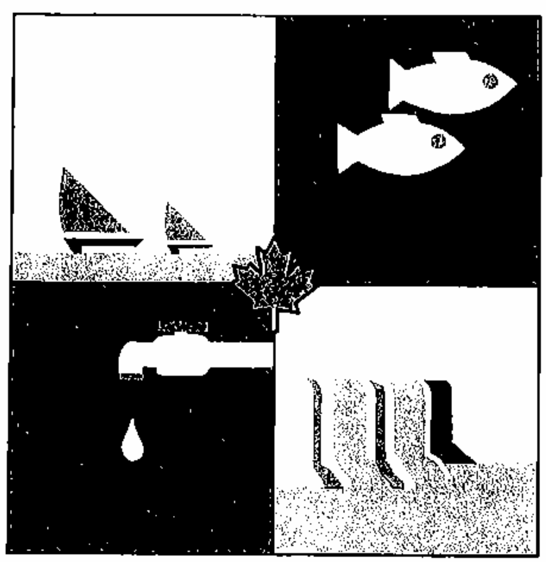
NIAGARA RIVER REMEDIAL ACTION PLAN

Stage 1 - *UPDATE*

Environmental Conditions and Problem Definition

March 1995



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Remedial Action Plan
Plan d'assainissement

Canada Ontario

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ACKNOWLEDGEMENTS

The remedial action plan process is a consultative, consensus building process involving many participants, representing many jurisdictions. The production of the Stage One Update Report, is the result of a collaborative effort.

The RAP is a challenging process to work within due to a large number of participants, jurisdictions and its use of consensus as a decision making tool. Interestingly, it is this consensus component that makes it an empowering process - it can and did get things done. The RAP process was able to provide a forum that combined the efforts of a diverse group of individuals representing a wide range of knowledge, expectations, interests, commitment and patience. The Stage One Update Report is the product of this process.

Members of the Public Advisory Committee (PAC) are community volunteers who are to be complimented and commended for their ability to articulate and work with the community perspective in this challenging process. Chairing such a body deserves a special thank you. Supporting the PAC, while an essential task, is never easy in a consensus process. The role of the PAC Community Liaison Coordinator needs to be recognized for the essential service it really is.

RAP Team members also deserve to be recognized for their efforts to move the RAP forward by integrating it into their agencies' agendas. The RAP Team Coordinator played a key role in meshing the RAP process with government policies and procedures.

The Technical Advisory Committee members are to be thanked for their review and comment on the information contained in the Stage One Update Report. Members contributed to both the comprehensiveness and detail of the material in the Remedial Action Plan.

In addition to these Niagara River RAP participants, there is a diverse umbrella of agencies, organizations and individuals outside of the formal RAP process who, through their advice and comments, supported the cleanup efforts of the Niagara River RAP. In this sense, they were very much partners in the Niagara River RAP process working to make their environment better. This report was written by Jim Martin.

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INTRODUCTION

Since its completion and release in September 1993, the Stage One Report "Environmental Conditions and Problem Definition" has been the subject of two forms of review, one formal, the other informal.

The Stage One Report was formally reviewed by Federal and Provincial government agencies (July 1993) and the International Joint Commission (December 1993). Both reviews identified missing information or data gaps, information that was felt to be essential for the reader to have a complete picture of environmental conditions in the Niagara River Area of Concern (AOC). The missing information can be categorized as: surveys and inventories; species impact studies (e.g., reproduction, physical deformities) and wildlife and fish populations habitat studies.

In addition to this formal review, the Remedial Action Plan (RAP) process has continued its own evolution. Stage 2 now includes a review and consideration of not only sites adjacent to the waterbody but also upland woodlots, forests and oldfields (meadows) and the connection between the rivers and surrounding lands. Appendix A of 'The Cleanup Connection' *(the Stage 2 Report)* discusses the need to include all biota and habitat sites in a discussion of water quality in the rivers and tributaries.

The Stage One Update Report includes: information that was identified as missing from the Stage One Report; new information from recent studies, and; information that was previously considered 'outside' the scope of the Stage One Report.

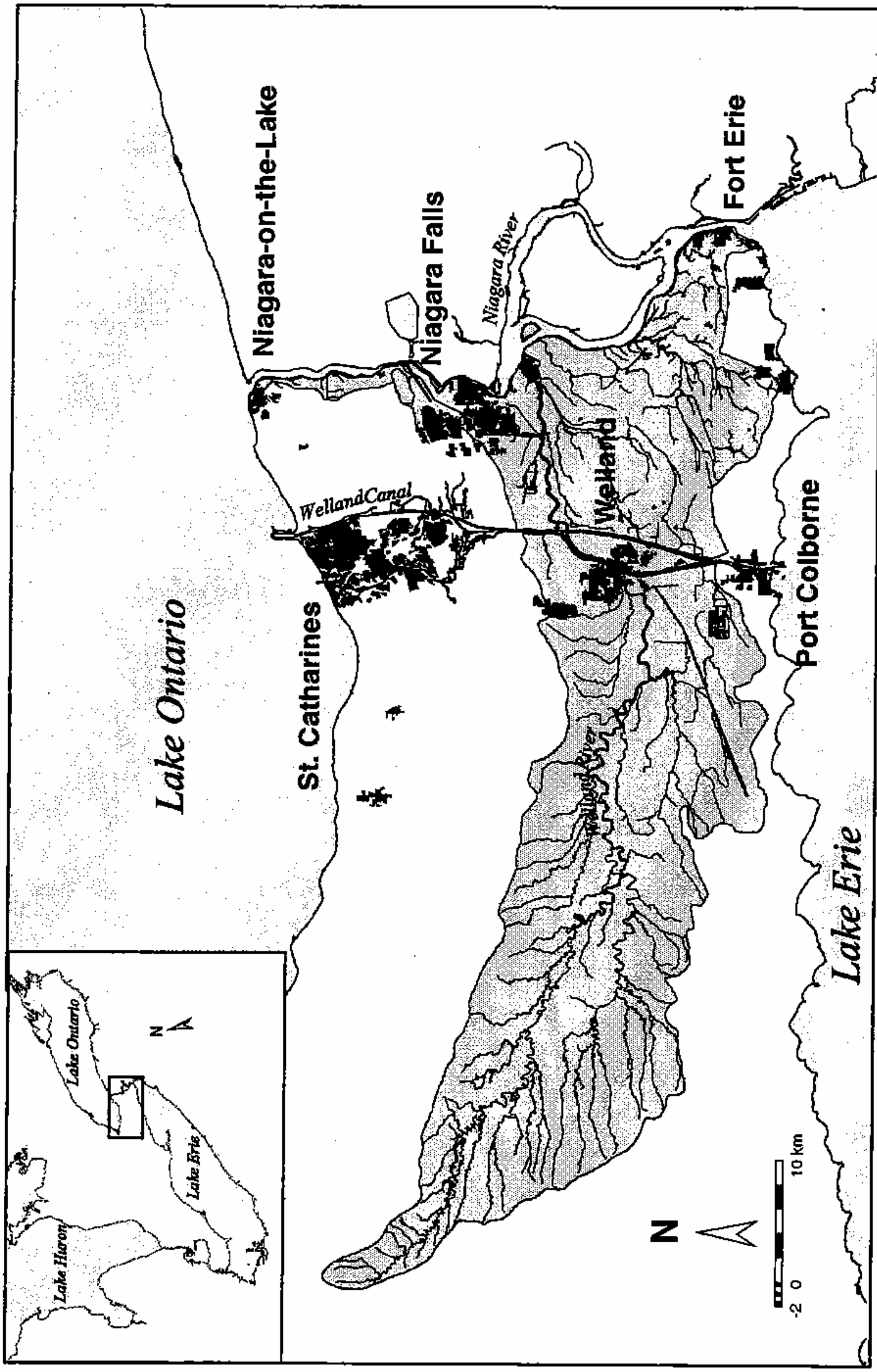
Public Information Centre

The Ontario Ministry of Environment and Energy maintains a Public Information Centre. The purpose of the Centre is to handle all general inquiries, provide a reading area for reference copies of MOEE publications and distribute MOEE publications. The Centre can also provide sources and contacts for environmental and energy information in MOEE offices, other ministries, government and non-government organizations.

All MOEE reports cited in this report are available to the public through the Public Information Centre.

For calls outside of Toronto, the Centre can be reached at 1-800-565-4923. The Centre is located at 135 St. Clair Avenue West, 1st Floor, Toronto, Ontario M4V 1P5.

Niagara River Watershed (Ontario)



Data Source: Watershed digitized from Water Resources of the Niagara Frontier and the Welland River Drainage Basin (Gartner Lee Ltd., 1987). Rivers extracted from Natural Resources Canada 1:50 000 mapsheets.

Map created by Water Issues Division
Environment Canada
Environnement Canada

Map 1

DESCRIPTION OF NIAGARA RIVER AREA OF CONCERN

HISTORICAL FOOTNOTES OF THE NIAGARA RIVER

A Sampling of Quotes through the Years
(Source: Anthology and Bibliography of Niagara Falls. Charles M. Dow, LL.D., Volumes 1 and 2. 1921)

"The spray from these waters (Niagara Falls) rebounding from the foot of certain large rocks in that place, forms stone or petrified salt, of a yellowish colour ... In this horrible place ther dwell also certain savages who live only on the elks, stags, wild cows, and other kinds of game which the rapids carry along and cast among these rocks..."
(Gendron, Le Sieur, 1644-45)

"The lands, which lie on both sides of (the river) to the east and west, are all level from the Lake Erie to the Great Fall. Its Banks are not steep...the water is almost always level with the land. The Isle (on the brink of the Falls) is full of Cedar and Firr."
(Hennepin, Louis 1678)

"This great Deluge of Water tumbling furiously over the greatest and most dreadful Heap in the World, an infinite Number of Fish take a great Delight to spawn here, and as it were suffocate here, because they cannot get over this huge Cataract: So that the Quantity taken here is incredible."
(Lahontan, Louis Armand de Lon D'Arce 1688)

"The soil of the three leagues I had to walk a foot to get hither, and which is called the carrying-place of Niagara, seems very indifferent; it is even very ill-wooded, and you cannot walk ten paces without treading on ant-hills or meeting with rattlesnakes, especially during the heat of the day."
(Charlevoix, Pierre Francois Xavier de. 1721)

Charlevoix confirms Father Hennepin's and Mr. Kelug's (?) account of the large trouts of those lakes, and solemnly affirmed there was one taken lately, that weighed 86 lb... that he saw a pike taken in a Canada river, and carried on a pole between two men, that measured five feet ten inches in length and proportionately thick.

"We often find on the shores of this basin, fish, bear, deer, geese, ducks and various kinds of birds which have been killed in passing over, having been drawn in by the water, or the current of air formed by the falls."
(Pouchot, M. 1755-1760)

"The lands (between Queenston and Niagara) are generally covered with white oak, but they are neither strong or well improved."
(Lincoln, Benjamin 1793)

"At the bottom of the Horse-shoe Falls is found a kind of white concrete substance, ... called spray. ... This concrete substance has precisely the appearance of petrified froth."
(Weld, Isaac 1796)

"I observed King-fishers, Pigeon -Hawks, Moths and Grasshoppers, but no Mosquitoes, and few Flies."
(Maude, John. 1800)

"Bears live in the clefts of the rocks below the Falls, as do also Wolves; and I may add Rattlesnakes, which are found in great number and extraordinary size."
(Maude, John. 1800)

"...For Niagara, I forsee that in a few years travellers will find a finger post, 'To the Falls' Tea Gardens,' with cakes, and refreshments, set out on the Table Rock."
(Hall, Frances 1816)

"In a few years, perhaps, the noise of the cataracts (Falls) may be drowned in the busy hum of men: and the smoke of clustering towns, or more crowded cities, obscure on the horizon the clouds of spray, which at present tower without rival."
(John Duncan 1818)

"In various places I have seen the bald eagle, or grey eagle; and the osprey."
(Hibernicus, 1822)

"Previous to the settlement of the country along the banks of the Niagara River, great numbers of wild beasts, birds, and fishes, might be seen, dashed to pieces, at the bottom of the Falls;... But since this part of the country has been thickly settled, scarcely anything is to be found in the bed of the river below the Falls, except fishes, and a few water fowl..."
(Talbot, Edward Allan 1823)

"The company at the hotel changed almost every day. Many parties arrived in the morning, walked to the falls, returned to the hotel to dinner, and departed by the coach immediately after it. Many groups were indescribably whimsical, both in appearance and manner."
(Trollope, Francis Milton 1832)

"In 1806 little had been done to change the wild aspect of the country: and bears and wolves were not uncommon in the forests. Wild geese abounded in the river, eagles were common, and swans were occasional visitors. Deer were frequently seen on goat island."
(Porter, Albert 1872)

NIAGARA PENINSULA CONSERVATION AUTHORITY

The Niagara Peninsula Conservation Authority (NPCA), established in 1959, is an independent body formed to further the conservation, restoration, development and management of the renewable natural resources within its jurisdiction, in cooperation with the Province and its member municipalities, on a watershed basis.

The jurisdictional area of the NPCA encompasses 2424 square kilometres and includes the whole Niagara River RAP Area of Concern. The NPCA owns approximately 2000 hectares of land.

Programs of the Authority range from tree planting, rural water quality improvement and preservation of heritage areas/landscapes to the development of parks for outdoor activities, flood warning systems, shoreland and floodplain management efforts.

More and more, the NPCA is adding water quality to its traditional concern of water quantity, through a variety of activities, including: natural area preservation; reforestation; urban and rural drainage; and water quality monitoring. In fact, the NPCA has been an active member of the Niagara River RAP through its participation on the PAC and RAP Team and is also participating in the Frenchman's Creek cleanup efforts. Most recently, the Authority has undertaken a Watershed Strategy Initiative *(See "The Cleanup Connection" Stage 2 Report for a brief description of the Initiative).*

For further information, contact:

The Niagara Peninsula Conservation Authority
Tel: (800) 263-4670 or (905) 227-1013.

THE NIAGARA PARKS COMMISSION

"Planning The Second Century"[1]

The quality and quantity of water in the River, the wildlife, the vegetation-indeed, the continuing health and well-being of the region as a whole-depend on the same awareness, priorities and activities of the people living along this exceptional environmental corridor. Over the next 100 years the Commission must consciously balance the needs of the natural environment, the desires of the residents and the requirements of tourism.

Underlying the long-range vision for Ontario's Niagara Parks is a new synthesis for the 21st century that would strike a more appropriate balance between the technological, the cultural and-especially-the natural components. Of these three, it is Niagara's natural landscape that presents the strongest base upon which to build. The water, rocks, plants and animals are the raw material for a new age of stewardship, of human values and of experiences that will touch visitors in a way that will make them want to return.

The Foundation for the 100-Year Vision can be thought of as an attitude, a broadly shared common goal for achieving a new symbiosis of human culture and natural processes based on:

— Health: Maintaining the integrity of the natural systems and the people living along it.

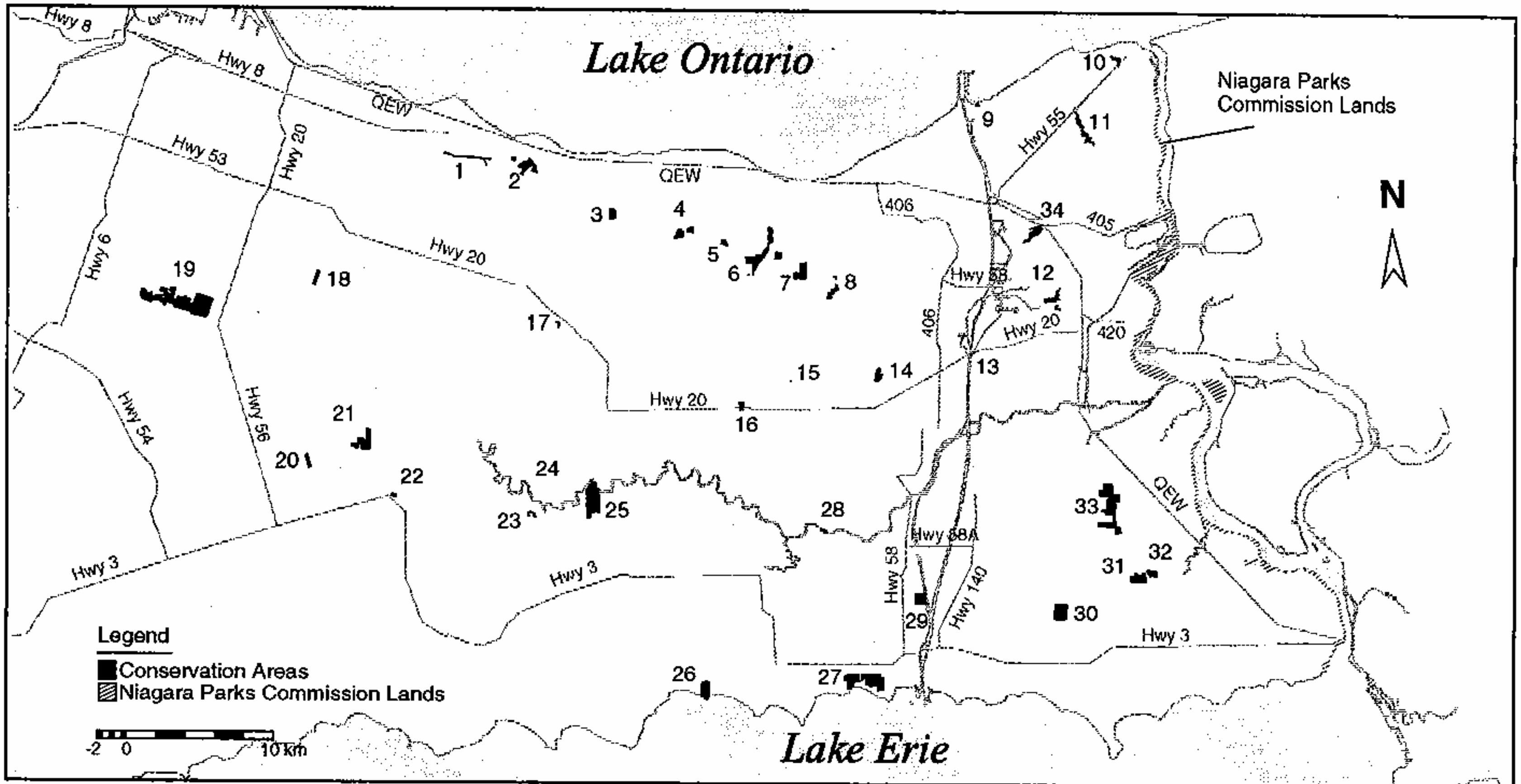
— Fit: Making whole the union of human beings, nature and technology; and

— Cooperation: Which is the commitment to achieve the common goal of health and fit, working together to achieve larger benefits, coordinating activities of mutual interest among jurisdictions and between the public and private sectors, and integrating the natural and cultural landscapes.

The synthesis of the first two components, health and fit, is dynamic and will evolve over the next 100 years. The third component, cooperation, will make that synthesis possible.

[1] Planning the Second Century. Niagara Parks Commission. October 1988.

Niagara Peninsula Conservation Areas and Niagara Parks Commission Lands



Conservation Areas

1	Woolverton	8	Rockway	15	Comfort Maple	22	Canboro	29	Mud Lake
2	Beamer Memorial	9	Happy Rolph's	16	Gainsborough	23	Oswego	30	Humberstone Marsh
3	Mountainview	10	Two Mile Creek	17	Smithville	24	Port Davidson	31	Stevensville
4	Cave Springs	11	Virgil Dam and Reservoir	18	Binbrook Tract	25	Chippawa Creek	32	United Empire Loyalist
5	Sugarbush	12	Shriner's Creek	19	Binbrook	26	Long Beach	33	Willoughby Marsh
6	Ball's Falls	13	Allanburg	20	Hedley Forest	27	Wainfleet Wetlands	34	Woodend
7	Louth	14	St. John's	21	Ruigrok Tract	28	E.C. Brown		

Data Source: Niagara Peninsula Conservation Authority and Niagara Parks Commission.

Map created by Water Issues Division

Environment Canada
Environnement Canada

Map 2

An Innovative Role

In this new synthesis, the Niagara Parks Commission has an innovative and catalytic role to play, bringing forward a new continuum of landscapes along the Niagara River. This role is critical, providing a coordinating overview between overlapping jurisdictions. By integrating and synthesizing, the Commission will be the key to creating a unified whole that can become more than the sum of its parts.

The Commission's role relates directly to the attitude embodying health, fit and cooperation and to the broad range of opportunities that can be gained from creating a new synthesis of landscapes. Specifically, these opportunities relate to:

- Bringing forward the historical and archaeological resources of the 12,000 years of human history along the Niagara River through research, site investigation, interpretation and animation;
- Protecting, conserving and making whole the integrity of those natural environments along the River and those that extend into the Region;
- Achieving greater unity between the natural system of the River and the landscaping of the Parks and Parkway;
- Balancing the impact of numbers of people with the need to preserve the delicate natural environment;
- Achieving an environmental continuity from Lake Erie to Lake Ontario of green, open-spaced linkages extending from the river's edge and park spaces into urban, residential and rural areas; and
- Creating new complementary uses as components of the Hydro and industrial landscapes become obsolete.

For further information, contact:

The Niagara Parks Commission, Planning Department
Tel: (905) 356-2241.

SIR ADAM BECK 3 HYDRO ELECTRIC DEVELOPMENT

Ontario Hydro plans to construct the Niagara River Hydroelectric Development (also known as Sir Adam Beck 3) adjacent to the existing Sir Adam Beck facilities at Queenston. This development will complement the existing facilities enabling Ontario Hydro to fully utilize the Canadian share of water available through the 1950 Niagara Diversion Treaty with the United States.

The project has been included in this report because its construction may have environmental effects (e.g., turbidity, noise, dust) and its operation will alter flow conditions in portions of the Niagara River, Chippawa Creek and the Power Canal. A brief description of the proposed project is provided here.[(2)]

Proposed Generation Facilities

Ontario Hydro proposes to divert water from the Grass Island Pool through two new submerged intakes at the International Niagara Control Works. The water would flow through two new concrete-lined tunnels to the existing Sir Adam Beck diversion canal cross-over area. The new tunnels would follow a horizontal alignment similar to the existing tunnels under the City of Niagara Falls.

