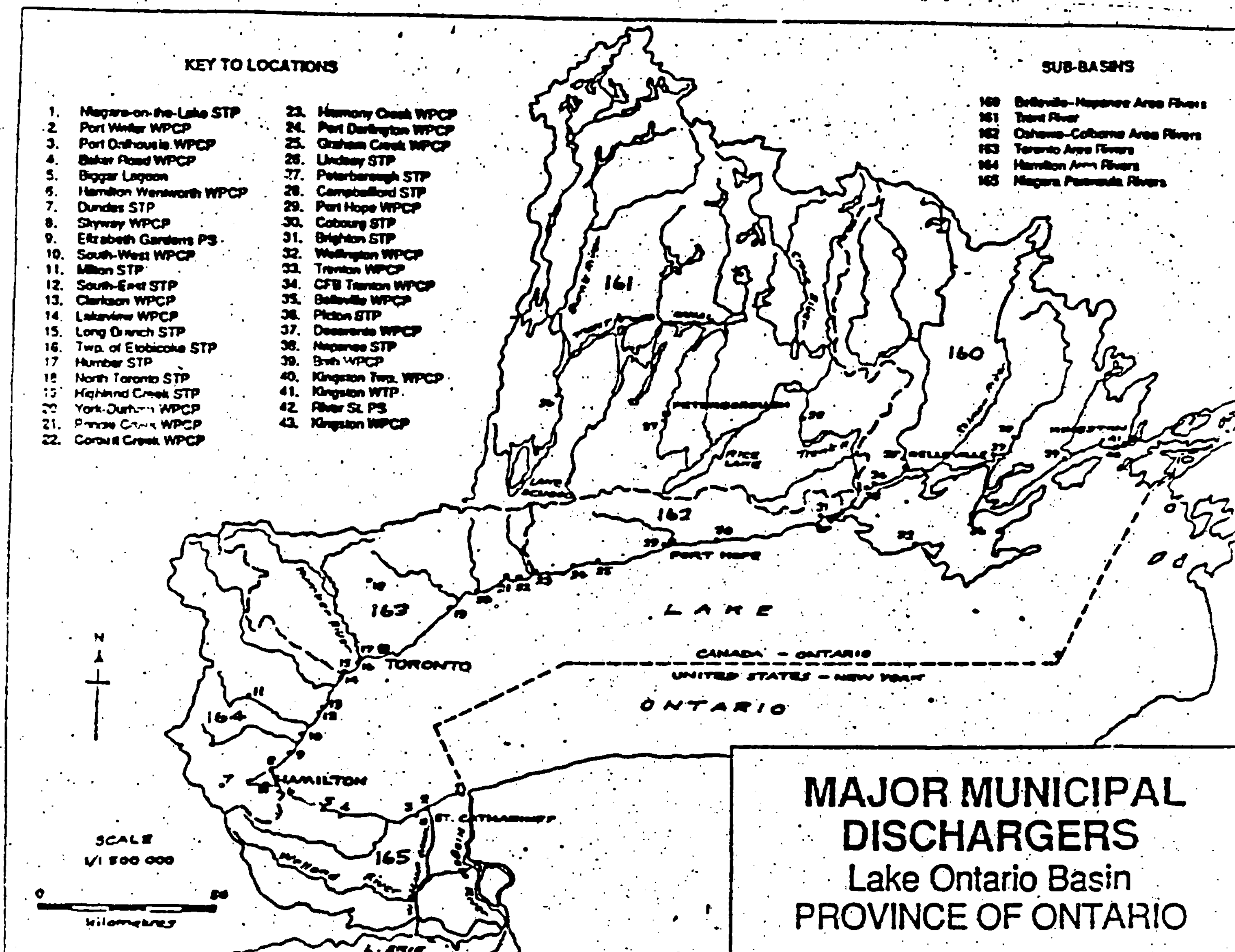
R - loading estimates (kg/day) for all STPs in Lake Ontario basin.
F - fraction of flow of STPs not receiving monitoring.
For organic parameters: $F = 0.87^{-1}$
For arsenic and mercury: $F = 0.91^{-1}$
For lead: $F = 0.94^{-1}$
S - load from all STPs monitored (kg/day)

See Table 7C for an estimation of loadings from STPs for the Lake Ontario basin.

In most cases the value of the detection limit was assigned to censored data. However, if the chemical was not detected in the effluent of a certain plant zero was applied. With relatively high detection limits and a low frequency of occurrence for the organics this approach underestimates loads.

Uncertainties in the analytical results are fairly low due to high frequencies of detection for metals: 46% for effluent samples. The highest uncertainties in analytical results are for dioxin and polyaromatic hydrocarbons, which where detected at very low frequencies (15 to 0%). Relatively high detection limits, coupled with low frequencies of occurrence, contribute significantly to the uncertainties in loadings.

Map 3: MAJOR MUNICIPAL DISCHARGERS IN LAKE ONTARIO BASIN



SOURCE: Lake Ontario Secretariat. 1989. Lake Ontario Toxics Management Plan, 1989. U.S. Environmental Protection Agency, Environment Canada, New York State Department of Environmental Conservation and Ontario Ministry of the Environment.

TABLE 7A : SEWAGE TREATMENT PLANTS DISCHARGING TO THE LAKE ONTARIO DRAINAGE BASIN

Name of Plant	Operating Authority	Watercourse Discharged to	Treatment	Design Capacity (Avg.Flow) 1000m3/day	Actual Average Flow 1000m3/day	% of Total Flow	# of mos. Design Capacity Exceeded	Plans to Upgrade Or Review	Population Served	In Compliance with BOD, SS, TP	# of times Parameters Exceeded BOD	SS	TP
CENTRAL REGION, MINISTRY OF THE ENVIRONMENT													
Acton STP	Halton, Reg. Municipality	Black Creek	Conventional Activated Sludge	4.54	2.57	0.1	0	No	7,478	Yes	0	0	0
Bobcageon STP	MOE	Bobycageon River	Extended Aeration	3.05	0.9	0	0	No	1,610	Yes*	0	0	0
Brighton Lagoon	Brighton Municipality	Presquile Bay	Aerated Cell plus lagoon	3.86	2.99	0.1	1	No	3,750	No*	0	0	1
Burlington Skyway STP	Halton, Reg. Municipality	Hamilton Harbour	Conventional Activated Sludge	93.19	67	2.4	0	No	120,100	Yes	0	0	0
Campbellford STP	MOE	Trent River	Conventional Activated Sludge	5.91	5.99	0.2	5	No	3,255	Yes	0	0	0
Cardiff Lagoon (Haliburton)	Bircroft Municipality	Mink Cr. To Paudash L	Conventional Lagoon Continuous	0.45	0.61	0	6	Yes	595	NA-No P Limit	0	2	2
Clarkson STP South-Peel System	MOE	Lake Ontario	Conventional Activated Sludge	109.1	84.6	3.0	0	No	150,000	Yes	0	0	0
Cobourg STP No. 1	Cobourg Municipality	Lake Ontario	Extended Aeration	11.7	3.89	0.1	0	No	5,500	Yes	0	0	0
Cobourg STP No. 1	Cobourg Municipality	Cobourg Brook	Conventional Activated Sludge	16.04	7.02	0.3	0	Yes	5,500	No	4	2	7
Colbourne STP	Colbourne Municipality	Colbourne Creek	Sutton Process	1.37	1.18	0	4	No	1,800	Yes	0	0	0
Corbett Creek STP(Whitby)	Durham, Reg. Mun.	Lake Ontario	Conventional Activated Sludge	36.36	25.3	0.9	0	Yes	26,100	Yes	1	1	0
Duffin Creek STP	Pickering Municipality	Lake Ontario	Conventional Activated Sludge	181.84	193.68	6.9	11	Yes	64,386	No	7	1	1
Fenelon Falls STP	MOE	Fenelon River	Oxidation Ditch	1	1.04	0	6	No	1,817	Yes	1	0	0
Georgetown STP	Halton, Reg. Municipality	Silver Creek	Conventional Activated Sludge	13.63	9.2	0.3	0	No	20,100	No	0	0	1
Graham Creek STP (Newcastle)	Durham, Reg. Mun.	Lake Ontario	Extended Aeration	1.81	1.41	0.1	1	No	1,866	NA-No P limit	2	0	8
Haliburton STP	Dysart-et-al Municipality	Drag R. to Grass Lake	Extended Aeration	0.45	0.29	0	0	Yes	920	Yes	0	0	0
Harmony Cr.STP No. 1&2	Durham, Reg. Mun.	Lake Ontario	Trickling Filter, Conventional Act	68.18	48.49	1.7	0	Yes	154,407	No	7	0	1
Hastings STP	MOE	Trent River	Oxidation Ditch	1.05	0.87	0	3	No	959	Yes	0	0	0
Havelock Lagoon	MOE	Plato Creek	Conventional Lagoon Seasonal	0.58	0.82	0	12	No	1,362	Yes	0	0	0
Highland Creek (Scarborough)	Metro Toronto, Mun. of	Lake Ontario	Conventional Activated Sludge	218.2	179.5	6.4	0	No	310,000	Yes	0	5	0
Humber STP (Etobicoke)	Metro Toronto, Mun. of	Lake Ontario	Conventional Activated Sludge	409.14	402.85	14.4	3	No	540,000	Yes	0	0	0
Kleinburg STP	York, Reg. Municipality	Humber River	Extended Aeration(no P removal)	0.22	0.21	0	4	No	900	NA-No P limit	0	0	12
Lakeview STP South-Peel System	MOE	Lake Ontario	Conventional Activated Sludge	284.12	259.69	9.3	1	No	470,000	Yes	4	0	0
Lindsay Lagoon	Lindsay Municipality	Scugog River	Conventional Lagoon Cont.	17.18	11.58	0.4	0	Yes	15,176	No	0	0	3
Main STP	Metro Toronto, Mun. of	Lake Ontario	Conventional Activated Sludge	818.28	779.02	27.9	3	No	1,250,000	Yes	0	1	0
Millbrook STP	MOE	Baxter Creek	Extended Aeration	1.13	0.91	0	1	No	1,026	Yes	0	0	0
Milton STP	Halton, Reg. Mun.	Oakville Creek	Conventional Activated Sludge	12.91	9.92	0.4	0	No	23,203	Yes	0	0	0
Minden WPCP (Haliburton)	Minden Municipality	Gull River	Extended Aeration, Polishing	0.94	0.66	0	0	No	984	Yes	0	0	6
Nonquon River Lagoon (Port Perry)	Durham, Reg. Mun.	Lake Scugog	Conventional Lagoon Seasonal	3.64	2.32	0.1	0	Yes	5,215	Yes*	0	1	0
North Toronto STP	Metro Toronto, Mun. of	Don River	Conventional Activated Sludge	45.46	35.46	1.3	0	Yes	85,000	No	0	2	2
Norwood STP	MOE	Ouse River	Oxidation Ditch	0.72	0.53	0	0	No	1,135	Yes	0	0	0
Omemee Lagoon	MOE	No discharge	Lagoon and Spray	0.61	0.32	0	0	No	653	NA-No P limit			
Peterborough STP	Peterborough Municipality	Otonabee River	Conventional Activated Sludge	68.19	52.04	1.9	0	No	62,945	Yes	0	0	0
Port Darlington STP	Durham, Reg. Mun.	Lake Ontario	Conventional Activated Sludge	4.54	8.5	0.3	12	Yes	12,831	Yes	3	0	0
Port Hope STP	Port Hope	Lake Ontario	High Rate	9.09	5.3	0.2	0	No	9,700	Yes	0	0	0
Pringle Creek STP no. 1	Durham, Reg. Municipality	Pringle Creek	Conventional Activated Sludge	5.68	2.86	0.1	0	Yes	10,925	Yes	2	2	0
Pringle Creek STP no. 2	Durham, Reg. Municipality	Pringle Creek	Conventional Activated Sludge	9.09	4.16	0.1	0	No	10,925	Yes	2	0	0
South East STP(Oakville)	Halton, Reg. Municipality	Lake Ontario	Conventional Activated Sludge	22.73	19.09	0.7	0	No	21,900	Yes	0	0	0
South West STP (Oakville)	Halton, Reg. Municipality	Lake Ontario	Coventional Activated Sludge	47.73	36.02	1.3	0	No	58,200	Yes	0	0	0
Stouffville STP	York, Reg. Municipality	Duffin Creek	Conventional Activated Sludge, E	3.86	3.53	0.1	1	No	5,500	Yes	0	0	0
Warkworth Lagoon	Percy Municipality	Mill Creek	Conventional Lagoon Seasonal	0.39	0.28	0	0	No	457	No	0	1	0
Woodland Acres STP	MOE	Otonabee River	Extended Aeration	0.36	0.21	0	0	Yes	435	NA-No P limit	0	0	2

LEGEND:

* Missing Data
NA - not applicable having no limit for phosphorous

PARAMETERS	CRITERIA	
Biolical Oxygend Demand (BOD)	25.0 mg/l	assessed yearly
Suspended Solids (SS)	25.0 mg/l	assessed yearly
Total Phosphorous (TP)	1.0 mg/l	assessed monthly

Note: most but not all STPs are required to meet the above criteria for BOD,SS and TP. However, all STPs were compared to these criteria for the last 3 columns

TABLE 7A : SUMMARY OF SEWAGE TREATMENT PLANTS DISCHARGING TO THE LAKE ONTARIO BASIN (continued)

Name of Plant	Operating Authority	Watercourse Discharged to	Treatment	Design Capacity (Avg.Flow) 1000m 3/day	Actual Average Flow 1000m 3/day	% of total flow	# of mos. Design Capacity Exceeded	Plans to Upgrade Or Review	Population Served	In Compliance with BOD, SS, TP	# of times Parameters Exceeded BOD	SS	TP
SOUTHEASTERN REGION, MINISTRY OF THE ENVIRONMENT													
Amberstview Lagoon	MOE	Collins Cr. N. Channel	Conventional Lagoon Continuous	2.39	2.36	0.1	5	Yes	6,900	No	11	11	12
Batawa WPCP (Sidney)	MOE	Trent River	Conventional Activated Sludge	0.56	0.41	0	0	No	300	No	0	0	2
Belleville WPCP	MOE	Bay of Quinte	Conventional Activated Sludge	54.55	29.25	1.0	0	No	35,351	Yes	1	1	0
Deloro WPCP	MOE	Moira River	Communal Septic Tank	1.74	ND	0	ND	No	157	NA – no P limit	0	0	12
Deseronto WPCP	MOE	Bay of Quinte	Extended Aeration	1.36	1.33	0	5	No	1,732	Yes	0	0	0
Frankford WPCP	MOE	Trent River	Contact Stabilization	1.36	1.59	0.1	2	Yes	2,190	Yes	0	1	0
Kingston WPCP	MOE	Lake Ontairo	Conventional Activated Sludge	25	19.51	0.7	1	No	28,000	Yes	0	0	0
Madoc Lagoon	MOE	Deer Creek to Moira L.	Conventional Lagoon Seasonal	1.36	0.81	0	0	No	850	Yes*	0	1	0
Marmora WPCP	MOE	Crowe River	Extended Aeration	0.86	0.77	0	2	No	1,067	Yes	0	0	0
Napanee WPCP	Napanee Municipality	Napanee River	Conventional Activated Sludge	9.09	6.07	0.2	1	Yes	7,500	No	0	0	3
Odessa WPCP (Ernestown)	MOE	Millhaven Creek	Extended Aeration	0.9	1.25	0	9	Yes	973	No	5	5	4
Picton WPCP	Picton Municipality	Picton Bay	Contact Stabilization	4.54	3.06	0.1	1	Yes	4,500	Yes	0	0	0
Stirling Lagoon	Stirling Municipality	Rawdon Creek	Conventional Lagoon Seasonal	1.13	1.69	0.1	1	Yes	1,700	No*	0	3	1
Trenton WPCP	MOE	Bay of Quinte	Conventional Activated Sludge	15.91	11.38	0.4	0	Yes	15,346	Yes	1	1	0
Tweed Lagoon	MOE	Moira River	Conventional Lagoon Seasonal	1.2	1.24	0	6	Yes	1,607	No*	0	0	1
Wellington WPCP	Wellington Municipality	Lake Ontario	Extended Aeration	1.5	0.54	0	0	Yes	1,077	No	0	0	2
WEST CENTRAL REGION, MINISTRY OF THE ENVIRONMENT													
Baker Road WPCP (Grimsby)	Niagara, Reg. Municipality	Lake Ontario	Conventional Activated Sludge	18.18	13.18	0.5	0	No	19,850	Yes	5	0	0.
Biggar Lagoon (Grimsby)	Niagara, Reg. Municipality	Lake Ontario	Aerated Cell Plus Lagoon	1.13	1.06	0	5	Yes	1,075	NA – no P limit	0	1	11
Dundas King St. WPCP	Hamilton – Wentworth, Re	Cootes Paradise	Conventional Activated Sludge, B	18.18	10.61	0.4	0	No	19,501	Yes	0	0	0
Niagara – on – the – Lake Lagoon	Niagara, Reg. Municipality	Lake Ontario	Aerated Cell Plus Lagoon	3.84	3.32	0.1	3	No	5,210	NA – no P limit	3	8	12
Orangeville WPCP	MOE	Credit River	Conventional Activated Sludge, E	14.54	9	0.3	0	No	16,515	Yes	0	0	0
Port Dalhousie WPCP (St. Catherine	Niagara, Reg. Municipality	Lake Ontario	Conventional Activated Sludge	61.37	45.04	1.6	0	Yes	60,430	No	1	1	1
Port Weller WPCP (St. Catharines)	Niagara, Reg. Municipality	Port Weller Harbour	Conventional Activated Sludge	37.5	45	1.6	12	Yes	75,690	No	4	0	0
Smithville Lagoon (West Lincoln)	Niagara, Reg. Municipality	Twenty Mile Creek	Conventional Lagoon Seasonal	1.56	0.82	0	0	Yes	1,980	NA – no P limit*	0	1	2
Watertown WPCP(Flamborough)	Hamilton – Wentworth, Re	Grindstone Cr.	Conventional Activated Sludge, B	2.72	2.17	0.1	0	No	3,900	Yes	0	0	0
Woodward Ave. WPCP (Hamilton)	Hamilton – Wentworth, Re	Redhill Cr.	Conventional Activated Sludge	409.14	310.57	11.1	0	No	300,000	Yes	0	0	0
**Sum for All WPCPs on Lake Ontario					2794.84	100			4,082,016		64	52	103

LEGEND:

* Missing Data
NA – not applicable having no phosphorous limit
ND – no data

PARAMETERS	CRITERIA	
Biolical Oxygend Demand (BOD)	25.0 mg/l	assessed yearly
Suspended Solids (SS)	25.0 mg/l	assessed yearly
Total Phosphorous (TP)	1.0 mg/l	assessed monthly

Note: most but not all STPs must meet the criteria listed above for BOD, SS and TP. However, in the last three columns these are the criteria used for the number of times exceeded.

SOURCE (ADAPTED FROM): Ministry of Environment (MOE). 1991. Report on the 1989 Discharges from Sewage Treatment Plants in Ontario. Queen's Printer for Ontario, Toronto.

TABLE 7B : LOADINGS OF EIGHTEEN PERSISTENT TOXICS TO LAKE ONTARIO FROM SEWAGE TREATMENT PLANTS

SEWAGE TREATMENT PLANTS / TOXICS	* Detection Limit (g/L)	Loadings in Kilograms per Day: * Hamilton Woodward	* Kingston Twp	* Kingston City	* Niagara-on-the-Lake	* Miss. Lakeview	* Miss. Clarkson	* Toronto Highland	* Whitby	* Toronto North	* Pickering Duffin	* Oakville	* Grimsby	* Burlington	$ Main Toronto	* Humber Toronto
Arsenic	6E-05	ND	ND	ND	ND	14.015	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benz(a) anthracene	NI	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(b) fluoranthene	NI	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (k) fluoranthene	NI	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo (a) pyrene	NI	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlordane	1E-08	ND	ND	ND	ND	0.007	ND	ND	ND	ND	ND	ND	ND	ND	0.001	ND
Chrysene	NI	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.001	ND
DDT & metabolites	1E-07	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.002	ND	ND	ND	ND	0.004
Dieldrin	2E-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dioxin (2,3,7,8-TCDD)	1E-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexachlorobenzene	1E-09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.001	ND
Lead	7E-05	12.274	ND	ND	ND	14.015	2.266	5.166	0.285	1.364	4.895	ND	ND	ND	9.000	11.808
Mercury	1E-07	0.016	ND	0.005	ND	0.039	0.004	0.003	0.003	0.001	0.005	0.011	ND	0.010	0.039	0.043
Mirex	1E-07	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Octachlorostyrene	5E-08	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.017	ND
PCBs	2E-07	0.016	ND	ND	ND	0.018	ND	ND	ND	ND	ND	ND	ND	0.003	ND	ND
Tetrachloroethylene	1E-05	0.921	0.059	0.156	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.198	ND	0.842
Toxaphene	1E-06	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TOXICS	Detection Limit (g/L)	Loadings in Kilograms per Day: @ Dundas Hamilton	@ Water-down	@ Cobourg #1	@ Cobourg #2	~ Harmony	~ Corbett	~ Graham	* Port Dal St. Cats	* Port Wel St. Cats	TOTAL FOR MONITORED STPs	TOTAL FOR BASIN (extrapolated from monitored STPs)
Arsenic	1.0E-05	0.029	0.005	ND	ND	0.259	0.001	ND	ND	ND	14.309	15.724
Benz(a) anthracene		NI	NI	NI	NI	NI	NI	NI	ND	ND	ND	ND
Benzo(b) fluoranthene		NI	NI	NI	NI	NI	NI	NI	ND	ND	ND	ND
Benzo (k) fluoranthene		NI	NI	NI	NI	NI	NI	NI	ND	ND	ND	ND
Benzo (a) pyrene		NI	NI	NI	NI	NI	NI	NI	ND	ND	ND	ND
Chlordane		NI	NI	NI	NI	NI	NI	NI	ND	0.001	0.009	0.009
Chrysene		NI	NI	NI	NI	NI	NI	NI	ND	ND	ND	ND
DDT		NI	NI	NI	NI	NI	NI	NI	ND	ND	0.006	0.007
Dieldrin		NI	NI	NI	NI	NI	NI	NI	ND	ND	ND	ND
Dioxin (2,3,7,8-TCDD)		NI	NI	NI	NI	NI	NI	NI	ND	ND	ND	ND
Hexachlorobenzene		NI	NI	NI	NI	NI	NI	NI	ND	ND	0.001	0.001
Lead	1.0E-06	0.071	0.013	0.204	ND	2.812	ND	0.008	ND	ND	64.182	69.268
Mercury	5.0E-07	0.014	0.026	ND	ND	NI	NI	NI	ND	0.001	0.220	0.243
Mirex		NI	NI	NI	NI	NI	NI	NI	ND	ND	ND	ND
Octachlorostyrene		NI	NI	NI	NI	NI	NI	NI	ND	ND	ND	ND
PCBs		NI	NI	NI	NI	NI	NI	NI	ND	ND	0.036	0.041
Tetrachloroethylene		NI	NI	NI	NI	NI	NI	NI	ND	ND	2.176	2.501
Toxaphene		NI	NI	NI	NI	NI	NI	NI	ND	ND	ND	ND

LEGEND

* – Canviro Consultants (1988)
~ – Environment Ontario Field Samples, 1990
@ – Leclair (1992)
$ – Poulton and Beak Consultants (1991)
NI – no information
ND – less than detector below 1 g/day

8. Releases of Wastewater from the Sewer System

Releases of untreated or partially treated wastewater can occur at the collector system resulting in combined sewer overflow and at the sewage treatment plant (STPs) resulting in byppasses.

