Remedial Action Plan for
Hamilton Harbour

Goals, Options and Recommendations

Volume 2 - Main Report

RAP STAGE 2 November 1992

THE

REMEDIAL ACTION PLAN

Hamilton Harbour

Goals, Options and Recommendations

VOLUME 2 - THE REPORT

A PLAN TO IMPROVE WATER QUALITY AND HABITAT IN HAMILTON HARBOUR AND COOTES PARADISE, TO RE-ESTABLISH A HEALTHY AQUATIC ECOSYSTEM, AND TO IMPROVE THE POTENTIAL FOR MORE EXTENSIVE RECREATIONAL USES WHILE MAINTAINING ITS ESSENTIAL ECONOMIC FUNCTION

This Plan has been developed by a Technical Team and the Hamilton Harbour Remedial Action Plan Stakeholders, a public advisory committee. As such, it is a community-based proposal. It is not a government report.

Stage 2A Report

November 1992

Remedial Action Plan
Plan d'Assainissement

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Canada Ontario

Canada-Ontario Agreement Respecting Great Lakes Water Quality
L'Accord Canada-Ontario relatif à la qualité de l'eau dans les Grand Lacs

Remedial Action Plan for
Hamilton Harbour

TO: J.S. Ashman, Provincial Co-Chair - COA Review Board
V. Shantora, Federal Co-Chair - COA Review Board

Our File: 5010-20-9

FROM: G. K. Rodgers, Coordinator
Hamilton Harbour
Remedial Action Plan
CCIW - Burlington, Ontario

October 1992

SUBJECT: Transmission of the Hamilton Harbour Remedial Action Plan Stage 2 Report to the Canada-Ontario Agreement Board

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On behalf of the Hamilton Harbour Remedial Action Plan Team and the Hamilton Harbour Stakeholders Group, I am pleased to provide you with the Hamilton Harbour Remedial Action Plan Stage 2 Report.

This document presents the principles and goals stipulated by the Stakeholders at the beginning of the planning process and the recommendations which followed from their discussion of many technical and policy aspects of the Plan and the environmental conditions that they wished to see remediated. This report also provides delisting criteria that have been developed with advice from both the Remedial Action Plan Team and the Stakeholders. The report also designates a ranking of technical options and recommends an organizational arrangement to manage the implementation and to provide advice as the Plan develops.

This memorandum is accompanied by a letter from the President of the Bay Area Restoration Council, Mrs. Anne Redish, who is acting on behalf of the Stakeholder executive.

Existing federal and provincial programs, as well as independent initiatives by Regional municipalities, industry and private citizen groups (who are part of the Stakeholder Group) have already taken action on the key and most cost-effective remedial measures. Indeed, about one-half of the rehabilitation had been completed before the RAP planning process was in place. The impact of these measures is already evident in the Harbour. In addition, a great deal of the preliminary engineering and demonstration studies for the more major components of the next stages of the Plan have also been undertaken.

It remains for all levels of government involved to present a statement of commitment to the execution of the overall Plan and the monitoring of conditions that will define the completion of Stage 3 - the full rehabilitation of the Harbour.

This work has been a challenging endeavour. The Team wishes to acknowledge the extensive help that has come from the Stakeholders themselves and from colleagues in all of our agencies who have provided data, advice, investigative work and reports to assist in our endeavours.

Keith Rodgers

G.K. Rodgers,
Coordinator, HHRAP

Hamilton Harbour RAP Team:

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cc: H. Wong, Director - WCR/OMOE
J. Merritt, Director - CR/OMOE
F. Fleischer, Chairman - RAP Steering Committee

Remedial Action Plan for
Hamilton Harbour

14 September 1992

Messrs. V. Shantora & J. Ashman
Co-Chairmen
Canada-Ontario Agreement Review Board

Dear Messrs. V. Shantora and J. Ashman:

The Hamilton Harbour Stakeholders enthusiastically endorse the Stage 2 Report of the Hamilton Harbour Remedial Action Plan (RAP). We have had the opportunity to review thoroughly the recommendations and to make appropriate changes. We are pleased that the Stage 2 Report reflects our two primary principles;

- that the RAP be developed within the context of an ecosystem approach, and
- that the controls of input of persistent toxic chemicals shall eventuate to zero discharge.

After six years of deliberation we feel that the Stage 2 Report fully addresses our concerns about retaining our Harbour as a multiple-use facility. We envision accommodating not only shipping and navigation, industrial uses and acceptable wastewater effluent; but also recreational boating, water sports, swimming, a reproducing warmwater fishery, a protected wildlife habitat and an educational resource. Strong recommendations directed towards a continued high standard of human health and the promotion of public access and aesthetic improvements to the Harbour will help win public acceptance and support for the total Remedial Action Plan implementation.

The Stage 2 Report has separated the recommendations into six problem areas. We recognize that these problems are so interconnected that in order to achieve success in any one area all others must improve at the same time. Therefore, we forcefully recommend that, while special emphasis must be placed on the high priority solutions, it is essential that action occurs on all fronts simultaneously.