Up to three 300 megawatt (MW) units would be installed in a new underground powerhouse located north of the Sir Adam Beck Generating Station No. 1. Water would

[(2)] *Further References:*

Niagara River Hydroelectric Development. Environmental Assessment. Ontario Hydro. March 1991.

Project Update, Ontario Hydro, July 1992.

Review of Ontario Hydro's Niagara River Hydroelectric Development Environmental Assessment. Environmental Assessment Branch. Ontario Ministry of the Environment. August 1992.

Project EA Amendment, Ontario Hydro, June 1993.

Review of Project EA Amendment, Ontario Ministry of the Environment and Energy. December 1993.

be taken from the Power Canal system through penstock tunnels and discharged to the lower Niagara River through tailrace tunnels and an outlet structure.

Transformers, in a separate gallery next to the powerhouse, would step-up the voltage of the electrical output from the generators for delivery by insulated high-voltage cables to the existing surface switching station and the transmission lines. It is proposed that the new station would have an installed generating capacity of up to 900 MW and that the additional diversion capacity would be about 1000 m^3/s.

The diversion facilities would consist of intake works, two tunnels and outlets, and provisions for a dewatering station for future maintenance. The tunnels would be excavated one-at-a-time, using a tunnel boring machine, starting at the downstream (outlet) end and moving to the upstream (intake) end. After the first tunnel is completed, the tunnel boring machine would begin excavation on the second tunnel. Excavated material would be transported back through each tunnel and removed at the outlet end.

Proposed Transmission Facilities

The proposed transmission facilities would include a new double-circuit 230 kV transmission line about 76 km long, replacing an existing double-circuit 115 kV overhead line. This work would involve the removal and replacement of existing transmission facilities over much of its length, so that the overall change in total number of towers present would be very small, and the effect on agriculture would be of short duration and relatively low.

It would also be necessary to erect a single-circuit 115 kV pole line along some sections of the right-of-way in order to maintain supply to local loads that would otherwise be affected by removal of the existing 115 kV overhead line. In addition to the new transmission lines, most of the existing 230 kV overhead lines on the Niagara Peninsula would be upgraded.

For further information, contact:

Ontario Hydro Niagara Plant Group at (905) 357-0322.

MAHARISHI VEDA LAND

(Niagara Falls Proposal)

Maharishi Veda Land-Niagara Falls, as recently proposed[3], will be a $879 million, 700-acre theme park. The development will include: a 500 room luxury hotel, a business conference centre, Maharishi Ayaur-Ved Health Centre, and a Maharishi Institute of Vedic Science with residential facilities for 7,000 students.

Located to the east of the QEW and straddling the Welland River where it joins the Power Canal *(See Map 3)*, the theme park and development will be environmentally friendly and non-polluting. "All construction will be of natural, non-toxic materials; all waste products will be recycled. Only electric vehicles will be used. The grounds will be lush with trees, flower gardens, streams, lakes and waterfalls."[4]

The park opening, originally scheduled for fall 1993, has been rescheduled to summer 1996.[5] As of February 1995, the Niagara Falls Planning Department has received one incomplete rezoning application for the Maharishi Veda Land-Niagara Falls proposal.[6] The site is presently designated for resort commercial purposes in the City's Official Plan.

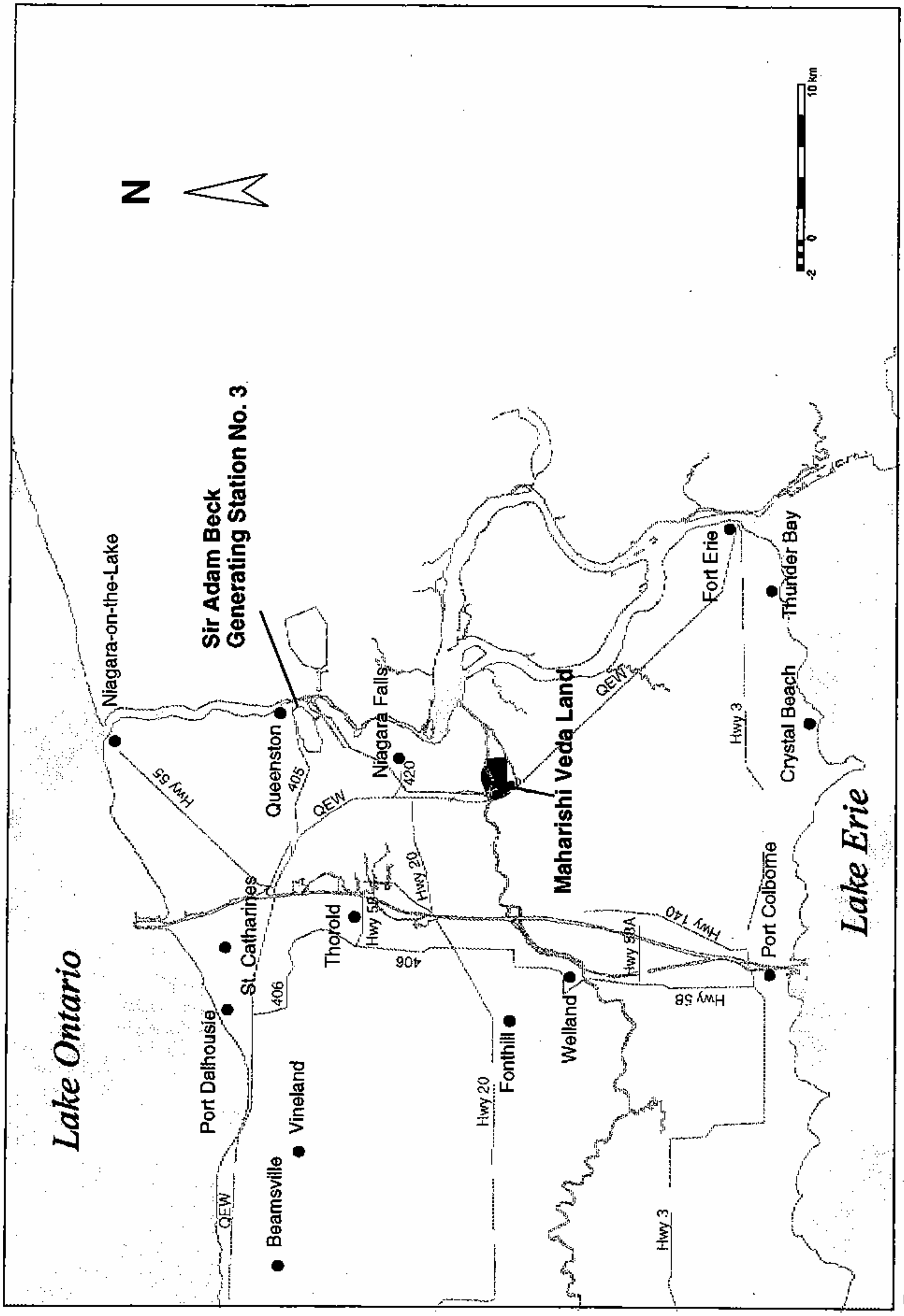
(3) Maharaishi Veda Land. "The Pride of Canada." News Bulletin Volume 1, December 3, 1993.

(4) Maharishi Veda Land - Niagara Falls Information Poster 1992.

(5) The Last Magic Show. Jennifer Wells. Report On Business Magazine. Globe and Mail. April 1994.

(6) Personal correspondence with the City of Niagara Falls Planning Department. February 2, 1995.

Proposed Landuse Developments



Map created by Water Issues Division

Environment Canada
Environnement Canada

Data Source: Ministry of Environment and Energy, 1994

Map 3

This section addresses environmental issues that have a broad impact on the chemical, physical and biological intergrity of the water in the watershed (Canadian portion). While sediment and biota/habitat issues have an impact on water quality, they have been addressed within their own sections.

WATER QUALITY

MUNICIPAL

The Municipal section has been divided into two parts: treatment facilities (water pollution control plants) and collection facilities (sanitary sewers, combined sewers, stormwater sewers).

Water Pollution Control Plants (WPCP) are sometimes referred to as point sources. The term implies that there is a distinct, identifiable source, in this case, the pipe discharging effluent to the environment. Collection facilities are referred to as non-point sources. Non-point sources have been described as a source of pollution in which pollutants enter the environment at intermittent intervals, come from an extensive area before reaching surface waters, are not routinely monitored and whose origins are difficult to trace.

Water Pollution Control Plants

Within the Niagara River AOC, all WPCP are operated by the Regional Municipality of Niagara. Table 1*(page 18)* lists WPCP upgrades since the release of the Stage One Report.

All direct dischargers to the Niagara River watershed are currently monitored under Utility Monitoring Information System (UMIS) and/or the Niagara River Toxic Management Plan (NRTMP). In a May 1994 Report[7], MOEE reported a reduction 83% in loadings of the 18 Chemicals of Concern by municipalities between 1986 and 1992. Municipalities reduced by 99.5% the total loading of the 10 chemicals targeted for a 50% reduction by 1996.

These measurements of *daily* point source loadings have been made at various levels of intensity from once per year to once per month. Considerable uncertainty is introduced by the extrapolation from *daily* to *annual* loads. Although estimates have been made, these estimates are not statistically valid for demonstrating the 50% reduction in *annual* loads between 1986 and 1996. Some of the inherent difficulties are highlighted in the sidebar 'Loadings calculations are influenced by...'

Loadings calculations are influenced by...

- the frequency of monitoring;
- the accuracy of sample collection;
- the accuracy of sample preservation, transport and storage;
- the number of parameters analyzed;
- the accuracy of the analytical method;
- the analytical detectability of small amounts of contaminants; and
- the accuracy of the flow measurements.

Facility Performance

All municipal facilities complied with Certificate of Approval (C of A) requirements, MOEE Effluent Guidelines and all plants have achieved or exceeded a 50 % reduction in the NRTMP chemicals targeted for 50% reduction.

The implications of the Municipal Industrial Strategy for Abatement (MISA) Municipal Program for municipal treatment plants is contingent upon the formalization of the MISA Sewage Treatment Plant (STP) Regulation. It is anticipated that the regulation will impose strict monitoring protocols for treatment plants and will provide for the control of acute lethal toxicity, set STP effluent limits and reporting requirements and will require a minimum standard of secondary treatment.

(7) *Update Report. Reduction of Toxic Chemicals From Ontario Point Sources Discharging To The Niagara River 1992. Ministry of Environment and Energy. May 1994.*

Table 1

Improvements to Niagara River Municipal Point Source Discharges*

Facility	Treatment Improvement	Anticipated Result
Niagara Falls WPCP	JobsOntario grant of $3.3 million to increase capacity to treat storm related peaks (August 1994)	Reduce the volume of stormwater bypass at the Plant.

**Since Niagara River RAP Stage One Report release in 1993.*

Sanitary Sewers, Combined Sewers and Stormwater Sewers

The purpose of the *municipal sewage system* is to collect and treat all sewage and industrial process discharges before being discharged to a receiving waterbody. Treatment facilities (WPCP) and collection facilities (combined sewers, sanitary sewers and pumping stations) comprise the sewage system.

The purpose of the *municipal stormwater system* is to collect and remove rainwater (called runoff) from urban areas. Doing this as quickly as possible was, until recently, the sole focus of the stormwater system. Today, the quality of that stormwater as it affects the water it is discharged into, is an important consideration in the design of a stormwater system. Consequently, the stormwater system includes not only conduits or pipes, but also treatment facilities.

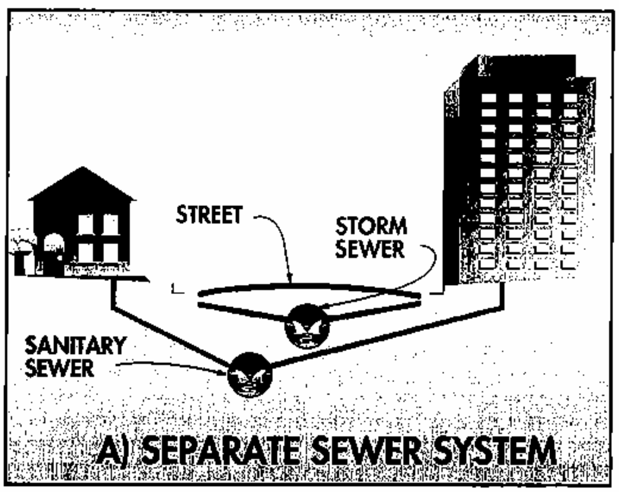


Figure 1. Separate Sewer System

(Clean Waters, Clear Choices, Metro Toronto and Region RAP)

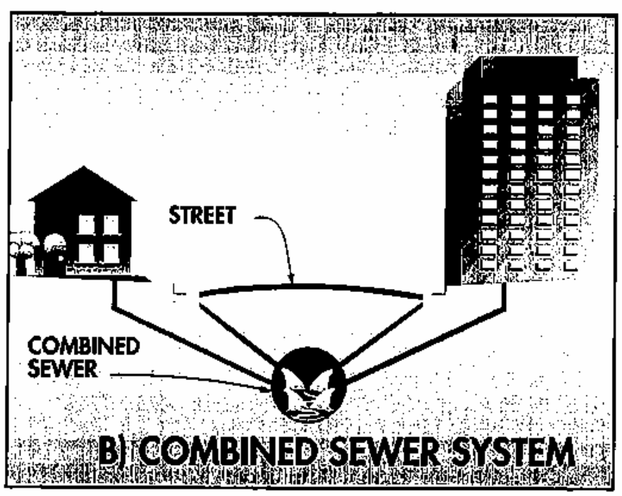


Figure 2. Combined Sewer System

(Clean Waters, Clear Choices, Metro Toronto and Region RAP)

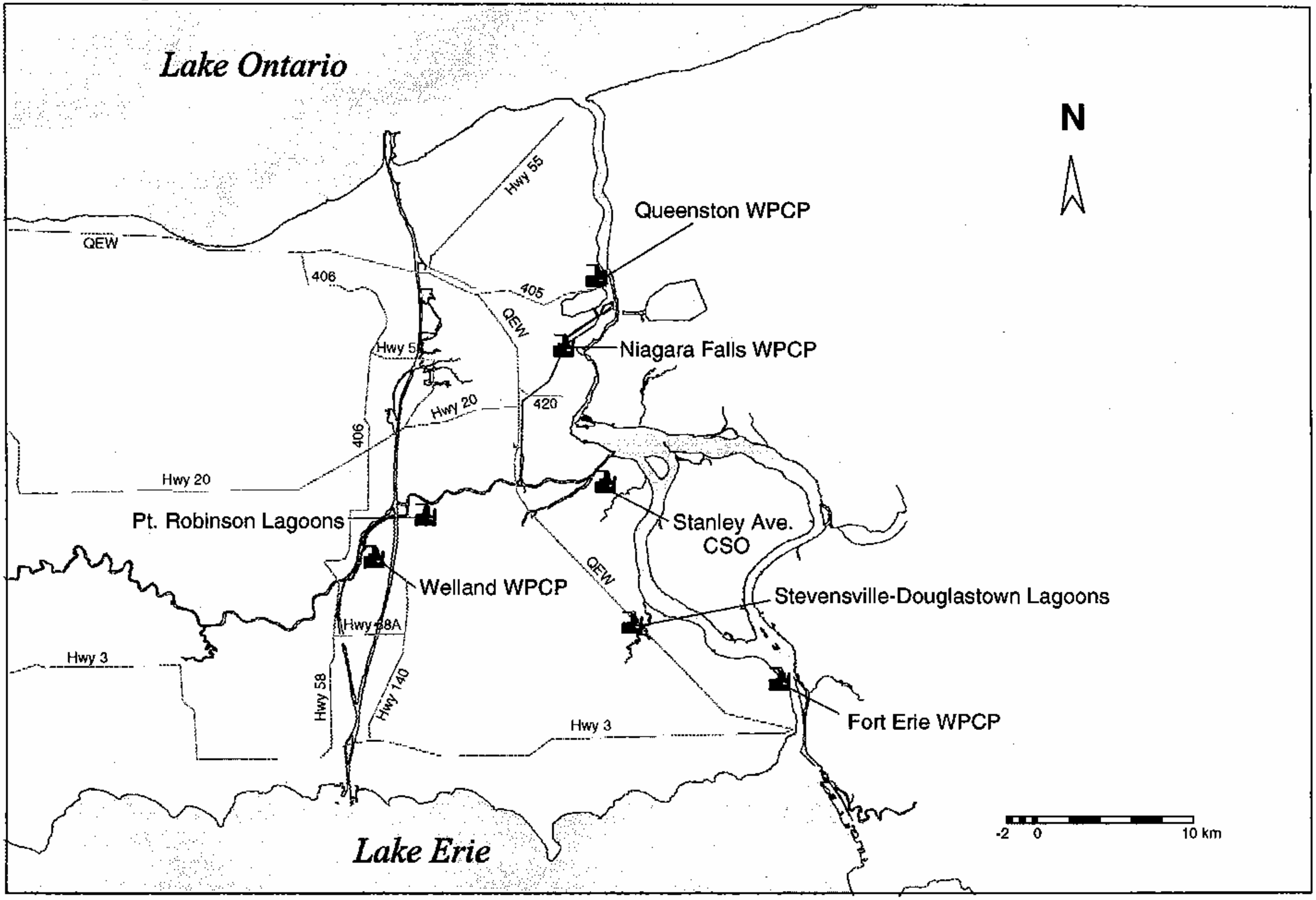
Today, the municipal sewage and stormwater collection systems are designed and built as separate systems *(See Figure 1)*. Since the mid 1960s, all new urban development has been serviced by both sewage and stormwater systems. If they are connected at all, it is at the treatment facility - some stormwater may be directed to the WPCP for treatment, depending on available capacity at the plant.

In the past however, the sewage and stormwater collection functions were combined into one pipe, called a *combined sewer, (See Figure 2)*. There are approximately 40 combined sewers in each of Welland and Niagara Falls and three in Fort Erie. Not all of these combined sewers discharge to a water course. Many have been the focus of remedial efforts and are now connected to a plant.

During dry weather conditions, combined sewers function as a sanitary sewer, conveying sewage to the WPCP. However, during a rainstorm, the combined sewer is designed to collect urban runoff as well as sewage.

Due to the impervious nature of urban areas (e.g., pavements, roof tops, sidewalks), a rainstorm can generate a significant amount of runoff. In one study it was reported that on an annual basis, stormwater comprises 34.5% of the total flow volumes discharged into the

Municipal Point Sources



Data Source: Update Report Reduction of Toxic Chemicals from Ontario Point Sources Discharging to the Niagara River 1992. (MOEE, 1994)

Map created by Water Issues Division
Environment Canada
Environnement Canada

Map 4

Niagara River.[8] During a rainstorm however, this figure increases dramatically to 78.9%. *Figure 3* illustrates the impact of rain on the flow in a sanitary sewer.

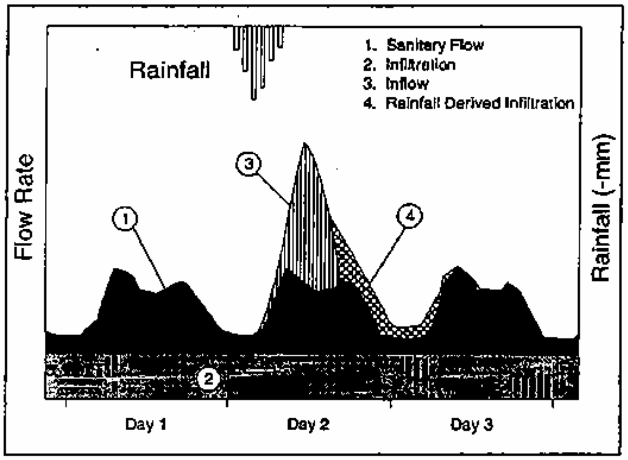


Figure 3. Components of Sanitary Sewage Flows

(How is your sewer? Region of Niagara. 1991)

During a storm, the volume of rainwater flowing into the combined sewer may exceed the flow capacity of either the pumping station (that pumps the combined sewer flow to the WPCP) or the water pollution control plant. In this situation, the flow, consisting of sewage and stormwater, is diverted from the treatment plant and is discharged into a water body. This is referred to as a *combined sewer overflow or CSO*.

Raw sewage in the environment has a number of associated impacts: water quality changes (e.g., depletion of dissolved oxygen, nutrient overloading, bottom sediment contamination and water column toxicity); public health risks (e.g., bacteria and viruses); and aesthetic deterioration (e.g., reduced clarity, sanitary and runoff debris).

In addition, CSOs can also be a source of heavy metals, conventional pollutants and toxic chemicals[9]. The exact parameters of each CSO will depend on a number of factors including: type of discharges to the combined sewer, the enforcement level of a Sewer Use Bylaw, the duration of the overflow, etc.

A second source of discharges of untreated sewage include structural problems - sanitary sewer hookups to the storm water sewer, tree root penetration into the pipes, cracked pipes, leaky joints and blocked or plugged pipes. These can be viewed as mechanical failures in the sewer system as opposed to the volume bottlenecks described above.

Remediation Philosophy

The Region of Niagara, MOEE and the area municipalities have a shared goal of virtually eliminating direct discharges of untreated sewage to the environment. In the Niagara River AOC, this means controlling CSOs to one occurrence per disinfection season[10], as well as addressing any structural problems *(See Table 2, page 22)* for an example of planning level cost estimates of achieving three CSOs per year, the equivalent of one CSO per disinfection season).

In April 1993 the province released its Proposed CSO Policy/Guideline Recommendations For Ontario. The policy recognizes that the selection of CSO control options is very dependent on site-specific conditions. It suggests that solutions can only be properly determined through a Pollution Prevention and Control Planning study.

In the municipalities of the Niagara River AOC, these studies have been ongoing for some time and are known as Infrastructure Needs Studies (INS). The information generated by these studies form the basis for developing implementation programs to improve the municipal sewage system. INSs are a cooperative effort among MOEE, the Region of Niagara and the area municipalities.