In the older portions of many communities a single system, combining storm and sanitary sewers, receives both storm runoff and wastewater from domestic, commercial and industrial sources. Before the advent of STPs, sewers transported all flows directly to nearby watercourses but, presently, interceptors in combined sewers convey this wastewater through STPs. However, during periods of rainfall or snowmelt, the capacity of the interceptor or treatment plant is often exceeded creating CSOs and bypasses of STPs to rivers and lakes without treatment. Groundwater infiltration, which occurs where sewers are cracked or broken or combined, may also cause an overflow or bypass.

8.1 Combined Sewer Overflows

Combined sewer overflows (CSOs) release diluted sanitary sewage wastewater, containing industrial and domestic chemicals, from the sewer system to surface water. This usually occurs when rainfall causes the sewer system to overflow but also can occur during dry weather, as a result of the occasional malfunction of combined sewer regulators.

An IJC (1983) report[70] concluded that where combined sewers are still in use overflows of untreated wastewater occur routinely. The report found that changes in municipal population, surface characteristics, or poor maintenance and operation practices often result in increased overflow volumes and frequencies. The combined sewer areas are extensive in some areas (See Table 8A). For example the city of Hamilton has overflows averaging 86,000 m^3/day. Holding tanks at the largest of the 26 CSO locations collect some of this overflow for diversion back into the system for treatment.

An estimate of loadings from CSO is presented in Table 8C. Data were obtained from Shroeter and Associated (1992).

8.1.1. Loading Calculations

See Shroeter and Associates (1992)[9] for the methodology used to calculate CSO loads. The report provides loading estimates for the Lake Ontario basin in kg/year for cities, areas of concern and Great Lakes basins.

The flows were determined from a weighted average of surface runoff and dry weather flows. The concentration of CSO effluent was estimated from a blending of surface runoff concentrations from Marsalek and Shroeter (1988) and raw sewage concentrations from Canviro Consultants (1988)[9].

The deposited dry weather solids were calculated using a sediment transport/deposition model using the following variables: pipe network lengths; slopes; and, dry weather sewage rates. An allowance for the solids deposited in dry weather that are later scoured during wet weather events was made.

Uncertainties include: average sewage flow; combined sewer contributing area; CSO weighting factors; combined sewer pipe length and mean slope; and, annual precipitation.

The loadings from CSOs are considered to be accurate within ± 50 to 80% (Shroeter and Associated, 1992)[9].

TABLE 8A: SUMMARY OF AREAS WITH COMBINED SEWERS IN THE LAKE ONTARIO BASIN

CITY	AREA SERVED BY COMBINED SEWER (ha)	TOTAL AREA SERVED BY SEWERS (ha)	PERCENT OF TOTAL AREA SERVED BY COMBINED SEWERS
Ajax	65	1,250	5.2
Belleville	328	1,430	22.9
Brampton	32	5,580	5.7
East York	1,596	2,126	75.07
Etobicoke	223	12,393	1.8
Hamilton	4,430	11,269	39.3
Kingston	431	2,060	20.9
North York	134	17,687	0.76
Scarborough	1,440	18,770	7.67
St. Catherines	2,389	4,110	58.1
Toronto	7,286	9,715	75
York	1,020	2,318	44
TOTAL	19,340	138,800*	13.9

* Includes sewered areas for all urban centres in the Lake Ontario Basin

SOURCE : Schroeter and Associates. 1992. Loadings of Toxic Contaminants from Urban Nonpoint Sources to the Great Lakes from Ontario Communities. Inlands Water Directorate. Final report submitted to the Wastewater Technology Centre, Burlington, Ontario. Reference 91-3

TABLE 8B: LOADINGS OF 18 PERSISTENT TOXICS FROM COMBINED SEWER OVERFLOWS (CSOs) FOR AREAS OF CONCERN AND THE LAKE ONTARIO BASIN (CANADIAN-SIDE)

Chemicals	AREAS OF CONCERN Loads in kg/day				
	Hamilton Harbour	Toronto Waterfront	Port Hope	Bay of Quinte	Lake Ontario
Arsenic	0.077	0.160	0	0.011	0.342
Benz(a)anthracene	NI	NI	NI	NI	NI
Benzo(b)fluoranthene	NI	NI	NI	NI	NI
Benzo(k)fluoranthene	NI	NI	NI	NI	NI
Benzo(a)pyrene	NI	NI	NI	NI	NI
Alpha Chlordane Gamma Chlordane Total Chlordane	8.8e-5 8.2e-5 1.7e-4	1.8e-4 1.6e-4 3.4e-4	0 0 0	1.3e-5 1.2e-5 2.5e-5	3.8e-4 3.8e-4 7.6e-4
Chrysene	NI	NI	NI	NI	NI
pp DDE pp DDT DDT and metabolites	5.2e-5 1.1e-4 1.6e-4	1.1e-4 2.3e-4 3.4e-4	0 0 0	7.1e-6 1.1e-5 1.8e-5	2.4e-4 4.7e-4 7.1e-4
Dieldrin	4.1e-5	9.0e-5	0	5.5e-6	1.9e-4
Dioxin (2,3,7,8,-TCDD)	NI	NI	NI	NI	NI
Hexachlorobenzene	2.1e-4	3.8e-4	0	3.3e-5	0.001
Lead	2.55	4.68	0	0.394	11.088
Mercury	0.001	.003	0	1.9e-4	0.006
Mirex	2.7e-5	6.3e-5	0	3.3e-6	1.26e-4
Octachlorostyrene	NI	NI	NI	NI	NI
PCBs	0.003	0.005	0	4.4e-4	0.012
Tetrachloroethylene	NI	NI	NI	NI	NI
Toxaphene	NI	NI	NI	NI	NI

LEGEND: NI - no information

SOURCE : Schroeter and Associates. 1992. Loadings of Toxic Contaminants from Urban Nonpoint Sources to the Great Lakes from Ontario Communities. Final report submitted to the Wastewater Technology Centre, Burlington, Ontario. Reference 91-3.

8.2 Bypassing

Bypassing occurs when excess volumes of wastewater pass through STPs, without being properly treated, to the environment. Bypassing sewage after primary treatment, or at the plant gate before it receives any treatment, occurs routinely at STPs (every heavy rain according to some Municipal authorities). Municipal authorities must bypass wastewater to prevent sewage back-up flooding basements, and avoid structural damage to the STPs.

8.2.1 Loadings Calculations

To estimate loadings bypass volumes were obtained from bypass occurrence reports in the Report on the 1988 Discharges from Sewage Treatment Plants in Ontario[22] and the "typical" bypass concentrations were obtained from the mean raw sewage concentrations and primary effluent concentrations in Schroeter and Associates (1992)[9].

The following equation was used to calculate loadings:

$$L = R \times r + P \times p$$

L = chemical loading for basin as a result of bypassing (kg/day)
R = mean concentration of chemical in raw sewage (kg/m^3)
r = volume that bypassed plant (m^3)
P = mean concentration of chemical in primary effluent (kg/m^3)
p = volume that bypassed primary effluent (m^3)

Loading estimates for bypassing of STPs are presented in Table 8D.

TABLE 8C : SUMMARY OF BYPASSES OF SEWAGE TREATMENT PLANTS OCURRING IN 1989 FOR LAKE ONTARIO

Sewage Treatment Plant (STP)	Operating Authority	Plant Bypass				Secondary Bypass			
		Volume (1000 M3)	Duration (Hours)	Total # of times	% Plant Effluent	Volume (1000M3)	Duration (Hours)	Total # of times	% Plant Effluent
CENTRAL REGION, MOE									
Bobcageon STP	MOE	ND	ND	96	ND	ND	ND	96	ND
Burlington Skyway STP	Halton, Reg. Mun.	ND	ND	ND	9	29.18	57	4	0.12
Acton STP & Lagoon	Halton Reg. Municipality	127	148	3	13.52	35.4	6.3	3	3.77
Humber STP (Etobicoke)	Metro Toronto, Mun. of	0	0	0	0	48.99	10.6	4	0.03
Main STP (Toronto)	Metro Toronto, Mun. of	0.4	4.5	1	0	9.56	23.6	8	0
Milton STP	Halton, Reg. Mun.	0.06	0	0	0	0	0	0	0
Clarkson STP South-Peel	Peel, Reg. Mun.	36.4	ND	3	0.12	4.54	1	1	7.5
Port Darlington STP	Durham, Reg. Mun.	15.12	61	3	0.49	3.16	46	3	0.1
South West STP	Halton, Reg. Mun.	0	0	0	0	0.2	0.5	1	0
Peterborough STP	Peterborough Muncipality	0	0	2	0	78.18	107.5	13	0.41
Corbett Creek STP	Durham, Reg. Mun.	1.23	5	1	0.01	122.27	7	3	1.32
Pringle Creek STP No. 1	Durham, Reg. Mun.	0	0	0	0	0.7	23	1	0.07
WEST CENTRAL REGION, MOE									
Woodward Ave STP (Hamilton)	Hamilton-Wentworth, Reg. Mun.	15.2	79	4	ND	ND	582.9	ND	ND
Orangeville STP	MOE	ND	ND	31	ND	ND	ND	31	ND
Port Dalhousie STP	Niagara, Reg. Mun.	19.5	121.4	5	ND	0	0	0	0
Port Weller STP (St. Catherines)	Niagara, Reg. Mun.	219.98	ND	7	15	0	0	0	0
SOUTHEAST REGION, MOE									
Belleville STP	MOE	72	ND	184	0.86	802.95	1813	321	9.55
Deloro STP	MOE	ND	ND	ND	0.4	195.08	812.8	45	ND
Deseronto STP	MOE	4.32	48	30	1.07	0	0	0	0
Odessa STP	MOE	ND	3	0	ND	0	0	0	0
Napanee STP	Napanee Municipality	47.3	ND	9	2.13	6.09	53.5	4	0.27
Picton STP	Picton Municipality	0	0	0	0	8.03	34	5	0.79
Batawa STP	MOE	0	0	0	0	13.2	ND	14	8.98
Trenton STP	Bay of Quinte	21.98	ND	3	0.59	0	0	0	0
Wellington STP	Wellington Municipality	0.43	20.9	4	0.22	0.15	8	1	0.08
**TOTAL BYPASSING FOR ALL STPs		580.92	490.8	386	NA	1357.68	3586.7	558	NA
**AVERAGE BYPASS FOR STPs		23.2368	19.632	15.44	1.7364	54.3072	143.468	22.32	1.3196

LEGEND:	
	ND – No Data
	NA – Not Applicable

TABLE 8D: LOADING ESTIMATES FOR BYPASSING OF SEWAGE TREATMENT PLANTS IN THE LAKE ONTARIO BASIN

CHEMICALS	CONC. FOR RAW SEWAGE (2)	LOAD FROM BYPASSING PLANT(1)	CONC. FOR PRIMARY EFFLUENT (2)	LOAD FROM BYPASSING SECONDARY TREATMENT	TOTAL LOAD FROM BYPASSING
	ug/L	kg/day	ug/L	kg/day	kg/day
Arsenic	16.80	0.027	16.70	0.062	0.089*
Benz(a) anthracene	5.03	0.008	1.00	0.004	0.012*
Benzo (b) fluoranthene	5.01	0.008	1.00	0.004	0.012*
Benzo (k) fluoranthene	5.03	0.008	1.00	0.004	0.012*
Benzo (a) pyrene	5.00	0.008	1.00	0.004	0.012*
Chlordane	0.02	0	0.01	0.000	0
Chrysene	5.00	0.008	1.00	0.004	0.012*
DDT	0.06	0	0.04	0	0
Dieldrin	0.01	0	0.01	0	0
Dioxin (2,3,7,8-TCDD)	NA	0	NA	0	0
Hexachlorobenzene	0.01	0	0.01	0	0
Lead	59.50	0.095	20.80	0.077	0.172
Mercury	0.23	0	0.05	0	0
Mirex	0.01	0	0.01	0	0
Octachlorostyrene	NA	0	NA	0	0
PCBs	0.06	0	0.03	0	0
Tetrachloroethylene	21.51	0.034	4.39	0.016	0.051*
Toxaphene	0.04	0	0.02	0	0

MONITORING DATA FOR BYPASSING OF LEAD AND MERCURY (3):		LEAD	MERCURY
	PORT WELLER, ST. C.	0.04	0
	PORT DALHOUSIE,	0.048	0.004
	TORONTO WATERFRONT	0.24	0.001
	*TOTAL	0.328*	0.005*

LEGEND
NA : not available
* : data used in loadings matrix

SOURCE:
(1) Ministry of the Environment (MOE). 1990. Report on the 1989 Discharges from Sewage Treatment Plants in Ontario. Queen's Printer for Ontario, Toronto.
(2) Schroeter and Associates. 1992. Loadings of Toxic Contaminants from Urban Nonpoint Sources to the Great Lakes from Ontario Communities. Final report submitted to the Wastewater Technology Centre, Burlington, Ontario. Ref 91-3.
(3) Canviro Consultants. St. Catharines Area Pollution Control Plan (SCAPCP): Urban and Industrial Discharges Study. City of St. Catherines, SCAPCP.

9. Spills

According to the Occurrence Reporting Information System (ORIS), spills are a routine occurrence at Dofasco and Stelco, the two largest sources of spills to Lake Ontario. Many of the "spills" are excessive air emissions but many others are releases to water. Dofasco spilled more than 6,200,000 litres to water in 1991. The hot mills, blast furnace, and byproducts plant were most frequently the source. Stelco spilled more than 1,700,000 litres to water in 1991. The blast furnace and caster machines were most frequently the source. The concentration of the spills is unknown but is believed to be several orders of magnitude higher than the maximum levels in the effluent under normal conditions. Thus, these spills could contribute high levels of PAHs, lead and arsenic.

As well as the spills of the two iron and steel industries, 13,747 litres of petroleum were spilled in 1991. Petroleum products, such as fuel oil, are known to contain relatively high concentrations of PAHs and heavy metals and so may contribute loadings of the 18 persistent toxics. See, Appendix G, Table G2 for a summary of spills to Lake Ontario from January 1987 to December 1991 obtained from the ORIS reports.

9.1 Loadings Calculations

The vast majority of the spills are from two iron and steel industries, Dofasco and Stelco. However, estimations of spill loadings were only carried out for Dofasco since Stelco was accounted for in the industrial loading estimates from the iron and steel sector (see Table 5D for Stelco's emergency overflow).

To estimate Dofasco's spills:

L = (D X d)/365.25

D = the total volume of spills in 1991 for Dofasco as obtained from the Occurrence Report Information System (ORIS).

d = average of maximum MISA concentration of the 2 streams from which most of the spills resulted {average of maximum concentration of 0200 Ottawa street sewer and 0700 coke-plant discharge (obtained from MISA data) multiplied by ten to represent an other than normal condition (spill situation)}. Ten (one order of magnitude) was chosen as a conservative estimate of spill conditions.

See Table 9A for loading estimates from spills. These estimates are most probably underestimated since the importance and magnitude of other spills was not evaluated. Uncertainties in the estimate are also related to the concentration of the spills, the volume of unreported spills and the accuracy of reported volumes.

TABLE 9A : LOADING ESTIMATES OF PERSISTENT TOXICS THAT DOFASCO SPILLS TO LAKE ONTARIO

	Max. Conc. in #2 Coke Plant (ug/l)	Max Conc. at Ottawa Sewer (ug/l)	Average Conc. of two X 10 for spill condition	Load (kg/day)
Benz(a) anthracene	150	0.107	750.535	0.013
Benzo(b)fluoranthene	140	0.508	702.54	0.012
Benzo(k)fluoranthene	95	0.608	478.04	0.008
Benzo(a)pyrene	1500	0.333	7501.665	0.129
Chrysene	130	0.01	650.05	0.011

NOTE: The volume Dofasco spills is approximately 6,265,000 l/ year (17,153 l/day)

10. Urban Runoff

Lake Ontario is the receiving body of water for the largest volume of persistent toxic substances from urban runoff in Canada[44]. Detection of toxic contaminants in urban runoff led to the consideration of runoff pollution controls through discharge permits in both Canada (MOE, 1986) and the U.S. (U.S. EPA, 1987).

Urban runoff is a significant source of nutrients, metals and pesticides[71]. Urban runoff contributes to the general degradation of waterfront and to problems with sediment contamination, stress on aquatic communities, and disruption of habitat. Sources of urban runoff include:

- atmospheric sources (wet and dry deposition from both local and remote sources);
- sources related to land-use activities, i.e.:
  - agricultural and household chemicals;
  - vehicular traffic by-products (heavy metals and PAHs);
  - pesticides (from lawn maintenance);
  - industrial and domestic chemicals from spills and intentional dumping; and,
  - industrial and domestic activities.

Urban areas contribute via their storm sewer systems. According to Marsalek and Schroeter (1988)[44], typically 75% of annual total toxics loadings are carried by water and 25% by solids. Due to large areas of impervious surfaces in cities much of the rainwater runs off. The quantity and quality of urban runoff depend on both the population, and land-use characteristics.

Loading estimates from urban runoff are presented in Table 10A. These urban runoff loadings are considered to be accurate within ± 50 to 80%, by Schroeter and Associates[9]. Among the various groups of contaminants, the highest frequencies of detection were observed for trace metals, followed by PCBs, pesticides/herbicides, volatile organic compounds, and dioxin. Therefore the accuracy of the loading estimates for the trace metals will be highest followed by PCBs and pesticides/herbicides.

Loadings Calculations

For the detailed methodology for calculating loading estimates please refer to Marsalek and Schroeter (1988)[44] and Schroeter and Associates (1992)[9]. The loads were obtained from the Schroeter and Associates (1992)[9]. In summary computations were done by:

- applying mean toxic concentration values for sediment and water collected in 12 urban centres scattered throughout southern Ontario in 1988 to the Great Lakes Communities based on land use characteristics; and,
- calculating runoff volumes and sediment yields for each land use. Three land uses-residential, commercial and institutional - were applied, according to the proportion it was represented in each urban community. Open space was considered but the loadings from this land use were not estimated.

TABLE 10A: LOADING ESTIMATES OF 18 PERSISTENT TOXICS FROM URBAN RUNOFF IN AREAS OF CONCERN AND THE LAKE ONTARIO BASIN (CANADIAN SIDE)

Chemicals	AREAS OF CONCERN Loads in kg/day				
	Hamilton Harbour	Toronto Waterfront	Port Hope	Bay of. Quinte	Lake Ontario
Arsenic	0.258	2.026	0.014	.083	3.641
Benz(a)anthracene	NI	NI	NI	NI	NI
Benzo(b)fluoranthene	NI	NI	NI	NI	NI
Benzo(k)fluoranthene	NI	NI	NI	NI	NI
Benzo(a)pyrene	NI	NI	NI	NI	NI
Alpha Chlordane Gamma Chlordane Total Chlordane	4.1e-4 3.8e-4 7.9e-4	3.3e-3 3.0e-3 6.3e-3	2.3e-5 2.3e-5 4.6e-5	1.3e-4 1.3e-4 2.6e-4	0.006 0.005 0.011
Chrysene	NI	NI	NI	NI	NI
pp DDE. pp DDT DDT and metabolites	1.7e-4 7.4e-5 2.4e-4	1.3e-3 5.7e-4 1.8e-3	9.3e-6 4.1e-6 1.3e-5	5.5e-5 2.4e-5 7.9e-5	0.002 0.001 0.003
Dieldrin	1.1e-4	8.5e-4	6.0e-6	3.6e-5	0.002
Dioxin (2,3,7,8,-TCDD)	NI	NI	NI	NI	NI
Hexachlorobenzene	1.2e-3	9.5e-3	6.6e-5	3.8e-4	0.017
Lead	14.209	111.704	0.789	4.545	200.137
Mercury	0.006	0.045	3.3e-4	0.002	0.080
Mirex	3.6e-5	2.7e-4	1.9e-6	1.1e-5	4.9e-4
Octachlorostyrene	NI	NI	NI	NI	NI
PCBs	.016	0.127	9.0e-4	5.1e-3	0.227
Tetrachloroethylene	NI	NI	NI	NI	NI
Toxaphene	NI	NI	NI	NI	NI

LEGEND : NI - no information

SOURCE : Schroeter and Associates. 1992. Loadings of Toxic Contaminants from Urban Nonpoint Sources to the Great Lakes from Ontario Communities. Final report submitted to the Wastewater Technology Centre, Burlington, Ontario. Ref 91-3.

11. Agricultural Runoff

Agricultural runoff is an important source of pesticides entering Lake Ontario. Although five pesticides are among the list of eighteen persistent toxics, their use has been restricted for more than ten years. They are, therefore, expected to be found in soil and runoff at lower levels than previously. Monitoring studies have not been performed to confirm this and so, "typical" levels of pollutants in non-urban areas are not available.

Large areas of the Lake Ontario basin are rural. This amounts to approximately 15,000 km^2 of farmland and 13,000 km^2 of forests[72]. The 1986 Census of Agriculture shows a lower figure for farmland area of approximately 13,000 km^2.

The Metro Toronto waterfront drainage basins' nonpoint source pollution is considered to originate mainly in the upper rural areas[71]. Rural land uses account for about two-thirds (1,391 km^2) of Metro river basins (predominantly in the upper reaches of Etobicoke Creek and of the Humber, Don and Rouge Rivers). Studies have found exceedences of Provincial Water Quality Objectives (PWQO) for lead and several non-persistent toxics, in the Upper Humber River during both wet and dry weather (although exceedence was much greater during wet weather)[71].

Row crop production and conventional management practices cause soil erosion, and, associated with this, herbicide, pesticide and fertilizer losses. Both the use of larger machinery and current soil management practices cause soil compaction and decrease water infiltration, and therefore increase runoff.

Most of the agricultural runoff is associated with particulate, unlike the urban runoff. Soil serves as a vehicle for the movement of chemicals, especially agricultural chemicals such as pesticides, to water bodies. Vegetation assists in stabilizing the soil and preventing water and soil runoff.

The amount of pesticides applied to agricultural crops in 1988 was over 7,200 tonnes in Ontario. The herbicides used in largest quantities on field crops were metalochlor (1,709 tonnes) and atrazine (1,041 tonnes). During 1988, 909 tonnes of herbicides were used in the Lake Ontario River Basin (Canadian-side)[73].

Modelling of the pesticide atrazine has been done in southern Ontario[74]. Atrazine is a commonly used, relatively persistent (half-life of 46-95 days) pesticide. It has been the most commonly detected pesticide from 1979 to 1985 in the Great Lakes. About 10% of that applied typically persists from one season to the next. Soil erosion and the washoff of soil-attached atrazine is highly event-based, related to snowmelt runoff and major storms. As a result, atrazine losses, to the watershed over its entire area, amounted to 3.3% and 0.84% of that applied in 1985 and 1986 respectively. The majority of atrazine decayed within the soil matrix.

The loadings of 4 pesticides from agricultural runoff is presented in Table 11A.

11.1 Loading Calculations

The concentrations of 4 pesticides in urban sediment and runoff from Marsalek and Schroeter (1988) were applied to agricultural runoff. The PLUARG regression relationship was used to estimate unit area loading rates for agricultural areas:

Sediment Loading rate = -204 + 11.0 (% clay) + 7.9 (% row crops)

The levels of clay (18%) and farmland (10%) in row crops that are present in the Bay of Quinte Watershed were applied to the entire Lake Ontario basin[13].