The Stakeholders recommended that during the implementation stage of the Remedial Action Plan they be re-organized into two groups with distinctly different responsibilities. One group, The Bay Area Implementation Team (BAIT), would be responsible for the implementation of the Remedial Action Plan while the other group, the Bay Area Restoration Council (BARC), would be charged with monitoring the progress of the Remedial Action Plan implementation and in keeping the public informed. We are pleased that the Bay Area

Restoration Council was established in the Fall of 1991. The creation of its counterpart, the essential and vital Bay Area Implementation Team, is imperative for the smooth co-ordination of the implementation of the Remedial Action Plan.

The Hamilton Harbour Stakeholders have worked very diligently in conjunction with the Remedial Action Plan coordinator, and the Remedial Action Plan Writing and Technical Teams. In addition, we have had the benefit of suggestions made by our local citizens during the Public Advisory Campaign. We have recommended that the consultant's summary of the ideas gleaned from the public be included in the appendix to the Stage 2 Report.

We are very pleased that both the Stakeholder constituent groups and the general public are strongly supportive of the Remedial Action Plan, and that in their comments they recommend immediate implementation. It should be noted that many of the Hamilton Harbour Stakeholder constituent groups have worked to assist in the development of the Remedial Action Plan and have already incorporated many of the recommendations into their own planning. Consequently the water quality of the Harbour is already responding well to the actions that have been taken.

In conclusion, the Stakeholders of Hamilton Harbour are fully supportive of the recommendations in Stage 2 of the Remedial Action Plan. We urge our governing bodies to ensure its rapid fulfilment.

Yours truly,

Anne Redish

Mrs. Anne Redish
President
Bay Area Restoration Council on behalf of the
Hamilton Harbour Remedial Action Plan Stakeholder Group

PREFACE

Under the Great Lakes Water Quality Agreement (Amended 1987) and the Canada-Ontario Agreement Respecting Great Lakes Water Quality, the Governments of Canada and Ontario are developing Remedial Action Plans to restore impaired uses of the aquatic ecosystem in seventeen of the forty-three Areas of Concern on the Great Lakes. Hamilton Harbour is one of these Areas of Concern.

A team of technical experts from federal and provincial agencies (RAP Team) has been working with the Hamilton Harbour Stakeholders Group, which is made up of individuals representing a broad range of local interests, to develop a draft Remedial Action Plan. This report represents the product of their effort.

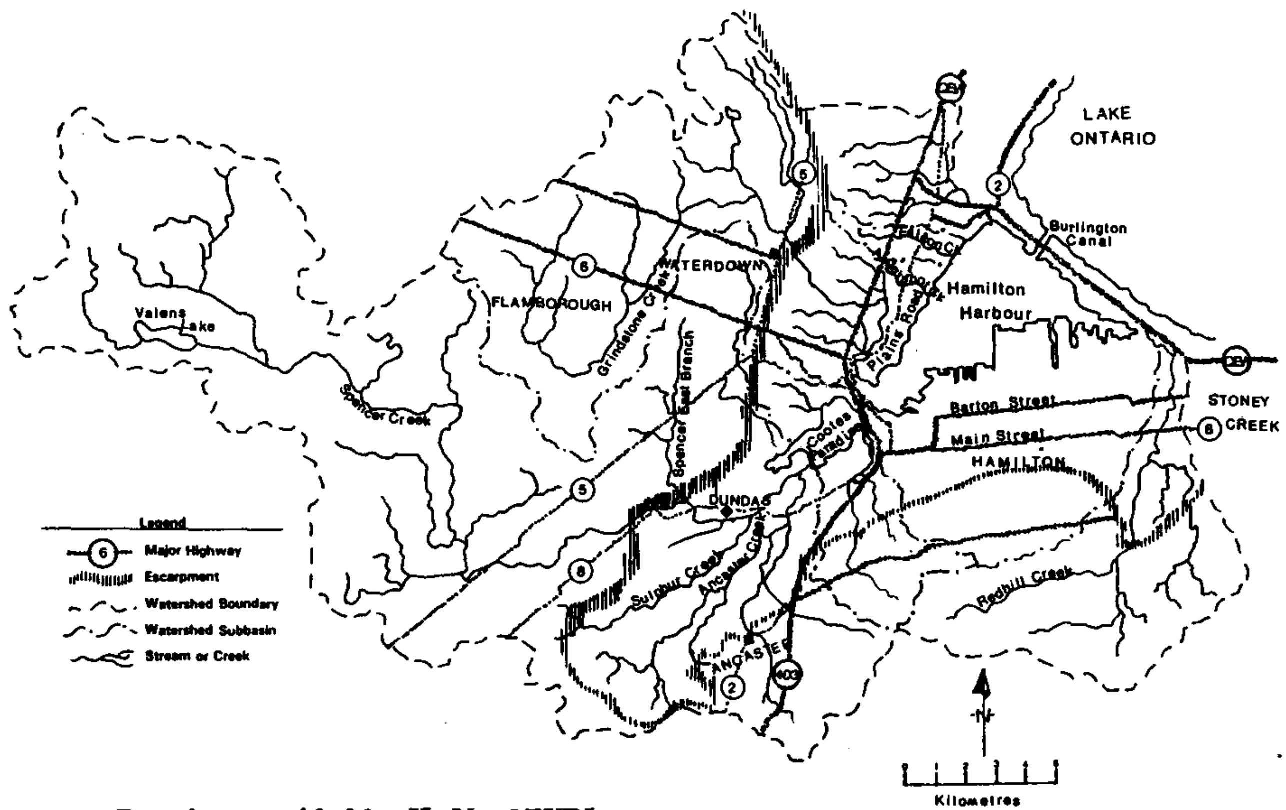
The RAP takes an ecosystem approach to restoring water quality, cleaning up sediments, and re-establishing fish and wildlife habitat in Hamilton Harbour. The ultimate objective of the Plan is to restore and preserve the beneficial uses of the Harbour for present and future generations.