INSs take a comprehensive view of the sanitary sewer system. As part of their review, INSs are used to identify system deficiencies that lead to untreated sewage discharges to the environment. INSs make two types of recommendations - those that can be implemented as the study progresses (easily implementable) and those that, following council approval, are incorporated in the municipal capital works budget.

Presently, INSs for each of Niagara-on-the-Lake and Fort Erie have been completed. Recommendations from each of the studies are in various stages of implementation.

The Niagara-on-the-Lake INS recommended constructing an oversized sanitary

(8) *"Loadings of Toxic Contaminants from Urban Nonpoint Sources in Ontario RAP Sites. Final Report." Prepared for Environment Canada. Prepared by Schroeter & Associates. March 1992.*

(9) *Refer to report "Toxic Contaminant Loadings from Municipal Sources in Ontario RAP Sites. Final Report." Schroeter and Associates. March 1993.*

(10) *The Disinfection season is established by the Regional Medical Officer of Health. It corresponds to the swimming season and is the equivalent of three CSO events per year.*

trunk sewer through the city (to contain all the flows), increased pumping station capacity and increased sewage treatment plant capacity to handle the increased flows. The trunk sewer and pumping station work has been completed, while work continues on the expansion of the sewage treatment plant.

The Fort Erie INS recommended increasing the capacity of the pumping stations, as overflows from the pumping station were a problem. The municipality has been actively upgrading its pumping stations. In addition, to address extraneous flows into the sewers, Fort Erie established a "Comprehensive Extraneous Flow Investigation Program."

The INS for Niagara Falls is a multi-phase study. Some of the earlier studies have been completed and recommendations implemented (e.g., sewer separation projects, reducing infiltration and inflow to the sanitary sewer, downspout disconnection program). The City is presently developing a comprehensive water conservation program.

JobsOntario recently announced a $3.3 million grant to the Stamford Avenue Pollution Control Plant to increase capacity to treat storm related peaks and so, reduce the volume of stormwater bypass at the Plant to the Hydro Canal and the Niagara River.

The Welland INS is underway and is expected to be completed in 1995.

Treatment of Stormwater

Remedial measures related to stormwater are directed at managing the impact of stormwater on the waterbody it is discharged into and include both quantity and quality concerns. While different studies have shown that all urban runoff contains similar parameters(11), addressing urban runoff's impact on water quality will depend on inputs from the drainageshed and the quality of the receiving waterbody. This is true for existing urban areas as well as developing urban areas.

Therefore, in contrast to CSOs, stormwater will be assessed and addressed on an outlet or drainageshed basis. It is not assumed that all urban runoff needs to be treated before discharging to the environment.

There is a growing body of literature describing "Best Management Practices" - the "how to" of urban runoff management.(12) The goal of these practices is to ensure that the quality and quantity of runoff from a development will be the same as or better than it was before development. These practices are identified and described in stormwater management plans, which themselves are a condition of approval for any new subdivision in the municipalities in the Niagara River AOC.

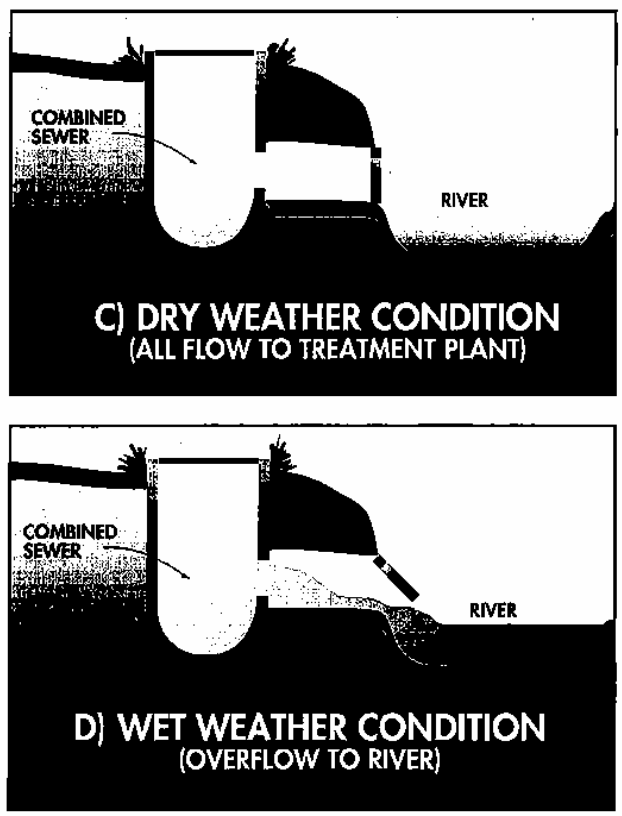


Figure 4. Combined Sewers

(Clean Waters, Clear Choices, Metro Toronto and Region RAP)

(11) *For example, refer to:*

"Sixth International Conference on Urban Storm Drainage. Proceedings - Volume 1 and 2." Niagara Falls, Ontario. 1993.

"Stormwater Management and Combined Sewer Control Technology Transfer Conference Proceedings." Wastewater Technology Centre. 867 Lakeshore Rd., P.O. Box 5068, Burlington, Ontario. 1993

(12) *"Sixth International Conference on Urban Storm Drainage". Proceedings - Volume 1 and 2. Niagara Falls, Ontario. 1993.*

"Urban Drainage Systems Design and Operation." J. Marsalek et.al. Water Science Technology. Vol.27 #12, pp. 31-70. 1993.

Table 2

Cost of Reducing Combined Sewer Overflows to Three per Year per Municipality

	Annual Number of Overflows	Treatment at Central Plant ($)	Treatment at Satellite Plant ($)
Niagara Falls	51	155,160,000	19,660,000
Fort Erie	35	10,690,000	6,080,000
Welland	36	21,450,000	11,450,000

Source: Combined Sewer Overflow Control Costs At Ontario RAP Sites. Summary Report. Prepared for MOEE. Prepared by CH2M Hill Engineering Ltd. July 1992.

The Bottom Line - Water Conservation

Water conservation. The message is clear. If we each save a little, it can add up to major savings in water, energy and money. For the average household, reductions in water use as high as 40 per cent or more are feasible.

The benefits don't stop at the household or business. The municipal water and sewer department gets a break on the amount of water it has to pump to our homes and businesses and on the amount of wastewater it has to treat in sewage treatment plants. Water conservation can extend the useful life of municipal water supply and treatment plants, and will benefit the operating efficiency - and life expectancy - of private septic disposal systems.

And, finally, water conservation can generate significant environmental benefits. It can reduce water diverted and the pollution loadings on our lakes and rivers by reducing the volumes of wastewater which we have to treat. This can help to protect our drinking water and the ecological balance in sensitive aquatic ecosystems.

If we all practice water conservation; everyone - and everything - benefits.

(from: Water Conservation - Every Drop Counts. Freshwater Series A-6. Environment Canada. November 1992.)

Niagara River Area of Concern Update....

Niagara-on-the-Lake has completed a program of disconnecting roof leaders (downspouts) from sanitary sewers (as recommended in their Infrastructure Needs Study). The municipality has a policy of replacing sanitary sewers up to eight metres from the lot line or right up to the house, whichever is less. This allows the municipality to remediate any infiltration problems on private property.

The City of Niagara Falls is presently developing a Water Conservation Program. The City has a Downspout Disconnection Program, an Infiltration and Inflow Reduction Program and is reviewing the issue of residential water metering. Presently, water is metered in residential buildings of three or more units, and in institutional, commercial and industrial buildings.

The Town of Fort Erie has a mandatory Water Metering Program that includes commercial, industrial, institutional and residential buildings. Within the program, the Town will provide a water conservation kit to all voluntary program subscribers. As well, the Town requires water conservation fixtures for all new construction. Their Extraneous Flow Bylaw prohibits any connection to the sanitary sewer for storm or groundwater (e.g., roof leaders, basement sump pumps).

INDUSTRIAL

Direct Discharges

The term "direct discharger" refers to industries whose effluent is discharged, via a conduit, directly into a water body (river, tributary or connecting ditch). In 1986 there were 14 direct dischargers in the Niagara River AOC. Today, there are 9 direct dischargers. They are: Atlas Specialty Steels, Cytec Welland Plant, Geon Canada, Norton Advanced Ceramics of Canada Ltd., Washington Mills Ltd., Washington Mills Electro Minerals Corp., Fleet Industries, Gencorp Canada Inc., and Stelpipe Welland.

Information Sources
Direct Discharge Effluent

- "Report on the Industrial Direct Discharges in Ontario." (MOEE).
- "Non-Compliance Report". 1992. (MOEE).
- "Update Report: Reduction of Toxic Chemicals from Ontario Point Sources Discharging to the Niagara River 1986-1991. (MOEE).
- "Update Report: Reduction of Toxic Chemicals from Ontario Point Sources Discharging to the Niagara River 1993. (MOEE).

All Ontario direct dischargers are monitored by Ontario under the Niagara River Toxic Management Plan (NRTMP). In a May 1994 Report[13], MOEE reported a reduction of 62% in loadings of the 18 Chemicals of Concern by industries between 1986 and 1992. Industries reduced by 91% the total loading of the 10 chemicals targeted for a 50% reduction by 1996.

These measurements of *daily* point source loadings have been made at various levels of intensity from once per year to once per month. Considerable uncertainty is introduced by the extrapolation from *daily* to *annual* loads. Although estimates have been made, these estimates are not statistically valid for demonstrating the 50% reduction in *annual* loads between 1986 and 1996. Some of the inherent difficulties are highlighted in the sidebar "Loadings calculations are influenced by..." *(page 17)*.

[13] *Update Report. Reduction of Toxic Chemicals From Ontario Point Sources Discharging To The Niagara River 1992. Ministry of Environment and Energy. May 1994.*

MISA Monitoring

Background

In 1986 the Ministry of Environment and Energy initiated the Municipal/Industrial Strategy for Abatement (MISA). In Ontario most industrial point source dischargers fall under the MISA program. MISA was designed to implement a legislative, uniform approach to the identification, reduction and virtual elimination of persistent toxics to the environment. The first phase of this program included an effluent monitoring program of over 300 point source dischargers in 9 industrial sectors. Eight facilities discharging to the Niagara River or its tributaries were involved in the first phase of the MISA program. These were: Atlas Specialty Steels in the Iron and Steel Sector; CanadianOxy Chemicals and Geon Canada in the Organic Chemical Sector; Cytec Niagara and Welland, Norton Advanced Ceramics, Washington Mills Ltd. and Washington Mills Electro Minerals in the Inorganic Chemical Sector. Since much of the MISA monitoring program is directly related to the Niagara River Toxics Management Plan, there is an exchange of resources and information between the two programs.

Monitoring Results

With the evolution of monitoring programs, effluent discharges from point sources discharging to the (Ontario) Niagara River Area of Concern have been thoroughly

Table 3

Improvements to Niagara River Industrial Point Source Discharges*

Facility	Treatment Improvement	Anticipated Result
Atlas Specialty Steel	1993 — Ceased pickling operations.	Improved effluent quality.
Geon Canada	June 1990 — Adopted process for compounding PVC with plasticizers and stabilizers — Installation of distillation column — Stabilization Pond replaced with equalization basins — Biological treatment increased to tertiary	Decrease in conventional and toxics discharges, particularly Vinyl Chloride monomer.
CanadianOxy	June 1993 — Cooling water closed - looped	Eliminated a point source.
Cytec (formerly Cyanamid) Niagara Falls	March 1992 — Plant taken out of operation	Elimination of this point source.
Cytec (formerly Cyanamid) Welland Plant	1993 — Dicyanamide plant taken out of operation, eliminating a cooling water discharge	Improved effluent quality.
Norton Advanced Ceramics Inc.	Improved slaking (thermal hydraulic processing of lime)	Reduced suspended solids loadings.

**Since Niagara River RAP Stage One Report release in 1993.*

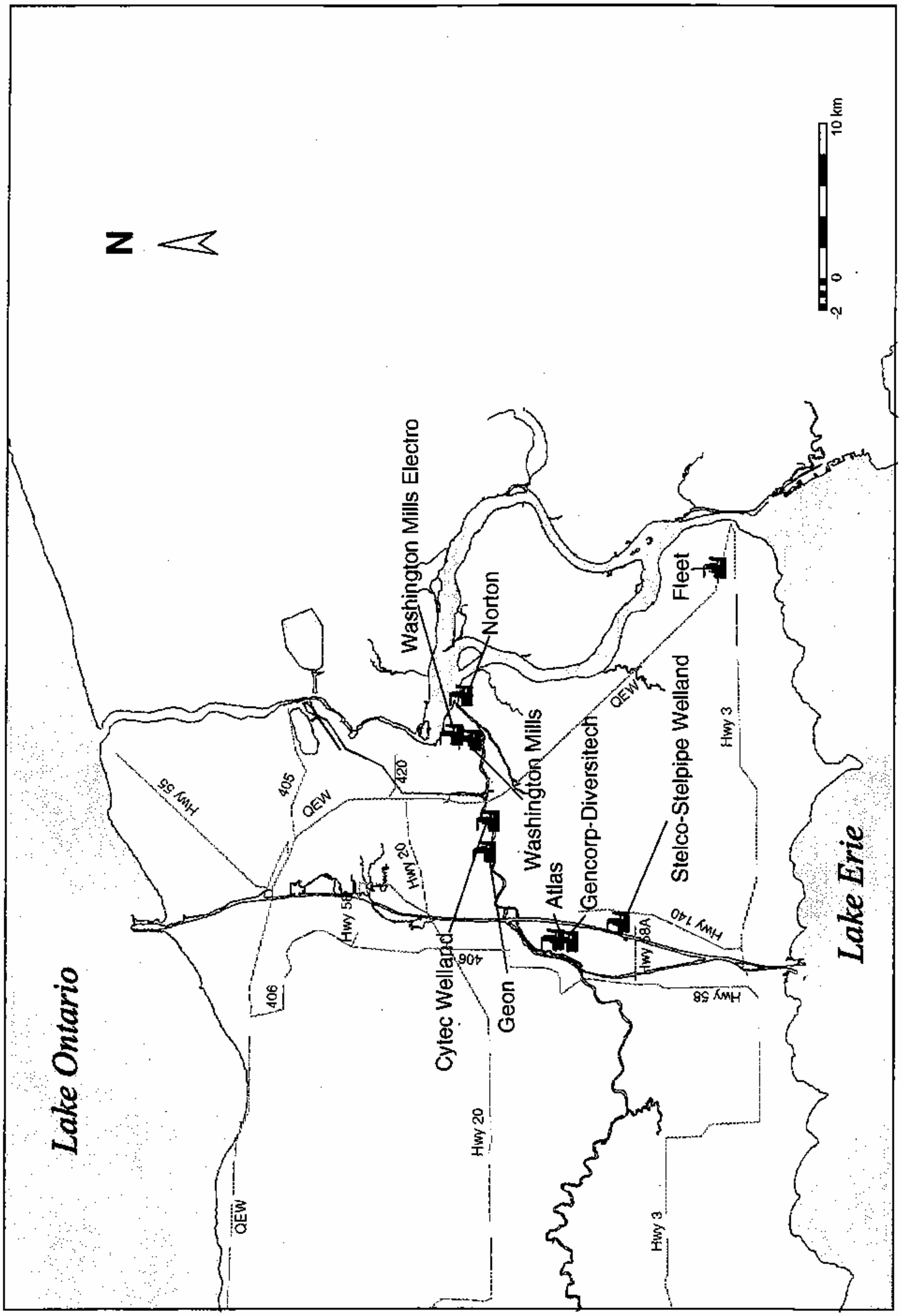
characterized with respect to deleterious, toxic and bioaccumulative substances. Corresponding abatement measures have been undertaken that have been successful in reducing pollutants. Legislation is also evolving to ensure that monitoring and abatement continues to improve with technology and that Ontario point sources discharges do not contribute to the degradation of water quality of the Niagara River.

Data Evaluation

The monitoring phase was used to characterize industrial effluents. Results of this monitoring phase are summarized by facility for the Niagara River Chemicals of Concern *(See Table 4, page 28)*. In comparing MISA monitoring data with that of NRTMP, some differences should be noted. The MISA Program is based on end of pipe (gross) loadings and intake water information is not considered. Some facilities voluntarily monitored intakes for a limited number of parameters. The data presented here includes net loadings, where applicable. MISA data includes concentrations for parameters found at extremely low levels. Where the analytical result is less than one-tenth of the analytical method detection limit, the value zero is used for the purpose of calculating a loading. NRTMP utilizes values which are reported as a fraction of the analytical method detection limits and assumes that samples with analytically unquantifiable results for a given parameter have a concentration of zero for that parameter.

Data collected under both the MISA Program and NRTMP are relatively similar with respect to analytical results. Some variation exists, but the differences are re-

Industrial Point Sources



Map created by Water Issues Division
Environment Canada
Environnement Canada

Data Source: Update Report Reduction of Toxic Chemicals from Ontario Point Sources Discharging to the Niagara River 1992. (MOEE, 1994)

Map 5

flected in the loadings calculations. Factors affecting calculated loadings include no netting of loadings for facilities both drawing from and discharging to the Niagara River and its tributaries, inherent variability associated with differences in sampling frequency, and variability of effluent quality. Overall, a strong database which characterizes industrial effluents has been developed.

The second phase of the MISA program has been initiated. Comprehensive effluent monitoring and limit setting 'Clean Water Regulations' have been promulgated for the Petroleum; Pulp and Paper; Metal Mining; Metal Casting; Industrial Minerals; Organic Chemical Manufacturing; and Inorganic Chemical Sectors. In December 1994, MOEE released draft 'Clean Water Regulations' for the Iron and Steel Manufacturing and the Electric Power Generating Sectors for public discussion. Promulgation for these sectors is anticipated in 1995. The 'Clean Water Regulations' establish limits for pollutants discharged by manufacturing plants in the sectors. The regulations are sector and facility specific and include the following elements:

1. Effluent limits are established for a list of parameters on a sector/facility specific basis. Limits are based on the best available technology (economically achievable) for an industrial process.
2. All effluents are required to be not acutely lethal to rainbow trout and water fleas.
3. In order to proceed towards virtual elimination, industries are required to undertake a storm water control study and to implement a storm water management plan.

Six facilities within the Niagara River AOC will be subject to the industrial MISA limits regulations. They are:

Atlas Specialty Steels

Atlas' effluent is currently not toxic to rainbow trout and water fleas. Atlas Specialty Steels has incorporated water reduction strategies to reduce total plant loadings to the environment and has made process changes in order to treat two thirds of the plants' storm water.

CanadianOxy

The facility has isolated or close-looped all of its process and cooling water streams so that storm water is the only discharge from the facility. CanOxy will be encouraged to proceed with its storm water management plan, but having eliminated all process related waste water, the facility will not be subject to wastewater limits.

Geon Canada

Geon has adopted the most stringent Best Available Technology option for its waste water treatment. The company has constructed a new treatment facility, made process changes and separated storm water from its process effluents.

Cytec (Niagara Falls)

The former Cyanamid Niagara facility has ceased operations and wastewater discharges and therefore will not be included in MISA limits regulations. The facility is required to meet MOEE decommissioning guidelines.

Cytec (Welland)

This facility has intermittent effluent toxicity to rainbow trout and water fleas and needs to address phosphorus, RSP, pH and nitrogenous compound control in order to attain the first level of BAT options.

Norton Advanced Ceramics

The facility close-looped one of its effluent streams. Norton is also attempting to optimize its lime slaking operation which should provide better control of suspended solids and pH. Improved housekeeping practices and the preparation of a storm water control and management study will move Norton toward the optimal effluent treatment and quality for its sector.

Washington Mills Ltd.

This facility has obtained an alternate source of water to its on-site well. The former intake had high levels of naturally occurring sulphates which affected effluent quality. Since this change was made, Washington Mills Limited needs to implement better management practices for oil and grease control in order to achieve the maximum sectoral reduction of pollutants. A storm water control and management study should also be undertaken.

Washington Mills Electro Minerals Corp.

The facility must apply better management practices for oil and grease and undertake a storm water control and management study in order to attain the maximum sectoral reduction of pollutants from its effluents.

Several facilities which are direct dischargers within the AOC, are currently not subject to the MISA program. Effluent streams from Fleet, Ford, Gencorp and StelPipe are being assessed against Ministry of Environment and Energy Guidelines for Industrial Waste Water Discharges. Ford's Niagara Glass plant has ceased operations and will be subject to the Ministry's decommissioning guidelines. Fleet and StelPipe have effluents which are below MOEE's Guidelines for the Industrial Waste Water Discharges. Gencorp has been working with the ministry in a pollution prevention process modification which is anticipated to improve effluent quality.

Table 4

MISA Overview / Industrial - Direct Dischargers

Facility	Legislated Discharge Control	Proposed Discharge Limits	Effluent Quality	Proposed Abatement
Atlas Specialty Steels		MISA	Occasional exceedance of guidelines for oil and grease and suspended solids due to storm run off	Atlas may conduct a Storm Water Control Study
CanadianOxy Chemicals Ltd.			Process effluent discharge eliminated in 1993	CanOxy may conduct a Storm Water Control Study
Cytec Niagara Plant	Certificate of Approval	No discharge	Process effluent discharge eliminated in 1992	The facility will follow the Ministry's decommissioning guidelines
Cytec Welland Plant	Certificate of Approval	MISA	Occasionally exceeds C of A requirements for suspended solids, phosphorus and pH due to storm water runoff	Cyanamid Welland may conduct a Storm Water Control Plan and improve pH, solids and nutrient controls
Diner's Delight	Certificate of Approval	Sewer Use By-Law	Direct discharge eliminated in 1986	Not applicable
Fleet Industries		Sewer Use By-Law {MISA}	Effluent does not exceed MOEE Industrial Waste Water Discharge Guidelines	Not applicable
Ford Motor Company Niagara Glass Plant		No effluent discharge	Effluent discharge eliminated in 1994	The facility must follow the Ministry's decommissioning guidelines
Gencorp Canada Inc.				Has switched from salt bath curing to air curing in order to improve effluent quality
Geon Canada	Certificate of Approval	MISA	C of A exceedances were noted for pH, Ammonia+Ammonium, flow and suspended solids	Exceedances are attributable to the commissioning of the new production and waste treatment system. Geon must adjust process waste water flow in order to optimize treatment efficiency and may conduct a Storm Water Control Plan
Gould Manufacturing of Canada Ltd.			No direct discharge	Not applicable
Norton Advanced Ceramics of Canada Ltd.	Certificate of Approval	MISA	In compliance with C of A	Norton may conduct a Storm Water Control Plan and improve lime slaking and housekeeping practices for the control of RSP and oil and grease
StelPipe - Welland Tube Works			Effluent does not exceed MOEE Industrial Waste Water Discharge Guidelines	Not applicable

(') *Indicates previous involvement* { } *Indicates proposed involvement*

Table 4 (cont'd)

MISA Overview / Industrial - Direct Dischargers

Facility	Legislated Discharge Control	Proposed Discharge Limits	Effluent Quality	Proposed Abatement
Washington Mills Ltd.		MISA	Effluent does not exceed MOEE Industrial Waste Water Discharge Guidelines	Washington Mills may conduct a Storm Water Control Plan and improve housekeeping practices for the control of oil and grease
Washington Mills Electro Minerals Corp		MISA	Effluent does not exceed MOEE Industrial Waste Water Discharge Guidelines	Washington Mills Electro may conduct a Storm Water Control Plan and improve housekeeping practices for the control of oil and grease

Non-Point Sources

The term "non-point sources" refers to a source of pollution in which pollutants enter the environment at intermittent intervals, come from an extensive area before reaching surface waters, are not routinely monitored and whose origins are difficult to trace (sometimes referred to as diffuse discharges). Landfill sites and atmospheric deposition are discussed in this section.