TABLE 11A: LOADING ESTIMATES FOR RESTRICTED PESTICIDES FROM AGRICULTURAL AREAS TO LAKE ONTARIO

Chemical	Suspended Solid Conc. (mg/kg)	Pesticide Load to Lake Ontario (kg/day)
Chlordane-gamma	0.021	0.005
Chlordane-alpha	0.025	0.006
Chlordane-Total	0.046	0.011
Dieldrin	0.0044	0.001
DDT-total	0.024	0.006
Mirex	0.0013	0.000
Unit area of sediment(kg/ha/year):		73
Daily sediment load for Lake Ontario Basin (kg/day of sediment):		259,822

The uncertainties associated with loading estimates are numerous and include the following assumptions:

- concentrations of pesticides that banned/restricted for at least 10-20 years in urban surface sediment are similar to that of agricultural soils as they result from the same processes: historical agricultural applications and atmospheric deposition; and,
- level of clay content and farmland in row crops in the Bay of Quinte area is typical of that found throughout the Lake Ontario basin.

12. Niagara River

The Niagara River is the main source of water to Lake Ontario, accounting for more than 80 percent of its incoming flow[1]. Lake Ontario is the last of all the Great Lakes and receives their flow of water and pollutants via the Niagara River. Discharges from sites along the Niagara River are, also, a source of pollutants to Lake Ontario.

Monitoring at the head and mouth of the river show significant loadings are coming from the Niagara River basin itself for the following chemicals:

- PCBs;
- mirex;
- benz(a)anthracene;
- benzo(b)fluoranthene;
- benzo(k)fluoranthene;
- benzo(a)pyrene;
- chrysene;
- chlordane; and,
- hexachlorobenzene.

12.1 Loading Calculations

The loadings at the mouth and head of the Niagara River are presented in Table 12A. Values were extracted from Kuntz (1990)[10]. Concentration values for whole water, suspended solids fractions, and water fractions were multiplied by the flow to determine loadings. Recombined whole water (RWW) values are based on the results of combined statistical analysis. RWW is defined as the sum of the mean chemical concentrations in the water and suspended solids fractions.

Estimates of concentrations and loads were computed for all chemicals with three or more measured values above the practical detection limit by the Maximum Likelihood Estimation method (ML). The ML estimates a likely value for the censored data from the frequency of detection, detection limits and the detected values. This method provides an unbiased estimation of censored data (see section 14.1 for more information on ML). The 90% confidence intervals are provided in Kuntz (1990)[10]. Accuracy varies with the chemical.

This program represents the best monitoring program in the basin and was designed with the purpose of calculating loadings.

TABLE 12A: **LOADINGS ESTIMATED FROM UPSTREAM/DOWNSTREAM NIAGARA RIVER MONITORING DATA, 1988-1989**

	LOADINGS	AT FORT (Head of Niagara R.) (kg/day)	ERIE	LOADINGS	NIAGARA- (Mouth of the Niagara R.) (kg/day)	ON-THE-LAKE	FE-NOTL (kg/day)
CHEMICAL	FILTERED WATER	SUSPENDED SOLIDS	SUM or WHOLE WATER	FILTERED WATER	SUSPENDED SOLIDS	SUM or WHOLE WATER	DIFFERENCE
Arsenic	NI	NI	332.7	NI	NI	374.8*	42.05
Benz(a)anthracene	0.1298	1.176	1.3081@	.2525	2.069	2.3266*	1.017
Benzo(a)pyrene	ND	ND	ND	ND	1.518	1.518*	1.518
Benzo(b)fluoranthene	ND	ND	ND	ND	1.560	1.560*	1.560
Benzo(k)fluoranthene	ND	ND	ND	ND	1.641	1.641*	1.641
Alpha-chlordane	ND	0.0054	0.0054	ND	0.0067	0.0067	0.0013
Gamma-chlordane	ND	ND	ND	ND	ND	ND	ND
Total chlordane	ND	0.0054	0.0054	ND	0.0067	0.0067*	0.0013
Chrysene	0.1507	ND	0.151	0.314	1.9112	2.225@*	2.074
P,P'-DDE	ND	0.0924	0.092	ND	0.0334	0.033	-0.059
P',P'-DDD	ND	0.0934	0.093	ND	0.0296	0.030	-0.0638
P',P'-DDT	ND	0.023	0.023	ND	0.0193	0.019	-0.036
TOTAL	ND	0.208	0.208	ND	0.0823	0.082*	-0.163
Dieldrin	0.1433	0.0161	0.1594@	0.1344	0.0166	0.151*	-0.008
Dioxin(2,3,7,8-TCDD)	ND	ND	ND	ND	ND	ND	ND
Hexachlorobenzene	NI	NI	ND	ND	0.1137	0.1137*	0.1137
Lead	NI	NI	875.8	NI	NI	624.2*	-251.6
Mercury	NI	NI	6.745	NI	NI	6.165*	-0.5801
Mirex	ND	ND	ND	ND	0.013	0.013*	0.013
Octachlorostyrene	NI	NI	NI	NI	NI	NI	NI
PCBs	ND	0.3344	0.334	ND	0.942	0.942*	0.6076
Tetrachloroethylene	NI	NI	33.7	NI	NI	46.54*	12.89
Toxaphene	NI	NI	NI	NI	NI	NI	NI

LEGEND:
ND - below detection limit
NI - no information
@ - Recombined Whole Water
* - Values used in loading matrix.
FE - Fort Erie
NOTL - Niagara-on-the-Lake

SOURCE : Kuntz, K. 1990. Joint Evaluation of Upstream/Downstream Niagara River Monitoring Data, 1988-1989. Niagara River Data Interpretation Group, River Monitoring Committee.

13. The Exit Load

Water in Lake Ontario is considered to have a residence time of approximately 6 years before exiting via the St. Lawrence River. It is estimated that only a fraction (5 to 30%) of pollutants that enter the Lake exit via the St. Lawrence River. Persistent toxics may biodegrade, volatilize, or deposit in bottom sediments. See Appendix H for the results of a chemical fate model.

Environment Canada is monitoring the exit load from Lake Ontario to the St. Lawrence River at a Station on the south-side of Wolfe Island station. It is monitored on a weekly basis over the entire year[46].

Loadings Calculations

Estimates of the exit load for 1989 and 1990 were provided by Hans Biberhofer from the Inland Waters Directorate (see Table 13A). Concentration values for whole water, suspended solids fractions, and water fractions were multiplied by flow to determine loads. Recombined whole water (RWW) values are based on the results of combined statistical analysis. RWW is defined as the sum of the mean chemical concentrations in the water and suspended solids fraction. The 90% confidence intervals are available from Mr. Biberhofer. Accuracy varies with the chemical.

Estimates of concentrations and loads were computed for all chemicals with three or more measured values above the practical detection limit by the Maximum Likelihood Estimation method (ML). The ML estimates a likely value for the censored data from the frequency of detection, detection limits and the detected values. This method provides an unbiased estimation of censored data (turn to Chapter 14 for more information on ML).

TABLE 13A : 1989 AND 1990 LOADS EXITING FROM LAKE ONTARIO VIA THE ST. LAWRENCE RIVER

	WOLFE ISLAND (kg/day) 1989			WOLFE ISLAND (kg/day) 1990		
CHEMICAL	SUSPENDED SOLIDS	FILTERED WATER	SUM OR WHOLE WATER*	SUSPENDED SOLIDS	FILTERED WATER	SUM OR WHOLE WATER*
Arsenic			333.3*			358.4*
Benz(a)anthracene						
Benzo(a)pyrene						
Benzo(b)fluoranthene				.1108		.1108
Benzo(k)fluoranthene				.0789		.0789
Alpha-chlordane		.04245	.04245			
Gamma-chlordane		.2194	.2194			
Total chlordane		.26185	.26185			
Chrysene						
P,P'-DDE	.009081		.009081	.01274		.01274
P',P'-DDD				.04165		.04165
P',P'-DDT						
TOTAL			.009081	.05439		.05439
Dieldrin	.01102	.2058	.21682	.01255	.1732	.18575
Dioxin(2,3,7,8-TCDD)						
Hexachlorobenzene	.00435		.00435	.005196	.02975	
Lead			251.6*			391.8*
Mercury						ND
Mirex	.005497		.005497	.005603		.005603
Octachlorostyrene						
PCBs	.1079	1.931	2.0389	.1606	1.158	1.3186
Tetrachloroethylene						
Toxaphene						

LEGEND:
Blanks were left to indicate either no information or non-detect (as this was preliminary information it was not certain that all parameters were provided).
* - Whole water samples

SOURCE : Biberhofer, Hans. Unpublished, preliminary results. Inlands Water Directorate, Environment Canada.

14. Tributaries (other than the Niagara River)

Tributaries provide a pathway for pollutants to enter the lake from point and nonpoint sources along their drainage basin (see Table 14A for point sources discharging to tributaries). Data from the MOE program, described in Section 3.2.13, was used to calculate the loadings.

Four years of monitoring data (January 1987 to December 1990) were used to calculate concentrations because of the high proportion of censored data. At least 3 samples were detected over these 4 years of sampling for:

- lead (30 tributaries);
- mercury (10 tributaries); and,
- arsenic (1 tributary, the Moira River).

For organic parameters the results were invariably "censored" without 3 detects for any one organic chemical. Although this result provides an indication that the concentration is below the detection limit it does not allow a precise or reliable estimation of the chemical's loadings to Lake Ontario.

The Maximum Likelihood Estimation (ML) program, the preferred method, could not be used to estimate the value of samples that were less than the detection limit. ML estimates the likely value of the censored data from the: frequency of detects; detection limit; and, concentrations of the samples detected. ML requires three samples over the method detection limit to run the computer program which would greatly limit the chemicals (to metals) and tributaries for which loadings could be estimated. The limitations of the database would result in the underestimation of loadings for all parameters by the ML method. However, ML was used as a diagnostic tool, as it addresses problematic features that could severely distort the results for standard statistical treatment (i.e., non-normality, numerous outliers, co-variables[75], to assign a value to apply to censored data. See Appendix L. As a result metals with their high frequency of detection were assigned half the detection limit to censored data and, organics with their low frequency of detection were assigned a value of a tenth of the detection limit.

Several assumptions had to be made to calculate loadings from tributaries, with the data available, including the following:

- Grab samples taken were assumed to be representative of water quality;
- Tributaries which were not sampled for organics or metals were assumed to have levels of persistent toxics below the detection limit;
- The detection limit divided by 10 is assumed to be the best estimate for the parameters for which less than 3 detects were found. The detection limit divided by 2 is assumed to be the best estimate of the concentration for the parameters where more than 3 detects were found; and,
- All the pollutants discharged to tributaries reach the Lake.

Uncertainties in the analytical results are high due to low frequencies of detection (0 percent detection for organic samples). The highest uncertainty in analytical results were for organics which were invariably censored (see Table 14D). High detection limits (see Table 3G for a comparison of detection limits of the tributary monitoring program with others), coupled with low frequencies of occurrence, contribute significantly to uncertainty levels in the loadings[9].

Monitoring and gauge locations do not always coincide but are usually proximate in location. The flow gauge is sometimes found upstream from the mouth, taking into account only part of the drainage basin, and so the gauge may underestimate the flow. Generally, the flow gauge is located near the mouth and covers more than 80% of the drainage basin.

With predominately censored data and high volume flows the loads estimated are not very accurate.

For some toxics, particularly lead, there is a discrepancy between loadings from tributaries compared to the loadings from point and nonpoint sources. It is uncertain whether tributary loadings overestimate loadings or point and nonpoint sources are underestimated. For others, such as arsenic and mercury, there seems to be significant loadings not accounted for by other source categories which are revealed by tributary loadings.

TABLE 14A: SUMMARY OF THE STPs AND INDUSTRIES DISCHARGING INTO TRIBUTARIES IN THE LAKE ONTARIO BASIN

LIST OF STREAMS	MUNICIPAL SEWAGE TREATMENT PLANTS DISCHARGING TO STREAM	INDUSTRY
Cobourg Brook	Cobourg #1	
Colbourne Cr.	Colbourne	
Credit River	Orangeville	
Don River	North Toronto	
Duffins Cr.	Stoufville	
Grindstone Cr.	Watertown (Flamborough)	
Highland Creek	Highland Creek	
Humber River	Kleinburg	
Millhaven Cr.	Odessa (Ernestown)	
Moira River	Deloro, Tweed Lagoon, Madoc Lagoon	Deloro gold mine(ceased operations in 1961)- site runoff still significant.
Napanee River	Napanee	Strathacona Paper Co.
Oakville Cr.	Milton	
Pringle Cr.	Pringle Creek #1 Pringle Creek #2	
Spencer Cr.		Orenco. Tend-R-Fresh Division.
Trent River	Campbellford, Hastings, Frankford, Batawa.	Domtar Packaging, Trent Valley Paperboard, Domtar Wood Preserving.
Twelve Mile Cr.		Beaver Wood Fibre Co., Domtar Fine Papers, Noranda Forest, Quebec and Ontario Paper Co., Exolon.
Welland Ship Canal	Seaway	General Motors, Stelco Page Hersey Works.

SOURCES:
(1) Dolan, D. 1991. Ontario, Lake Ontario Municipal Phosphorous Load Summary, Water Year 1989. IJC, Windsor.
(2) Ministry of the Environment (MOE). 1990. Report on the 1989 Discharges from Industries (and Sewage Treatment Plants) in Ontario. Queen's Printer for Ontario, Toronto.

14.1 Loading calculations

First, the concentration was calculated for each chemical as shown by the equation below.

$C = C_d \times P_d + D/Q \times P_n$

- C_d - Average Concentration (kg/m^3) for detected values (from Jan.1, 1987 to Dec 31, 1990)
- P_d - Percentage of samples detected
- D - Detection limit
- Q - coefficient of detection limit(Q = 2 for those tributaries and parameters with greater than three detects and Q = 10 for non-metals).
- P_n - Percentage of samples having censored data

$L = F \times C$

- L - load for tributary
- F - Average Flow for 4 year period - Jan. 1987 to Dec. 1990(m^3)
- C - Average Concentration (kg/m^3) for four year period

The loads from the different tributaries with monitoring data in the basin where summed together to obtain a load for the basin, as shown by the equation below:

$S = L_1 + L_2 + L_3 + L_n$

- S - load from all tributaries with gauges (kg/day).
- $L_{1 \text{ to } n}$ - loads from each tributary (kg/day).

NOTE : total flow of all tributaries with gauges was 42,100,000 m^3/day.

TABLE 14B: Loading Estimates of Pollutants from Tributaries to Lake Ontario

CHEMICALS	Detection Limit (ng/L)	Loadings from Tributaries with >3 detects	Loadings from Tributaries with <3 detects	Total Load (kg/day)
Arsenic	1000	14.02	3.970	17.990
Chlordane	2		0.008	0.008
DDT	5		0.021	0.021
Dieldrin	2		0.008	0.008
Hexachlorobenzene	1		0.004	0.004
Lead	5000	120.73	4.285	125.015
Mercury	20	0.349	0.017	0.366
Mirex	5		0.021	0.021
Octachlorostyrene	1		0.004	0.004
PCBs	20		0.084	0.084
Toxaphene	500		2.105	2.105

SOURCE: Harangozo, S. 1991. Water Quality Data Ontario Lakes and Streams 1987, Southeastern Region West Central and Central, Volume XXIII. Queen's Printer for Ontario, Toronto. (Loadings computed by S. Thompson).

To avoid double counting the loadings from CSOs, urban and agricultural runoff, STPs, bypasses, and industries were subtracted from the tributary load, by the equation below.

$$E = A - (B + C + D)$$

E = tributary load that is not accounted for in other point and nonpoint source loads
A = Total tributary load
B = (CSO load+urban runoff load+agricultural runoff load) x 0.96*
C = (STP load + bypass load) x 0.102^
D = (industrial load discharging into tributary)

* Based on area: 4% of the total area of the Lake Ontario Basin consists of lakeside land and 96% of area is inland.
^ 10.2% of the flow of the STPs in the Lake Ontario basin discharge to tributaries.

Arsenic in the Moira River seems to be a special case. Arsenic was not detected in any of the other tributaries but the Moira River, in which it was detected 89% of the time at very high levels. Due to contamination of soils and sediments immediately around Deloro, present arsenic levels in the river remain elevated). Loadings to the Lake from CSOs, runoff and STPs to the Lake where subtracted from the Moira River load as shown in the equation below:

$$F = 14.02 - (B + C)$$

F = Moira tributary load that is not accounted for in other point and nonpoint source loads
B = (CSO load + urban runoff load + agricultural runoff load) x 0.96*
C = (STP load + bypass load) x 0.00136^

It should be noted that the Moira R. has received elevated inputs of arsenic, heavy metals and other elements such as uranium, since 1866 when mining and mineral processing activities began at Deloro. Records indicate that arsenic concentrations downstream of Deloro have been as high as 56 mg/L but have since declined to between 1.5 and 4.0 mg/L after mining and mineral processing activities at Deloro ceased in 1961[76].

TABLE 14C: LOADING TO TRIBUTARIES AFTER REMOVING DOUBLE COUNTING BY OTHER SOURCE CATEGORIES

CHEMICALS	{a} Total Load to Tributaries (kg/day)	{b} Runoff & CSO Load to Tributaries (kg/day)	{c} STP & Bypass Load to Tributaries (kg/day)	{d} Industry Load to Tributaries (kg/day)	{e} Unaccounted for Load to Tributaries (kg/day) {a-(b+c+d)}	Corrected Unaccounted for Load to Tributaries (kg/day)
Arsenic	17.990	3.8237	4.7844	ND	9.3819	13.766{f}
Chlordane	0.008	0.1169	0.0058	NI	-0.1147	0
DDT	0.021	0.0093	0.0058	NI	0.0059	0.006
Dieldrin	0.008	0.0003	0.0029	NI	0.0052	0.005
Hexachlorobenzene	0.004	0.0173	0.0014	ND	-0.0147	0
Lead	125.015	202.7760	7.0988	7.5720	-92.4318	0
Mercury	0.366	0.0826	0.0253	0.0020	0.2565	0.257
Mirex	0.021	0.0010	0.0029	NI	0.0172	0.017
Octachlorostyrene	0.004	ND	ND	ND	0.004	0.004
PCBs	0.084	0.2294	0.0063	ND	-0.1517	0
Toxaphene	2.105	ND	ND	NI	2.105	0^

LEGEND:

A - Total tributary load
B - (CSO load+urban runoff load+agricultural runoff load) x 0.96*
C - (STP load + bypass load) x 0.102^
D - (industrial load discharging into tributary)
E - tributary load that is not accounted for in other point and nonpoint source loads
F - Moira tributary load that is not accounted for in other point and nonpoint source loads
NI - No information
^ - Toxaphene loadings from this method of estimation were considered to be unrealistic, resulting from high detection limits. The 2.105 kg/day of toxaphene was not applied to the final loadings matrix (loadings of toxaphene were considered to be less than 1 g/day).
ND - Censored data

TABLE 14D : THE DETECTION OF ORGANIC PARAMETERS FROM 1987 TO JULY 1991

ORGANIC PARAMETERS	Chlordane alpha	gamma	DDT & mets DDD	DDE	DDT	Dieldrin	Hexachloro-benzene	Mirex	Octachloro-styrene	PCBs	Toxaphene
DETECTION LIMIT	2 ng/L (2E−9 g/L)		5 ng/L (5E−9 g/L)			2 ng/L (2E−9 g/L)	1 ng/L (1E−9 g/L)	5 ng/L (5E−9 g/L)	1 ng/L (1E−9 g/L)	20 ng/L (2E−8 g/L)	500 ng/L (5E−7 g/L)
Welland Canal – sample number	10	10	10	10	10	10	10	10	9	10	5
– % detects	–		–			–	–	–	–	10%	–
12 Mile Cr. – sample number	57	57	58	58	58	57	59	58	57	56	34
– % detects	–		–	2%	–	–	–	–	–	2%	–
Credit River – sample number	57	57	57	57	57	57	57	57	57	57	30
– % detects	–		–	4%	–	–	–	–	–	–	–
Etobicoke Cr. – sample number	62	62	62	62	62	62	62	62	62	62	34
– % detects	1%	1%	–	3%	3%	2%	–	–	–	–	–
Humber River – sample number	92	92	140	140	140	92	140	140	92	92	51
– % detects	–		–			–	–	–	–	–	–
Don River – sample number	34	34	34	34	34	34	34	34	34	34	34
– % detects	–		–			–	–	–	–	–	–
Redhill Cr. – sample number	34	34	29	29	29	34	29	29	34	33	29
– % detects	–		–			–	–	–	–	–	–
Trent River – sample number	7	7	7	7	7	7	7	7	7	7	5
– % detects	–		–			–	–	–	–	–	–

LEGEND

[shaded box] 0% of samples above detection limit

15. Groundwater Seepage

Groundwater can become contaminated by leachate from hazardous waste sites/landfills and, from land-use activities (i.e., industrial and commercial). Industrial land-use is considered the greater concern of the two for sources on the Canadian-side of Lake Ontario[77].

Contaminated groundwater can contribute loadings to Lake Ontario through seepage. It is difficult and expensive to investigate, sample and measure contaminant flow in groundwater. Therefore no loading calculation from groundwater have been attempted in this report. Only a summary of problems related to groundwater contamination from the two principles sources of loadings to groundwater is presented below.

15.1 Hazardous Waste Sites and Landfills

Although hazardous waste sites and landfills are a major source for toxic loading to the Niagara River, this does not seem to correspond to the Lake Ontario situation.

Wastes containing persistent toxics produce leachate that can intersect with surface water by moving gradually down into the groundwater regime and by surface seepage[40]. In Ontario, there are 190 active and 513 inactive or closed sites, all of which are of the landfill type and include sanitary landfills. A listing of all the waste sites in the Lake Ontario basin can be found in the Waste Disposal Site Inventory, organized by county. The number of active and closed waste sites in the Lake Ontario basin, known to contain hazardous/industrial waste, are 12 and 11, respectively. (See Tables 15A and 15B for their locations.)

No loading estimates from hazardous waste sites and landfills are available for sites in Lake Ontario although a Bay of Quinte RAP study attempted to quantify loads. The Bay of Quinte RAP concluded that the landfill sites in the RAP area were considered to be potential sources of cadmium, copper, zinc, nickel, and iron to the Bay of Quinte. However, unknown factors such as the subsurface residence time and the rate of biodegradation of products containing these metals prevented loading estimates to be determined. Landfills located on or in close proximity to the shoreline of the Bay were considered to be a more significant source of heavy metals in the short term, because of a potential increased movement of leachate and the shorter subsurface residency time. For further discussion of this subject please refer to Beak Consultants Ltd (1989)[79].

TABLE 15A : **INVENTORY OF ACTIVE WASTE DISPOSAL SITES IN THE LAKE ONTARIO BASIN WITH HAZARDOUS WASTE.**

COUNTY	SITE #	MUNICIPALITY	HAZARDOUS WASTE (%)	LIQUID INDUSTRIAL WASTE (%)	CLASS
HALTON	A210207	HALTON HILLS	0	100	A3
HALTON	A210403	OAKVILLE	100	0	A1
HALTON	A210405	OAKVILLE	0	100	A1
HALTON	A210406	OAKVILLE	0	100	A1
HALTON	A210408	OAKVILLE	0	100	A1
HASTINGS	A360204	TRENTON	0	100	A1
LENNOX&A	A370809	ERNESTOWN	0	100	A1
PEEL	A220111	MISSISSAUGA	0	100	A1
PEEL	A220102	MISSISSAUGA	100	0	A1
PRINCE EDWARD	A350906	MARYSBURGH SOUTH	0	100	A2
PRESCOTT	A471504	HAWKESBURY WEST	0	2	A2
RENFREW	A412603	MCNAB	0	2	A1

TABLE 15B : **INVENTORY OF CLOSED WASTE DISPOSAL SITES CONTAINING HAZARDOUS WASTE**

SITE #	COUNTY	MUNICIPALITY	YEAR OF CLOSING	CLASS
A380101	FRONTENAC	KINGSTON	1974	A1
A380803	FRONTENAC	KINGSTON	1975	A1
A380804	FRONTENAC	KINGSTON	*	A2
A360201	HASTINGS	TRENTON	1974	A1
A361902	HASTINGS	LIMERICK	1979	B2
A361903	HASTINGS	LIMERICK	1979	B2
A361904	HASTINGS	LIMERICK	1979	B2
A362101	HASTINGS	MARMORA & LAKE	1974	A1
A312204	NORTHUMBER	MURRAY	1974	A2
A471902	PRESCOTT	RUSSEL	1975	B2
A350101	PRINCE EDWARD	PICTON	1979	A1

Source for Table 15A &15B: Ministry of the Environment (MOE). 1991. Waste Disposal Site Inventory, 1991. Queen's Printer for Ontario, Toronto.