Landfill Sites (LFS)

Since the Stage 1 Report was written, there has been a follow up study of the four landfills under Ontario's jurisdiction, which had been judged to be contributing measurable loadings to surface waters, and ultimately the Niagara River. Those four are: the Cytec Niagara Falls plant site, Cytec Welland plant site, Atlas Specialty Steels, and Fort Erie Bridge Street Municipal LFS.

A 1990 Monenco study[14], based on a review of all available data, had reported loadings for the four sites as indicated in *Table 5, page 31*. The 1993 Jagger Hims study[15] reported loadings in *Table 5*. The latter study used a single sampling event at each site as the basis for calculations.

The Jagger Hims parameter list included several parameters not previously tested. While loadings figures were generally lower in 1992/93, the figures for the Bridge Street landfill showed a sharp increase. The latter was due almost entirely to the inclusion of zinc, which comprised over 90% of the load at all sampling sites. The origin of that zinc, whether from the landfill or background contributions from the bedrock or upstream sources, could not be reliably determined by the study.

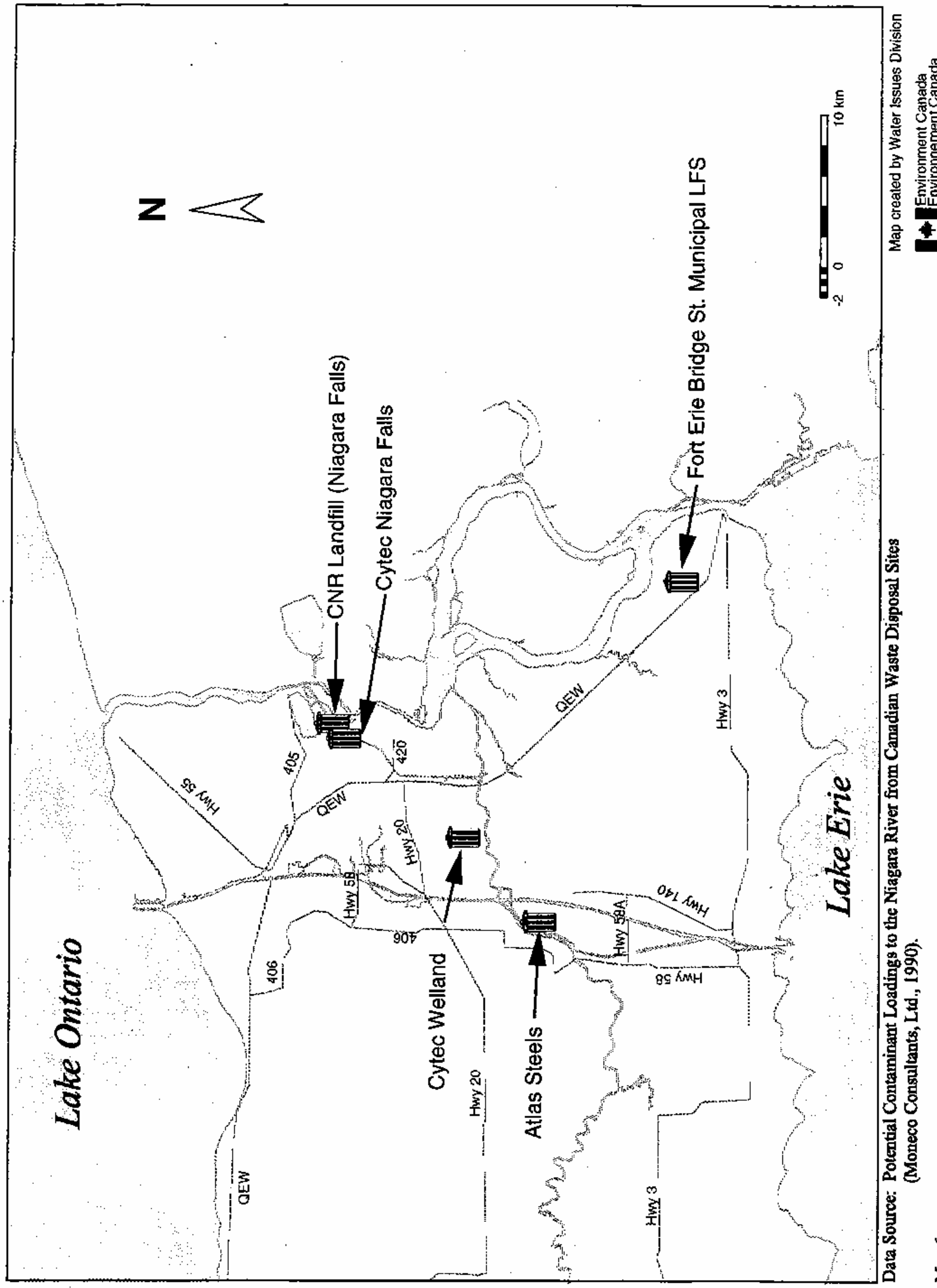
Trace levels of tetrachloroethylene, hexachlorobenzene and chlordane were detected but could not be quantified at three of the sites.

Plans are under way to virtually eliminate these contributions to the River. Site decommissioning at the Cytec Niagara Site includes negotiation for the removal of buried tanks (coal tar), relocation of some wastes, removal of some wastes, and capping to reduce infiltration and leachate generation, all subject to public consultation. Closure plans are being developed for Cytec Welland's Brown's Line and West Dump Landfill Sites. These closure plans will include monitoring and perpetual care. Atlas Specialty Steels will continue monitoring to ensure compliance with effluent requirements.

(14) *Potential Contaminant Loadings to the Niagara River. From Canadian Waste Disposal Sites. Monenco Consultants Ltd. January 1991.*

(15) *Preliminary Assessment Contaminant Loadings. From Ontario Based Landfills. Jagger Hims Ltd. July 1993.*

Canadian Landfill Sites



Data Source: Potential Contaminant Loadings to the Niagara River from Canadian Waste Disposal Sites (Moneco Consultants, Ltd., 1990).

Map 6

(16) Source: Potential Contaminant Loadings To The Niagara River from Canadian Waste Disposal Sites, January 1991.

Preliminary Assessment Contaminant Loadings. From Ontario Based Landfills. Jagger Hims Ltd. July 1993.

(17) 1991 study did not measure from zinc, 1993 study did.

(18) Zinc accounted for 97% of the total inorganic concentration in ground water and surface water samples.

(19) The elevated 1993 loading estimate is the result of differences in the parameters included in the two studies and the inclusion of surface water loadings to the Niagara River from Thompson Creek in the 1993 study.

Table 5

Potential Loadings to Surface Water(KG/D) from Landfill Sites[16]

Location	Waste Site	1991	1993
Town of Fort Erie	Bridge Street Landfill	0.51[17]	4.8186[18]
City of Niagara Falls	Cytec Landfill	26.9	6.4176
	CNR Landfill	2.0	No change
City of Welland	Atlas Landfill	0.7	0.0543
	Cytec Landfill	0.004	0.3677[19]

Atmospheric Deposition

Direct deposition from the atmosphere (the combination of wet and dry deposition) may represent a significant source for a number of the chemical species found in the water of the Great Lakes according to published estimates. (See insert "For More Information".)

The situation in the Niagara River Area of Concern is somewhat different, however, since the surface area of the water is relatively small. It therefore concludes that the amount of material deposited from the atmosphere will be limited, and may thus be considered negligible with respect to the amounts discharged directly. It appears that the toxic chemicals deposited from the atmosphere to the ground remain there, and do not easily find their way into streams and rivers. This is why only deposition directly to the water surface is of concern.

It should be stressed that the state of the science is developing rapidly and work continues in the area of refining estimates of atmospheric deposition. Sampling and analytical methods for airborne toxic chemicals are constantly improving, as is knowledge of the movement of these chemicals once deposited. The conclusion that atmospheric deposition is relatively unimportant in the Niagara River Area of Concern may therefore have to be re-examined in the future.

For more information

- W.M.J. Strachan and S.J. Eisenreich, "Mass Balancing of Toxic Chemicals in the Great Lakes", International Joint Commission Workshop, Scarborough, Ontario October 1986. This information has been updated at two subsequent IJC workshops, February 1992 Burlington, Ontario and June 1994 in Windsor, Ontario. Contact the IJC for information.

- The U.S. EPA in its First Report to Congress, "Deposition of Air Pollutants to the Great Waters" (May 1994) reviewed the scientific information currently available on: i) the contribution of atmospheric deposition to pollutant loadings; ii) the environmental or public health effects of such pollution; iii) the source or sources of such pollution, and; iv) a description of any regulatory reviews under applicable Federal laws that may be necessary to assure protection of human health and the environment.

- Environment Canada. Atmospheric Environment Service. "Mystery On The Great Lakes." 1994.

Arrows and flow depict pollution that deposits from the atmosphere directly to water surfaces and travels through the Great Lakes system. The percentages reflect the amount of such pollution compared to that from all other routes. For example, approximately 63% of Lake Huron's PCB loading is from atmospheric deposition to the lake itself and approximately 15% is from atmospheric loading to the upstream lakes. The remainder of Huron's PCB loading is from non-atmospheric sources (approximately 22%).

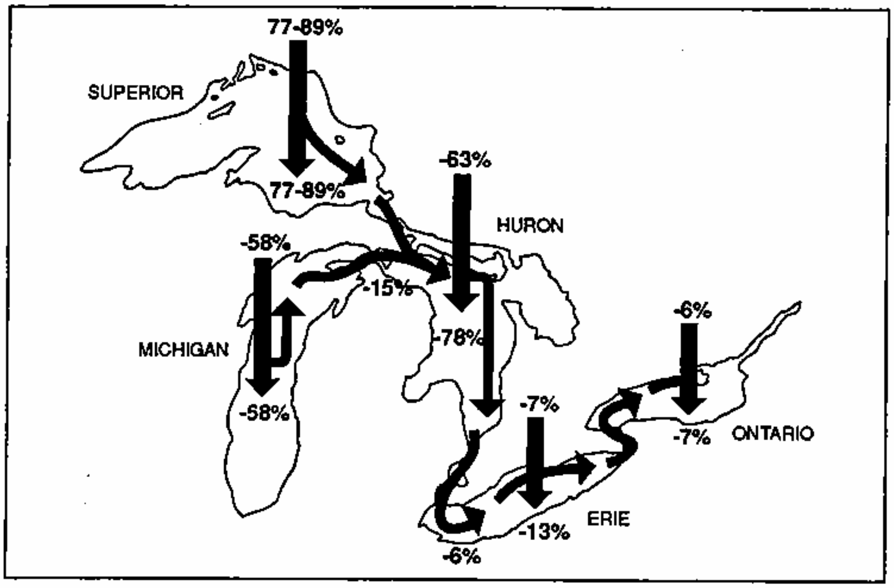


Figure 5. Atmospheric Loading of PCB to the Great Lakes

(Deposition of Air Pollutants to the Great Waters. First Report to Congress. EPA. May 1994.)

RURAL NON-POINT SOURCES

Inland streams in the Niagara River Area of Concern exhibit poor water quality. Faecal bacteria levels generally exceed recreational use standards throughout the Welland River watershed. Excess turbidity and unattractive algae blooms have limited the diversity and health of the entire aquatic ecosystem.

An analysis of water quality samples from the Welland River provides clear documentation of rural non-point pollution. Phosphorus is a problem - in one study 85% to 100% of samples analyzed exceeded the Provincial Water Quality Objective (PWQO) of .030 mg/L total phosphorus.[20] At faecal coliform monitoring stations non-compliance with the PWQO (100 counts/100 mL) ranged from 13% to 100%.[21]

[20][21] Water Resources of the Niagara Frontier and The Welland River Drainage Basin. Prepared for MOEE. Prepared by Gartner Lee Ltd. October 1987.

Phosphorus Loading Estimates (Welland River Watershed)

Erosion	78.7%
Septic	9.0%
Milkhouse	7.7%
Urban	2.0%
Manure	2.0%
Livestock Access	.5%

Bacteria Loading Estimates (Welland River Watershed)

Septic	60.0%
Manure Spreading	15.0%
Manure Storage	10.0%
Livestock Access	8.0%
Urban	6.2%
Milkhouse	.8%

From: Niagara Peninsula Conservation Authority, 1994.

The problem with excess turbidity and suspended solids in the Welland River was recognized in the Stage 1 Report. The report states that "the problem of contamination of the Welland and Niagara Rivers from agricultural areas on the Canadian side of the Niagara River has traditionally been viewed as a minor contribution to a much larger and complex problem. Suspended solid information for the Welland River, measured at Empire Corners, suggest that this may not be a minor problem but may be a significant cause of degraded fish populations in the Welland River".

Poor inland stream and water quality can also be considered an indication that the resources and wastes in the watershed are not being managed properly. For example, topsoil erosion caused by inappropriate land management is measured as excess turbidity and phosphorus in the stream. Improperly managed livestock manure and domestic septic systems are a potential health hazard that is measured as excess stream bacteria and nutrients. In contrast, proper soil and manure management is essential to maintain the long-term productivity of the land. Properly managed and applied livestock manure will provide crop nutrients and improve soil quality.

** Attema, 1994. Rural Water Quality Monitoring Program, unpublished data.*

*** Canadian Water Quality Guidelines, 1987. Prepared by the Task Force on Water Quality Guidelines of the Canadian Council of Resource and Environment Ministers.*

^ U.S. EPA Guideline for High Level of protection to fisheries. According to U.S. EPA Guidelines, 25-80 mg/L suspended solids is considered good or moderate. With 80-400 mg/L good fisheries are unlikely.

Table 6

Water Quality Problems in the Niagara River AOC
(Welland River and Niagara River Tributaries)

Problem	Range*	Goal**
Suspended Solids	15 - 185mg/l	<25mg/l^
Phosphorus	.10-.60mg/l	.03mg/l
Bacteria	20-11,700 E. Coli/100ml	<200E. Coli/100ml for recreational use of water
Oxygen	Less than 47% saturation measured at all 13 sample locations upstream of the Old Welland Canal. Dissolved oxygen ranged from 1.9 to 9.85 ppm	MOEE states that at no time should oxygen levels be less than 47% saturation. This is approximately 4 ppm oxygen at stream temperature common in the Welland River.

Identifying specific "non-point" pollution sources is not an easy task. Each farm and every rural septic system is a potential pollution source. Each field tile drain, through milkhouse waste, household septic connection, barnyard/feedlot drainage, is also potentially a significant source of bacteria and nutrients.

However, some identified rural non-point source pollution sources are:

1) human waste from the rural population;
2) livestock manure storage and field application;
3) direct cattle access to watercourses;
4) milkhouse washwater waste; and
5) erosion of topsoil, streambanks and drainage ditch banks.

Each is discussed as follows.

For the purposes of this report, bacteria, phosphorus and suspended sediment loads were estimated based on the best available information. The "1992 Agricultural Statistics for Ontario" provided rural population, livestock and crop area data. Nutrient, sediment and phosphorus pollution load estimates are based on loading algorithms developed by the MOEE 'Clean Up Rural Beaches' (CURB) program and HSP Incorporated.

Sources of Rural Non-Point Pollution

Septic Systems

Faulty and inadequate septic systems may be a major source of water pollution in the Niagara River AOC. A survey completed in the headwater area of the Welland River (Binbrook Reservoir) showed that up to 40% of rural septic systems provide inadequate waste water treatment. Problems ranged from direct discharge from the septic tank to "grey-water" by-pass of the septic system. "Grey-water" from kitchen sinks, laundry and showers has very high concentrations of phosphorus, dissolved solids and bacteria.

(22)(23) *"Septic Issue, A Sleeping Giant: Widespread Use Raises Contamination Concerns." Volume 1, Number 3 (December 1991). The Commission on Planning and Development Reform in Ontario.*

(24) *Water Resources of the Niagara Frontier and the Welland River Drainage Basin. Prepared for MOEE. Prepared by Gartner Lee Ltd. October 1987.*

(25)(26)(27) *Rural Non-Point Source Working Group, Niagara River RAP. 1994.*

The Commission on Planning and Development Reform in Ontario has also recognized the widespread problem with septic systems in rural areas. In 1990, the MOEE inspected 9067 systems province-wide. Thirty-four percent were found to be malfunctioning.[22] MOEE studies in Haliburton and Muskoka found one-third of the systems were designed to current standards and worked properly, one-third were designed below current standards, and one-third were classifiable as a public health nuisance.[23] It is also widely recognized that low permeability materials such as silt or clay cause operational difficulties with private septic systems[24]. Much of the soil in the Niagara River Area of Concern is low permeability material.

A faulty septic system with direct hook-up to a surface ditch pollutes more than runoff from a large manure storage. On average, four "grey-water" discharge situations pollute as much as one completely failing system. There are approximately 7,000 rural homes serviced by septic systems in the Niagara River Area of Concern. Based on a 40% failure rate it is estimated that septic systems from 2800 homes (servicing a population of more than 10,000), are not functioning properly and are polluting surface and groundwater. Septic system pollution is therefore estimated to contribute 60% of the bacteria load and 9% of the phosphorus load to inland streams in the Niagara River Area of Concern. Repair of septic systems has been identified as the most cost effective method of reducing rural bacteria pollution.[25]

A properly designed and maintained septic system can do an adequate job of treating human waste. Unfortunately many septic systems are not properly maintained. Similarly, failing systems are not replaced as required. Septic systems are not designed to last forever - on average the system can be expected to function properly for fifteen to twenty years. Policies and programs that encourage proper maintenance and periodic upgrades or replacement of septic systems are critical to the long term health of the aquatic ecosystem in inland streams in the Niagara River Area of Concern.

Livestock Manure Storage and Field Application

Improved livestock manure storage and management is required in the Niagara River Area of Concern. Traditional practices, involving outdoor storage without containment of polluted runoff and field application in close proximity to the streams and rivers, are no longer adequate.

Specialization in and the rapid growth of the poultry industry in particular have greatly increased the volume of manure produced. Annual manure production in the Niagara River Area of Concern is about 356,441 tonne's per year. This represents a faecal bacteria quantity equivalent to the human excrement from 9.3 million people. Measured as biological oxygen demand (BOD) the pollution potential is equal to about 556,000 people.[26]

Large, specialized, and high manure volume farms often do not have an adequate land base for proper manure application and utilization. The market demand for manure from crop farmers is very limited since commercial fertilizer can be conveniently purchased and applied for less cost than low cost or free animal manure. As a result, manure application rates are often determined by available land base rather than attempts to maximize nutrient value or minimize pollution potential. Runoff after manure application accounts for much of the manure pollution of surface water.

Other livestock manure sources are estimated to contribute 25% of the bacteria load and 2% of the phosphorus load to inland streams in the Niagara River Area of Concern.[27]

Direct Cattle Access

Allowing cattle direct access to the watercourse for drinking water has been a normal and accepted farm practice for decades. Cattle continue to be pastured in lowland and creek bank areas. Careful monitoring in recent years has shown that even a few cattle in the creek has a tremendous impact on water quality. Ten cattle with direct access to a creek will pollute more than a manure stack runoff from 100 cattle. Cattle also trample stream banks, making them more susceptible to erosion.

Noticeable changes in the creek can be observed almost immediately after the cattle are removed. The stream banks quickly reestablish. Wide, shallow slow moving channels are changed by bank vegetation into a narrow, deep channel with a faster current. The faster current absorbs more oxygen from the air and improves the ecological functions of the streambed.

It is estimated that there are about 82 cattle access locations on inland streams in the Niagara River Area of Concern. Direct cattle access pollution is estimated to contribute 8% of the bacteria and less than 1% of the total phosphorus to inland streams in the Niagara River Area of Concern.[28]

(28)(29) *Rural Non-Point Source Working Group. Niagara River RAP. 1994.*

Milkhouse Washwater

Approximately 80% of the dairy farmers in the Area of Concern dispose of milkhouse washwater through sub-surface drainage tiles directly to a watercourse.

Milkhouse washwater contains high levels of phosphorus, organic matter and chlorine. Once the chlorine dissipates the nutrients and milk solids provide an ideal breeding ground for bacteria. Often subsurface drainage tiles deliver the contaminated water directly to the watercourse. There is no opportunity for bacteria to die off naturally and little opportunity for phosphorus to be absorbed by the soil. The net result is that one milkhouse washwater problem can contribute as much bacteria pollution as the runoff from a large manure stack or a completely failing household septic system. The phosphorus bearing detergent used to clean milkhouse piping directly loads up to 35 kg of phosphorus/site/year. That is equal to dumping 600 - 1 kg boxes of laundry detergent into a stream.