15.2 Land-use Activities Loadings to Groundwater

Industrial activities often result in contamination of the surrounding area. For example, industrial land-use involving petroleum (ie., product storage, refining and distributing facilities) typically results in contamination of soil and groundwater with petroleum products due to spillage and leakage[78]. In addition to the potential presence of free product (i.e. oil, gasoline, etc.), such industrial land-use often results in contamination of soil and groundwater with metals, volatile organics and polynuclear aromatic hydrocarbons (PAHs).

Intera Kenting (1990) studied the impact of industrial activities on land and groundwater contamination in the East Bayfront post industrial area in Toronto. During the Phase 1 portion of the study elevated levels of organic contaminants and heavy metals were observed at: sites at which hydrocarbons were processed and/or stored; a coal tar distillation facility; and, a foundry site[78]. Each of the sites, for which geochemical information was available, indicated some degree of contamination from past land-use which exceeded one or more provincial guideline. It was noted that groundwater discharge from the industrial sites to the harbour may represent a major environmental pathway and an impact on aquatic habitat.

At the municipal incinerator site, numerous heavy metals were found at elevated levels in the soil, and elevated levels of lead and zinc were found in groundwater. These concentrations were probably related to the deposition of airborne particulate from the incinerator stack, and handling of incinerator ash. The deposition of airborne contaminants by this source was considered to contribute both organic and inorganic contaminants to adjacent sites.

High PAH concentrations were generally found in soils which had high oil and grease concentrations as well as at the coal tar site[78]. Furthermore, at all former coal storage facilities, elevated arsenic was found in soil samples. Arsenic is a trace element of coal and its occurrence may relate to residual coal dust, or to coal fragments present in the soil at these sites. Similarly the coal tar sites listed in Table 15C, are expected to have elevated levels of arsenic, as well as PAHs. To what degree, if any, they are contributing loadings to Lake Ontario is unknown.

TABLE 15C : SUMMARY OF INDUSTRIAL SITES PRODUCING AND USING COAL TAR AND RELATED TARS IN THE LAKE ONTARIO BASIN.

MUNICIPALITY	COMPANY	SITE ACTIVITY	LOCATION	YEARS OF OPERATION (APPROX.)
Deseronto	E.W.Rathburn/ Standard Chemical Co.	Wood Distillation Plant	Main St.	1890-1920
Hamilton	Dominion Foundries & Steel/ Dofasco	By-Product Charcoal and Coke Oven Plants of the Iron and Steel Industry	Burlington St. E.	1951-Present
Hamilton	Currie Products	Coal Tar Distillation	Wentworth St. N.	1978-Present
Hamilton	Steel Co. of Canada	Ibid.	Wilcox St.	1918-Present
Hamilton	Building Products Ltd./ Bird & Son Division	Roofing Felt and Tarred Paper Products Manufacturing	Beach Rd.	1910-1954
Hamilton	Dominion Tar & Chemical/ Domtar Chemicals	Coal Tar Distillation	Strathearne Ave.	1950s-Present
Hamilton	Dominion Tar & Ammonia/ Hamilton Tar & Ammonia/ Hamilton Tar Products/ Currie Products	Coal Tar Distillation	Caroline St.	1901-1977
Toronto	Pintsch Compressing Co.	Industrial Manufactured Gas Plant	Peter St.	1906-1960
Toronto	Toronto Asphalt Roofing Manuf. Co.	Ibid.	Oxford Dr.	1922-1950
Toronto	Imperial Varnish & Colour	Coal Tar Distillation	Lakeshore Blvd. E.	1900-1960
Toronto	Barrett Co.	Coal Tar Distillation	Lakeshore Blvd. E.	1922-1960s
Toronto	Dominion Tar & Chemical/ Domtar Chemicals	Coal Tar Distillation	Lakeshore Blvd. E.	1925-1974
Toronto	J.D.Paterson Co./ Barrett Co.	Coal Tar Distillation	Hahn Place	1900-1922
Toronto	Paterson Manufacturing Co.	Ibid.	Front St. E.	1882-1899
Trenton	Canada Creosoting Co./ Domtar Chem.	Creosoting	Marmore St.	1913-Present

SOURCE : Ministry of the Environment (MOE). 1991. Waste Disposal Site Inventory, 1991. Queen's Printer for Ontario, Toronto.

16. Atmospheric Deposition

The sources of atmospheric deposition are numerous and include:

- discharges from industrial processes (fugitive and stack emissions);
- by-products of incomplete combustion (PAHs and trace metals are emitted by industries using fossil fuels for production or heating purposes);
- motor vehicle exhaust;
- aerial spraying of pesticides;
- vaporization from waste treatment systems;
- evaporation from landfills;
- incinerator emissions;
- paint and solvent applications; and,
- uncontrolled emissions at facilities (e.g., dry cleaners and auto-finishing plants)[79].

Secondary emissions occur from the recycling by resuspension and volatilization of already deposited chemicals[5] (e.g., mercury and PCBs can volatilize from water and land surfaces).

Once emitted into the atmosphere, the processes by which pollutants are transported/deposited depend primarily on: their distribution between aerosol and vapour phase[5]; effective height of release; and, meterological conditions.

Loadings of wet and dry deposition have been estimated. In the dry deposition process the aerosol particles can be regarded as falling under the influence of gravity to the earth's surface. This deposition velocity is quite slow and depends on the: condition of the atmosphere; size and properties of the aerosol particle: and, nature of the ground surface.

In the wet deposition process the particles may be scavenged, or swept out of air, by rain/snow. Each rain drop sweeps through a volume of air about 200,000 times its volume as it descends to land or water surfaces and, thus, has the potential to remove a considerable quantity of aerosol from the atmosphere.

Due to wind dispersal and the inefficient nature of wet and dry deposition processes, only a fraction of air emissions are expected to be deposited adjacent to its source. As a result chemicals can be carried great distances from its source. However, short range transport process do contribute significant loadings in urban and industrial areas as indicated by higher rates of wet deposition for trace metals in downtown Toronto are typically about five times those at surrounding rural sites[71].

Other than deposition, transport between air and water occurs by vapour transfer into the water across the air-water interface (absorption). In turn, pollutants are emitted into the atmosphere from water bodies and land by volatilization.

The relative importance of these processes is determined by the physical/chemical properties of pollutants and, their particle size distribution[5]. Chemical-physical properties, such as vapour pressure and water solubility, determine the distribution of a chemical between vapour and particulate phases and the dominant deposition mechanism.

Atmospheric deposition of contaminants directly to Lake Ontario represents a fraction of the loadings which are accounted for in tributary and urban runoff loadings when the deposition lands in the basin.

Loading Calculations

The load estimates in Table 16A were taken from Eisenreich and Strachan (1992)[19] (converting them to kg/day). The method that was used to determine the loads is outlined below. Please refer to the original report for the complete methodology.

$$L\ (dry) = C_{T,air} \times phi \times v_d \times fd \times SA \times 1.55$$

Where:

L (dry)	=	loading resulting from dry deposition (kg/day)
$C_{T,air}$	=	total (aerosol and dissolved) concentration in air(ng/m^3)
phi	=	fraction of chemical in the particle phase in the season of interest. The calculation of phi is dependent on the variation of chemical subcooled liquid pressure and its relationship to gas-particle distribution. The Junge Pankow model was applied to subcooled liquid phase vapour pressures at 0°C, 10°C, 20°C, representative of the winter, spring-fall and summer temperatures, respectively.
SA	=	Lake surface area ($1.95 \times 10^{10} m^2$)
fd	=	fraction of year not raining/snowing (assumed = 0.90).
v_d	=	dry particle deposition velocity (assumed 0.2 cm/sec, which is typical of submicrometer particles)

1.55 is the unit correction applied.

$$L\ (wet) = C_{T,rain} \times P \times SA \times 2.74e^{-12}$$

Where :

L (wet)	=	loading resulting from wet deposition (kg/day)
$C_{T,rain}$	=	total (aerosol and dissolved) concentration in rain(ng/L)
P	=	annual precipitation intensity (m/year)
SA	=	Lake surface area ($1.95 \times 10^{10} m^2$)

$2.74e^{-12}$ is the unit correction applied.

Although, in some cases vapour exchange is significant[19] it is not factored into the load estimation.

According to Eisenreich and Stachan (1992)[19], there are some uncertainties and errors associated with estimating loadings from atmospheric deposition. There is a larger degree of uncertainty associated with rate constants from air. For wet deposition, precipitation concentrations are considered to dominate errors. Thus the error in wet loads will be of the same order as the variation in the measured precipitation concentrations. In the case of PCBs this error is approximately 120%[19].

For dry deposition, the estimated error in deposition velocity has been stated to be as high as a factor of 10. If true, the error would largely be dominated by the error in the deposition velocity rather than the variation in the air concentration or the error in determining gas particle distributions.

TABLE 16A: LOADING ESTIMATES FROM ATMOSPHERIC DEPOSITION TO THE SURFACE OF LAKE ONTARIO OF 18 PERSISTENT TOXICS

Chemicals	DEPOSITION (kg/day)		
	WET	DRY	TOTAL
Arsenic	9.500	3.039	12.539
Benz(a)anthracene	0.048	0.014	0.061
Benzo(b)fluoranthene	0.119	0.041	0.160
Benzo(k)fluoranthene	0.095	0.041	0.136
Benzo(a)pyrene	0.072	0.014	0.085
Chlordane	0.007	0.002	0.010
Chrysene	0.048	0.064	0.112
DDT	0.024	0.002	0.026
Dieldrin	0.002	0.002	0.004
Dioxin (TCDD)	0	0	0
Hexachlorobenzene	0.003	0.0003	0.003
Lead	118.220	12.129	130.349
Mercury	0.950	0.605	1.555
PCBs	0.095	0.0208	0.116
Toxaphene	0.010	0.003	0.013

SOURCE : Eisenreich, S. and W. Strachan. 1992. Estimating Atmospheric Deposition of Toxic Substances to the Great Lakes: An Update (Draft). Great Lakes Protection Fund and Environment Canada. (converted to kg/day by S. Thompson)

17. Sediment Resuspension

Sediments acts as both a sink and a source of contaminants. Results from models of Lake Ontario indicate that sediments provide a net sink and not a load to Lake Ontario. In some specific areas (such as Hamilton Harbour, for PCBs and other persistent toxics) sediments may provide a loadings source.

The sediment near most urbanized nearshore areas exceed dredging criteria[80]. For instance, many areas across the Toronto Waterfront contain sediment depositions which exceed the Ministry's Open Water Disposal Guidelines for Dredged Material. Furthermore, studies along the Toronto Waterfront indicate that sediment can be a significant source of copper, zinc, mercury, and PCBs to biota.

Contaminants (particularly lipophilic ones) have a tendency to associate with sediments that are typically deposited at a rate of 0.5 to 2 metres per day[5]. This is sufficient to remove most of the suspended matter from Lake Ontario during the course of a year. Bottom sediments serve as depositories for much of the toxic material discharged into water. At depths greater than 60 m, the bottom of Lake Ontario has a nepheloid-active layer (a layer consists of 95% water and 5% particles and is often highly organic in nature).

The major source of suspended sediment to the Lake is the Niagara River, which contributes 40% of the suspended sediment load to Lake Ontario, (45% of that originating from Lake Erie). Approximately 94% of the suspended sediments entering Lake Ontario are retained in the depositional basins. Lake Ontario has four sedimentation basins (i.e., Niagara, Mississauga, Rochester, and Kingston basins), separated by non-depositional sills.

Chemicals present in sediments are primarily removed by degradation and burial. Some of the deposited particulate matter is resuspended from the bottom sediment by the action of currents, storms and the disturbances caused by bottom dwelling fish and invertebrates (benthic organisms). Resuspension does occur, especially in winter: Lake Ontario is unstratified in the winter and frequent violent storms penetrate the depths of the Lake, resuspending bottom surface sediments. However, it is not clear how much of the contaminants from the sediments are released back into the open waters. Resuspension of sediments from the contaminated nearshore areas and from the depositional basin may be a potential source of contaminants. In this report, no attempt was made at estimating the loadings from sediments to the Lake.

18. Loadings of Persistent Toxics to Lake Ontario

Based on the available data and estimation methods described in this report, Lake Ontario receives over 1,500 kg (1,554 kg) of eighteen persistent toxics every day from the Niagara River and point and nonpoint sources on the Canadian-side. Lead loadings are the largest, representing roughly two-thirds (1,059 kg/day) of the total loadings, followed by: arsenic (424 kg/day); tetrachloroethylene (49 kg/day); mercury (8 kg/day); the five PAHs (each loading between 2-3 kg/day); and, PCBs (1.4 kg/day). The remaining five organochlorine pesticides and two chlorinated organics together have loadings less than 1 kg/day. For the estimated contributions of each source category see Table 18A.

18.1 Loadings from the Different Sources

Approximately two-thirds of the estimated total load enters via the Niagara River, which represents the aggregate loadings from 4 Great Lakes and their connecting channels. For all but chlordane, DDT, octachlorostyrene and toxaphene it constitutes the major source of loadings, representing:

- 95% of tetrachloroethylene loadings;
- 88% of arsenic loadings;
- 74% of mercury loadings;
- 59% of lead loadings;
- 65 to 88% of polyaromatic hydrocarbons (PAHs);
- 14% of chlordane loadings;
- 70% of PCB loadings;
- 88% of mirex loadings;
- 82% of hexachlorobenzene loadings;
- 93% of dieldrin loadings; and,
- 63% of DDT loadings.

No information is available on its loadings of toxaphene and octachlorostyrene.

Urban runoff appears to be the next dominant source (13% of total loadings). It provides substantial quantities of lead, PCBs, mercury and hexachlorobenzene. It does not appear to be a major source of pesticides, other than chlordane (22% of total loadings). No information is available for the PAHs, toxaphene, tetrachloroethylene, octachlorostyrene or dioxin although it is expected that urban runoff may potentially contribute significant amounts of PAHs.

Atmospheric deposition represents 9% of the total loadings of toxics to the Lake. It is most significant for: toxaphene (100% of loadings); mercury (19%); DDT (20%); lead (12%); chlordane (20%); and, PCBs (9%). For PAHs the importance of this source varies from 2 to 8%. It should be noted that loading information from other sources for toxaphene is very limited.

The industrial sector contributes relatively small loadings to the Lake: approximately 2% of the loadings of persistent toxics. However, industry does contribute 8 to 25% of PAH loadings. Only 27 of the 44 industries that discharge into Lake Ontario are accounted for in this report.

TABLE 18A : LOADING ESTIMATES OF 18 PERSISTENT TOXICS FROM CANADIAN SOURCES AND THE NIAGARA RIVER TO LAKE ONTARIO

LOADINGS IN KILOGRAMS PER DAY												
GROUP CATEGORY	INDUSTRIAL			RUNOFF		MUNICIPAL						
SOURCE CATEGORY LOTMP Persistent Toxics	INDUSTRY	SPILLS FROM DOFASCO	NIAGARA R. & GREAT LAKES	URBAN RUNOFF	AGRICULTURAL RUNOFF	COMBINED SEWER OVERFLOW	MUNICIPAL STPs	BYPASSING	WATER FILTRATION PLANTS	ATMOSPHERIC DEPOSITION	TRIBUTARIES (loadings not accounted for in other source categories)	TOTAL LOAD
Arsenic	1.625	ND	374.800	3.641	NI	0.342	15.724	0.089	1.237	12.539	13.766	423.763
Benz(a) anthracene	0.220	0.013	2.322	NI	NI	NI	ND	0.012	ND	0.061	NI	2.628
Benzo(b) fluoranthene	0.228	0.012	1.560	NI	NI	NI	ND	0.012	ND	0.160	NI	1.972
Benzo (k) fluoranthene	0.274	0.008	1.641	NI	NI	NI	ND	0.012	ND	0.136	NI	2.071
Benzo (a) pyrene	0.581	0.129	1.518	NI	NI	NI	ND	0.012	ND	0.085	NI	2.325
Chlordane	NI	NI	0.007	0.011	0.011	0.001	0.009	ND	ND	0.010	ND	0.049
Chrysene	0.372	0.011	2.225	NI	NI	NI	ND	0.012	ND	0.112	NI	2.732
DDT	NI	NI	0.082	0.003	0.006	ND	0.007	ND	ND	0.026	0.006	0.130
Dieldrin	NI	NI	0.151	0.002	0.001	NI	ND	ND	ND	0.004	0.005	0.163
Dioxin (2,3,7,8-TCDD)	ND	ND	ND	NI	NI	NI	ND	ND	ND	ND	NI	0
Hexachlorobenzene	0.003	ND	0.114	0.017	NI	0.001	0.001	ND	ND	0.003	ND	0.139
Lead	22.517	ND	624.200	200.137	NI	11.088	69.268	0.328	0.979	130.349	ND	1,058.866
Mercury	0.034	ND	6.165	0.080	NI	0.006	0.243	0.005	0.002	1.555	0.257	8.347
Mirex	NI	NI	0.013	ND	ND	ND	ND	ND	ND	NI	0.017	0.030
Octachlorostyrene	ND	ND	NI	NI	NI	NI	ND	ND	ND	NI	0.004	0.004
PCBs	0.012	ND	0.942	0.227	NI	0.012	0.041	ND	ND	0.116	ND	1.350
Tetrachloroethylene	0.046	NI	46.540	NI	NI	NI	2.501	0.051	ND	NI	NI	49.138
Toxaphene	NI	NI	NI	NI	NI	NI	ND	ND	ND	0.013	ND	0.013
SUM OF 18 TOXICS	25.912	0.173	1,062.280	204.118	0.018	11.4495	87.794	0.533	2.218	145.169	14.055	1,553.719
PERCENT OF TOTAL	1.6%	0%	67.0%	12.9%	0%	0.7%	5.5%	0%	0.14%	9.2%	0.9%	

LEGEND:
ND – less than the detection limit or 1 g/day
NI – No information

With the information available at this stage of the MISA process, the iron and steel industry appears to be the largest industrial discharger of metals and PAHs. Stelco and Dofasco contribute 30% and 55%, respectively, of the total loadings for the industry. Of the total loadings from all sources, these two industries account for 1 to 2% of the estimated total loadings to the Lake for metals and PAHs in particular (see section 5.2).

Many industries appear not to emit priority toxic chemicals; however, analytical detection limits used in the industrial sector are much higher than many other programs, and values from monitoring data are generally below detection limits.

Municipal sewage treatment plants (STPs) and combined sewer overflows (CSOs) account for approximately 6 to 7% of the loadings from all sources. STPs contribute high loads of metals and pesticides. Of the STPs that discharge into Lake Ontario the major sources are: Hamilton Woodward; Mississauga Lakeview; Toronto Main; and, Toronto Humber. These plants contribute most of the total loadings of the heavy metals for the Municipal STPs, and, together, account for approximately 1% of the total loadings from all sources. For municipal sources, the Metro Toronto area contributes the largest flow volumes and priority pollutant discharges to Lake Ontario from STPs, urban runoff and CSO.

The other source categories all appear to provide relatively small loadings of the 18 persistent chemicals with the exception of spills for benzo(a)pyrene which contribute approximately 10% of the total load. However, overall, spills and bypasses account for less than 0.5% of total loadings. Groundwater contributions could not be estimated from the limited data available, but they are considered relatively minor in terms of total load. Backwash from water filtration plants provide small but measureable loadings of metals (less than 0.1% of total load).

The current tributary loadings estimates are considered uncertain due to the low detection frequencies observed and high detection limits used. By comparing the tributary loading estimates to the point and nonpoint sources for tributary basins, arsenic and mercury appear to have loadings unaccounted for by known sources.

Sediments are considered to act as a net sink and not a source of toxic chemicals. However, in some specific areas (e.g., Hamilton Harbour, for PCBs, PAHs and other persistent toxics), sediments may be a loadings source

18.2 Loadings of the Different Chemical Groups

Metals, being ubiquitous, are contributed in large quantities by all source categories. The dominate source is the Niagara River. Runoff and atmospheric deposition provide large loads of lead. Municipal STPs are a relatively large source of arsenic and mercury.

The banned/restricted pesticides appear to originate from several sources (i.e., the Niagara River, atmosphere, runoff and municipal sources). Toxaphene loadings (with the limited data available) appear to result exclusively from atmospheric deposition.

The PAHs originate from the Niagara River (65 to 88%), industry (8 to 25%) and the atmosphere (2 to 8%). The PAHs in urban runoff were not estimated by Schroeter and Associates (1992). The loadings from urban sources are not known. However, the monitoring data from municipal STPs indicate that PAHs are generally below the detection limit in effluent, although they are detected in raw sewage).

There is very little information available on dioxin (2,3,7,8-TCDD). It was detected in industrial effluent but the loadings are well below 1 g/day.

PCBs are mainly discharged from the Niagara River, urban runoff and the atmosphere. For the other chlorinated organics (ie., tetrachloroethylene, hexachlorobenzene and octachlorostyrene) variable sources and loadings have been observed. Of the three, load quantities are largest for tetrachloroethylene which is contributed almost exclusively by the Niagara River. Hexachlorobenzene also originates mainly from the Niagara River but also, in much smaller quantities, from industrial and municipal sources.

18.3 Overall Comprehensiveness and Uncertainties of Loading Estimates

The available information to estimate loadings from point and nonpoint sources is often fragmentary. It is most reliable and comprehensive for the Niagara River and industrial point sources. The MISA data for direct discharging industry is reliable and current (1990-1991). However all the forty-four industries have not been monitored yet and some MISA effluent streams were only sampled for a few toxics. The data for sewage treatment plants (STPs) is less current (1987) and comprehensive (only 17 of the 57 STPs were fully monitored) but the monitored STPs represent 87% of the total effluent flow. In our opinion several source categories have insufficient data to determine reliable loading estimates (e.g., runoff from agricultural and open areas, spills, groundwater loadings from hazardous waste sites and industrial operations, bypassing and, tributaries).

The accuracy of loading estimates for the different source categories are quite variable. They are considered best for the Niagara River and the industrial (MISA) data, but they can extend to an order of magnitude for other source categories (i.e., atmospheric deposition and tributaries). For all sources, the loading estimates are more accurate for metals, as the frequencies of detection are higher.

Despite the data gaps and the uncertainties attached to several of the estimates they represent the most comprehensive, current and reliable loadings estimates from the Niagara River and Canadian-side of the Lake Ontario basin. This report has attempted to make the best possible use of all available data and should be of assistance in directing control actions and for planning purposes.

19. Recommendations

During the course of this study, the author has made all possible efforts to integrate information from different sources and to evaluate data that was not specifically collected for the purpose of estimating loadings. Gaining from this experience, this section is intended to provide guidance on ways to improve the integration of information and the loading estimates. Recommendations to develop loading reduction priorities are also provided.

19.1 To Improve Loading Estimates

* 26 of 57 municipal sewage treatment plants (STPs) for which monitoring information is not available and Stelco Page Hersey Works should be monitored for toxic persistents and the data integrated (along with the MISA loadings from the electrical power generation sector when it becomes available) in the loading estimates.

* Monitoring of agricultural runoff in the Lake Ontario basin should be carried out to improve loading estimates for this category. The environmental impacts of pesticides currently used (i.e., less persistent toxics) is not known and deserves further study.

* The emphasis of monitoring programs should be on specific point sources (i.e., sources to runoff and the atmosphere, and industries discharging to STPs) where significant concentrations and loadings are suspected other than that from direct dischargers.

* The uncertainties associated with atmospheric loadings estimates should be reduced through appropriate research (e.g., mass-transfer coefficients and the deposition process).

* Censored data should be treated in a consistent manner (e.g., by regression analysis or the unbiased Maximum Likelihood Estimation method).

* Loadings from groundwater and surface runoff resulting from industrial activities should be obtained, particularly for sites proximate to the lakeshore or tributaries.

* Information on loadings to the Lake from leachate of landfills bordering tributaries and lakeshore should be obtained.

* Loadings from spills and by-passing should be estimated, based on improved monitoring data.

* Loadings of air pollutants from short range transport to Lake Ontario should be determined.

19.2 To Better Integrate Load Information From Different Sources

* A computer network should be developed to integrate concentration and loading information from the different organizations (i.e., Ontario Ministry of the Environment, Environment Canada, and the U.S. State and Federal governments). Application of a Geographical Information System (GIS) would provide a spatial framework to loadings and surface water concentration data.

* The flow and concentration databases for tributaries should be integrated to facilitate estimating their loadings.

* The development of the National Pollutant Release Inventory, an inventory of chemical emissions for Ontario, should be expedited. It should require industries to provide regular (annual or bi-annual) estimates of the quantities of toxic chemicals used and of their emissions to each compartment of the environment.

* Life cycle analysis of all products, in which toxic persistent chemicals are used, should be carried out by its manufacturers. This analysis should estimate the quantity and pathways of each pollutant leaking into the environment (and, subsequently, to the Lake) as the result of manufacturing, use, and disposal of a product.

* The list of eighteen persistent toxics studied in this report should be reviewed regularly to update it for future loadings estimates. Some of the restricted pesticides should not be researched as it is known that insignificant loadings result from groundwater seepage, runoff and the atmosphere (e.g., toxaphene).

19.3 To Develop Priorities for Loadings Reduction

* Pollution prevention planning should focus on reducing the quantity of toxics produced and used by the sources identified in the loadings table as polluting (e.g., Dofasco and Stelco for lead, arsenic and PAHs). All sources and pathways of the chemicals should be studied for reduction opportunities (e.g., in the industrial sector - process change or modification, raw material substitution, product reformulation or replacement and good housekeeping - and in the agricultural sector - different practices and alternatives to chemicals for pest management). This approach should include whole facility auditing, life-cycle analysis and product stewardship.

* A comprehensive and systematic process should be developed to phase-out chemicals, processes or products identified by either the loadings estimates or product/manufacturing/use information as releasing persistent toxics (e.g., severely restrict the manufacture/use of lead and mercury consumer goods to reduce runoff, atmospheric and point source loadings).

* The limited opportunities to reduce the five pesticides studied (for which production/use has been restricted for 10 or 20 years) should be pursued (i.e., remediation of contaminated sites and international pressure to restrict their use in other countries).

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APPENDIX A

Loadings to Lake Ontario of 18 Persistent Toxics (Estimated in 1989)

SOURCE: Lake Ontario Toxic Committee. 1989. Lake Ontario Toxics Management Plan. Environment Canada, United States Environmental Agency, Ontario Ministry of the Environment, New York State Department of Environmental Conservation.

TABLE III-9
LOADINGS MATRIX

Chemical (Numbers in column headings refer to accompanying footnotes)	Loadings in Kilograms/Day: Niagara River & Upstream Great Lakes(1)*	Tributaries		Municipal STP's			Industrial Facilities		Atmospheric Deposition(8)
		NY(2)	Ontario(3)	NY(4)	Ontario (5): 3 Toronto Plants (67%)	Ontario (5): Remaining 9 Plants** (33%)	NY(6)	Ontario(7)	
Category IA									
PCB	1.03	NI	0.10	(1.51) ND	(0.06) ND	(0.02) ND	0.02	NI	0.39++
Mirex	0.01	NI	0.00	NI	(0.01) ND	(0.01) ND	(NI) ND	NI	0.01++
Chlordane	(0.03) ND	NI	0.05	(0.14) ND	NI	NI	(0.02) ND	NI	NI
Dioxin (2,3,7,8-TCDD)	(0.01) ND	NI	NI	NI	NI	NI	NI	NI	NI
Mercury	NI	NI	0.75	(0.60) ND	0.03	0.03	(0.03) ND	NI	0.17++
Aluminum	286,380.	NI	7688.	NI	93.44	85.15	NI	NI	25.84+
Iron	519,630.	NI	3613.	(16.68) 185.56**	1425.	1475.	0.04	NI	18.87+
Category IB									
DDT	0.05	NI	0.04	(0.29) ND	(0.06) ND	(0.02) ND	(0.02) ND	NI	0.07++
Dieldrin	0.20	NI	0.05	(0.04) ND	(0.01) ND	(0.01) ND	(0.00) ND	NI	0.09++
Hexachlorobenzene	0.18	NI	0.00	(0.72) ND	(0.01) ND	(0.01) ND	(0.66) ND	NI	0.03++
Octachlorostyrene	NI	NI	(0.03) ND	NI	NI	NI	NI	NI	NI

TABLE II (Continued)
LOADINGS MATRIX

Chemical	Niagara River & Upstream Great Lakes(1)*	Tributaries NY(2)	Tributaries Ontario(3)	Municipal STP's NY(4)	Municipal STP's Ontario (5) 3 Toronto Plants (67%)	Municipal STP's Ontario (5) Remaining 9 Plants** (33%)	Industrial Facilities NY(6)	Industrial Facilities Ontario(7)	Atmospheric Deposition(8)
Category IIA									
Benz(a)anthracene	1.61	NI	NI	(2.73) ND	(2.78) ND	(1.02) ND	(0.66) ND	NI	NI
Benzo(a)pyrene	0.99	NI	(0.02) ND	(0.92) ND	(2.78) ND	(1.02) ND	(0.66) ND	NI	0.17++
Benzo(b)fluoranthene	1.46	NI	(0.05) ND	(1.71) ND	(2.78) ND	(1.02) ND	(0.66) ND	NI	NI
Benzo(k)fluoranthene	1.52	NI	(0.01) ND	(0.92) ND	(2.78) ND	(1.02) ND	(0.66) ND	NI	NI
Chrysene	2.06	NI	NI	(0.92) ND	NI	NI	(0.66) ND	NI	NI
Tetrachloroethylene	478.90	NI	NI	(1.15) 1.02	(0.54) 0.19	(0.18) ND	(0.66) ND	NI	NI

Sources not included:
- Direct surface runoff
- Direct groundwater inflow
- Direct stormwater discharges and combined sewer overflows
- Small tributaries, municipal STPs and industrial discharges

Other factors influencing the mass balance:
- Recycling of toxics from Lake Ontario sediments
- Output of toxics to the St. Lawrence River

* Footnotes qualifying the data for each source are listed on succeeding pages.
** Partial. Not available from some facilities.
\+ Based on U.S. data only; wet deposition.
++ Entire lake (U.S. and Canada); total deposition (wet and dry).
NI No Information
ND Not Detected
(xx.xx) Incremental load if non-detects were present at the detection level.

TABLE III-9

FOOTNOTES

1. Loadings from the Niagara River and the Upstream Great Lakes are based on the 1986-87 data developed under the Niagara River Toxics Management Plan. The table below shows the separate Upstream Great Lakes and Niagara River components of the loadings.

CHEMICAL (Kg/day)	UPSTREAM GREAT LAKES	NIAGARA RIVER
PCBs	2.424	-1.391*
Mirex	0.00	0.014
Chlordane	ND	ND
Dioxin (2,3,7,8-TCDD)	ND	ND
Mercury	ND	ND
DDT	0.347	-0.294*
Dieldrin	0.210	-0.005*
Hexachlorobenzene	0.00	0.179
Aluminum	182,286.	104,094.
Iron	285,439.	234,191.
Octachlorostyrene	NI	NI
Benz(a)anthracene	1.049	0.562
Benzo(a)pyrene	0.00	0.993
Benzo(b)fluoranthene	0.00	1.463
Benzo(k)fluoranthene	0.00	1.518
Chrysene	1.619	0.439
Tetrachloroethylene	166.441	312.456

NI = No information.
ND = Not detected frequently enough to allow calculation of a mean loading.
* = The negative numbers indicate that a higher loading was measured at Fort Erie than at Niagara-on-the-Lake.

2. The tributary monitoring program that has been carried out by NYSDEC until quite recently was not designed to measure loadings. Detection limits were high so that organic chemicals were only rarely detected and the sampling frequency was insufficient to provide a good estimate of loadings during high flow events. Consequently, no estimates of loadings from the New York tributaries are available at this time.

3. The 1986 Ontario tributary loadings include tributaries that are ranked as significant sources to the lake. These tributaries are: Hamilton Harbour, Twelve Mile Creek, Trent River, Don River, Humber River, and the Welland Canal. The sampling strategy for Ontario tributaries emphasizes a frequent collection of sampling during high flow events. In general, 75% of the samples are collected during high runoff periods (snow melt or intensive summer rain events). The total number of samples from the significant tributaries amounted to eleven for trace organics and up to 64 for selected heavy metals.

The Committee has not yet had the opportunity to review the location of sampling stations in order to ascertain that data from these sites accurately represent tributary loadings to Lake Ontario.

Hamilton Harbour is suspected to be a major contributor to the total Ontario tributary load for many chemicals. At the mouth of the harbour (and within the harbour itself), a complex flow situation exists that includes:

- mixing of tributary input within the harbour;
- seiches on Lake Ontario that may reverse net flow;
- thermal stratification within the harbour and in the outlet; and
- seasonal variations.

A description of harbour flow modeling has been submitted but a closer review of how the chemical data are collected and used in calculations will be needed to develop a more reliable loading estimate.

4. In the top 90% of municipal sewage treatment plants in the Lake Ontario basin, New York has three that discharge directly to the Lake. Van Lare and Northwest Quadrant are under a continuing monitoring program for 126 priority pollutants. Nine samples have been obtained from each plant between 12/84 and 12/86 for volatiles and metals. Three samples have been obtained in the same time period for base/neutrals, and all other USEPA priority pollutants. Twenty-four hour composites are used for all sampling except for volatiles where three grab samples are taken over a twenty-four hour period. Most of the loadings in Categories 1A and 1B were below the detection Limit (ND). The Town of Webster submits analyses for selected heavy metals, methylene chloride, and 1,1,1-trichloroethane through its quarterly self-monitoring reports required under the SPDES program.

All analyses are required to be by USEPA approved methods published in the Federal Register, October 26, 1984.

5. In the top 90% of municipal sewage treatment plants in the Lake Ontario basin, Ontario has twelve that discharge directly to the Lake. Analytical results presented in the table were accumulated from the three Toronto plants (Main, Humber, and Highland Creek), and four of the remaining nine (York-Durham, Clarkson, Lakeview, and Oakville-Southwest).

Twelve samples were collected between 1/26 and 7/24/87. Trace organics were analyzed by GC/MS according to the USEPA sampling/analytical protocols. A total of 160 contaminants, including USEPA priority pollutants, were measured.

6. Alcan is the priority industrial discharge that goes directly to the Lake on the New York side. A priority pollutant scan in 1981 showed only Arochlor 1016 (of all the chemicals in the Loadings Matrix) to be above the detection level. Alcan has a SPDES permit that requires it to monitor on a prescribed schedule for this PCB, which has a permit limit of 0.02 Kg/day. The loading figure is for the period April 1986 through March 1987. Arochlor 1016 was monitored monthly with grab samples analyzed in accord with the USEPA method published in the October 26, 1984 Federal Register.

7. DuPont Canada is the priority industrial discharge that goes directly to the Lake. Currently there are no data available on organics and heavy metals.

8. Aluminum and iron loadings are taken from USEPA's Great Lakes Atmospheric Deposition (GLAD) network. The values for PCBs, DDT, benzo(a)pyrene, and mirex appear in Strachan and Eisenreich's paper entitled "Mass Balancing of Toxic Chemicals into the Great Lakes: The Role of Atmospheric Deposition", 1988, IJC. Mercury, Dieldrin, and hexachlorobenzene figures were secured in a personal communication from Steve Eisenreich on July 29, 1988, and are from his unpublished data.

APPENDIX B

The Legacy of Persistent Toxics in Lake Ontario

B. The Legacy of Persistent Toxics in Lake Ontario

Industrial, agricultural and municipal sources have emitted toxic chemicals into the air, land and water - especially since the 1950s. These chemicals find their way into Lake Ontario via many pathways. The highest contaminant levels are found in the industrialized harbours and embayments: the main hot-spots in Lake Ontario are Toronto, Hamilton, and Rochester. Other important ports are Kingston and Oswego. Seven areas, including four in Canada, and the Niagara River, have been designated as Areas of Concern in need of remediation by the International Joint Commission.[1]

DDT, chlordane and dieldrin caused most of the many consumption advisories during the 1970s. These chemicals adversely affected wildlife; the collapse of the cormorant population from DDT-induced eggshell thinning is well-known. Since the early 1980s, the ban or severe restrictions on manufacturing and use of these persistent pesticides resulted in a gradual decrease of their levels in the Great Lakes Basin and in fish. Presently, mirex, PCBs and mercury are the only contaminants leading to consumption advisories in Lake Ontario.

Canadian Consumption advisories in Lake Ontario are predominantly due to PCBs and mirex in the western basin and to mercury in the eastern basin (particularly in the Bay of Quinte). Mirex, a persistent pesticide, was responsible for triggering more consumption advisories than either PCBs or mercury[2]. PCB and mirex concentrations in larger sizes of many fish species are considered unsafe to eat i.e., trout (brown, rainbow, lake), salmon (coho, chinook), American eel, white perch, channel catfish, carp, brown bullhead, and gizzard shad. Mercury concentrations in larger sizes of northern pike, walleye, largemouth bass and channel catfish exceed guidelines.

Other organic substances (e.g., DDT, lindane, heptachlor, aldrin and dieldrin) and heavy metals (e.g., copper, zinc, cadmium, nickel, lead and arsenic) are found, but at levels below concern. Test results for the most toxic dioxin isomer, 2,3,7,8-TCDD, have not resulted in restricted consumption of fish. However, if other dioxins and dibenzofurans, expressed as toxic equivalents of 2,3,7,8,-TCDD, are analyzed for, as is being considered, consumption restrictions will be issued for certain sizes of lake trout at Jordan Harbour, and brown trout (>45 cm) at the mouth of the Credit River[2].

As a result of this long history of toxic contamination, residents of Ontario are afraid to eat fish from Lake Ontario - 60% of anglers discard their fish, and 95% of the commercial catch from Ontario is exported. Indeed, the commercial fishing industry has been crushed by contaminant levels in fish (although overfishing also played its role). The federal government imposed bans on fish and a decline in the international reputation of Canadian fish products have dramatically reduced marketing opportunities.

Looking at the positive side, a recent Environment Canada report states: "no new ubiquitous, highly toxic and persistent contaminants were detected in any of the Great Lakes since 1982"[3]. However, the "old" persistent toxics have not gone away. This is especially apparent with the banned/restricted organochlorines which have no new sources, notably mirex. Mirex, although banned in the mid-1970s, is still causing consumption advisories.

The Problem of Toxic Chemicals in Lake Ontario

Toxic chemicals in Lake Ontario present both human and biotic health concerns, as illustrated by the examples below.

- Hexachlorobenzene, DDT and metabolites, and dieldrin are found in ambient water column at levels above the standards and criteria designed to protect human health (although in treated filtered, drinking water they are well below dangerous levels).

- Toxics may play a role in inducing developmental and neurological human health impacts at lower concentrations than those related to carcinogenic effects[3]. However, generally accepted direct indicators regarding the impact of toxics in Lake Ontario on human health are not currently available.

- Sport fish have bioaccumulated certain persistent toxics to levels unsuitable for unrestricted human consumption. Fish consumption advisories have been issued by the Province of Ontario for 21 species from 35 locations in Lake Ontario. The edible portions of fish tissue in the larger specimens of some Lake Ontario sport fish, most frequently salmon and trout, have exceeded Canadian and/or U.S. standards for PCBs, mirex, mercury, chlordane, and dioxin - and exceed the more stringent, but unenforceable, EPA guidelines for hexachlorobenzene, DDT and metabolites, and dieldrin.

- Toxics that exceed NYSDEC unenforceable guidelines for protection of piscivorous wildlife are: PCBs, dioxin (2,3,7,8-TCDD), chlordane, mirex, dieldrin, DDT and metabolites, mercury and octachlorostyrene.

- PCBs are found in the water column at levels above the standards and criteria designed to protect aquatic life.

- There is evidence that toxics are linked to birth deformities and reproductive failures in aquatic wildlife[3].

Since the 1980's, contaminants in fish have reached an equilibrium revealing that persistent toxic inputs continue from:

- manufacturing operations and energy generation emissions (i.e., polyaromatic hydrocarbons, heavy metals and dioxins are released in coal-making and as by-products of combustion and heavy metals are widely used)
- cycling within the aquatic ecosystem as a result of re-mobilization of sediments;
- use and disposal of consumer goods containing persistent toxics;
- atmospheric deposition; and,
- leaking hazardous waste sites[1].

Mercury has been touted as "the next DDT". Its levels in the environment are considered high and its use in manufacturing is widespread[4].

REFERENCES

1. Environment Canada et al. 1991. Toxic Chemicals in the Great Lakes and Associated Effects: Volume 1 Contaminant Levels and Trends. Government of Canada.

2. Rang, S. et al. 1992. The Impairment of Beneficial Uses in Lake Ontario. Report submitted to Great Lakes Environment Office, Environment Canada.

3. Lake Ontario Secretariat. 1991. Lake Ontario Toxics Management Plan:1991 Update. Environment Canada, United States Environmental Agency, Ontario Ministry of the Environment, New York State Department of Environmental Conservation.

4. Modelling Uncertainty Workshop. February 3-5, 1992. Workshop on Reducing Uncertainty in Mass Balance Models of Toxics in the Great Lakes sponsored by U.S. Environmental Protection Agency, Lakes Research Station SUNY University, Buffalo, New York.

APPENDIX C

Standards and Guidelines

C. Standards and Guidelines

TABLE C1 :WATER COLUMN STANDARDS FOR LAKE ONTARIO

JURISDICTION	EPA		NYSDEC		IJC	MOE	H & W
	Aquatic	DW	Aquatic	Health			
CHEMICAL NAME	Values	in	ug/L				
Arsenic			190	50	50		50
Benz(a)anthracene				.002			
Benzo(b)fluoranthene				.002			
Benzo(k)fluoranthene				.002			
Benzo(a)pyrene			.0012	.002			
Chlordane	.0043		.002	.02	.06	.06	.006
Chrysene				.002			
DDT & metabolites	.001		.001	.01	.003	.003	.001
Dieldrin	.0019		.001c	.0009	.001c	.001c	.004c
2,3,7,8-TCDD							
Hexachlorobenzene				.02		.0065	.0065
Lead	3.2b	50	5.10	50	25	7	2b
Mercury	.012	2	.2	2	.2	.2	.1
Mirex	.001		.001	.04		.001	
Octachlorostyrene							
PCBs (total)	.014		.001	.01		.001	.001
Tetrachloroethylene	840a		1	.7			260
Toxaphene	.0002	5	.005	.01	.008		.008

LEGEND:

a - insufficient data to develop criterion, value presented is the lowest observed effect level.
b - hardness dependent criterion (100 mg/L used)
c - sum of aldrin and dieldrin
EPA - Environmental Protection Agency
NYSDEC - New York State Department of Environment
IJC - International Joint Commission
MOE - Ontario Ministry of Environment
H & W - Health and Welfare Canada

SOURCE: Kuntz K. et al. 1990. Joint Evaluation of Upstream/downstream Niagara River Monitoring Data for the Period April 1988 to March 1989. The Niagara River Data Interpretation group River Monitoring Committee.

TABLE C2: FISH CONSUMPTION CRITERIA

(parts per million, wet weight except dioxin, parts per trillion wet weight)

Parameter	Great Lakes Water Quality Agreement Specific Objective[2]	Health & Welfare Canada Regulatory Limit[3]	U.S. FDA Action Level[4]	Ontario Sport Fish Consumption Guideline[5]
Aldrin/Dieldrin	0.3	0.1	0.3	—
DDT (total)	1.0[6]	5.0	5.0	5.0
Dioxin (2,3,7,8-TCDD)	—	20 (ppt)	25[7] (ppt)	20 (ppt)
Endrin	0.3	0.1	0.3	—
Heptachlor/Heptachlor Epoxide	0.3	0.1	0.3	—
Hexachlorobenzene (HCB)	—	0.1	0.3	—
Kepone	—	0.1	0.3	—
Lead	—	—	—	1.0
Lindane	0.3	0.1	0.3	—
Mercury	0.5[6]	0.5	1.0	0.5[8]
Mirex	Substantially absent[6]	0.1	0.1	0.1
PCBs	0.1[6]	2.0	2.0	2.0
Toxaphene	—	0.1	5.0	—

1. Criteria based on skinless fillet unless otherwise footnoted.
2. Based on the protection of the most sensitive species, which accounts for lower values for some compounds.
3. HWC regulatory limits apply to fish in commerce only. The Province of Ontario applies these as guidelines to sport fish consumption.
4. U.S. Food and Drug Administration (FDA) action levels based on fillet with skin on.
5. Ontario guidelines refer to restricted frequency of consumption of fish: If level of a single contaminant in a skinless dorsal fillet is below the guideline then unrestricted consumption is allowed: If the level exceeds the guideline then restriction in frequency of fish meals is advised. For women of child-bearing age and children under 15 years, restrictions apply below the guideline levels and no consumption is recommended for levels that exceed the guideline.
6. Criteria based on whole fish.
7. No consumption where TCDD levels exceed 50 ppt.
8. No consumption is recommended if the level for mercury exceeds 1.5 ppm.

A number of studies have shown that reduction of fat in fish flesh can decrease the amount of fat-soluble contaminants in the portions of fish consumed. Fats in fish flesh can be reduced by trimming fatty areas, puncturing or removing skin prior to cooking, cooking so that fats are drained (e.g., baked, broiled or grilled on a rack), or deep frying. These methods do not reduce the mercury content in fish flesh since this chemical is stored primarily in muscle tissue (fillet).

SOURCE : Environment Canada et al. 1991. Toxic Chemicals in the Great Lakes and Associated Effects: Synopsis. Government of Canada. P. 20.

APPENDIX D

The Hazards of the 18 Persistent Toxics

D. The Hazard of the 18 Persistent Toxics

A review of the hazard of eighteen persistent toxics is carried out as indicated by their: persistence; ability to bioaccumulate; toxicity; carcinogenicity; and, quantity in the environment[1].

These terms are defined in the following sections and hazard properties of the chemicals are summarized in tables.

D.1 Bioaccumulation

Bioaccumulation is the increase in concentration of an organism by uptake from food and water. (Bioconcentration refers to the uptake from water and biomagnification refers to the increase in concentration from food to fish.) A chemical is accumulated when uptake exceeds elimination and it is stored in fatty tissue[1]. As smaller organisms are consumed by larger ones, the concentration of toxic substances increases at each trophic level, becoming greatly "magnified" at the highest levels.

A useful indicator of biomagnification is the octanol-water partition coefficient (Kow) of chemicals, which measures the relative affinity of chemicals for water or lipids. The more lipophilic the chemical the more it partitions from water across gill membranes to be stored in fish. A Kow of 3.0, is used as a preliminary threshold value[2] for designating bioaccumulative chemicals[1]. See Table D2. All of the organics but tetrachloroethylene are considered bioaccumulative by this "yardstick".