There are about 180 milkhouse washwater problem locations in the Niagara River Area of Concern. Milkhouse washwater pollution is estimated to contribute less than 1% of the bacteria but up to 8% of the total phosphorus to inland streams in the Niagara River Area of Concern.[29]

Topsoil Erosion

Water draining from agricultural fields carries top soil, phosphorus, pesticides and other pollutants. A relatively small amount of pollution from over 63,000 hectares translates into the largest source of agricultural pollution. Run-off studies on fall plowed clay soils have shown phosphorus pollution of up to 2.63 kg/ha (Allsop et al, 1987). That is equal to dumping 45-1 kg boxes of laundry detergent into a stream for each hectare of land. It is estimated that topsoil erosion accounts for up to 78% of the agricultural phosphorus pollution in the Niagara River Area of Concern. Soil erosion from stream banks, road ditches, municipal drains and construction practices also contributes to the problem.

In theory reducing topsoil erosion is simple. A 30% crop or crop residue ground cover on the soil surface for the entire year will reduce topsoil erosion and phosphorus pollution by more than 50%. The crop or crop residue cover provides soil surface protection similar to a grass field or forest cover. Traditional fall plowing results in less than 10% ground cover for at least six months of the year.

Crop rotation with forage crops is the easiest and best method of achieving a minimum of 30% ground cover in the Niagara River Area of Concern. Unfortunately, a forage based crop rotation may not be an economically viable alternative for cash crop farmers. The 30% ground cover goal can be met through minimum tillage and no-tillage topsoil management. At least two barriers to wide scale adoption of minimum and no-tillage topsoil management have been identified.

First, no-tillage and minimum tillage is particularly difficult on the poorly drained clay soils that predominate in the Niagara River Area of Concern. No-till results with crops other than corn, including soybeans, spring grains, winter wheat and forages, have been encouraging. There is a need for further research on tillage systems that will produce crop yields and/or profits similar to traditional fall plowing while minimizing soil erosion. Secondly, within the farm community there is some resistance to change from proven fall tillage systems to unproven technology. Capital expenditure of $30,000 or more is required to purchase minimum-tillage or no-tillage equipment. There is a need to market alternative tillage systems to the farm community through demonstration projects and other incentive programs.

In addition, soil erosion can result from poor construction practices - everything from building of homes to road construction to drainage ditch construction and restoration. Erosion results when ground cover is cleared exposing the earth to rain. Construction activities can increase the amount and rate of soil erosion by up to 40,000 times that of undeveloped lands or forests.

In response to environmental problems caused by erosion and sediment loss during construction, sediment and erosion control guidelines outlining Best Management Practices (BMP) have been developed. BMPs emphasize prevention and so the objective of BMP is to reduce erosion due to storm runoff and minimize the amount of sediment moving off construction sites before construction begins and problems occur. BMP manuals generally address four issues: erosion control measures; sediment control measures; drainageway protection; and preparing an erosion and sediment control plan[30].

Developing strategies to reduce topsoil erosion will be a challenging task. In order to meet suspended sediment and total phosphorus objectives much progress is required in this area.

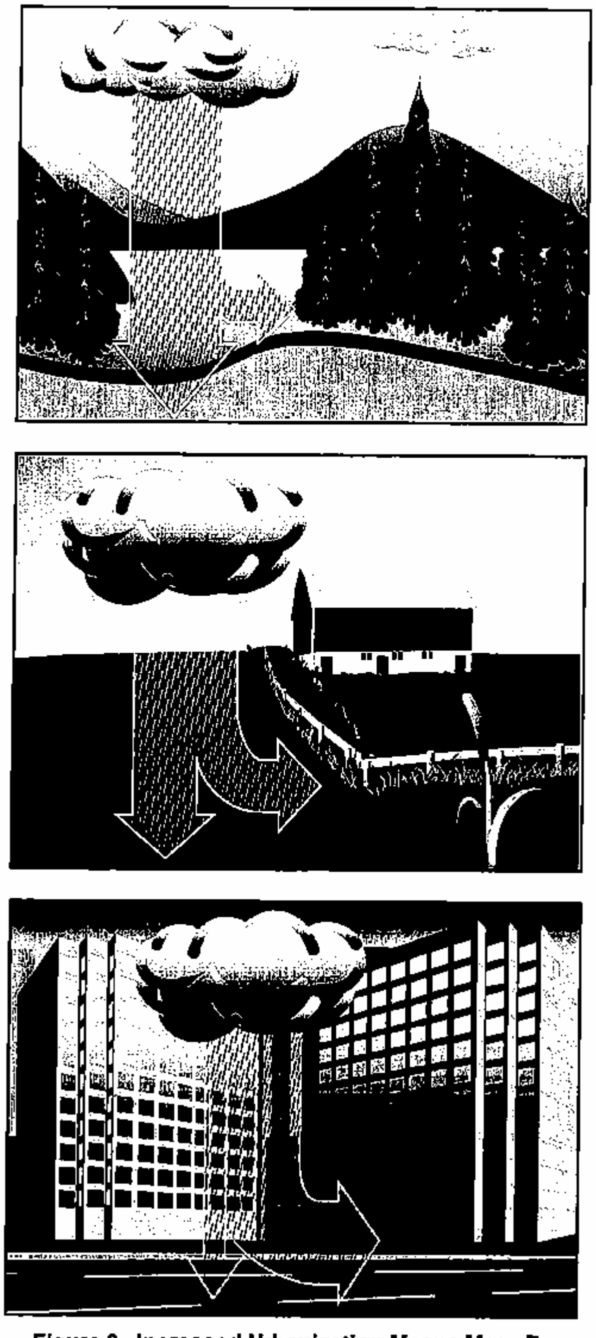


Figure 6. Increased Urbanization Means More Runoff and Less Infiltration

(Clean Waters, Clear Choices, Metro Toronto and Region RAP)

(30) *Examples of Best Management Practice Guides include:*

Keeping Soil On Construction Sites. Erosion and Sediment Control Guidelines for Hamilton Harbour Watershed and Region of Hamilton-Wentworth. Hamilton Conservation Authority. January 1994.

Guidelines On Erosion and Sediment Control For Urban Construction Sites. Ontario Urban Drainage Implementation Committee. Ontario. Jan. 1995.

Best Management Practices. Water Management. Agriculture Canada. 1994.

SEDIMENTS

PROBLEMS AND IMPAIRED BENEFICIAL USES

Due to the fast flowing nature of the Niagara River, there are very few deposits of sediment. The river bed is virtually swept clean and much of the sediment load is deposited in Lake Ontario. A few areas in the tributaries feeding the Niagara River, however, have had sediments contaminated with organic compounds or heavy metals. These substances can pose a threat to the health of the ecosystem and contribute to the impairment of the beneficial uses of the resource.

Sediments are both a source and a sink for contaminants. Sediments become sources when fine particles (to which contaminants adhere) are resuspended in the water through disruptive activities such as dredging or natural processes such as high flows or wave action. Sediment-bound contaminants may re-enter the water column through chemical diffusion or be consumed by bottom-dwelling organisms. These contaminants may become "bioavailable" through the food chain to higher organisms such as fish, birds, small mammals and humans. Sediments act as a sink in areas of slow moving water where deposition occurs and contaminants may accumulate and be buried.

Sediment concerns primarily focus on the presence of elevated levels of contaminants in a number of creeks in the Area of Concern. These areas have been shown to have various contaminants above the Ontario Ministry of Environment and Energy's sediment quality guidelines. These guidelines are based on the effects of contaminants on benthic (bottom-dwelling) organisms. Other indicators of sediment contamination include lack of benthic species abundance and diversity. In some areas, only pollution-tolerant species survive. Some studies have reported mutagenic effects.

Sediments in the lower Welland River show metal concentrations above dredge spoil disposal guidelines and benthic diversity has decreased to more pollution tolerant species. In areas with extremely high metal concentrations, no benthic organisms exist (eg. Welland River Reef). Due to a lack of suitable substrate as well as the fast flowing current, benthic organisms are relatively sparse in the Niagara River. However, in backwater areas, benthic species abundance and diversity does not appear to be impaired.

Bottom sediments can be contaminated by point or non-point sources. Control of the contaminant source is the essential first step in dealing with a contaminated sediment problem. Source control can be achieved directly through effluent regulations, pollution prevention measures, land use controls, sound environmental agricultural practices and other measures to reduce the release of contaminants to water bodies. Recommendations to address specific sources are listed in the Stage 2 Report. In some cases sediment contamination resulted from

Provincial Sediment Quality Guidelines

The purpose of the guidelines is to protect the aquatic environment by setting safe levels for metals, nutrients and organic compounds. The guidelines replace MOEE's 1976 Open Water Disposal Guidelines.

The guidelines establish three levels of effect - No Effect Level, Lowest Effect Level and Severe Effect Level. The Lowest Effect Level and Severe Effect Level are based on the long-term effects which the contaminants may have on the sediment-dwelling organisms. The No Effect Level is based on levels of chemicals which are so low that no contaminants are passed through the food chain.

From: Guidelines For The Protection and Management of Aquatic Sediment Quality In Ontario. MOEE. June 1992.

historical discharges or spills. If the sources of contaminants have been eliminated or are controlled, surface sediment contamination may be gradually covered over in time with less contaminated material. If improvements in sediment quality are not satisfactory, choosing a sediment remediation option may be the next step.

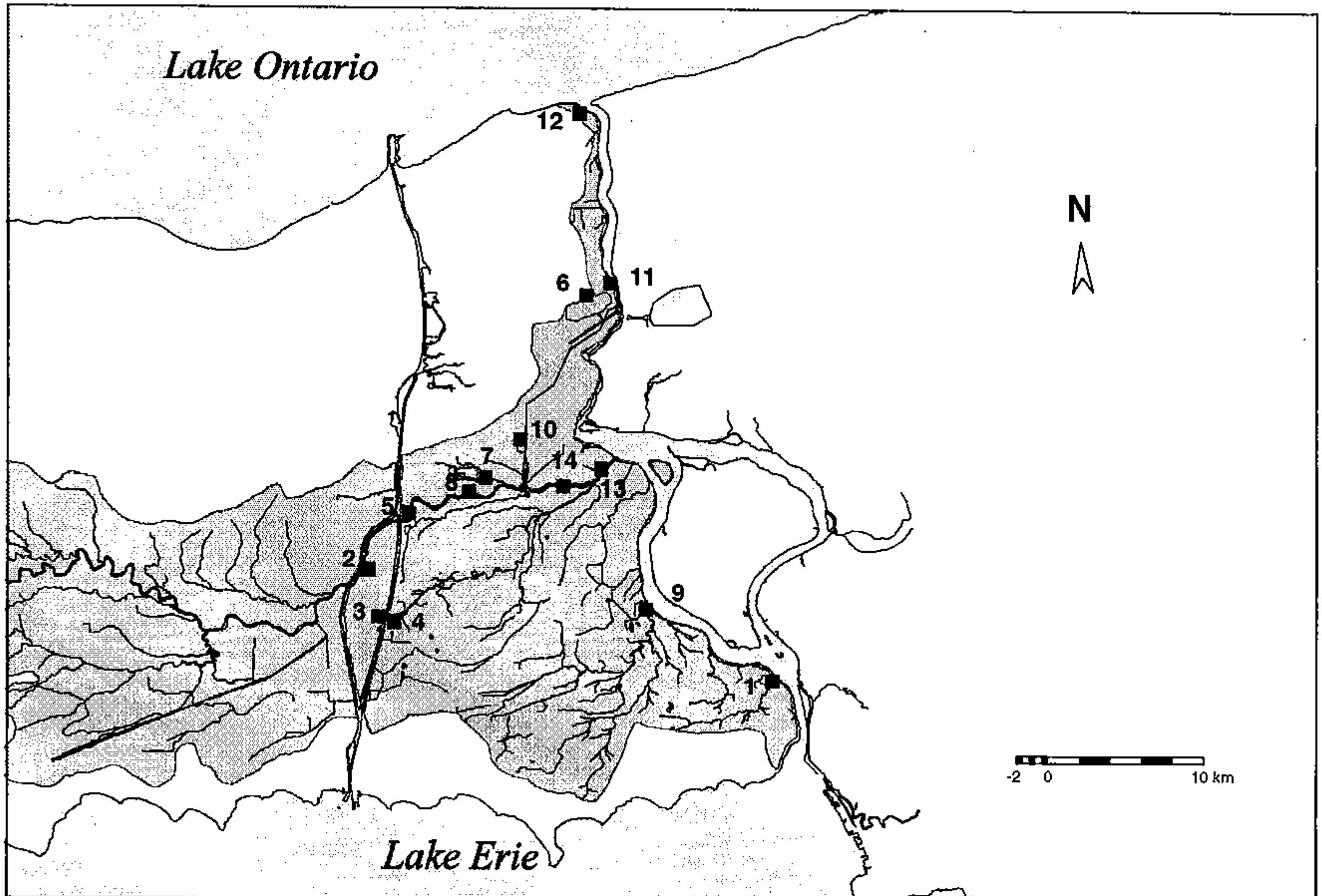
Prior to any decision beyond source control, the degree and extent of contamination would require a detailed assessment. Priority areas for further assessment were identified by a Sediment Working Group comprised of agency, industry and PAC representatives and are presented in this report.

Level 1 identifies those areas where there are known contaminated sediments that require remediation and/or further detailed assessment. Level 2 are those areas where previous studies have shown possible contamination or a contaminant related issue (eg. toxicity, deformities) but the studies were inconclusive. The available information indicates that further (site specific) evaluation is warranted, followed by a decision to move to level 1 or 3. Level 3 are those areas where contaminants have been found by some studies but the sampling programs were designed with inadequate numbers of samples or the contaminant concentrations were not severe. These sites will be included in the long-term monitoring program to confirm previous findings for the Remedial Action Plan.

CONTAMINATED SEDIMENT SITE DESCRIPTIONS

In preparation for the Spring 1993 Option Selection Workshop, a comprehensive list of possible contaminated sediment sites was prepared for review and action. At the workshop it was agreed to review the list with an aim to determine which sites were in the process of being remediated, which sites needed further sampling to determine the extent of their contamination, and which sites should be included in any long term monitoring program to confirm previous findings. That work has been completed and forms the body of this section.

Contaminated Sediment Sites



Contaminated Sediment Sites

1 Frenchmans Creek
2 Welland River Reef
3 Lyons Creek West
4 Lyons Creek East
5 Welland River at Port Robinson
6 Sir Adam Beck Rerservoir
7 Thompsons Creek at Cytec
8 Welland River at Geon
9 Black Creek
10 Chippawa Power Canal
11 Niagara River at Queenston
12 Niagara River at Niagara-on-the-Lake
13 Pell Creek
14 Chippawa Creek

Data Source: Ministry of Environment and Energy, 1994

Map 7

Map created by Water Issues Division

Environment Canada
Environnement Canada

LEVEL ONE SITES

1. Welland River Reef

Sediment contamination in the Welland River, adjacent to Atlas Specialty Steels, was first investigated in the mid 1980's by researchers from Brock University (Dickman et al, 1990) who concluded that the benthic invertebrate population in the area was impaired. The impairment was attributed to the heavy metals found in the river mill scale.

In 1987 Atlas Specialty Steels committed itself to cleaning up the river mill scale, commonly referred to as the "Atlas Reef". A number of studies followed in the next few years. Atlas Specialty Steels retained a consultant to conduct three separate investigations of the contaminated area.

In the area of the McMaster Avenue and the Atlas-Gencorp industrial discharges, there are deposits of industrial mill scale. The sediments associated with the mill scale contained levels of heavy metal contamination exceeding those of the upstream sediments and the Severe Effect Level (SEL) as established by the Provincial Sediment Quality Guidelines (PSQG).

The sediments between these two outfalls and downstream from the Atlas-Gencorp discharges were found to be contaminated as well. These sediments are fine grained organic silts[31] which are known to have a high contaminant adsorption capacity. The metal contamination level in this area is above the upstream background levels and some of the sites were above the SEL.

The impact of this contamination on the benthic invertebrate community has been addressed by several studies. The Brock University researchers found that the area of the river near the Atlas-Gencorp outfall did not support a benthic community. Density and diversity of benthic organisms increased downstream toward the WPCP. Chironomid species[32] richness and density was lower in the impacted area downstream from the outfall than at an upstream control. Also, the incidence of chironomid species labial plate deformities was reported higher in the impacted area than at the upstream control site.

In 1990 the MOEE studied the sediment and benthos in the area to determine the relationship between contaminants and benthic community structure[33]. Bioassays were also conducted on sediment samples from the same stations[34]. The results of these studies suggest that the invertebrate community structure is impaired in the area of the outfalls. Due to the confounding influence of varying substrate types and organic content, no obvious relationship between contaminant levels and invertebrate community impairments was established. The linkage between contaminant and invertebrate mortality and growth was not well established either, due to mortality at control sites.

In 1991, Environment Canada also conducted sediment bioassays. Mortality was observed in the test of Welland River sediment from the identified area. The relationship to contaminant level was not established, as no corresponding chemical analyses were conducted.

In October and November of 1991 a Contaminated Sediments Removal and Treatment Demonstration Project was conducted at this site. The demonstration removed 230 m^3 of mill scale and sediment. The sediment was transported in a flexible pipeline to a multi-stage sediment treatment plant. Generally the demonstration was considered successful[35] and a great deal of technical information was gained.

Presently, a submission has been made to Environment Canada for further remediation of the site. The project involves the removal of extensive contamination (approximately 6500 cubic metres of sediment) from the river (not flood plain). It is anticipated that actual Removal Demonstration will commence in the Summer 1995. The Demonstration Area requiring remediation will be defined by correlating the biologically impacted areas with those areas previously defined as exceeding the SEL.

(31) Acres International Ltd. The Welland River Dredging and Treatment Demonstration. Vol. 1 of 2 Main Report. Page 5-21. February 1993.

(32) The larval stage of midges, a small nonbiting insect that commonly occur in swarms near bodies of water. The larvae are found in lakes, rivers and streams usually living in the sediment.

(33) Jaagumagi, R. Welland River Sediment and Benthos Study. Ontario Ministry of the Environment. Interim Report. 1991.

(34) Bedard, D. and Petro, S. Welland River Study -1990- Laboratory Sediment Bioassay Report. Ontario Ministry of Environment and Energy. 1991.

(35) Acres International Ltd. The Welland River Dredging and Treatment Demonstration. 1993.

(Areas of Chemical & Heavy Metal contamination). This biological study was completed in the summer of 1994 by the MOEE.

Atlas Specialty Steels has committed substantial funding towards the cleanup effort and has also requested partial funding for the project from both Environment Canada and the Ministry of Environment and Energy. This funding is presently under review. As well, municipal and industrial dischargers have been approached to participate in the Demonstration Project.

Public participation has been extensive in both Public Liaison Committees (Welland River Reef and Friends of the Welland River). Both Committees have representation on each other's Committee. The Friends of the Welland River Committee's objective is to address the aesthetics of the Welland River while the Welland River Reef Committee's objective is to address the remediation of the contamination in the Welland River. Both public liaison committees have restricted their mandate to those areas of the Welland River within the City of Welland. These committees meet on a monthly basis.

2. Lyons Creek West

The upper reaches of Lyons Creek have been heavily impacted by human interference. Originally the creek drained the Wainfleet Marsh and the south section of the City of Welland. The construction of the "new" Welland Canal in 1972 severed Lyons Creek into two unconnected streams.

The actual watershed of Lyons Creek West is a small open area (23 ha.) between Humberstone Road, Welland and the south-west area of the City of Welland's residential area municipal drainage and the canal. This open area contains a low lying drainage area (3 ha.) which is the only remnant of the former southerly portion of Lyons Creek. The total watershed area also contains 147 hectares of 'municipal drainage' from the City of Welland. An open ditch carries the untreated municipal drainage past the wetland and discharges, through three culverts, into the Welland ship canal. Approximately 80% of the flow volume in this drain is treated process and storm water from StelPipe, Stelco Inc. (formerly the Page-Hersey works). StelPipe manufactures small diameter steel pipe at this facility.

This drainage area has not been classified by the Ontario Ministry of Natural Resources. The diversity of plant species is low and no rare or unusual species have been reported.

In May of 1990, an accidental spill of PCB contaminated oil (less than 10 ppm) occurred at Ontario Hydro's Crowland Transformer Station in Welland. The spill flowed into the municipal ditch which connects to Lyons Creek West. Samples of water and sediment were taken subsequent to the remediation of the spill. The water samples did not indicate any detectable PCB contamination (greater than 0.05 ppm). Sediment sample results indicated PCB contamination, however, the type(s) (Arochlors) of PCB's detected were different from those spilled by Ontario Hydro.

The PCBs present were determined to be weathered and relatively old. PCB concentrations as high as 648 ppm were discovered at a depth of 25 cm. in the sediments of Lyons Creek West. These levels define the contamination as PCB waste. The sediments are also contaminated with heavy metals. The PCB contamination is generally confined to the top meter of organic material within the drainage area. The municipal drain and upper reaches of the creek are presumed to be the historical pathway of contamination. No definite sources has been identified by any study and PCB's are not presently entering the canal system.

Public meetings have been held and the Lyons Creek (West) Liaison Committee has been established to develop a remedial plan. The committee is composed of local residents, city officials and provincial/federal agency staff and the three property owners (Ontario Hydro, St. Lawrence Seaway Authority and the City of Welland).

Federal Fisheries officials have indicated although not a wetland, some fishery habitat restoration is required at this site. The three property owners agreed to restore the mouth of the discharge channel into additional fish habitat. The MNR has endorsed their restoration plan.

A bioremediation technique for treatment has been proposed. Funding for this demonstration project has been requested from the Federal Government and is presently under review. Funding for a Demonstration Project for a Removal Technique has been granted to the St Lawrence Seaway Authority, one of the property owners. The construction of the diversion channel part of this Demonstration Project commenced fall 1994. A pad will be constructed to contain the contamination on St. Lawrence Seaway Authority property. The Liaison Committee has endorsed this Project.

3. Lyons Creek East

Lyons Creek East flows from the Welland Canal through a wetland and connects to the Welland River which then discharges to the Niagara River. The source of water for this section of the Creek is continuously pumped from the canal to maintain both summer and winter base flows in the stream. The Lyons Creek East wetland is classified by Ontario Ministry of Natural Resources as a Class 1 and is of Provincial significance. This wetland is 150 hectares in area and supports a community of several fish species and other wildlife.