Another indicator, bioconcentration factors (BCFs), measure the concentrations of chemicals in fish relative to water. Chemicals that bioconcentrate in fish more than 100 times (log 2) the levels observed in water should be regarded with concern. (See Table D2 for the BCFs of these chemicals.) Although tetrachloroethylene does not bioconcentrate more than 100 times, benz(a)anthracene, dieldrin, tetraethyl lead, mirex, octachlorostyrene, PCBs and toxaphene bioconcentrate greater than 10,000 times.

D.2 Persistence

Substances that are persistent do not degrade or break down quickly into less toxic substances through physical, chemical (photochemical) or microbial processes. If a chemical is emitted at a steady, albeit small, rate and has no removal mechanism, the concentration will continue to build up indefinitely from less than toxic to toxic levels[1].

Many persistent toxic substances are "elements" (ie., arsenic, lead and mercury), and thus cannot be broken down into simpler substances. Other toxic chemicals are complex, stable organic compounds which do not readily break down.

The Great Lakes Water Quality Agreement (GLWQA) considers any substance that has a half-life of more than 8 weeks persistent (e.g., a chemical, such as phenol, which through rapid biodegradation is diminished by half in a few hours, poses less of a threat than PCBs, for which the half-life is greater than 10 years in the environment). A chemical's half-life, varies with the environment it is in, as different reaction and advective processes occur in different environments (i.e., chemicals subject to rapid photolysis will not be degraded by this customary removal mechanism in deep, murky sediments).

The half-lives listed in Table D1 are for degradation processes and do not consider transport processes[3]. The overall half-life determination is based on high and low degradation rates of the most important degradation process in a particular medium. In soil, surface water and groundwater the most common degradation mechanism is biodegradation with the exception of chemicals that undergo rapid hydrolysis. In surface water direct photolysis and photo-oxidation are also important. Generally, in groundwater biodegradation proceeds at a slower rate than that in surface waters because microbial populations are limited in terms of both numbers and enzymatic capability (usually anaerobic). In air the fastest degradation is as a result of hydroxyl radicals although for certain chemicals, photo-oxidation with ozone and direct photolysis are more important.

Long residences of chemicals, particularly in sediments, reveal that the lowering of inputs or banning a chemical will not result in an immediate decline in the chemical concentration. The half-life of DDT and metabolites is as much as 15.6 years in soil and surface water. The PAHs and tetrachloroethylene are degraded more quickly. For all chemicals, but hexachlorobenzene, the breakdown processes in the atmosphere occur relatively quickly.

It is important to note that the product of a degrading process can be other toxic persistent contaminants. Such is the case with the methylation of mercury (to methyl-mercury), and the oxidation of benzo(a)pyrene - the product of reaction is actually more harmful than the parent compound[1].

In contrast to degrading processes transport processes simply move a chemical from one environment to another (e.g., air is transported from the troposphere to the stratosphere and sediment is buried from the well-mixed layers to the depths making it essentially inaccessible)[1].

Chemicals with high vapour pressures volatilize to the air, to be deposited subsequently. Highly hydrophobic chemicals frequently adhere to soil or sediment, often to be captured in a "sink", such as bottom sediments. Microbial action or physical disturbance of bottom sediments may subsequently re-release these substances[1].

TABLE D1: THE HALF-LIFE OF CHEMICALS

CHEMICAL	AIR (hours)	SOIL (Years)	GROUND WATER (Years)	SURFACE WATER
Benz(a)anthracene	1-3	0.28-1.86	0.56-3.73	1-3 hours
Benzo(b)fluoranthene	1.43-14.3	0.99-1.67	1.97-3.34	8.7-720 hours
Benzo(k)fluoranthene	1.1-11	2.49-5.86	4.99-11.7	3-499 hours
Benzo(a)pyrene	0.37-1.1	0.156-1.45	0.312-2.9	0.37-1.1 hours
Chlordane	5.2-51.7	0.77-3.8	1.55-7.6	0.77-3.8 years
Chrysene	0.802-8.02	1.02-2.72	2.04-5.48	4.4-13 hours
DDE	17.7- 177	2-15.6	0.044-31.3	15-146 hours
DDD	17.7-177	2-15.6	0.192-31.3	2-15.6 years
DDT	17.7-177	2-15.6	0.04-31.3	7-350 days
Dieldrin	4-40.5	0.479-3	0.003-6	.479-3 years
Dioxin (2,3,7,8-TCDD)	22.3-223	1.15-1.62	2.29-3.23	1.15-1.62 years
Hexachlorobenzene	0.43-4.2 years	2.7-5.7	5.3-11.4	2.7-5.7 years
Tetrachloroethylene	16-160 days	0.5-1	1-2	0.5-1 years

SOURCE : Howard, P.H. et al. 1991. Handbook of Environmental Degradation Rates. Lewis Publishers Inc., Michigan.

D.3 Toxicity

Toxicity is the capacity of a substance to cause temporary or permanent adverse effects in living organisms or their offspring (e.g. behavioral abnormalities, cancer, genetic mutation, and physiological or reproductive malfunctions)[1].

The toxicities of chemicals are measured predominately by acute laboratory tests (as chronic testing is too expensive)[3] in which increasingly concentrated doses are applied until the threshold level (the level of observable effect) is found, and then until a lethal dose is reached. LC_{50} refers to the measured median lethal concentration (m moles/L) for 50% of test organisms in a 96 hour exposure. Acute lethality (LC_{50}) to rainbow trout, bluegills and fathead minnows are provided in Table D2 as surrogates for aquatic toxicity.

Table D2 shows that dioxin (T4CDD) is acutely toxic to fish at extremely small doses (1.74e-7 micro moles/L) and most pesticides are acutely toxic at small doses.

D.4 Carcinogenicity

Some substances (i.e. cancer-causing agents) may have no threshold, that is, any amount of a substance has the potential to trigger genetic mutation.

Carcinogenicity is usually estimated through the experiments with rats, or through mutagenicity experiments with bacteria[2]. Table D2 ranks the chemicals according to whether a compound is:

a proven carcinogen	(2)
a suspected carcinogen	(1)
not a carcinogen	(0)
carcinogenicity unknown	(-1).

Table D2 shows that 11 of the 18 persistent toxics are proven carcinogens.

D.5 Levels in the Environment

The levels in the environment of a chemical are the result of the quantity discharged and its persistence. All the five pesticides on the list of 18 have restricted uses and the chemical intermediates or by-products (e.g., octachlorostyrene and hexachlorobenzene) are present at lower levels than in the past in the environment. See Table D3 for concentrations of the 18 persistent toxics in the environment.

TABLE D2: MEASURES OF THE HAZARD OF THE PRIORITY CHEMICALS							
					LC50 (micro moles/L)		
CHEMICAL	KOW	MW (g/mol)	LOG BCF	CARCIN-OGENICITY	RAINBOW TROUT	BLUE-GILLS	FATHEAD MINNOWS
Arsenic		74.92		1	356.4		198
Benz(a)anthracene	5.61	252.3	4.00				
Benzo(b)fluoranthene	5.22	254.0		2			
Benzo(k)fluoranthene	6.06	252.3		-1			
Benzo(a)pyrene	6.06	252.3		2			
Chlordane	5.16	409.8	2.51	2	.05	.14	.09
Chrysene	5.65	228.2		2			
Dieldrin	5.48	380.9	4.11	2	.026	.021	.042
Dioxin/Furans							
2,3,7,8 TCDF	5.70	305.9		-1			
T4CDD	5.50	321.9	3.67	2			1.74e-7
Hexachlorobenzene	5.23	284.7	3.89	2		.43	
Lead		207.2	3.00	1	5.79	114.9	31.2
Tetraethyl lead	6.12		4.00	-1			
Mercury		200.5	3.70	1		.80	.79
Mirex	6.89	545.4	4.26	2	>183	>183	>183
Photomirex	6.0	511.0		-1			
Octachlorostyrene	6.29	376	4.52	-1	1.76		
PCBs (total)	5.0		4.7	2			
Tetrachloroethylene	2.53	165.8	1.69	2		78.0	81.2
Toxaphene	3.30	413.8	4.88	2	.013	.045	.034

LEGEND:
KOW - log octanol water coefficient
MW - molecular weight (grams/mol)
LOG BCF - logarithmic biocentration factor from water to fish i.e., Log 2 = 100, Log 3 = 1,000, Log 4 = 10,000.

CARCINOGENICITY
2 - a proven carcinogen
1 - a suspected carcinogen
0 - not a carcinogen
-1 - carcinogenicity unknown

SOURCE: Niagara River Toxics Management Plan. 1991. Persistent Toxic Chemicals of Concern for the Niagara River: Draft Discussion Paper. Niagara River Toxics Management Plan.

TABLE D3 : CONCENTRATIONS OF THE 18 PERSISTENT TOXICS IN THE ENVIRONMENT

CHEMICAL	SURFACE WATER^ (ppt) {1}	BOTTOM SEDIMENTS (ppb) {1}	AIR (ng/m3) {2}	RAIN (ng/L) {2}
Arsenic	500 (1986)		1	200
Benz(a)anthracene			.02	2
Benzo(a)pyrene		300(1986)	.005	2
Benzo(b)fluoranthene			.03	1.5
Benzo(k)fluoranthene			.05	2.5
Chlordane			0.02-0.08	0.15
Chrysene			0.3	1
Total- DDT	0.1 (1986)part. 0.1 (1986)diss.	50 (1986)	0.02-0.1	0.5
Dieldrin	0.331 (1986)	10(1986)	0.02-0.08	0.04
Dioxin (2,3,7,8-TCDD) TCDD			* .0000015	* .0003
Hexachlorobenzene	0.063 (1986)	10(1986)	0.1-0.15	0.06
Lead	300 (1986)diss. 100 (1986) part.	100,000 (1986)	1.0-4.0	2000
Mercury	10~ (1985)	800(1986)	2	20
Mirex	ND (1986)	50(1986)		
PCBs	1.41 (1986)	100 (1986)	0.1-0.4	2
Toxaphene	0.4 (1986)diss. 0.2 (1986)part.		0.01-0.06	0.2

LEGEND: ^ - whole water
~ - median value
diss. - in dissolved form in water
part. - in particulate form in water

{1}SOURCE: Environment Canada et al. 1991. Toxic Chemicals in the Great Lakes and Associated Effects, Volume 1 Contaminant Levels and Trends. Government of Canada. P. 139.

{2}SOURCE : Eisenreich, S. and Strachan, W. 1992. Estimating Atmospheric Deposition of Toxic Substances to the Great Lakes: An Update (Draft). Great Lakes Protection Fund and Environment Canada.

NOTE : This was not an exhaustive search for concentrations in the environment but was limited to the two sources listed.

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2. Niagara River Toxics Management Plan. 1991. Persistent Toxic Chemicals of Concern for the Niagara River: Draft Discussion Paper. Niagara River Toxics Management Plan.

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APPENDIX E

Origins of 18 Persistent Toxic Chemicals

E. The Origins of 18 Persistent Toxic Chemicals

The 18 chemicals fall into one of the following four categories:

- Metals;
- Pesticides;
- Chlorinated Organics; and,
- Polyaromatic hydrocarbons (PAHs).

E.1 Metals

Arsenic (CAS #:7440382)

The principal emissions of arsenic, in Ontario, occur from iron/steel production (54%), copper/nickel refining (40% of total emissions), and gold refining (3%)[1].

Some arsenic (about 1%) is emitted from the power generation sector. Arsenic can also be found in a number of insecticides and pesticides (<1%) including Paris green, calcium arsenate, disodium methanearsenate arsenic acid. It should be noted that none of these pesticides appear in the Survey of Pesticide Use in Ontario, 1988[2].) Arsenic is emitted as a by-product of various industries (e.g., glass manufacturing, pigment manufacturing, wood preserving, and, semi-conductor). See Table E1.

In Ontario, arsenic is found in mineral deposits associated with pyrite. Deloro, a closed gold mine, discharges arsenic to the Moira River (5 to 15 kg per day are attributed to this mine that closed in 1961. In earlier times loads were considered to be much higher).

It should be noted that U.S. data for arsenic emissions is radically different from Canadian data[1]. According to the U.S. data, pesticide production/use accounts for the majority of emissions (about 45% of the total emissions), followed by coal combustion (40%) and smelting (10%).

Lead (CAS #:7439921)

95-99% of lead emissions result from human activities[1]. In 1982, before the phase-out of leaded gasoline, more than 2,200 tonnes of lead were emitted from gasoline-powered motor vehicles in Ontario. It is estimated that approximately 600 tonnes/year are emitted from this activity in the early 1990's.

Other significant sources of lead in Ontario include emissions from: primary iron and steel production (238 tonnes); primary copper/nickel production (205 tonnes); ferrous foundries (172 tonnes); waste oil incineration (53 tonnes); metal fabricating industries (42 tonnes); aircraft fuel combustion (39 tonnes); metal, milling and concentrating lead-bearing ores (31 tonnes); and, municipal refuse incineration (23 tonnes)[1]. See Table E1.

Lead is found in many products (e.g., ammunition, automobiles, babbitt and bearing alloys, brass and bronze, electrical cable sheathing, enamels, glassware, inks, radiation shields, lubricants, paints and pigments, piping, solder, fertilizer, storage batteries, tank lining and, type metal). In the past, some pesticides in the United States and Canada contained lead. Lead is still used in fungicides and preservatives[1].

Mercury (CAS #:7439976)

Estimates of mercury emissions from natural sources vary greatly, but they generally exceed those from anthropogenic sources. In Ontario, it was estimated that a little over 1% of the total annual emissions, in 1982, resulted from people's activities[1]. However, these estimates are in conflict with the information from U.S. sources, which indicate that anthropogenic sources account for approximately 40%[1]. Natural emissions of mercury include releases from soil, vegetation and, forest fires.

The largest single use of mercury is in the chlor-alkali industry (e.g., chlorine gas, sodium hydroxide and hydrogen gas production). Also, mercury can be found in an estimated 3,000 consumer products (e.g., electrical equipment, industrial control instruments, agricultural and industrial pesticides and paint). According to the EPA, consumer use and disposal of these products eventually release more mercury to the overall environment than the manufacturing processes themselves. About 60% of the mercury in consumer goods goes to landfills in the United States. Judging from its action in other media, its movement in landfills would probably progress from deposition in sediments or soil, followed by chemical interactions, evaporation or resuspension/re-entrainment.

E.2 The Pesticides

Chlordane (CAS #: 56553)

Chlordane is an insecticide used for :controlling wood-boring insects in structures; maintaining lawns and golf greens; and, treating agricultural soil against infestations of a wide variety of crops used against corn rootworms, strawberry root weevil, wireworms, white grubs, and subterranean cutworms[1].

The peak usage of chlordane was in 1971 when 131 tonnes of chlordane were sold in Canada. The use of chlordane was restricted in the U.S. and Canada in the late 1970s.

TABLE E1: ORIGINS OF THE CHEMICALS

CHEMICAL SOURCE	PAHs	PCBs	PESTICIDES	DIOXIN	OCTACLORO	TETRACLORO	HCB	LEAD	MERCURY	ARSENIC
INDUSTRIAL EMISSIONS	A	B		C	A	A	A	A	A	A
ORGANIC CHEMICALS	A				A	A	A	A	A	
IRON & STEEL	A						B	A	B	A
METAL CASTING	A	B						A	B	A
PETROLEUM REFINING	A	B			A	A	A	A	A	B
INORGANIC CHEMICAL										
INDUSTRIAL MINERALS	C			C				C	C	C
MINING & REFINING	C							C	C	C
PULP AND PAPER	B					A	A	A	A	A
POWER GENERATION	C	C		C				C	C	C
MUNICIPAL INCINERATORS	C	C		C				C	C	C
HAZARDOUS WASTE INCINERATORS	C	C		C				C	C	C
MUNICIPAL STPs		A	B	A		A	A	A	A	A
LANDFILLS								C	C	C
RUNOFF		B	B					B	B	B
CONSUMER PRODUCTS								X	X	X
PESTICIDE SPRAYING			X					X	X	X
MOBILE SOURCES	C			C				C	C	C

LEGEND

A - Ministry of the Environment (MOE). 1988. The Effluent Monitoring Priority Pollutants List (1987). Queen's Printer for Ontario.

B - From the loadings tables in this report.

C - ORTECH International, 1991. Report No. 50-11520 and 50-23392, prepared for Environment Canada.

X - Voldner, E. and L. Smith. 1991. Production, Usage and Atmospheric Emissions of 14 Priority Toxic Chemicals. IJC.

NOTE: A few restricted uses remain for pesticides/fungicide with lead, mercury and arsenic as an active ingredient.

OVERVIEW OF PESTICIDE USE
****
The use of persistent pesticides (e.g., DDT and dieldrin) after World War II, resulted in widespread distribution of these organochlorine pesticides in the Great Lakes Basin. In addition, local manufacturing or processing of some pesticides (e.g., mirex) caused regional pollution problems in Lake Ontario. Since the early 1970s, however, the U.S. and Canada banned or severely restricted their use - resulting in gradually declining contaminant levels in fish and wildlife. However, pesticides leaching from waste sites, and cycling of the contaminants already in the environment are still causing problems[3].

Between 1966 and 1981, agricultural use of less persistent herbicides and insecticides nearly tripled, with most agricultural cropland receiving treatment, and acreage treated with herbicides and insecticides increased more than threefold. Even greater increases were seen in the amounts of herbicides applied to corn, soybeans and wheat - the principal crops in the Great Lakes Basin.

In future, pesticide use may expand because the more traditional methods of pest and weed control, such as rotating crops and tillage, are increasingly being replaced with chemical controls. However, expansion will be limited as the vast majority of cropland already receives treatment, and acreage of cropland is decreasing in the Great Lakes region.

Agricultural chemicals, that are widely used at present, have most often localized environmental impacts. However, monitoring, by both the U.S. and Canada since 1978, has identified increasing levels of these chemicals in tributaries and Lakes. Also, they can be found in municipal sewage treatment plants and industrial samples. For example, in the Bay of Quinte region, organophosphorus insecticides (malathion and diazinon) were occasionally found in STP and industrial samples[4].

Short, medium and long-term impacts of less persistent herbicide and insecticide usage deserves further study. While studying banned or restricted chemicals makes us confront the legacy of our overdependence on persistent chemicals, these chemicals are nearing the end of their life cycle and will pose less of a problem in the future.

DDT (CAS #: 50293) (1,1,1-trichloro-2,2-bis (4-chlorophenyl)ethane)

DDT, a broad spectrum contact insecticide, was widely used from 1949 to 1972 in Canada and the United States. Peak-usage of DDT was reached in the U.S., in 1959, and in Canada, in 1969, before its popularity declined. In 1972 both the U.S. and Canada banned it, although, the last remaining products were only restricted in 1989[1]. Present-day sources of DDT include:

- transportation from its continued use in Central America, South America and Asia;
- use of the pesticide, Dicofol, which contains traces of DDT and its metabolites; and,
- use of the insecticide, methoxychlor, which produces DDT as a photolytic product[1].

Dieldrin (CAS #: 60571)

Dieldrin is an insecticide used to control soil insects, mosquitoes, and moths[1]. It is produced in the environment by the metabolic oxidation of another pesticide, aldrin, which is from the same cyclediene chemical family. Dieldrin has been used since 1948 and was the most widely used pesticide in the U.S. in the 1960s and 70s, along with aldrin. Both aldrin and dieldrin's use was restricted in 1974.

Mirex (CAS #:2385855)

Mirex was both a pesticide and an industrial chemical. Mirex was used as a pesticide in the Southern U.S. from 1961 to 1978 although Canada never permitted it to be used for agricultural purposes[1].. However, under the trade name Dechlordane, 145.5 tonnes of mirex were imported to Canada before 1976. Inmont Pesticide, in Georgetown, Ontario, imported 130.2 tonnes of Dechlordane for manufacturing expanding rubber-based sealant for the automotive industry (General Motors and Chrysler).

The principal sources of mirex are two historical sources :

- the Hooker Chemical Company which had a manufacturing plant on the Niagara River, that closed in 1976. The 1979 load of mirex from the Niagara River was estimated to be 13.3 kg, originating from this historical discharge and from continuing leakage from landfill sites. Biomonitoring studies using clams indicate that its primary source at present is a sewer from an Occidental Chemical Corporation site in Niagara Falls, New York; and,
- the Armstrong Cork Company which had a distribution plant in Oswego, New York. (During its routine operation, the distribution plant was estimated at loading a relatively small amount, 6 g/year. However, a spill from its storage area is known to have released a large amount into the Oswego River. Recent research indicates that high loadings from the Oswego River are not from resuspension of contaminated sediment in the Oswego River, as previously thought, but from seepage or runoff from waste/industrial sites in the river basin.

Some estimates suggest that it may be almost 100 years before mirex-contaminated sediments in Lake Ontario are covered up by "clean" sediments.

Toxaphene (Camphechlor) (CAS #: 8001352)

Toxaphene was the most heavily used insecticide in the Southern U.S. during the 1960s and 1970s. It was applied to a variety of crops (e.g., cotton, cereal, grains, fruits, nuts, oil, seeds and vegetables)[1]. Annual application in the U.S. reached 35,000 tonnes in the early 1970s[1]. In contrast, toxaphene use in Canadian agriculture was limited to treating scabies on livestock. It was also used as a piscicide in fish eradication programs. The U.S.A EPA deregistered toxaphene in 1982 for all but a few uses.

E.3 Chlorinated Organics

Hexachlorobenzene (CAS #: 118741)

Prior to the mid 1970s, hexachlorobenzene (HCB) was manufactured for use primarily as a fungicide[1]. Since then, it has not been manufactured in either Canada or the U.S. HCB has not been imported into Canada since 1983, although restricted fungicidal uses are still permitted.

HCB is generated as a by-product of:

- the production of chlorinated solvents, i.e., tetrachloride, trichloroethylene, and perchloroethylene. (HCB is usually found as a residue in the heavy ends or still bottoms during the distillation or purification of solvent.);
- the synthesis of several industrial chemicals;
- pesticide production, mainly in the Southern U.S. but also in Canada (as an impurity);
- municipal waste incineration (detected in flue gas); and,
- the electrolytic production of chlorine, caustic soda and sodium chlorate.

HCB is present in many waste sites around the U.S., although numerical estimates for releases from those sites have not been made.

PCBs (polychlorinated biphenyls)
(CAS #: not applicable :200 different compounds)

PCBs (polychlorinated biphenyls) were produced commercially in North America from 1929 until 1978, when they were restricted[1].

Until 1971, PCBs were incorporated into many products (e.g, closed system electrical and heat transfer fluids (approximately 60% of total uses), various plasticizers (25%), hydraulic fluids and lubricants (10%) and many other products, such as flame retardants, adhesives, inks and carbonless copy paper (5%)[5].

After 1971, uses of PCBs were restricted to closed electrical systems to act as insulators, coolants or dielectrics.

Although never manufactured in Canada, 40,000 tonnes of PCB fluid were imported into Canada. Ontario received roughly 40% of these PCBs. The majority of PCBs can be found in electrical equipment (ie., capacitors (649.4 tonnes),transformers (7964.4 tonnes), electromagnets (25 tonnes), and others (41.3 tonnes)[5]).

Also, PCBs can be found in mechanical equipment (i.e., hydraulic equipment(7.7 tonnes),heat transfer equipment (0.1 tonne) and vacuum equipment (1.0 tonne)).

The amount of PCBs in storage for disposal (including on-site and commercial storage) amounts to 880.6 tonnes in Ontario. These storage sites are located predominantly in the Hamilton and Toronto areas. Sources not reflected in this figure are PCBs in:

- lamp ballasts;
- many consumer products (e.g., consumer electronics, refrigerators, washing machines, and, air conditioners).
- contaminated mineral oils; and
- chemicals containing PCB contaminants.