The analysis of sediment samples from Lyons Creek East showed that they were also contaminated with PCB's. Concentrations of PCB's reached a maximum of 180 ppm in the sediment. This contamination was at a depth of 25 cm. Further sediment and water sampling results indicate that the primary area of PCB contamination is confined to the portion of the Creek between the Welland Canal and Hwy. 140. The water samples did not indicate any PCB contamination (greater than Detection Limits of 0.05ppm).

Biological accumulation of PCB's in various fish has been assessed (A. Hayton-MOEE) and do not exceed the Sport Fishing Guide for human consumption. Further benthic community studies have been undertaken to assess the presence of PCB contamination in the benthic community. PCB contamination does exist in the sediment dwelling organisms. The mobility of the PCB's was also studied and preliminary indication is that the PCB's appear to be confined in the sediment (Jaagumagi-MOEE). The Medical Officer of Health has been informed of the presence of PCB contamination in both the benthic community and fish within this area. Further sampling surveys downstream have been undertaken in both surface water and sediment to determine the extent of the contamination (R. Vickers-MOEE). Results are expected in 1995.

The Lyons Creek Action Committee, composed of local residents, municipal officials and provincial/federal agency staff, has been formed to develop a remedial plan. Plans call for the retention of a consultant to define the impact of this contamination, define the biological community and recommend remedial options. The Committee has requested financial assistance of the Government Agencies to obtain a consultant to undertake such a study. This request is presently under review as to what funding programs are available to assist this Committee in such a study.

Further studies of biological accumulation of PCB's in Shiners (C. Sun-MOEE) will be undertaken in 1995.

4. Welland River from Port Robinson to Power Canal

In 1991 researchers from Brock University observed deformities among chironomid larvae in the vicinity of Ford Glass on the Welland River. Ford Glass discharges to the Welland River just west of the QEW. Brock University suggested that the Ford Glass discharge was responsible for the observed chironomid deformities. A consultant was hired by Ford Glass to determine the extent of sediments potentially affected by the Ford Glass discharge.

It was determined that there are elevated levels of oils and grease, Total Kjeldahl Nitrogen and Total Phosphorus in the river sediments adjacent to Ford Glass. The Ford Glass discharge is responsible for these contaminants. During the course of the study it was found that the sediments in the area around Ford Glass, and at two stations upstream, are contaminated with metals. The concentrations of oil and grease, nickel, iron, chromium, copper and silver in the sediments exceed the SEL in these three sample locations. These metals are not present in the Ford Glass effluent.

The consultant also tested for chironomid deformities in the vicinity of Ford Glass area. There was no difference in the percentages of deformities above and below the plant. The study further stated that frequency of deformities in chironomid larvae is an unreliable indicator of biological effects for the Welland River study area.

The company is investigating possible remediation of the oil and grease contamination in the sediment.

LEVEL TWO SITES

5. Sir Adam Beck Reservoir

An MOEE study[36] detected the presence of elevated levels of metals, the pesticide DDT and it's metabolites in the surficial sediments of Ontario Hydro's Sir Adam Beck Reservoir. The source of these contaminants were not identified in that study. Further work to identify sources, determine mobility of the contaminated sediments and monitoring the reservoir was recommended, although not undertaken to date, until the impact of this contamination is further assessed.

The concentrations of some metals found in the sediments of the Sir Adam Beck Reservoir were above the LEL, but not the SEL. Discovery of DDT was surprising since it was banned for agricultural uses in 1970. This suggests the breakdown of DDT has been delayed. This pesticide binds tightly to organic particulates and given the high organic nature of the sediments in the reservoir is not likely available to contaminate fish. Yellow perch captured in 1982 in the reservoir contained no DDT but did have concentrations of it's metabolites at levels low enough to be considered suitable for unrestricted human consumption.

Ontario Hydro has no plans for any activities, dredging or expansion, that could possibly disturb the sediments. The contaminants present there do not pose an immediate problem in the AOC, however the Sir Adam Beck Reservoir should be revisited to confirm these findings.

6. Thompson Creek

Hart[37] detected arsenic concentrations (6.1-8.7μg/g) between the LEL (6.0μg/g) and SEL (33μg/g) in bottom sediments. Richman[38] detected concentrations of arsenic (5.3μg/g) in bottom sediment in Thompson Creek.

Richman's bottom sediment monitoring indicated that chromium (100μg/g) and copper (52μg/g) were between the LEL (chromium 26μg/g, copper 16μg/g))and SEL (chromium 110μg/g, copper 110μg/g) at the mouth of Thompson Creek.
Nickel (130μg/g) exceeded the SEL (75μg/g).

(36) Contaminant Concentrations In Bottom Sediments of the Sir Adam Beck Power Reservoir and Niagara River Bar Dredgeate. MOEE. April 1987.

(37) Hart, Christopher. 1983 Niagara River Tributary Survey. Final Report. For Ontario Ministry of the Environment.

(38) The Niagara River Mussel and Leech Biomonitoring Study. October 1992. Ontario Ministry of Environment and Energy.

Thompson Creek receives cooling and process effluent from Cytec (Welland) plant. Based on data in the 1980s the facility was identified as a significant contributor of toxics in the Ontario portion of the Niagara River drainage basin by the Niagara River Toxics Committee review. Metals were the major sources of toxics cited at the time. Chromium and nickel were removed from Cytec's Certificate of Approval requirements in May 1991 as they were no longer in use at the facility.[39]

Followup sediment sampling for arsenic, chromium, copper and nickel (heavy metals) is underway (fall of 1994).

7. Frenchman Creek

Hart[40] detected chromium (150.0-290.0 µg/g)in bottom sediments, at the mouth of Frenchman Creek. The SEL for chromium is 110µg/g. The report notes that Fleet Manufacturing was not in compliance with the Ministry's Industrial Discharge criteria for chrome. In 1985 process wastewater from Fleet Manufacturing was diverted to the municipal sewer. Only non-contact cooling water is discharged to Frenchman Creek. In 1991 chromium was not detected in Fleet Manufacturing's discharge to Frenchman Creek.[41]

Anderson et al.[42] detected 7 CDD (chlorinated dibenzo-p-dioxin) (0.21 ng/g) and 8 CDD (chlorinated dibenzo-p-dioxin) (0.90 ng/g) and 6 CDF (chlorinated dibenzofuran) (0.06, 0.01 ng/g), 7 CDF (chlorinated dibenzofuran) (0.15, 0.44 ng/g), 8 CDF (chlorinated dibenzofuran) (0.11, 0.44 ng/g) in bottom sediments collected from the manhole of the Canadian Oxy-Chemical facility in Fort Erie.[43] The company as of 1993 discharges its process wastewater to the municipal sewer.

Friends of Fort Erie's Creeks, composed of local residents and government officials has undertaken cleanup activities in the Creek over the last four years and is currently developing a watershed plan for Frenchman Creek.

	Thunder Bay (Lake Erie)	Niagara-on-the-Lake
7CDD	0.32	0.81
8CDD	1.40	8.20
6CDF	0.18	0.047
7CDF	0.37	0.23
8CDF	0.48	0.20

39. Report On The 1991 Industrial Direct Discharges In Ontario. Ontario Ministry of Environment and Energy.

40. Hart, Christopher. 1983 Niagara River Tributary Survey. Final Report. For Ontario Ministry of the Environment.

41. Report On The 1991 Industrial Direct Discharges In Ontario. Ontario Ministry of Environment and Energy.

42. Niagara River Biomonitoring Study. July 1991. Ontario Ministry of the Environment.

43. Concentrations of Polychlorinated Dioxin and Furons (ng/g dry weight) in Surficial Sediments Collected During the Niagara River Biomonitoring Survey, 1993.

LEVEL THREE SITES

8. Welland River at Geon

Dickman (1991) identified a higher incidence of chironomid deformities in the Welland River adjacent to Geon Canada than at upstream sites. The study was not able to identify whether the problem was related to contaminated sediments or water quality. Traces levels of vinyl chloride exist in Geon's effluent. Geon hired a consultant to study the problem. The study was concluded in 1993. Conclusions in the report indicated that contaminated sediment thickness ranged from 8 cm. to 30 cm. Sediments exceeded the SEL for iron. Volatile organics were not detected and extractable organics were below the LEL. Abnormally high levels of deformities in chironomids were detected. Further study has been undertaken and MOEE review of this report is underway.

9. Black Creek Mouth

Creese [44] found levels of arsenic (4.23µg/g) in the sediments of the Niagara River at the mouth of Black Creek that were slightly higher than other areas in the river. Arsenic concentrations were below the LEL (6.0µg/g). The study also found a diverse benthic community that included species considered to be 'sensitive' to contaminants.

It is recommended that this site be included in a future monitoring survey to confirm these findings.

(44) (47) (48) (49) *Cresse, E.E. 1983 Benthic Survey of the Niagara River and Nearby Lake Ontario. Volumes 1 and 2. MOE Report Series. 1987.*

(45) (46) *Hart, Christopher. 1983 Niagara River Tributary Survey. Final Report. For Ontario Ministry of the Environment.*

10. Pell Creek Mouth

Hart[45] detected copper (120-160µg/g) in bottom sediment that exceeded the SEL (110µg/g) at the mouth of Pell Creek. Hart noted that the flow in Pell Creek is mainly industrial effluent from Washington Mills (formerly Carborundum Abrasives) and Norton Abrasives.

It is recommended that this site be included in a future monitoring survey to confirm these findings.

11. Chippawa Hydro Canal

(between Montrose, the Q.E.W. and the Sir Adam Beck Reservoir)

Hart[46] detected concentrations of cadmium (0.30-0.82µg/g) above the LEL (0.6µg/g) in the bottom sediments. Arsenic (3.0-5.6µg/g) and zinc (73-91µg/g) concentrations in bottom sediments were below the LEL (arsenic 6 µg/g, zinc 120 µg/g).

It is recommended that this site be included in a future monitoring survey to confirm these findings.

12. Niagara River at Queenston

Creese[47] found levels of cadmium, zinc, copper and mercury at concentrations slightly above the LEL in the sediments of the Niagara River off Queenston. There were no concentrations of zinc over the LEL found on the Canadian side of the Niagara River at Queenston. Zinc concentrations did slightly exceed LEL in several samples from the American side of the river.

Copper concentrations of 17µg/g and 16 µg/g were found in Canadian samples at this site. The LEL for copper is 16 µg/g. One American sample contained 113 µg/g of copper. This sample exceeds the SEL of 110 µg/g. The highest concentration of mercury found in a Canadian sediment sample at this site was .31 µg/g. The LEL is .2 µg/g and the SEL, 2 µg/g.

Creese[48] found a "highly diverse benthic community" including many 'sensitive' species in the sediments of the Niagara River off Queenston. Stations where species richness were depressed were either on the American side of the river and associated with high metal contamination or substrate differences. No explanation for low species richness was given for one Canadian sample. The biota at this site is not seriously affected by the metal concentrations in the sediments.

It is recommended that this site be included in a future monitoring survey to confirm these findings.

13. Niagara River at Niagara-on-the-Lake

Mercury concentrations above the LEL (.2 µg/g) were found in three samples at three stations reported by Creese[49]. None of these samples had concentrations of mercury above the SEL. The species richness of the benthic invertebrate community was low at one of these stations. This may be attributable to the higher mercury concentration.

It is recommended that this site be included in a future monitoring survey to confirm these findings.

14. Chippawa Creek[50]

Sediments in the Chippawa Creek portion of the Welland River was found to contain PAH-contaminated sediments (coal tar). Following studies to determine the extent of the contamination, a remediation plan was developed and implemented (April 1987 to March 1989). Remediation involved removal of contaminated sediments from the riverbed and shoreline.

Dickman et al.[51] found the frequency of chironomid abnormalities declined (from 14% to 7%, background is usually 6%) after the contaminated sediments had been replaced with clean sediments. Dickman concluded that the sediments in the "cleanup" area had been decontaminated.

It is recommended that this site be included in a future monitoring survey to confirm these findings.

(50) *See reports: Chippawa Coal Tar Cleanup (Acres, 1985); Chippawa Creek Cleanup - Environmental Study Report (Acres, 1986) and Chippawa Creek Cleanup: Report on Cleanup Activities, April 1987 - April 1989. (Acres May 1989)*

(51) *Dickman, Mike; Frances Fiore and Ian Brindle. The use of Benthic invertebrates in mapping toxic areas of sediment and determining the efficacy of sediment cleanup operations. From 1990 Environmental Research Technology Transfer Conference, Proceedings Vol.I.*

Table 7 **Niagara River Contaminated Sediment Sites**

Level 1: Detailed sediment assessment and/or remediation required/work underway.

IDENTIFIED SITE	CONTAMINANTS	POTENTIAL SOURCES	INFORMATION SOURCE	STATUS	ACTION ITEMS
1. Welland River Lincoln Avenue bridge to Port Robinson	Metals Oils and grease	Atlas Steels/Gencorp. effluent and groundwater Welland STP/WTP (RMON) Defunct sites - Welland Iron & Brass City of Welland storm sewers McMaster Sewer Broadview Ave. Sewer Coyle Rail Yard City of Welland landfill	Acres Reports 1990 to 93 Tarandus 1992 Dickman 1993	Liaison Committee established Dredging demo completed at McMaster Ave in 1991 Sediment assessment ongoing (all areas)	RAP/PAC involvement in liaison committee Review sediment assessment analysis MOEE/Environment Canada to complete required data collection
2. Lyons Creek west of Welland Canal	PCBs, metals	Historical PCB discharges	ESL Consultants	Liaison Committee established Source is unknown Property owner has hired consultant to investigate sediments, biota, phytotoxicology	Bioremediation pilot study (Grave, Dearborne) RAP/PAC involvement in liaison committee
3. Lyons Creek east of Welland Canal	PCBs, metals, oil & grease	Historical PCB discharges	MOEE - Regional / Water Resources Branch	Public meeting completed	Liaison committee established
4. Welland River Port Robinson to Power Canal	Metals Oils and greases	Upstream Ford Glass Plant	Beak Consultants 1992	Beak is undertaking further study to address independent comments on the 1992 study by Dickman & MOEE. Work is ongoing.	Company to investigate remediation, if necessary

Table 7 (Con't) **Niagara River Contaminated Sediment Sites**

Level 2: Available information indicates that further (site specific) sampling is required, followed by a decision to move to level 1 or level 3.

IDENTIFIED SITE	CONTAMINANTS	POTENTIAL SOURCES	INFORMATION SOURCE	STATUS	ACTION ITEMS
5. Sir Adam Beck Reservoir	Metals, organochlorine compounds (pesticides)	Welland River	Kauss 1987 Hart 1983	Ontario Hydro has no activities planned which would disturb sediments. Reservoir sediments will not be affected by the proposed Beck 3 development.	MOEE may sample reservoir within NRTMP.
6. Thompsons Creek at Cytec	Arsenic, chromium, copper, nickel, nitrogen and phosphorus compounds A water quality issue	Cytec discharge (historical) and landfill discharge	Hart 1983 Richman 1992	Followup sediment sampling (Fall 1994)	Refer to water quality
7. Frenchman Creek	Chromium Dioxins, furans,	Fleet Industries Canadian OxyDurez	Hart 1983 Richman 1992	Fleet discharges now to WPCP 1990 CanOxy process water in closed loop 1993 storm runoff to creek	Friends of the Creeks of Fort Erie study underway

Table 7 (Con't) **Niagara River Contaminated Sediment Sites**

Level 3: Sites to be included in monitoring program to confirm findings.

IDENTIFIED SITE	CONTAMINANTS	POTENTIAL SOURCES	INFORMATION SOURCE	STATUS	ACTION ITEMS
8. Welland River at Geon (formerly B.F. Goodrich)	Traces of Vinyl chloride in effluent	Geon (formerly B.F. Goodrich)	Dickman, 1991 Chironomid deformities; improvement by 1991	Consultants study (Beak, 1993) completed - no vinyl chloride found in sediment.	Monitor benthic community Refer to water quality
9. Black Creek mouth	Arsenic	Past agricultural practices	Creese 1987 Hart 1983		Include in future monitoring program to confirm findings
10. Pell Creek mouth	Copper	none identified	Hart 1983		Include in future monitoring program to confirm findings
11. Chippawa Power Canal (between Montrose & QEW & Sir Adam Beck Reservoir	Cadmium, zinc, copper, mercury	Welland River / Niagara River	Hart 1983		Include in future monitoring program to confirm findings
12. Niagara River at Queenston	Cadmium, zinc, copper, mercury	Niagara River	Creese 1987 Hart 1983		Include in future monitoring program to confirm findings
13. Niagara River at Niagara-on-the-Lake	Mercury	Niagara River	Creese 1987 Hart 1983		NRTMP may include Niagara River Bar in monitoring program
14. Chippawa Creek	Potential PAHs	Niagara River Norton Abrasives	Dickman 1993	Remediation has taken place	Monitoring to continue

BIOTA / HABITAT

CONTAMINANTS IN WILDLIFE

Routine contaminant monitoring of bird populations in the Great Lakes Basin has been underway by Environment Canada - Canadian Wildlife Service (CWS) since 1974. Work in the Niagara River Area of Concern has centred on: measuring contaminant levels in eggs of colonial waterbirds on an island above the Falls, American kestrel eggs in orchards, and red-winged blackbirds and tree swallows in wetlands.

Colonial Waterbird Census and Contaminant Monitoring Program

Colonial waterbirds are of special concern to CWS because during the nesting season they congregate on their colony sites and are highly vulnerable to predation and disturbance. In addition as top predators in the food web, they bioaccumulate contaminants that are present in the environment, and therefore can be used as indicators of contaminant levels and environmental health. Large-scale inventories of colonial waterbirds populations on the Great Lakes began in 1976. A lakes-wide inventory of all colonial waterbird species on both sides of the U.S./ Canada border was conducted during 1989-1991.

Contaminants in the Great Lakes

For a summary of recent trends in concentrations of various contaminants in the Great Lakes, please refer to: *"Contaminants in Herring Gull Eggs from the Great Lakes". State of the Environment Fact Sheet No. 90-2. 1990.*

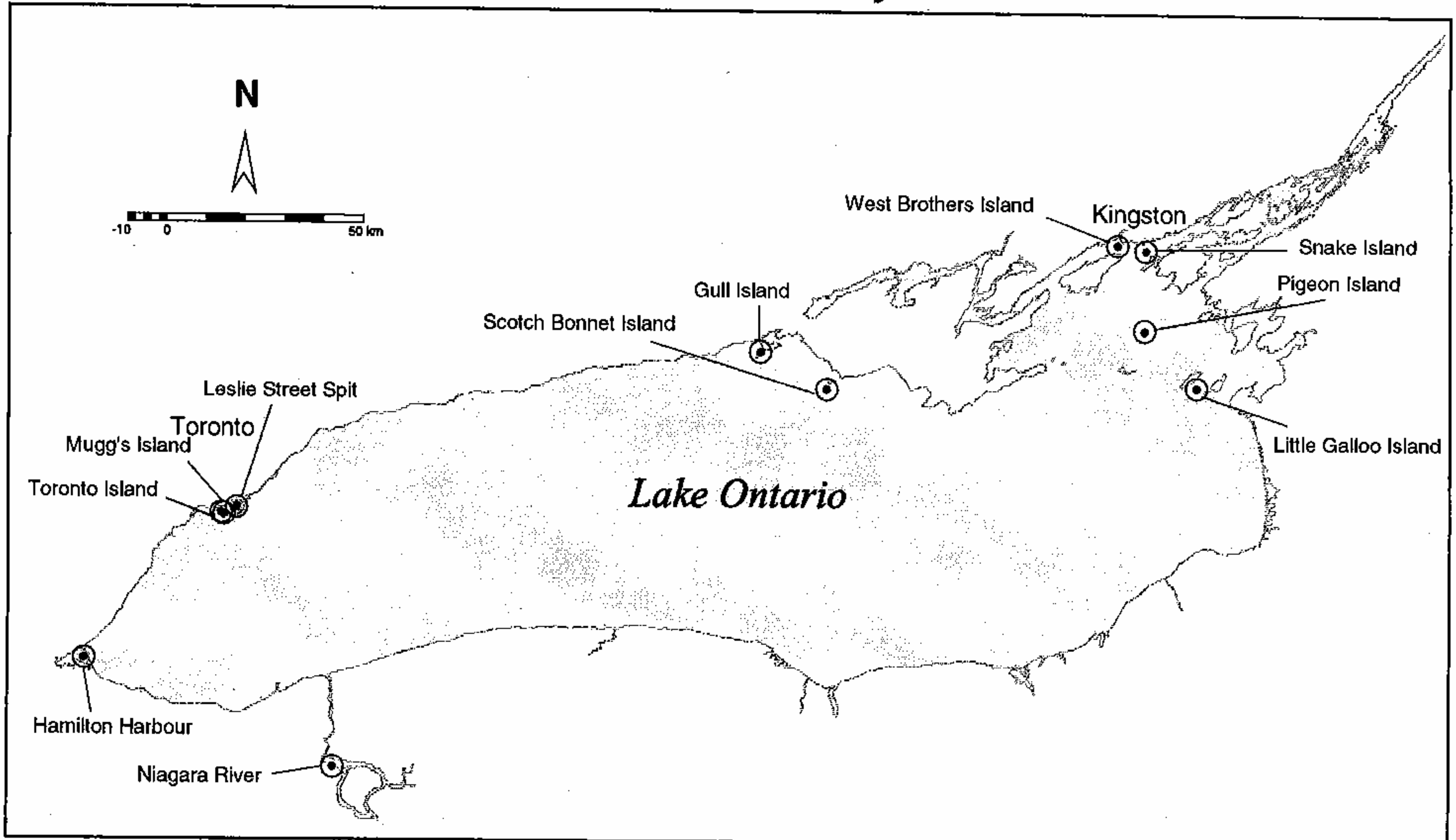
In 1977, 38 pairs of herring gulls and 400 pairs of ring-billed gulls nested along the Niagara River in colonies <400m above the Falls and along the cliffs of the Niagara Gorge. In 1990, 104 pairs of herring gulls and 400 pairs of ring-billed gulls were counted (Blokpoel and Tessier 1991).

Herring gull eggs from an island just above the Falls have been collected for contaminant analysis annually by CWS since 1979 (except for 1980). Data on contaminant levels found in herring gull eggs from the Niagara River are presented in Table 8 *(pg. 56)*. Contaminant levels have decreased. During the period 1989-present, levels have remained low, but have not shown any significant decreases. Contaminant levels in the eggs of Niagara River herring gulls are compared with other colonies in Lake Ontario in Table 9 *(pg. 57)*.

Contaminant levels found in herring gull eggs of three highly toxic chemicals, 2,3,7,8 - tetrachlorodibenzo-p-dioxin (2,3,7,8 - TCDD), 2,3,7,8 - tetrachlorodibenzofuran (2,3,7,8 - TCDF) and the organo-pesticide mirex are lower in the Niagara River colony when compared to sites on Lake Ontario *(Snake Island, Muggs Island and Scotch Bonnet Island - see Map #8)*. While this observation might seem to indicate that the Niagara River is cleaner than the other sites, there may be another explanation. Some of the gulls from the Niagara River colony appear to feed upstream of the hazardous waste landfills on the U.S. side of the river in Lake Erie, or in some cases inland and may not be impacted by local Niagara River toxic sources. On the other hand, herring gull colonies such as Scotch Bonnet Island (off Prince Edward Point, near Picton, Ontario) show high levels TCDD, TCDF, and mirex even though there appear to be no local sources of these chemicals. Sources of high contaminant levels found in these birds may be a result of toxic sources from the closed hazardous waste dumps and other sources on the Niagara River, transported around Lake Ontario by lake currents.

Therefore to assess the success of remedial actions such as toxic chemical containment/dredging of landfill sites that are still a source of contamination, especially TCDD and mirex, trends in herring gull eggs downstream (ie. Lake Ontario) must be monitored

Lake Ontario Colonies Of Fish-Eating Birds From Which Eggs Were Collected for Contaminant Analysis



Data Source: Canadian Wildlife Service, 1994

Map 8

Map created by Water Issues Division

Environment Canada
Environnement Canada

in the future. As on the Niagara River, the Lake Ontario colonies have experienced precipitous decreases in contamination through the late 1970s, and are now relatively stable and low *(see Table 9, pg. 57)*.

Wildlife and Persistent Organochlorine Contaminants in Orchards and Wetlands in the Niagara Peninsula

Despite restrictions on the use of DDT in the 1970s and an outright ban in 1986 in Ontario, the use and sale of existing stocks of DDT products were allowed until December 31, 1990 (Bishop and Weseloh 1990). Studies completed in the 1970s documented the presence of high levels of persistent organochlorines in soil and biological samples from agricultural areas in many parts of North America (see Bishop et al. in prep. for list of references).

From 1987-89, CWS conducted a study to assess differences in concentrations of organochlorine contaminants in bird eggs collected from areas of Ontario with different land use activities. Eggshell thickness and reproductive success were also examined in 1987 and 1988. Wet weight levels of DDE were greater in eggs from American kestrels (10.8 ug/g or ppm), American robins (17.3 ug/g), eastern bluebirds (7.6 ug/g) and in samples of earthworms (0.6 ug/g), soil (0.3 mg/g) and vegetation (8.7 ug/g) originating from the northern portion of the Niagara Peninsula than elsewhere in southern Ontario (Hebert et. al, 1994).

In 1991, CWS collected samples from two species of passerine birds: red-winged blackbird eggs and tree swallow eggs and nestlings, as well as sediment samples from twelve wetlands in the Great Lakes and St. Lawrence River basin. The maximum concentration (wet weight) of DDE in red-winged blackbird eggs (3088 ng/g (ppb)) was found at the Four Mile Creek site (four miles west of the mouth of the Niagara River on the Lake Ontario shoreline). Levels at Four Mile Creek were two to three times higher than the second most contaminated site (Holland Marsh, near Lake Simcoe) (Bishop et al. in press.). Elevated concentrations of DDE in birds in the Niagara Peninsula sample locations are probably a consequence of past use of DDT in agricultural areas. The Niagara Peninsula containing large acreages of orchards, has known DDT applications at a rate of 50-60 pounds/acre/year (Ginsberg and Reed 1954).

In a 1991 related study, Struger (pers. comm.) analyzed water samples from five sites on the Niagara Peninsula and other sites in southern Ontario for organophosphorus pesticides currently used in vegetable and fruit farming. The Four Mile Creek sample represented the highest level of guthion (21.96 ug/l) (Holland Marsh was second highest). Struger suggested contamination by spray drift was a possible cause. Guthion is known to be lethal in biota (96hr. LC50 rainbow trout, daphnia, stonefly at concentrations of 4.3, 1.7, and 1.9 ug/l (ppb) respectively).

WILDLIFE POPULATIONS IN THE NIAGRARA RIVER AREA OF CONCERN AND AREA

Overwintering Waterfowl Populations Along the Niagara River

In the winter of 1986-1987 and from February 1994 to February 1995, the Canadian Wildlife Service has been censusing the numbers and species of waterfowl utilizing the Niagara River. The purposes of these surveys were to determine changes in the numbers and species composition of waterfowl using the Niagara River, to locate areas of intensive use, and to relate this information to locations of contaminated sediments. Map 9 *(pg. 55)* identifies the locations of the 13 sampling areas used to sub-divide the Niagara River during the surveys. All waterfowl (loons, grebes, ducks, geese, and swans) utilizing the Niagara River were counted.

During the 1986-1987 surveys, the peak waterfowl count occurred on 17 February *(see Figure 7)* with 20230 observed, however in 1994 the highest count (which occurred 10 February), was substantially lower with only 11158 waterfowl observed. The number of different species of waterfowl observed using the river was similar for the survey dates that were common for both periods *(see Figure 7)*. The species composition of waterfowl utilizing the Niagara River has changed from being predominantly three species (Common Merganser (*Mergus merganser*), Common Goldeneye (*Bucephala clangula*), and Oldsquaw (*Clangula hyemalis*)) in 1986-1987 to being Greater/Lesser Scaup (*Aythya marila/affinis*) in 1994. As well, the areas within the Niagara River in which waterfowl are most abundant has changed from being sampling areas H (immediately above the Falls) and M (the lower 11 km of the River) in 1986-1987, to sampling area A (eastern end of Lake Erie to the Peace Bridge) in 1994.

The major factor that has influenced the numbers and species of waterfowl using Niagara River, as well as their location on the river may be the arrival of *Dreissena polymorpha*, the zebra mussel. Zebra mussels were found in Lakes Erie and Ontario in 1989 (Griffiths 1991). This new food source may be luring waterfowl to locations they previously would have ignored including different sections of the Niagara River and portions of Lake Ontario and Lake Erie where zebra mussels are quite abundant (Wormington and Leach 1992).

The highest concentrations of sediment contamination have been found in the Buffalo River area, which is adjacent to sampling area A (see Map 9), with varying degrees of contamination found along the Tonawanda-North Tonawanda and Wheatfield-Upper River segments *(see Map 9)*(NRTC 1984). On the U.S. side of the upper river, contaminated sediment that is dredged from navigation channels within Niagara River is deposited at a dumping ground in Lake Erie off Buffalo Harbour near the head of the Niagara River (NRRAP 1993), potentially impacting sampling area A and any overwintering waterfowl. As well the waterfowl which are using sampling area A are "downstream" from the contaminants entering from Lake Erie, Lake Huron, Lake Michigan, and Lake Superior, since all these lakes essentially drain through the Niagara River on their way to the St. Lawrence River and the Atlantic Ocean.

Waterfowl which use the Niagara River are potentially exposed to any and all contaminants released from the point sources along the length of the river as these chemicals enter the watershed and are swept downstream to Lake Ontario. The Niagara River is a major overwintering area for waterfowl. These birds arrive in late fall/early winter and leave in the spring *(see Figure 8)*. An indicator of the importance of the Niagara River is the appearance of Canvasbacks (*Aythya valisineria*) that arrive each fall. These birds indicate the existence of a good food base (primarily wild celery), and are a critical species for which habitat should be maintained. During these surveys Canvasbacks were observed in flocks of between 300-700, however historically up to 15,372 were counted on the Niagara River (Beardslee and Mitchell 1965).

Volunteer Wildlife Population Monitoring within the Niagara River Area of Concern

The Canadian Wildlife Service coordinates several volunteer wildlife population monitoring programs. The Forest Bird Monitoring Program (FBMP) is designed to monitor population changes and to describe species-habitat associations of forest birds. There is one FBMP route near Niagara-on-the-Lake that has been surveyed since 1989. Another monitoring program, the Breeding Bird Survey (BBS), is designed to detect and measure year to year and long term changes in breeding bird populations along a 40 km roadside survey. There are two BBS routes that intersect the Niagara River AOC at

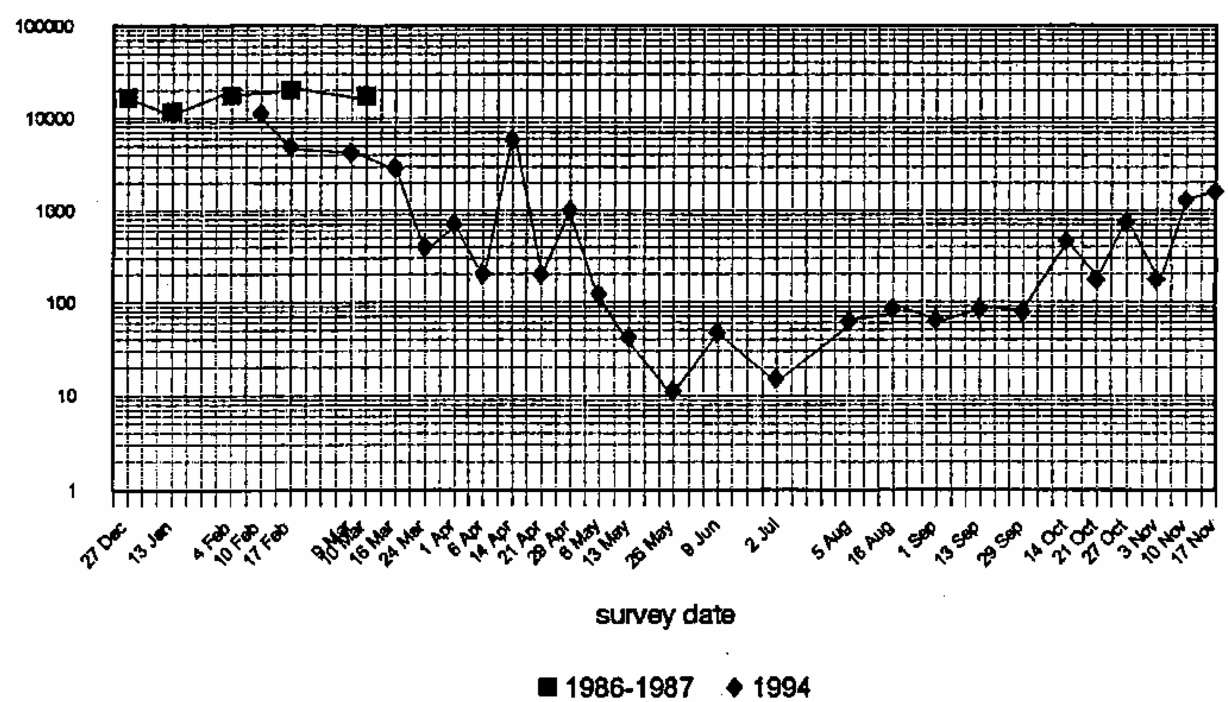


Figure 7.
Total Number of Waterfowl Observed Along Length of Niagara River During the 1986-1987 and 1994 Surveys.

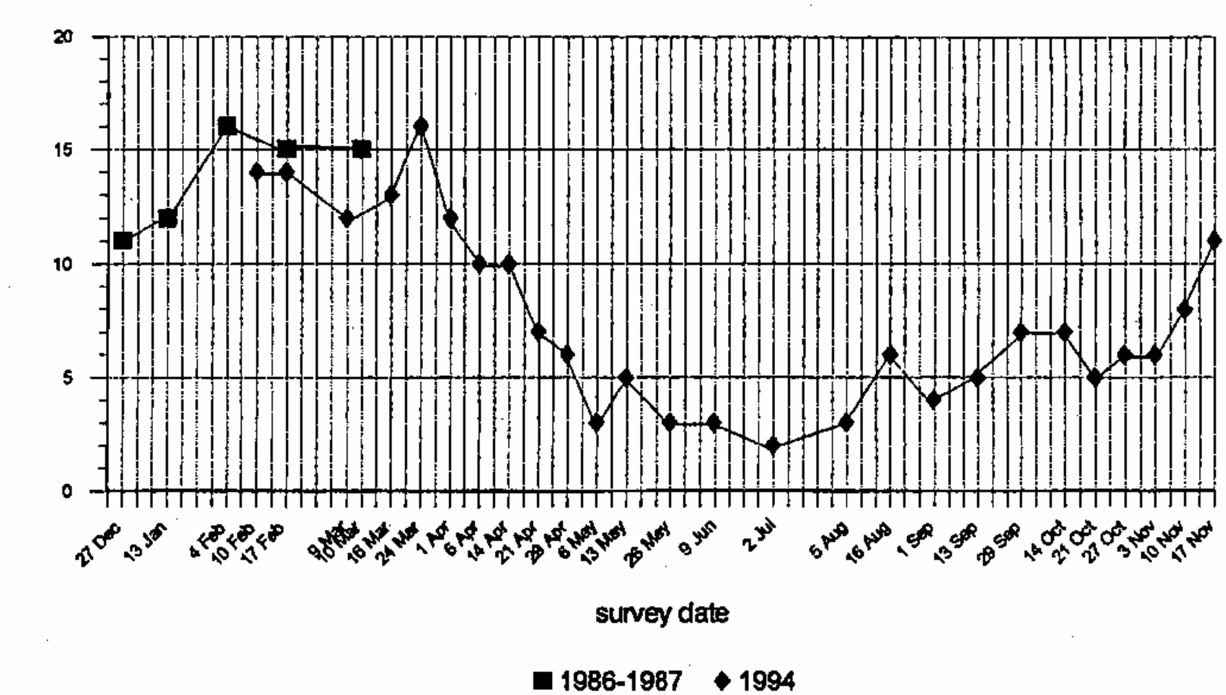
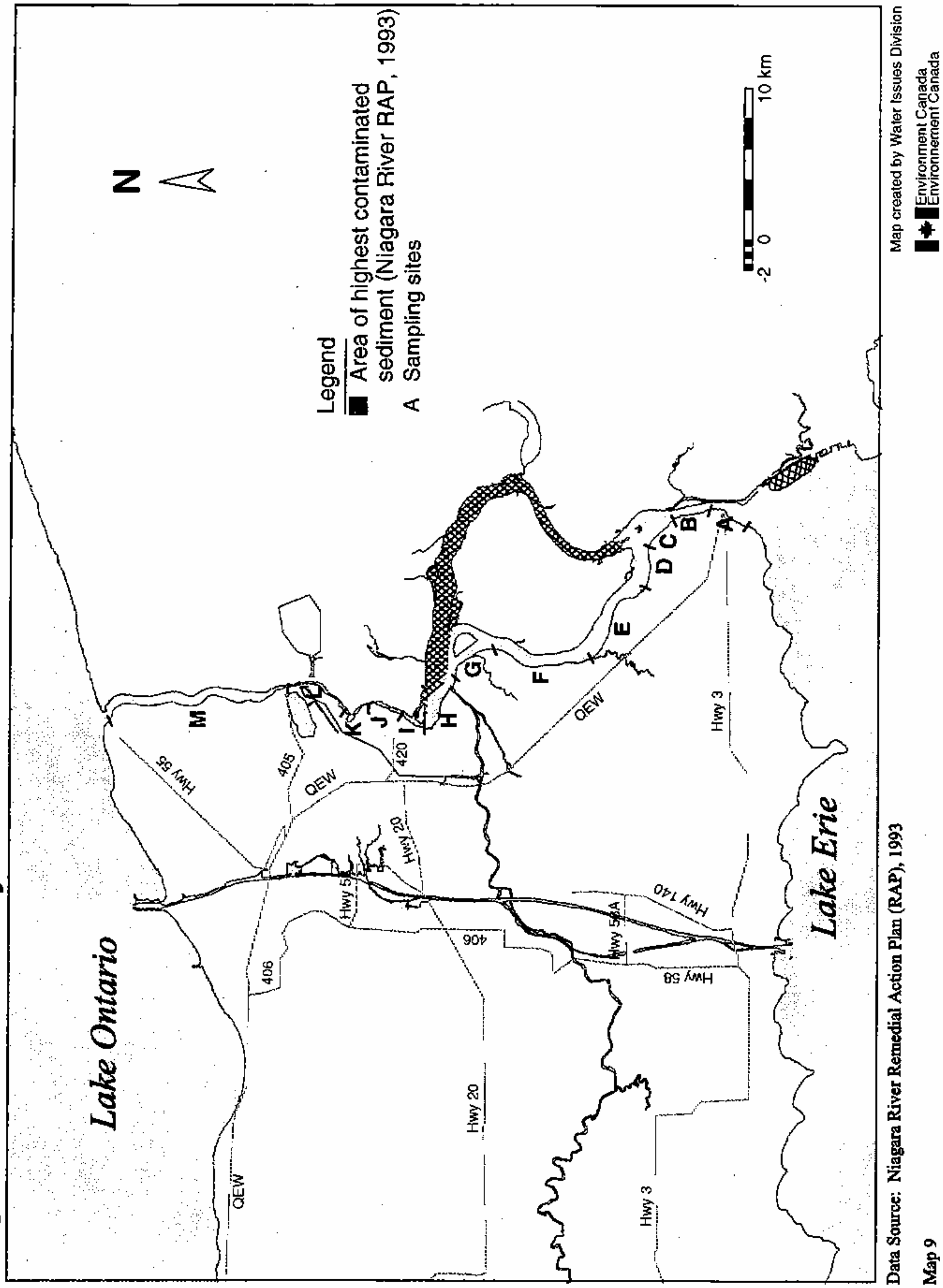


Figure 8.
Number of Species of Waterfowl Observed Along Length of Niagara River During the 1986-1987 and 1994 Surveys.

Sampling Locations for Overwintering Waterfowl Populations Survey



Data Source: Niagara River Remedial Action Plan (RAP), 1993

Map 9

several points. For details on these sites and data collected, please contact Michael Cadman, Canadian Wildlife Service, Guelph, Ontario office at (519) 766-1594.

Local naturalists' clubs participate in several other long-term monitoring programs - the Christmas Bird Count and the Mid-winter Waterfowl Survey. Data from these programs and other wildlife observations can be obtained from the Niagara Falls Nature Club, the Peninsula Field Naturalists and/or the Hamilton Naturalists' Club.

In 1991, the Hamilton Naturalists' Club conducted the first comprehensive inventory of natural areas in the Regional Municipality of Hamilton-Wentworth and has published the results in two volumes (Heagy 1991 and in press.). Three of the natural areas identified fall within the Welland River watershed and hence lie within the AOC. *(See Welland River Meanders, page 258; Binbrook Southwest Area, page 268; and Glanford Station West Wetland, page 274)*

Table 8

Contaminant Concentrations in Herring Gull and Black-Crowned Night-Heron Eggs from the Niagara River, 1979-1993

(Replaces Table 4.28 in the Stage One Report)

Species	Year	DDE[1] (ug/g) ppm	Sum of PCB cogeners(a)[2] ppm	Arclor 1254 : 1260 (b)[3] ppm
Herring Gull Eggs	1979	4.005 +/- 1.334	23.27 +/- 10.377	50.47 +/- 22.51
	1983	3.868 +/- 1.143	15.70 +/- 9.391	34.06 +/- 20.37
	1986	2.727 +/- 1.016	10.40 +/- 4.895	22.55 +/- 10.62
	1988	1.69	5.74	12.45
	1989	2.08	8.69	19.15
	1990	2.02	7.24	15.70
	1991	1.73	6.63	13.49
	1992	1.78	7.45	15.20
	1993	1.67	6.78	14.70
Black-crowned Night Heron Eggs	1982	4.81	8.71	18.9
	1986	3.27	15.4	33.4
	1989	5.27	9.04	19.0

Sources: (1) Bishop. C.A., D.V. Weseloh, N.M. Burgess, J. Struger, R.J. Norstrom, R. Turle and K. Logan, 1992. An atlas of contaminants in eggs of fish-eating colonial waterbirds of the Great Lakes (1970-1988) Volume I. Technical Report Series No. 152. Canadian Wildlife Service, Ontario Region. (2) Pettit, K.E., C.A. Bishop, D.V. Weseloh and R.J. Norstrom, 1994. An atlas of contaminants in eggs of fish-eating colonial waterbirds of the Great Lakes (1989-1992) Volume I. Technical Report Series No. 193. Canadian Wildlife Service, Ontario Region. (3) Unpublished 1993 data from CWS-Burlington, Ontario office. (4) Turel, R., R.P. Norstrom and B. Collins 1991. Comparison of PCB Quantification Methods: Reanalysis of Archives Specimens of Herring Gull Eggs From The Great Lakes. Chemosphere 22 (1-2): 201-213.

Note: Values without standard deviation expressed were pooled samples of ten eggs or more. Those values with standard deviation were analysis done on individual eggs.

[1]DDE is the persistent metabolite product of the pesticide DDT.

[2]These values represent a more accurate representation of total PCB cogeners in Lake Ontario herring gulls obtained from converting Aroclor 1254:1260 1:1 mixtures by a conversion factor (see Bishop et al. 1992 reference below p. 39)

[3]PCBs represented as Aroclor 1254:1260 1:1 mixture - provided for use in comparing results provided here with results obtained from other areas in the Great Lakes and elsewhere.