PCBs can be found in all industrial sectors in Ontario. Although restricted they are still in use and in storage for disposal/destruction in large quantities (see Table E1).

TABLE E2 : SUMMARY OF PCB TYPES IN ONTARIO

PCB Types	Units	Amount in Use	Amount in Waste
High level	Tonnes	8,900	1,600
Low level	Tonnes	Not available	9,600

SOURCE : Commercial Chemicals Branch. 1986. National Inventory of Concentrated PCB (Askarel) Fluids (1985 Summary Update). Conservation and Protection, Environment Canada, Ottawa.

<u>Octachlorostyrene</u> (CAS #: 29082744)

Octachlorostyrene (OCS) does not have any commercial uses. It is released into the environment as a by-product of some industrial processes (see Table E1). It's origins are believed to be from wastes generated from the tar chlorination used to bind graphite electrolytes. Octachlorostyrene has been found in the effluent of petroleum refineries, municipal STPs and organic chemical manufacturers[6].

<u>Tetrachloroethylene</u> (CAS #: 127184)

Tetrachloroethylene is a volatile organic chemical. It is manufactured in large quantities in the U.S. and Canada and used by many industries (e.g., the dry cleaning, and textile industry). As well, tetrachloroethylene has been found in the effluent of petroleum refineries, pulp and paper operations and organic chemical manufacturers[6].

Dioxin (2,3,7,8-TCDD) (CAS #: 1746016)

Dioxins are typically emitted as by-products of incomplete combustion. They have been found in the fly-ash from municipal solid waste incineration. These dioxins are not very reactive in the atmosphere and usually settle out with the particulate and aerosols in the atmosphere[7].

E.4 Polynuclear Aromatic Hydrocarbons (PAHs)

Polynuclear Aromatic Hydrocarbons

Benz(a)anthracene	(CAS #: 56553)
Benzo(b)fluoranthene	(CAS #: 205992)
Benzo(k)fluoranthene	(CAS #: 2070809)
Benzo(a)pyrene	(CAS #: 50328)
Chrysene	(CAS #: 218019)

PAH's are semi-volatile, aromatic petroleum compounds, formed primarily through incomplete combustion of organic compounds. There are numerous sources of PAHs (e.g., combustion of fuels for heat, power generation and transportation, solid-waste incineration, and many industrial processes, such as coal and coke processing and petroleum refining). Forest fires contribute significantly to their atmospheric emissions. Also, PAHs are synthesized by various bacteria and algae, e.g., *Chlorella vulgaris*. The natural production of BAP from various species ranges from 20 to 60 ug BAP produced per kg of dry bacterial biomass[7].

Estimated Canadian annual B(a)P anthropogenic emissions for 1980 are in the range of 19 to 22 tonnes. This did not include forest fires, woodstove burning and other uncontrolled burning. In Ontario, in 1983, total annual B(a)P emissions were estimated at 12.4 tonnes. Of this, coke production contributed 63%, and forest fires 35%[1].

U.S. data for BaP emissions is significantly different from Canadian data. Approximately 95% of emissions are attributed to wood combustion[1]. The rest (5%) is attributed to gasoline and coal combustion, and coke production.

PAHs are a main constituent of coal tar, coal tar pitches, creosote, petroleum pitch and asphalt[8]. Coal tars and their products are the result of the destructive distillation of coal (ie.,as a byproduct of metallurgical coke manufacturing). Coal tar pitches are the residues derived from distillation of coal tars.

Steel companies based in Ontario (Dofasco and Stelco, both discharging into Lake Ontario, and Algoma Steel discharging into Lake Superior) are Canada's major producers of coal tar. 200 kilo-tonnes of crude coal tar, supplied predominantly by these Ontario steel companies, are refined annually by two Ontario companies: Domtar Chemicals and Currie Products. About 105 kilo tonnes of coal tar pitch are produced[9]. Approximately 26 kilo-tonnes are used in Ontario to manufacture the following products:

- industrial carbon products (10 kilo tonnes);

- roofs and roofing products (7 kilo tonnes);
- clay pigeons (5 kilo tonnes); and,
- sealants and protective coatings.

The burning of fuels emits PAHs. The PAH emissions from bitumous coal are:
- 2 orders of magnitude larger than those from anthracite coal[9] and distillate oil (see Table E3); and,
- 4 orders of magnitude larger than those from natural gas.

Natural gas has emission factors of less than the detection limit to 0.011 mg/kilo L for benzo(a)pyrene (B(a)P)[9].

TABLE E3 : **CONCENTRATION OF BENZO(A)PYRENE FROM DIFFERENT STATIONARY SOURCES (MG/KG)**

	HARD COAL	ANTHRA-CITE	BROWN COAL	OIL FIRED STOVE	OIL FIRED HEATING
BENZO(A)PYRENE	2.8	0.035	3.01	0.01	7E-6

SOURCE : World Health Organization. 1984. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans, Polynuclear Aromatic Compounds. WHO.

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APPENDIX F

QUESTIONNAIRE TO OBTAIN LOADING DATA FOR THE LOTMP

Environment Canada
Conservation and Protection

Ontario Region
25 St. Clair Avenue East
Toronto, Ontario
M4T 1M2

Environnement Canada
Conservation et Protection

Région de l'Ontario
25, avenue St. Clair est
Toronto (Ontario)
M4T 1M2

Ms. Sandra Weston
Port Harbour RAP Co-ordinator
Environment Canada
25 St. Clair Ave. E., 7th Floor,
Toronto, Ontario
N9A 6T3

Your file Votre référence

Our file Notre référence

August 7, 1991

Dear Ms. Weston:

As you know, four environmental agencies (the United States Environmental Protection Agency, Environment Canada, the New York State Department of Environmental Conservation and the Ontario Ministry of the Environment) signed a declaration of intent, on February 4th, 1987, to develop a management plan for toxic chemicals in the Lake Ontario basin. In the 1989 report on the plan, eleven toxic chemicals were identified as exceeding criteria designed to protect human health or wildlife. For these chemicals, rudimentary estimates of loading to Lake Ontario were developed from a limited number of sources. In the 1990 update of this report, the development of toxic loading data, on more than a rudimentary basis, was identified as being necessary to reduce chemical inputs to safe levels.

To update these loading estimates Environmental Protection - Ontario Region has contracted Ms. Shirley Thompson to undertake an eight month study. Intensive study will be done of the chemicals in Lake Ontario that exceed criteria established to protect wildlife or human health and the priority toxic chemicals of the Niagara River Toxics Management Plan. However, any information on the loading of a toxic chemical into Lake Ontario is of interest and will be compiled in the course of this study. All available loading information, both estimates from models and monitoring data, is to be compiled on a chemical-by-chemical basis.

The loading information must be obtained from many sources in many offices. Your help is needed to compile this information. Please answer the following questionnaire and provide a copy of any relevant reports to ensure your area of expertise is covered in a comprehensive manner and an accurate estimate of the toxic chemical loading to Lake Ontario results.

Thank you for your assistance.

Yours very truly,

Shirley T.
for
Dr. Tom Tseng

Canada

QUESTIONNAIRE FOR THE
LAKE ONTARIO TOXICS MANAGEMENT PLAN

** PLEASE RETURN THE COMPLETED QUESTIONNAIRE BEFORE AUGUST 31, 1991 TO :*

ENVIRONMENT CANADA
c/o Shirley Thompson
25 St. Clair Avenue East, 7th Floor
Toronto, Ontario
Canada
M4T 1M2
FAX #: 416-973-7509

If you do not have any lengthy attachments to this questionnaire please return it by FAX, for expediency.

-PART A-

1. *Please indicate your area(s) of expertise/program responsibility:*

- Point Source Loading (general) ______
  - Direct industrial discharges ______
  - Municipal Treatment Plants ______
  - Niagara River ______
  - Other tributaries to Lake Ontario ______
- Non-Point Source Loading (general) ______
  - Atmospheric deposition ______
  - Surface Water Runoff ______
    - Urban stormwater ______
      - Residential/Commercial ______
      - Industrial ______
      - Combined sewer overflows ______
    - Rural stormwater ______
      - Agricultural ______
      - Resource extraction areas ______
  - Groundwater infiltration ______
      - Waste management sites ______
      - Toxic spills ______
      - Leaking sewers ______
      - On-site wastewater treatment systems ______
  - Contaminated sediments ______
  - OTHER (please specify) ______

2. *Please list the projects or programs for which you have direct responsibility, which relate to toxic loading estimates for Lake Ontario:*

______

______

______

3. *Please identify any people or projects that may provide valuable information relating to the estimation of toxic loading to Lake Ontario:*

NAME NAME OF PROJECT OR PROGRAM or ADDRESS/PHONE NUMBER

____

____

____

____

4. *Please provide:*

Name: ______________________________

Position/Title: ______________________________

Correct Address: ______________________________

____

____

Phone Number: ____________________

Fax Number: ____________________

In part B of this questionnaire the details of a specific project/program are requested. For each project/program *please complete a separate part B form of the questionnaire. So, if you have been involved in more than one project/program please photocopy the following two pages.*

Note: If you prefer to attach a copy of the report, rather than provide the specifics of it, this would be most helpful.

QUESTIONNAIRE - PART B: SPECIFICS OF THE PROJECT/PROGRAM

1. *What is the name of the project/program?*

____

____

2. *Who are the sponsoring and participating agencies of the project?*

____

____

3. *What source(s) of toxic chemicals is studied?*

____

____

4. *Please place a check beside the chemicals, below, for which study/analysis is done:*

arsenic		______	dioxin (2,3,7,8-TCDD)	(*)	______
benzo (a) anthracene		______	hexachlorobenzene	(*)	______
benzo (a) pyrene		______	lead		______
benzo (b) fluoranthene		______	mercury	(*)	______
benzo (k) fluoranthene		______	mirex/photomirex	(*)	______
chrysene		______	octachlorostyrene	(*)	______
chlordane	(*)	______	PCBs	(*)	______
DDT & metabolites	(*)	______	tetrachloroethylene		______
dieldrin	(*)	______	toxaphene		______

Note: Listed above are the current Niagara River Management Plan priority toxic chemicals and the chemicals, that exceed the criteria designed to protect human health and wildlife, for Lake Ontario, as indicated by the (*).

5. *Are any other toxic chemicals studied/analyzed?*

Yes _____ No _______

Toxic chemical (definition):

a substance which can cause injury to biological tissue i.e., death, disease, behavioral abnormalities, cancer, genetic mutations, physiological or reproductive malfunctions, or physical deformities in any organism or its offspring, or which can become poisonous after concentration in the food chain or in combination with other substances. Toxicity is a function of concentration, the length of exposure and the type of exposure.

Persistent Toxic Chemical (GLWQA definition):

a toxic substance having a half-life in water equal to or greater than eight weeks (56 days).

.../4

6. *Is information available on the:*

- concentration Yes ________ No ________
- flow Yes ________ No ________
- loading Yes ________ No ________

7. *Please place a check beside the type of information this study provides:*

- monitoring data ________
- estimates of loading based on models ________
- a model or parameters for model application ________
- other (please specify) ________

____

8. *What protocol for chemical analysis is used?*

____

____

9. *What quality control/quality assurance measures are applied?*

____

____

10. *Is the project/program completed?*

Yes ________ Date of Study ________

No ________ Expected Date of completion ________

11. *Where and how can this information be obtained?*

____

____

____

12. *Other Comments:* ____

____

____

____

INFORMATION SHEET ON THE LAKE ONTARIO TOXICS MANAGEMENT PLAN

Why develop a plan?

Toxic chemicals in Lake Ontario are a human and biotic health concern, as illustrated by the examples below.

- o Certain persistent toxic chemicals bioaccumulate in some Lake Ontario sportfish to levels that make them unsuitable for unrestricted human consumption and consumption by wildlife. For example, levels of PCBs, mirex, chlordane, dioxin and mercury exceed Canadian and U.S. consumption advisories for edible fish and state guidelines for the protection of wildlife.

- o Levels of hexachlorobenzene, DDT (and its metabolites) and dieldrin in the water column exceed standards designed to protect human health and aquatic life. General indicators of the impact of toxics in Lake Ontario on human health are not currently available. However, the role of toxic chemicals in inducing developmental and neurological human health impacts at lower concentrations than those related to carcinogenic effects is becoming evident.

- o Toxic chemicals have been linked to reproductive failure in fish-eating birds. The best known example of this is thinning of the eggshells of double crested cormorants and herring gulls, induced by the pesticide DDT.

To prevent these and other health effects a better control plan, that is both comprehensive and basin-wide, is required.

What is the goal of this plan?

The goal of the Lake Ontario Toxics Management Plan is a Lake that:

- provides drinking water and fish that are safe for unlimited human consumption: and,
- allows natural reproduction, within the ecosystem, of the most sensitive native species, such as bald eagles, ospreys, mink and otters.

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This goal will be met by:

- implementing control programs for any toxic chemicals exceeding enforceable standards;
- developing enforceable standards where unenforceable criteria or no criteria exists;
- developing more sensitive analytical protocol where detection limits are too high to compare with standards;
- obtaining ambient data for all toxic chemicals in the Lake;
- reducing toxic inputs with emphasis placed on the seven geographical areas recognized as being of concern, i.e., Hamilton Harbour;
- further reducing toxic inputs of specific chemicals based on a lake-wide analyses of pollutant fate and on eco-system objectives; and,
- working towards zero discharge of toxic persistent substances.

Who is developing the plan?

Four environmental agencies with mandates for Lake Ontario (the United States Environmental Protection Agency, Environment Canada, the New York State Department of Environmental Conservation, the Ontario Ministry of the Environment) signed a declaration of intent to develop a plan on February 4th, 1987.

What substances are going to be controlled?

To determine which toxic persistent chemicals require control evaluation will be carried out on substances exceeding criteria for toxic substances in water and fish. Exceedance of criteria places these chemicals in group:

- 1A, if the criteria is enforceable; or,
- 1B, if the criteria is unenforceable; or,
- 1C, if the criteria is not exceeded.

If the detection limit is too high to allow complete categorization of a chemical the chemical is placed in category 1D. For chemicals that have no criterion but have ambient data and for chemicals that have no ambient data, categories 1E and 2, respectively, have been developed.

The listing of chemicals in each category or sub-category will change as:

- knowledge about chemicals in these waterbodies increases;
- standards and criteria are improved/changed; and,
- additional information is gathered on ambient levels of these chemicals in Lake Ontario.

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APPENDIX G

SUMMARY OF SPILLS TO LAKE ONTARIO FOR THE 1989-91 PERIOD FROM MOE OCCURRENCE REPORTS

TABLE G1: SUMMARY OF SPILLS TO LAKE ONTARIO FOR THE 1989-91 PERIOD FROM MOE OCCURRENCE REPORTS				
Location	Controller of Material	Material	Amount	Date
Ajax	Unknown	Black film	film:1,500 m X 30 m	90/07/29
Amhertsburg	Ontario Hydro - Lambton	Oil sheen from North Floor Drain to River	Unknown	90/12/06
Belleville	Steven Howard Tug Boat	Petroleum oil - planned pumping out of bilge	Unknown	91/12/02
Belleville	Paperboard Industries Inc.	Paperboard Industrial Effluent bypassing	Unknown (10 ppm Solids)	91/08/12
Courtright	Lambton Generating Station	Water contaminated with coal dust/fly ash	912 L	90/06/05
Etobicoke	Humber STP	By-pass of sewage (primary treatment/chlorination)	Unknown	91/09/15
Hamilton	Dofasco	#2 Byproducts Plant clarifier overflow (high phenols)	Unknown (14 hours)(5-11 ppm)	91/02/03
Hamilton	Dofasco	#1 Hot Mill Wastewater (overflow of tanks/lagoons)	Unknown (150 ppm ss)	91/01/02
Hamilton	Dofasco	#2 byproducts plant clarifier overflow	2,487,600 L (18-61 ppm)	91/01/31
Hamilton	Dofasco	#1 Hot mill splinter box overflow-dirty water	2,000 L -conc. unknown	91/03/27
Hamilton	Dofasco	#1 Hot Mill Filtration Plant Dirty Water	9,000 L (70 ppm ss)	91/01/08
Hamilton	Dofasco	#2 Byproducts plant-Clarifier Effluent(high phenols)	Unknown	91/01/22
Hamilton	Dofasco	#1 Hot Mill dirty water (49 ppm ss average)-bypass	Unknown (24 hrs)	91/11/21
Hamilton	Dofasco	#1 Hot Mill Filtration Plant dirty water	Unknown	91/01/24
Hamilton	Dofasco	Dirty Water (4 ppm suspended solids: hot well overflow	18,000 L	91/10/01
Hamilton	Dofasco	Dirty Water:#1 Hot mill recycle :35ppm ss.	Unknown (26 hrs)	91/09/10
Hamilton	Dofasco	Dirty Water (178 ppm suspended solids) #1 Hot Mill	250 L	91/10/01
Hamilton Harbour	Marine Vessel(Vessel Winnipeg)	Petroleum- Bilge pumping	Sheen:900' X 10'	91/04/17

TABLE G1: SUMMARY OF SPILLS TO LAKE ONTARIO FOR THE 1989-91 PERIOD FROM MOE OCCURRENCE REPORTS

Location	Controller of Material	Material	Amount	Date
Hamilton	Dofasco	#2 Byproducts, clarifier overflow- 30-151 ppm P	Unknown(14 day)35 ppm	91/08/28
Hamilton	Dofasco	Calcium Carbonate precipitate	Unknown (few hours)	91/03/19
Hamilton	Dofasco	Dirty Water (4,000 ppm suspended solids) -#1 Hot Mill	341,000 L	91/07/09
Hamilton Harbour	Marine Vessel (Seaway Queen)	Petroleum oil: tar code 2 and perhaps tar code 3	Unknown	91/04/17
Hamilton	Power Tank Lines	Gasoline from truck overturning	32,000 L	91/03/01
Hamilton	Stelco Steel Hilton Works	Machine Wash with Nitrates due to valve leak	1,400 L (500 ppm NO2)	91/01/13
Hamilton	Stelco Steel Hilton Works	#2 Caster Machine Water (540 ppm nitrite conc.)	6,050 L	91/07/09
Hamilton	Stelco Steel Hilton Works	Blast Furnace Recycle Water - ss,iron, phenol,ammonia&cyanide	40,000 L	91/12/27
Hamilton	Stelco Steel Hilton Works	Hydraulic oil (42% oil)	2,250 L	91/09/06
Hamilton	Stelco Steel Hilton Works	Blast-furnace recirc. : iron, ss, cyanide & ammonia	500 L	91/05/15
Hamilton	Unknown	Light brown material/foam at Dofasco Outfall	Unknown	91/01/07
Hamilton Harbour	Marine Vessel (N.O.S)	Light Diesel fuel (container leak)	Small quantity	91/03/15
Hamilton	Unknown -Wellington St. Slip	Fuel oil	Unknown	91/03/15
Hamilton	Unknown	Orange coloured slick at Dofasco Dock	Unknown	91/09/13
Hamilton	Stelco Steel Hilton Works	Blast furnace recycle Water-ss, iron, phenol ,ammonia & cyanide	1,600 L	91/12/02
Hamilton	Stelco Steel Hilton Works	East Side Filtration wastewater	2,400,000 L	91/01/09
Hamilton	Stelco Steel Hilton Works	Chromate Water- tin free steel electrolyte solution	5,500 L	91/09/18
Hamilton	Stelco Steel Hilton Works	"E" Blast Gas Recycle Water(Suspended Solids)	5,000 L	91/09/12
Hamilton	Stelco Steel Hilton Works	East side filtration plant machine cooling water	3,050 L	91/09/06

TABLE G1: SUMMARY OF SPILLS TO LAKE ONTARIO FOR THE 1989-91 PERIOD FROM MOE OCCURRENCE REPORTS

Location	Controller of Material	Material	Amount	Date
Hamilton	Stelco Steel Hilton Works	Blast Furnace -dirty water from recirculation system	Unknown(912 L/minute)	91/08/12
Hamilton	Stelco Steel Hilton Works	Dirty water(suspended solids), iron and carbon	112,500 L	91/01/22
Hamilton	Stelco Steel Hilton Works	NO_2 contaminated machine cooling water - East Side Filtration	11,550 L (560 ppm NO2)	91/10/02
Hamilton	Stelco Steel Hilton Works	Blast furnace recycle water (NAOH & phosphoric acid)	559,200 L	91/01/22
Hamilton	Stelco Steel Hilton Works	Blast Furnace Recirc. Water: phenols, cyanide, ammonia	654,000 L	91/10/01
Hamilton	Dofasco	#1 Steelbottom effluent wastewater discharge/bypass	Unknown	91/10/01
Hamilton	Pleasure Craft	Petroleum	sheen: 100 m^2	90/06/30
Hamilton	Dofasco	Dirty/scale water from tank leak of Slab Cooling Pit	Unknown (22 min)	90/11/01
Hamilton	Dofasco	Lubricating oil	15 L	90/08/20
Hamilton	Stelco Steel Hilton Works	Oil Sheen	Unknown	90/03/09
Hamilton	Stelco Steel Hilton Works	Wastewater bypass (power interruption)	35,230 m^3	90/07/19
Hamilton	Unknown	Oil Tar Code 2	sheen:800'X 40-60'	90/06/14
Hamilton	Stelco Steel Hilton Works	Overflow (tanks, lagoons) due to electrical failure- Lime Slurry	Unknown	90/10/21
Hamilton	Dofasco	Calcium precipitate (West Bay Front Sewer)	Unknown	90/10/01
Hamilton	Dofasco	Calcium precipitate (West Bay Front Sewer)	Unknown	90/10/03
Hamilton	Unknown	Petroleum (light blue oil)	sheen: 60'x 200'	90/12/11
Hamilton	Stelco Steel Hilton Works	Calcium Hydroxide	100 L	89/06/12
Hamilton	Unknown	Oily Sheen	sheen:220'X 100'	89/11/27
Hamilton	Dofasco	Calcium precipitate (West Bay Front Sewer)	Unknown	90/10/02

TABLE G1: SUMMARY OF SPILLS TO LAKE ONTARIO FOR THE 1989-91 PERIOD FROM MOE OCCURRENCE REPORTS				
Location	Controller of Material	Material	Amount	Date
Hamilton	Dofasco	Phenol Spill from #2 Byproducts Plant	On-going	89/04/29
Hamilton	Dofasco	Calcium Hydroxide	Unknown	90/07/06
Kingston	Algoma Steel	Bunker "C" Spill	400 L	89/05/16
Kingston	Marine Vessel (NOS)	Diesel fuel & water mixture	sheen:360'X 70'	89/08/16
Kingston	Dupont	Dowtherm (1500 ppb)- entered through service sewer	158 kg	91/06/02
Mississauga	Ontario Hydro Lakeview TGS	Ammonium Nitrate- 50% solution	900 kg	91/04/15
Mississauga	Petro Canada	Tallow Spill	80,000 L	89/04/25
Mississauga	Petro Canada	Lubricating oil/grease	35 L	91/11/22
Mississauga	Ontario Hydro - Lakeview TGS	Furnace Oil	135 L	91/07/10
Mississauga	Otonobee Trucking	Sulfuric Acid/Furnace oil	1,200 L /6,500 L	89/11/14
Nanticoke	Ontario Hydro- Nanticoke	Lubricating oil (dyke failure of lagoons/ponds)	Unknown	89/12/11
Newcastle	Ontario Hydro-Darlington	Florescein sodium	400 L at 10 ppm	90/06/21
North York	Dehavilland	Waste Oil (4% oil)	12 drums	90/09/18
Oakville	Petro Canada	Asphalt Sealer	5 L	91/01/09
Oakville	C.N.R.	Petroleum gases N.O.S.	Unknown	90/06/15
Oshawa	Chieftain Cement	Portland Cement Powder	Unknown	91/07/05
Pickering	Pickering Nuclear Plant	sodium hypochlorite (12% solution)	150 L	91/11/07
Pickering	Motor Vehicle	Diesel Fuel	100 L	90/10/09
Prescott	L. Rochette/Voxg Marine Vessel	Oil sheen	Unknown	90/12/06
Scarborough	Unknown	Light oil sheen	Unknown	90/06/28
St. Catherines	Domtar Fine Paper	Paper Mill Effluent (100 ppm ss)	408,000 L	91/11/24
Thorold	Noranda Paper	Pulp Mill Effluent	Unknown (10 min.)	90/03/05
Toronto West	Lawson Graphics	Solvent spill in plant entered storm sewer	Unknown	91/07/25

TABLE G1: SUMMARY OF SPILLS TO LAKE ONTARIO FOR THE 1989-91 PERIOD FROM MOE OCCURRENCE REPORTS

Location	Controller of Material	Material	Amount	Date
Toronto Harbour	Unknown	Diesel Fuel from container lead	45 L	91/09/28
Toronto	Plaza 2 Hotel	Diesel fuel spill to ground and sewer	100 L	91/06/15
Toronto	Richvale Block and Ready-mix	Hydrochloric Acid	1,360 L	91/05/22
Toronto	Main STP	Processed but unchlorinated sewage	Unknown (150 min)	91/02/02
Toronto	Main STP	Processed but unchlorinated sewage	Unknown (80 min)	91/02/03
Toronto	Main STP	Digested Sludge (mostly foam) overflowed from digesters	10,000 L	91/10/31
Toronto Harbour	Unknown	Petroleum Oil	Unknown	91/11/22
Toronto Harbour	Trillium Ship	Diesel Fuel	200 L	90/05/29
Toronto	Texaco	Oily Water - tanks/lagoon overflow (storm)	Unknown	89/11/01
Toronto	Harbour Castle Hilton	Oil Sheen	Unknown	89/10/24
Toronto	C.N.R.	Diesel Fuel	Unknown	90/09/11
Toronto	Unknown	Oil Sheen, Oil Slick (N.O.S.)	sheen:6' x 1,000'	90/09/06
Toronto East	North York Hydro	Transformer Oil	<20 L at >50 ppm PCB	89/06/28
Toronto West	Malfunction and Breakdown Electrical Products	Cyanide contaminated well overflowed	Unknown	91/08/02
Toronto Harbour	Toronto Island Ferry	Diesel Fuel	Unknown	90/12/11
Toronto East	Ontario Hydro	Mineral Oil (50 ppm PCB)	675 L (50 ppm PCB)	90/04/25
Trenton	Domtar Wood	Oil & grease/phenols/penta-chlorophenol/ss	2250 L	91/03/27
Whitby	Brass Dolphin Sailboat	Diesel Fuel	20 L	90/10/07
York/Durham	Ajax Steam Plant	Bunker "C" oil	Unknown	89/09/06

APPENDIX H

MODELLING CHEMICAL FATE IN LAKE ONTARIO

H.1. Chemical Fate

These estimates of chemical fate are predictions developed by a model which are inherently uncertain. Prediction errors have several causes, including conceptual flaws and errors in model structure, neglect of phenomena of first order importance, and uncertainty in the appropriate values of model parameters. From the results of this chemical fate analysis it can be seen that most of the chemicals are deposited in sediment and are buried, although significant amounts of hexachlorobenzene and PCBs volatilize.