Table 9 **Concentrations of 2378 TCDD (dioxin) and 2378 TCDF (furan) and mirex in herring gull eggs from sites in Lake Ontario and the Niagara River 1981-1992. (Replaces Table 4.29 in Stage One Report).**

LOCATION	YEAR	2378 TCDD	2378 TCDF	Mirex
Niagara River	1979			0.49 +/-0.24
	1980			
	1981	87.0		0.74 +/-0.50
	1982	69.0		0.98
	1983	19.0		0.33 +/-0.26
	1984	41.0	2.0	0.57+/-0.20
	1985	41.0	ND	0.59 +/-0.31
	1986	40.0	ND	0.36 +/-0.14
	1987	23.0	2.0	0.24
	1988	12.0	<2	0.21
	1989	18.0	1.0	0.24
	1990	18.0	(1)	0.28
	1991	17.0	(1)	0.23
	1992	13.5	ND	0.19
Port Colborne Lighthouse Lake Erie	1974			0.84 +/- 0.51
	1975			0.42 +/- 0.17
	1976			0.51 +/- 0.2
	1977			0.38 +/- 0.16
	1979			0.25 +/- 0.1
	1980			0.28 +/- 0.18
	1981			0.42 +/- 0.47
	1982			0.6
	1983			0.29 +/- 0.23
	1984	32	5	0.38 +/- 0.25
	1985	17	Nd	0.24 +/- 0.08
	1986	32	ND	0.25
	1987	15	ND	0.21 +/- 0.17
	1988	17	ND	0.18
	1989	19	1	0.33
	1990	8	ND	0.12
	1991	11	ND	0.1
	1992	6.3	0.9	0.08 +/- 0.08
Lake Ontario Snake Island	1977			2.91 +/-1.09
	1978			1.74 +/-0.51
	1979			1.96 +/-0.61
	1980			1.58 +/-0.77
	1981	185.0		2.80 +/-1.64
	1982	129.0		2.48 +/-0.50
	1983	90.0		1.50 +/-0.58
	1984	101.0	2	2.02 +/-0.64
	1985	67.0	ND	1.68 +/-0.64
	1986	65.0	ND	1.21 +/-0.42
	1987	80.0	2	0.86
	1988	47.0	1	0.94
	1989	91.0	1	1.10
	1990	66.0	ND	0.60
	1991	51.0	(1)	0.54 +/-0.23
	1992	70.9	ND	0.75

Table 9 (Con't) **Concentrations of 2378 TCDD (dioxin) and 2378 TCDF (furan) and mirex in herring gull eggs from sites in Lake Ontario and the Niagara River 1981-1992.**

LOCATION	YEAR	2378 TCDD	2378 TCDF	Mirex
Lake Ontario Muggs Island	1974			7.44 +/-4.75
	1975			3.42 +/-1.42
	1977			2.05 +/-0.43
	1978			1.55 +/-0.51
	1979			1.81 +/-0.87
	1980			1.72 +/-1.05
	1981			2.53 +/-1.12
	1982			1.36 +/-0.59
	1983			1.72 +/-0.73
	1984	60.0	2.0	1.26 +/-0.56
	1985	39.0	ND	0.98 +/-0.29
	1986	49.0	2.0	0.50
	1987	45.0	<2	
	1988	-	-	
Hamilton Harbour	1984	50	2	
	1986	44	<2	
	1991	16	2	
	1992	29.3	1	
Strachan Island	1986	57	ND	
	1988	50	ND	
	1989	43	(1)	
	1990	46	(1)	
Lake Ontario Scotch Bonnet Island	1971	1996.0	5.0	
	1972	2347.0	6.0	
	1974	923.0	3.0	
	1976	489.0	2.0	3.86 +/-3.28
	1977	518.0	3.0	
	1978	261.0	ND	3.39 +/-2.37
	1979	169.0	2.0	
	1980	170.0	2.0	
	1981	229.0	2.0	
	1982	204.0	ND	

All values expressed in ppt.
(1) Trace amount, below detection limit for sample
ND Not detected

Note: Standard deviation has not been expressed as all samples were pooled.

Sources: 1. Bishop. C.A., D.V. Weseloh, N.M. Burgess, J. Struger, R.J. Norstrom, R. Turle and K. Logan, 1992. An atlas of contaminants in eggs of fish-eating colonial waterbirds of the Great Lakes (1970-1988) Volume I. Technical Report Series No. 152. Canadian Wildlife Service, Ontario Region. 2. Pettit, K.E., C.A. Bishop, D.V. Weseloh and R.J. Norstrom, 1994. An atlas of contaminants in eggs of fish-eating colonial waterbirds of the Great Lakes (1989-1992) Volume I. Technical Report Series No. 193. Canadian Wildlife Service, Ontario Region.

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APPENDIX A

ACRONYMS

Remedial Action Plan

AOC	Area of Concern
COA	Canada Ontario Agreement respecting water quality in the Great Lakes
PAC	Public Advisory Committee
RAP	Remedial Action Plan

Water Quality Issues

CofA	Certificate of Approval
COC	Chemicals of Concern (part of NRTMP)
CSO	Combined Sewer Overflow
GIS	Geographic Information Service
GLWQA	Great Lakes Water Quality Agreement (signed 1972 revised 1978 and 1987)
IMIS	Industrial Monitoring Information System
INS	Infrastructure Needs Studies
LEL	Low Effect Level (part of PSQG)
MISA	Municipal Industrial Strategy for Abatement
NRTMP	Niagara River Toxic Management Plan
PSQG	Provincial Sediment Quality Guidelines
SEL	Severe Effect Level (part of PSQG)
UMIS	Utilities Monitoring Information System
WPCP	Water Pollution Control Plant

Agencies and Organization

AC	Agriculture Canada
CWS	Canadian Wildlife Service (Environment Canada)
DFO	Department of Fisheries and Oceans
EC	Environment Canada
IJC	International Joint Commission
MOEE	Ministry of Environment and Energy
MOEE-WCR	Ministry of Environment and Energy - West Central Region
NGO	Non-Government Organization
NYSDEC	New York State Department of Environmental Conservation
NPC	Niagara Parks Commission
NPCA	Niagara Peninsula Conservation Authority
OH	Ontario Hydro
OMAFRA	Ontario Ministry of Agriculture, Food and Rural Affair
OMNR	Ontario Ministry of Natural Resources
OWMC	Ontario Waste Management Corporation
PIC	Public Information Centre (MOEE)
USFWS	United States Fish and Wildlife Service

APPENDIX B

UPSTREAM / DOWNSTREAM NIAGARA RIVER MONITORING PROGRAM

Organizational Framework of the Niagara River Toxics Management Plan

The presence of toxic organic pollutants in the Niagara River has been a source of concern to environmental agencies of both the United States and Canada for more than a decade. Until recently, however, most of the monitoring and abatement activities on the Niagara River have been a result of independent efforts of each of the four environmental agencies having interests in the Niagara River (United States Environmental Protection Agency (USEPA), New York State Department of Environmental Conservation (NYSDEC), Ontario Ministry of Environment and Energy (OMOEE), and Environment Canada (EC)). Formation of the four party Niagara River Toxics Committee (NRTC) in 1981; release of the NRTC Report[1] in 1984; development of the Niagara River Toxics Management Plan and the signing of the Declaration of Intent by the four parties in 1987 have contributed to a unified and coordinated approach to the issue of toxic contaminants in the Niagara River.

In the interest of furthering the degree of cooperation among the State, Provincial, and Federal agencies on both sides of the border, a formalized committee structure was established to coordinate the various activities agreed to in the Niagara River Toxics Management Plan (NRTMP). As part of this committee structure, the River Monitoring Committee (RMC) was formed to put into effect the ambient water quality monitoring program referred to in the NRTMP. Specifically, the RMC was given the responsibility for the design and execution of a mutually agreed upon program to monitor levels of toxic substances at the head and mouth of the Niagara River and to interpret the program results in a manner which had the full concurrence of the four parties. To assist the RMC in these tasks, three work groups, each made up of representatives from the four parties, were established. Two of these work groups (the Sampling Protocol Group and the Analysis Protocol Group) were, respectively, assigned the tasks of developing the protocols for sampling and chemical analyses of water and suspended solids samples from the Niagara River. The third group, the Data Interpretation Group is responsible for the statistical interpretation of the data. The terms of reference of this Group, as revised in July 1988, are to prepare an annual report summarizing and interpreting the Niagara River ambient water quality data using the Maximum Likelihood and the Sign Test methods to determine statistical differences between the upstream and downstream ends of the river.

A report entitled "Joint Evaluation of Upstream/Downstream Niagara River Monitoring Data 1984-1986"[2] prepared by the Data Interpretation Group was released in October 1986. This report was the first joint four party (United States Environmental Protection Agency, New York State Department of Environmental Conservation, Ontario Ministry of Environment and Energy, and Environment Canada) interpretation of the Environment Canada ambient water quality data collected at the head (Fort Erie) and mouth (Niagara-on-the-Lake) of the Niagara River from December 1984 to March 1986. Due to uncertainties related to sampling methods, analytical procedures and analytical quality assurance/quality control, only the most conservative interpretations were possible.

Efforts to minimize or eliminate these uncertainties resulted in the development of new sampling and analytical protocols and statistical methods, which were put into effect

[1] Niagara River Toxics Committee Report, October 1984. A Joint Publication of NYSDEC, EC, USEPA and MOEE.

[2] *Data Interpretation Group "C". October 1986. "Joint Evaluation of Upstream/ Downstream Niagara River Monitoring Data, 1984-1986. A Joint Publication of NYSDEC, EC, USEPA and MOEE.*

[3] *Data Interpretation Group "C". January 1988. "Joint Evaluation of Upstream/ Downstream Niagara River Monitoring Data, 1986-1987. A Joint Publication of NYSDEC, EC, USEPA and MOEE.*

by Environment Canada in April 1986. A second report ("Joint Evaluation of Upstream/ Downstream Niagara River Monitoring Data 1986-1987"(3)), discussing the results obtained from the improved program from April 1986 to March 1987, was prepared by the Data Interpretation Group and released in January 1988.

Similar reports covering the period from April 1987 to March 1992[4] have been prepared and released by the Data Interpretation Group.

Since sampling and analytical procedures, as well as the statistical methods used in interpreting the 1992-93 data set, were virtually identical to those used for the previous four reports (the 1988-89, 1989-90, 1990-91 and 1991-92 data sets), direct comparison of these data sets is considered acceptable. Large differences between the present sampling, analytical and statistical procedures and those used prior to April 1986 make only qualitative comparisons with the 1984-1986 data set possible. A group, called the "Niagara River Ad Hoc Work Group", has incorporated these data sets in their report on progress towards the 50% reduction in loadings target. The Four Party report, "Progress Report on Reduction of Priority Toxics in the Niagara River" was released in January 1993.

Sampling Methods

The sampling and analytical protocols developed and agreed to by the four parties included the requirement for audits of the field and laboratory operations as conducted by Environment Canada. The purpose of these audits was to ensure that the protocols that were agreed upon were indeed being followed by Environment Canada's field and laboratory technicians. The most recent laboratory and field audits were conducted in November 1991 and November 1993. The teams for the audits included representatives of the U.S. EPA; Ontario MOEE Environment Canada and NYSDEC.

In both cases, the audit teams concluded that the procedures followed by Environment Canada's field and laboratory staff were generally in keeping with those described in the sampling and analytical protocols and should therefore result in the generation of data of acceptable quality.

Water and suspended solids samples are collected at two permanent sampling stations located at the head (Fort Erie) and mouth (Niagara-on-the-Lake) of the Niagara River. The stations were chosen to provide samples that represented, as closely as possible, inflow to the Niagara River from eastern Lake Erie and outflow from the Niagara River into Lake Ontario. Site selection was also dictated by operational considerations such as acquisition and availability of property, accessibility, availability of electrical power, and site security. Since there was no single best site, sites were chosen to serve as the best possible compromise between acceptable representativeness and operational constraints. Recent studies conducted by Environment Canada indicate that the distribution of contaminants in the Niagara River at the Niagara-on-the-Lake station is homogeneous[5]. This suggests that the location of this station is adequate for the purpose of monitoring contaminant loading to Lake Ontario from the Niagara River. Studies expected to further resolve the question of station representativeness at the upstream site are being conducted in 1993-94. The ad hoc group on Physical Limnology and Hydraulics concluded, in its report on "Flow and Circulation Characteristics in the Eastern Lake Erie and Upper Niagara River Area"[6] that the water collected at the Fort Erie station should be representative of the water in eastern Lake Erie and that, to the best of their knowledge of the limnological and hydraulic processes of the system, the effluent from the Buffalo River and Smoke Creek does not mix with the water in the upper part of the Niagara River. Therefore, water samples collected at the Fort Erie station are not affected by this plume. However, to date, it is still not possible to determine whether loadings derived from samples collected at the upstream station reflect the actual loadings nor is it possible to determine the size of any potential error.

(4) *Data Interpretation Group "C". May 1989. "Joint Evaluation of Upstream/ Downstream Niagara River Monitoring Data, 1987-1988. A Joint Publication of NYSDEC, EC, USEPA and MOEE.*

Data Interpretation Group "C". December 1990. "Joint Evaluation of Upstream/ Downstream Niagara River Monitoring Data, 1988-1989. A Joint Publication of NYSDEC, EC, USEPA and MOEE.

Data Interpretation Group "C". March 1992. "Joint Evaluation of Upstream/ Downstream Niagara River Monitoring Data, 1989-1990. A Joint Publication of NYSDEC, EC, USEPA and MOEE.

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(5) *Green/Seastar, 1988. Determination of Contaminant Concentrations Across the Niagara River using Automatic Insitu Water Samples. Final Report, April 1988. Unsolicited proposal DSS contract No. 02SE-KW405-7-9195. David Green, Seastar Instruments Ltd., Dartmouth, N.S.*

(6) *Ad Hoc Group on Physical Limnology and Hydraulics. 1989. The Flow and Circulation Characteristics in the Eastern Lake Erie and Upper Niagara River Area. A Report to the River Monitoring Group.*

The sample collection system at both locations consists of an intake structure, intake line, pump, continuous-flow centrifuge, and Goulden Large Sample Extractor (GLSE). The intake structure, intake line and pump are permanently submerged in the river and the wells while the pump controllers, centrifuge and GLSE are housed on the river bank. Intakes were positioned in the water column such that they were sufficiently far from the bottom to avoid sampling bedload yet far enough below the surface so as not to constitute a hazard to navigation. Throughout the sampling system care was taken to ensure that, to the greatest extent practicable, all equipment coming in contact with the sample was made of chemically inert materials.

Whole water at the sampling location is separated into aqueous and particulate phases (suspended solids) by a Westfalia continuous-flow centrifuge which is operated for 24 hours. Grab, (whole water) samples are collected for volatiles and trace metals and grab, centrifuged water samples are collected for chlorophenols.

Outflow from the centrifuge (the aqueous phase), is extracted by a GLSE[7] which has been modified for 24-hr continuous operation.

The GLSE is essentially a mixer-settler in which the water sample is continuously passed through an agitated vessel containing the solvent dichloromethane (DCM). The solvent containing the extracted organic contaminants separates from the water and settles into the mixer. The effluent water then passes to waste. Since the effluent water contains a small quantity of the solvent and additional solvent losses can occur because of its volatility, a supply of fresh DCM is continuously added to the extractor. Detailed descriptions of both the sampling system and the operation of the GLSE are presented in the Niagara River Sampling Protocol[8].

Suspended solids and water samples are collected continuously over a period of 24 hours at both locations once per week. Suspended solids samples are analyzed for organochlorine pesticides (OCs), chlorobenzenes (CBs), polynuclear aromatic hydrocarbons (PAHs), phthalates, phenols, dioxin (2,3,7,8 - TCDD) and trace metals. Centrifuged water samples are continuously extracted over the 24-hr sampling period by the GLSE and the extracts are analyzed for OCs, CBs, PAHs, phthalates and dioxin (2,3,7,8 - TCDD). A 20L grab sample of centrifuged water is also collected for chlorophenol analysis. In addition, grab samples of whole water (not centrifuged), which include the suspended solids (particulate) fraction are collected. These samples are analyzed for volatile organics and trace metals.

Generally, sample collection at Fort Erie commenced on Tuesday afternoon of each week while sample collection at Niagara-on-the-Lake was started on Wednesdays. The 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 from Fort Erie to Niagara-on-the-Lake. Staggered sampling times could not account for storage and release of water from the Robert Moses and Sir Adam Beck power plant reservoirs. However, the introduction of time-delayed sampling provides a closer approximation of the river's hydrologic regime.

Findings

Contaminant concentrations in the Niagara River were compared with several sets of water quality criteria from U.S. E. P. A, DOE, MOEE and N.Y.S.D.E.C. These criteria have changed over the timeframe of this analysis and also the way in which the data were compared with the criteria has also changed. Those chemicals which violated the strictest criterion are summarised below in Table 2 *(pg 69)*.

One of the primary purposes of collecting this Upstream/Downstream data was to monitor changes with time in the river as reductions from point and non-point sources are implemented. This data analysis is presently underway and methodology is being developed. Results should be available for the 18 chemicals of concern which have measurable values above analytical detection limits by late 1995.

(7) Goulden P.D. and Anthony D.H.J., 1985. Design of a Large Sample Extractor for the Determination of Organics in Water. Analytical Methods Division, NWRI, CCIW, Burlington, Ontario, Report No. 85-121.

(8) Niagara River Sampling Protocol, 1986. A Joint EC, USEPA, NYSDEC and MOEE Report.

Niagara River Sampling Protocol, 1988. A Joint EC, USEPA, NYSDEC and MOEE Report.

Table 1 **Contaminants Showing an Increase in Loading at Niagara-on-the-Lake compared to Fort Erie**

Contaminant	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
1,4-dichlorobenzene	W S	W	W	W S	W S	W S	W S
1,2-dichlorobenzene	W S	W S	W S	W S	W S	W	W
1,3-dichlorobenzene	W S	W		W S	W	W	W
1,2,3-trichlorobenzene	W S	W S	W S	W S	W S	W S	W S
1,2,4-trichlorobenzene	W S	W S	W S	W S	W S	W S	W S
1,3,5-trichlorobenzene	W S	W S	W S	W S	W S	W S	W S
1,2,3,4-tetrachlorobenzene	W S	W S	W S	W S	W S	W S	W S
pentachlorobenzene	W S	W S	W S	W S	W S	W S	W S
hexachlorobenzene	W S	W S	W S	W S	W S	W S	W S
mirex	S	S	S	S	S	S	S
PCBs	S	S	S	S	S	S	S
alpha-BHC	S	S	S	W S	S	W S	W S
lindane		S				W	W S
methoxychlor		W					
hexachlorobutadiene	W S	W S	W S	W S	W S	W S	W S
benzo(a)pyrene	S		W S		W S	W S	S
benz(a)anthracene		S	W S	W S	W S	W S	W S
benzo(b/k)fluoranthene	S		W S	W	W S	W S	W S
chrysene/triphenylene	W	W S	W S	W S	W S	W S	W S
fluoranthene	W S	W S	W S	W S	W S	W S	W S
pyrene	W S	W S	W S	W S	W S	W S	W S
aluminum	WW	WW		WW	WW		WW

Table 1 (Con't) **Contaminants Showing an Increase in Loading at Niagara-on-the-Lake compared to Fort Erie**

Contaminant	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
arsenic	WW	WW		WW	WW	WW	
chromium	WW	WW		WW	WW		WW
iron	WW	WW		WW	WW		WW
manganese	WW	WW		WW	WW		WW
nickel	WW	WW		WW			WW
strontium	NA	WW					
vanadium	NA	WW		WW	WW		WW
barium	NA	WW		WW			WW
zinc	WW	WW		WW	WW		WW
copper	WW			WW			WW
alpha endosulfan		S	S	W	W S		W
dioctylphthalate		W	W			W	
gamma chlordane			W				
diethylphthalate			S			S	
benzylbutylphthalate			W				
2,4,6-trichlorophenol			W	W	W	W	W
2,4,5-trichlorophenol			W				
molybdenum			WW				
octachlorostyrene				W S	W S	W S	S
hexachlorocyclopentadiene				W	W S	W S	W S
methylene chloride				WW			
lithium				WW	WW		WW

Table 1 (Con't) **Contaminants Showing an Increase in Loading at Niagara-on-the-Lake compared to Fort Erie**

Contaminant	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
cobalt					WW		WW
cadmium					WW		WW
lead					WW		WW
beta endosulfan					W S	W	W S
2-methyl naphthalene					W	W	S
acenaphthylene					W	W	W S
fluorene					W	W S	W S
anthracene					W S	W S	W S
phenanthrene					W S	W S	W
ideno(1,2,3cd)pyrene					W		W S
benzo(ghi)perylene					W		W S
2,4-dichlorophenol					W		
2,6-dichlorophenol					W	W	W
3-methyl-4-chlorophenol					W		W
pentachlorophenol					W		
carbon tetrachloride					WW	WW	WW
chloroform					WW	WW	WW
tetrachloroethylene					WW	WW	WW
naphthalene						S	S
1-methyl naphthalene						W S	S
1,2-dichloroethane						WW	
dieldrin						W	

Table 1 (Con't) **Contaminants Showing an Increase in Loading at Niagara-on-the-Lake compared to Fort Erie**

Contaminant	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
bis(2-ethylhexyl)phthalate						S	
phenol						W	
molybdenum						WW	WW
heptachlor epoxide							W
dibenz(a,h)anthracene							W S

W - IN WATER PHASE S - IN SUSPENDED SOLIDS PHASE

WW- WHOLE WATER ANALYSIS INCLUDES SUSPENDED FRACTION NA - NOT ANALYSED

Table 2 **Chemicals Violating Strictest Criteria**

Contaminant	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93
benz(a)anthracene	N	N	N F	N	N F		N
benzo(b/k)fluoranthene	N	N F	N		N		N
benzo(a)pyrene	N		N		N	N	N F
chrysene/triphenylene	N F	N F	N	N	N F		N
PCBs	N F	N	N	N	N F	N F	N F
iron	N F	N F	N F		N F	N F	N F
tetrachloroetylene	N						
aluminum		N F	N F	N F	N F	N F	N F
mercury		N F	N F	N			
methylene chloride				N F			
copper					N F	N F	N F
lead					N F	F	
cadmium					N		
cobalt					N	N F	
strontium					N F	N F	N F
bis(2-ethylhexyl)phthalate					F	F	
cadmium						F	

N - VIOLATED CRITERIA AT NIAGARA-ON-THE-LAKE F - VIOLATED CRITERIA AT FORT ERIE