TABLE H1 : **CHEMICAL FATE AND TRANSPORT EXPRESSED AS PERCENTAGE OF LOADING FOR LAKE ONTARIO**

CHEMICAL	CHEMICAL FATE (% of load)			
	BURIAL	VOLATILIZATION	PHOTOLYSIS	OUTFLOW
Chlordane	53.0	32.6	0	14.4
DDT	50.1	13.3	23.0	13.6
Dioxin (TCDD)	46.44	17.8	28.3	7.45
Dieldrin	69.5	1.68	0.287	28.5
Hexachl.	16.9	77.7	0.238	5.2
Mirex	78.3	10.8	0.763	10.2
PCB (Aroclor 1248)	30.3	62.8	0	7.41
PCB (Aroclor 1254)	48.4	43.6	0	7.93

SOURCE : Endicott et al. 1991. A Steady State Mass Balance and Bioaccumulation Model for Toxic Chemicals in Lake Ontario. Environmental Research Laboratory. P. 52.

APPENDIX J

Industrial Sewer-use

TABLE J1 :SOURCES OF MUNICIPAL SEWAGE TREATMENT PLANT RAW SEWAGE

NAME OF SEWAGE TREATMENT PLANT (STP)	PERCENT OF RAW SEWAGE FROM SOURCES			PERCENT NOT ACCOUNTE FOR	TOTAL # OF INDUSTRIES •	# OF INDUSTRIES WITH WATER	# of SIC CODES	TOP 5 INDUSTRIES DISCHARGING TO STP (BASED ON WATER USE DATA)	SIC CODE	# OF COMPANIES
	INDUSTRY	COMMERCE	RESIDENCES							
Burlington Skyway	17	13	30	40	335	248	44	Chemicals/Chemical preparation	2011-2013	4
								Misc. Metals Fabricated Products	2899-2899	11
								Electrical and Electronic Comp.	3612-3690	17
								Stone, Clay and Mineral Products	3200-3299	15
Baker Road (Grimsby)	0	12	28	60	1	0	1			
Woodward Ave (Hamilton)	10	7	17	65	608	306	56	Iron & Steel	3300-3317	10
								Electrical/Electronic Cmpt	3612-3690	17
								Metal Finishing	3411-3469	71
								Rubber Mfg and Processing	3011-3069	5
Kingston City	2	7	15	76	99	40	23	Dairy	2021-2026	1
								Textile	2271-2269	2
								Stone, clay & mineral products	3200-3299	2
								Waste treatment & disposal	4592-4592	4
								Printing & Publishing	2700-2799	9
Kingston Township	4	8	18	71	55	24	19	Copper forming	3361-3367	1
								Plastics, resins & synthetics	2821-2824	3
								Fibers Mfg	3271-3273	4
								Cement Mfg	3600-3599	6
								Machinery Mfg	3070-3079	1
Lindsay	19	8	19	53	62	32	28	Asbestos Mfg	3292-3292	1
								Misc. Fabricated Metal Prod.	3490-3499	1
								Machinery Mfg	3070-3079	5
								Plastics, resins & synthetics	2821-2824	1
									3363-3366	1
Clarkson	25	12	28	35	NOT AVAILABLE					
Lakeview	12	8	18	62	2515	741	68	Transportation Equipment	3711-3799	93
								Pulp, paper, paperboard mills	2600-2631	4
								Machinery Manufacturing	3500-3599	531
								Grain Mills	2041-2048	10
								Metal Finishing	3411-3469	251
Niagara-on-the-Lake Lagoon	25	9	22	44	27	18	13	Fruit and Vegetables	2032-2038	2
								Dairy	2021-2026	1
								Transporation Equipment	3711-3799	2
								Beverages	2082-2087	4
								Metal Finishing	3411-3491	3
Oakville Southeast	0.4	13	29	58	312	32	42	Photographic Chemicals	3861-3861	2
								Transportation Equipment	3711-3799	24
								Primary Textile	2211-2269	3
								Pharmaceutical	2830-2834	1
								Coil Coating	3479-3479	5
Peterborough	22	9	20	49	144	51	28	Electrical, Electronic Cmpts	3612-3690	6
								Plastics Molding	3070-3079	7
								Machinery Mfg	3600-3699	15
								Misc. Converted Paper Products	2640-2665	4
								Grain Mills	2041-2048	2
Duffin Creek (Peterborough)	25	3	7	65	1185	146	55	Plastics Molding	3070-3079	46
								Metal Finishing	3411-3469	75
								Printing/publishing	2700-2799	162
								Wood/metal Furniture Mfg	2510-2699	62
								Nonferrous Metals Forming Mfg	3331-3369	8
Toronto Highland Creek	22	5	13	60	874	539	54	Misc. Converted Paper Products	2640-2656	37
								Electrical & electronic components	3612-3690	80
								Machinery Mfg	3600-3699	165
								Printing & Publishing	2700-2799	134
								Fruit & Vegetables	2032-2038	7
Toronto Humber	19	12	27	43	1777	1628	60	Beverages	2082-2087	18
								Printing & Publishing	2700-2799	162
HHBA AC								Metal Finishing	3411-2469	218
								Machinery Mfg	3600-3699	246
								Plastics Molding	3070-3079	91
Main (Toronto)	8	9	22	61	2488	1993	63	Printing & publishing	2700-2799	493
								Beverages	2082-2089	20
								Apparel & Other Textiles Products	2311-2399	318
								Transportation Equipment	3711-3799	22
								Pharmaceutical Mfg	2830-2834	16
North Toronto	8	12	27	53	91	83	28	Printing & Publishing	2700-2799	42
								Instruments & Related Products	3811-3873	4
								Machinery Mfg	3600-3699	7
								Electrical & Electronic Components	3612-3690	5
								Stone, clay & mineral products	3200-3299	2
Pringle Creek	22	12	27	40	108	24	29	Fruit & Vegetables	2032-2038	1
								Electrical & electronic components	3612-3690	6
								Misc. Converted Paper Products	2640-2666	2
								Electroplating	3471-3471	2
								Wood & Metal Furniture Mfg	2510-2699	5

SOURCE : Canviro Consultants (1988)

APPENDIX I

MISA Monitoring Schedules

TABLE II : Iron and Steel Sector's Effluent MISA Monitoring Requirements

Chemical	EFFLUENT	STORM WATER	WASTE SITE	COOLING WATER	STORAGE SITE	OVERFLOW
Arsenic	C (I,S)					
Benz(a)Anthracene	C(I,S)					
Benzo(b)Fluoranthene	C(I,S)					
Benzo(k)Fluoranthene	C(I,S)	M (I)	M (I)		M (I)	M (I)
Benzo(a)Pyrene	C(I,S)					
Chlordane						
Chrysene	C(I,S)					
DDT						
Dieldrin						
Dioxin (2,3,7,8-TCDD)	C(I,S)					
Hexachlorobenzene	C(I,S)					
Lead	C(I,S)	M (I,S)	M (I,S)	M (I,S)	M (I)	M (I,S)
Mercury	C(I)					
Mirex						
Octachlorostyrene	C(I,S)					
PCBs	C(I,S)					
Tetrachloroethylene	C(I,S)					
Toxaphene						

LEGEND:
C - characterization required for all final effluent and cooling waters
M - monthly monitored by the regulation
I- integrated steel mills, ie., Stelco Hilton Works and Dofasco
S - specialty steel and mini-mill operations ie., LASCO

Characterization is required initially (ie within 3 months of first routine sampling) once between six and nine months later, every three years thereafter and after each significant process change. The purpose of characterizing effluent discharges is to determine the presence or absence of pollutants of concern in petroleum refinery effluent, following consistent and uniform sampling and analytical principles and protocols.

TABLE I2 : PETROLEUM REFINING SECTOR'S MISA EFFLUENT MONITORING REQUIREMENT

Chemical	CHARACTERIZATION	PROCESS	LANDFARM LEACHATE	COOLING WATER
Arsenic	C	Q	Y	
Benz(a)Anthracene	C	Q	Y	
Benzo(b)Fluoranthene	C	Q	Y	
Benzo(k)Fluoranthene	C	Q	Y	
Benzo(a)Pyrene	C	Q	Y	
Chlordane				
Chrysene	C	Q	Y	
DDT				
Dieldrin				
Dioxin (2,3,7,8-TCDD)	C			
Hexachlorobenzene	C	Q	Y	
Lead	C	Q	Y	
Mercury	C	Q	Y	
Mirex				
Octachlorostyrene	C			
PCBs	C			
Tetrachloroethylene	C	Q	Y	
Toxaphene				

LEGEND:
C - characterization required for all final effluent and cooling waters
Q - 3 daily samples within one week, each quarter for process effluent
Y - Once per year for landfarm leachate
Characterization is required initially (ie within 3 months of first routine sampling) once between six and nine months later, every three years thereafter and after each significant process change. The purpose of characterizing effluent discharges is to determine the presence or absence of pollutants of concern in petroleum refinery effluent, following consistent and uniform sampling and analytical principles and protocols.

TABLE I5 : PULP AND PAPER SECTOR'S MISA EFFLUENT MONITORING REQUIREMENTS

Chemical	Process	Sulphite	De-inking	Bleached Pulp	Waste Disposal Site	Land use of Coal Storage/Waste Disposal Site
Arsenic						
Benzo(a)anthracene	M				M	
Benzo(b)fluoranthene	M				M	
Benzo(k)fluoranthene	M				M	
Benzo(a)Pyrene	M				M	
Chlordane						
Chrysene	M				M	
DDT						
Dieldrin						
Dioxin (2,3,7,8-TCDD)	S	M	M	B		
Hexachlorobenzene	M					
Lead	M				M	X
Mercury	M				M	X
Mirex						
Octachlorostyrene	M					
PCBs	S					
Tetrachloroethylene	M					
Toxaphene						

LEGEND
Categorization (cat.) - open characterization of volatile organic compounds and extractable organic compounds.
B - bimonthly monitoring
M - monthly monitoring
S - semiannual monitoring
Sulphite Mills - Quebec & Ontario, Paper
Corrugated Cardboard - Domtar Packaging, Trenton
De-inking Board - Kimberly Clark (St. Catherines), Beaver Wood Fibre Co. (Thorold), Noranda Forest (Thorold), Strathacona Paper Co.(Camden), Trent Valley Paperboard (Glen Miller).

APPENDIX K

MISA Preregulation Monitoring of General Motors

TABLE K1 : MISA PREREGULATION MONITORING OF GENERAL MOTORS AND LOADING ESTIMATES OF PRIORITY TOXIC CHEMICALS TO LAKE ONTARIO

	Number of Samples	Number of Detects	Detection Limit (g/L)	Average Conc. (mg/L)	Average Load (kg/day)
Arsenic	3	1	1e-06	0.001	0.136
Benz(a) anthracene	3	0	2e-07	ND.	ND.
Benzo(b) fluoranthene	3	0	2e-07	ND.	ND.
Benzo (k) fluoranthene	3	0	2e-07	ND.	ND.
Benzo (a) pyrene	3	0	1e-07	ND.	ND.
Chlordane	0			NI.	NI.
Chrysene	3	0	2e-07	ND.	ND.
DDT & DDE	0			NI.	NI.
Dieldrin	0			NI.	NI.
Dioxin (2,3,7,8-TCDD)	3	0	3e-10	ND.	ND.
Hexachlorobenzene	3	0	1e-05	ND.	ND.
Lead	3	1	1e-05	0.023	3.122
Mercury	3	1	1e-07	0.0002	0.027
Mirex	0			NI.	NI.
Octachlorostyrene	3	0	1e-05	ND.	ND.
PCBs	3	3	1e-07	0.12	0.016
Tetrachloroethylene	3	0	8e-04	ND.	ND.
Toxaphene	0			NI.	NI.

Flow : 135,760 cubic metres/day (from 1988 annual average as not available in report)

Source : MISA Preregulation Monitoring Metal Casting Sector, Canviro, 1989.

Treatment of non-detects: where one sample was above the method detection limit (DL), one-half the DL was assigned to censored data.

LEGEND
NI - no information
ND - non-detect

APPENDIX L

Determining the Value of Censored data for Tributary Loadings

L. Determining the Value of Censored data for Tributary Loadings

The maximum likelihood (ML) estimation method was used as a diagnostic tool to determine the most appropriate value to use for censored data. First, contaminant loadings from tributaries to Lake Ontario were calculated by ML for the parameters that registered three detects. The computer program requires at least three samples to be detected to run and so, greatly narrows down the parameters and the tributaries for which loadings could be estimated.

See Table L1 for the estimation of censored data. The ML method estimates the mean and standard deviation from censored data by approximating the likelihood function. ML has properties of asymptotic efficiency and unbiasedness. The mean square error of the ML estimator is significantly smaller than the variance of the best linear unbiased estimators. See El -Shaarawi and Dolan (1989)[1]. The ML approach was deemed most appropriate as typical aqueous concentration time series exhibit irregular sample spacing, high intrinsic variability, non-normality often as positive skew, numerous outliers, co-variable (i.e., flow or temperature) effects and other problematic features that could severely distort the results if standard statistical treatment was applied. The ML can be applied to data of log normal or normal distribution[2].

Second, in order to compare the ML loading estimates with loadings from arbitrary values estimates were made when the value of censored data was given: the detection limit, the detection limit divided by two, the detection limit divided by ten, and zero. As can be seen from Table L2 the value adopted as the detection limit changes the value of the loading significantly (due to large flows). If censored data is given the value of the detection limit the loadings from the Welland Canal to Lake Ontario are 127.76 kg/day and if given the value of zero, 31.30 kg/day.

Lastly, by comparing the loadings from the two tables it was determined that the detection limit divided by ten should be applied to parameters with low frequencies of detection and that the detection limit divided by two should be applied to parameters with high frequencies of detection. The loadings from ML were closest to the loadings divided by ten when the frequency of detection is low. Likewise the loadings from ML were closest to the loadings divided by two.

REFERENCES

1. El-Shaarawi, A.H. and D. Dolan. 1989. "Maximum likelihood estimation of water quality concentrations from censored data". Canadian Journal of Fisheries and Aquatic Sciences, Vol. 46. No. 6, p.p. 1033-1039.

2. Dolan, D. and A.H. El-Shaarawi. 1989. "Interferences about Point Source Loadings from Upstream/Downstream river Monitoring Data". Environmental Monitoring and Assessment, Vol. 12, pp. 343-357.

TABLE L1: Determining the Value of Censored data for Tributary Loadings using the Method Detection Limit

TRIBUTARY	NUMBER > PDL	NUMBER OF SAMPLES	MEAN CONC. (mg/L)	MAX. LOAD (kg/day)	MIN. LOAD (kg/day)	MEAN LOAD (kg/day)
Bronte	3	47	0.001593	0.218	0.04858	0.1143
Don	58	129	0.01164	5.377	2.887	4.011
Duffins	5	46	0.00283	1.426	0.1519	0.5876
Grindstone	10	46	0.004138	0.359	0.1382	0.2324
Highland	15	46	0.008946	1.695	0.4442	0.943
Humber	43	153	0.006221	3.706	2.038	2.794
Napanee	5	31	0.002844	2.707	1.125	1.809
Oakville	6	33	0.003014	0.4638	0.2084	0.3203
Oshawa	10	44	0.008871	2.036	0.2015	0.8315
Rouge	9	59	0.003237	0.6364	0.2286	0.4005
Salmon	3	31	0.002143	3.387	0.682	1.713
Trent	3	153	0.000107	25.95	2.945	10.89
Twelve	4	63	0.002821	2.319	0.05782	0.6898
Welland	8	46	0.003664	118.15	38.23	71.23
SUM OF SAMPLE				168.4302	49.3862	96.5664

LEGEND: PDL - practical detection limit

TABLE L2: APPLICATION OF VARIOUS VALUES FOR CENSORED DATA AND THE EFFECT IT HAS ON LOADING ESTIMATES FOR METALS IN TRIBUTARIES

RIVER/STREAM	Flow M3/day	Number Samples	Number Detects	Percent Detects	Average conc.(mg/L) Nd = 0	kg/day Loading ND=DL	Loading ND=DL/2	Loading ND=DL/10	Loading ND=0
LEAD									
Mimico	6.1E+04	12	10	83%	2.0E-02	1.27	1.26	1.25	1.23
Twelve Mile Creek	2.4E+05	63	4	6%	1.9E-03	1.58	1.02	0.47	0.46
Millhaven	1.3E+05	17	3	18%	1.2E-03	0.69	0.42	0.17	0.15
Welland Canal	1.9E+07	46	8	17%	1.7E-03	127.76	70.01	32.94	31.30
Oakville	1.1E+05	33	6	18%	1.2E-03	0.68	0.35	0.14	0.13
Credit River	6.8E+05	66	10	15%	2.4E-03	4.43	3.04	1.71	1.65
Humber River	4.5E+05	153	43	28%	4.7E-03	3.70	2.90	2.16	2.09
Highland Creek	1.1E+05	46	15	33%	6.6E-03	1.05	0.87	0.71	0.69
Duffins Cr.	2.1E+05	46	5	11%	1.8E-03	1.31	0.85	0.39	0.38
Carruthers	NI	43	4	9%	2.0E-03				
Lynde	7.9E+04	46	4	9%	2.6E-03	0.57	0.39	0.21	0.20
Pringle	NI	46	9	20%	2.8E-03				
Oshawa	9.4E+04	44	10	23%	5.6E-03	0.89	0.72	0.54	0.53
Farewell	5.1E+04	39	10	26%	1.1E-02	0.77	0.68	0.59	0.58
Soper	NI	19	7	37%	9.5E-03				
Etobicoke Creek	1.6E+05	56	21	38%	8.8E-03	1.89	1.64	1.42	1.39
Rouge River	1.2E+05	59	9	15%	2.3E-03	0.80	0.54	0.29	0.28
Gage River	NI	31	3	10%	5.4E-03				
Cobourg	NI	42	4	10%	1.9E-03				
Colbourne	NI	44	3	7%	4.6E-04				
Proctors	0.0E+00	42	3	7%	1.8E-03				
Millhaven	1.3E+05	31	3	10%	6.5E-04	0.67	0.38	0.09	0.08
Redhill	NI	30	9	30%	4.5E-03				
Spencer	NI	32	9	28%	5.4E-03				
Grindstone	5.6E+04	46	10	22%	3.5E-03	0.42	0.31	0.20	0.20
Trent	1.0E+07	153	3	2%	1.4E-04	51.42	26.45	1.57	1.47
Salmon River	8.0E+05	31	3	10%	1.1E-03	4.67	2.71	0.94	0.90
Napanee River	6.4E+05	31	5	16%	1.5E-03	3.59	2.26	0.97	0.92
Bronte	7.2E+04	47	3	6%	5.7E-04	0.38	0.21	0.04	0.04
Don River	3.4E+05	129	58	45%	9.5E-03	4.21	3.74	3.34	3.26
SUM OF LOADING FOR LEAD						212.67	120.73	50.14	47.96
MERCURY									
Don River	3.4E+05	127	32	25%	1.5E-06	0.003	0.002	0.001	0.001
Moira River	2.4E+06	65	3	5%	1.8E-06	0.026	0.016	0.004	0.004
Trent River	1.0E+07	139	42	30%	1.1E-05	0.183	0.163	0.143	0.112
Redhill	NI	27	3	11%	7.0E-06	0.000	0.000	0.000	0.000
Twelve Mile Creek	2.4E+05	63	4	6%	2.4E-06	0.003	0.002	0.001	0.001
Millhaven	1.3E+05	8	3	38%	2.1E-05	0.004	0.003	0.003	0.003
Welland Canal	1.9E+07	46	8	17%	3.3E-06	0.226	0.139	0.065	0.062
Credit	6.8E+05	55	12	22%	1.9E-06	0.018	0.016	0.013	0.013
Humber	4.5E+05	153	15	10%	6.9E-06	0.007	0.005	0.004	0.003
Etobicoke Creek	1.6E+05	56	14	25%	1.9E-05	0.005	0.004	0.003	0.003
SUM OF LOADING FOR MERCURY						0.475	0.349	0.237	0.201
ARSENIC									
Moira	2.4E+06	65	58	89%	5.4E-03	14.19	14.02	13.11	12.90

LEGEND: NI – NO INFORMATION, ND – NON DETECTS

DL – DETECTION LIMIT FOR: LEAD=0.005mg/L. ARSENIC = 0.001 mg/L. MERCURY 0.00002 mg/L

Note: not all 42 streams were reported as they had less than 3 detects for the 4-year period. For years 1987 to 1990 (MOE data).