Release of the report is intended to provide information on options which have been considered and on a recommended approach to clean-up of the Harbour. The report in its current form represents the conclusions of the RAP Team and the Stakeholders Group and has not been officially adopted by the federal or provincial governments.

THE WATERSHED

Hamilton Harbour

Three major creeks - Grindstone, Spencer and Redhill feed into Hamilton Harbour from the Watershed



Source: Drawing provided by H. Ng, NWRI.

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EXECUTIVE SUMMARY

This report presents the final results of a consultation amongst Hamilton Harbour Stakeholders and the staff of several provincial and federal agencies regarding the means by which the desired beneficial uses of Hamilton Harbour can be realized. Many existing and potential uses of the Harbour are impaired because of pollution or because of destruction of natural habitat. The process of developing this Plan has been carried out under the auspices of the Canada-Ontario Agreement respecting the response of Canada and Ontario to the Great Lakes Water Quality Agreement between Canada and the United States (1978,1987).

The description of environmental conditions, updates on trends in these conditions, and the cause of water quality problems, contaminated sediment and habitat restrictions have been presented periodically throughout the discussion of the Plan. The formal presentation of the Stage 1 Report which summarizes the situation for Hamilton Harbour was first done in 1989 and then updated in 1992 as a companion to this report. The results of the most recent assessment are summarized in this report (Section II). This lays the groundwork for assessing remedial options, establishes baseline conditions against which to gauge future trends, and provides guidance in setting the delisting objectives for the Harbour.

In 1986 and 1987, early in the process, the Stakeholders Advisory Group - a community roundtable with federal and provincial agencies, municipal politicians, industry and citizen groups represented - set down the principles and goals which they wished to see followed or achieved in the development of the Plan (Section III). These included the primary principles of the overall Ecosystem Approach, and of the Zero Discharge/Virtual Elimination Approach to persistent toxic chemicals. Secondary principles regarding human health, involvement of the public in the RAP process, the need for more public access to the Harbour, land use in the watershed and around the Harbour, restrictions on infilling and wastewater discharges, and the impact of the Harbour discharge on Lake Ontario, were developed. A series of goals were also developed in the context of nine water uses, including:

- recreational boating
- water sports
- shipping and navigation
- industrial use
- wastewater discharge
- fisheries
- wildlife
- swimming, and as an
- educational source.

The close links between these water uses and the beneficial uses listed in the Great Lakes Water Quality Agreement are detailed.

The remedial options available to remedy the identified barriers to achievement of the desired uses are described and assessed in Section IV. The technical options were assessed in a four-day Stakeholders' Workshop and ranked in importance. These rankings and the 50 recommendations regarding remedial options are presented in Section V. The recommendations address concerns for current wastewater discharges, current activities affecting the quality and quantity of streamflow entering the Harbour, and current activities having a deleterious effect on the amount and quality of fish and wildlife habitat. The recommendations also address the historical 'residue' of past pollution, and infilling activities as it relates to altered hydraulics, contamination in the bottom sediments and major losses of fish and wildlife habitat. Finally, the recommendations address ways and means of maintaining the desired quality of the Harbour ecosystem. For example it sets nutrient loading targets for the Harbour and recommends that regional and municipal planning be carried out in such a manner as to ensure that economic development and environmental conditions are developed in concert.

A variety of technical and monetary challenges will accompany the implementation of this Plan. While many matters are straightforward (such as the need to substantially reduce periodic discharge of raw sewage to the Harbour), cost-efficient technologies and better confidence in the scientific projections of what can be achieved in regard to restoration of the aquatic ecosystem will be required. Hence the special significance of surveillance, research and development (Section VIII) - all of which have allowed us to document what has already been achieved, allowed us to recommend initial, very cost-effective means to reduce sewer wastewater contamination to the Harbour and allow us to assess effective means to remediate contaminated sediments. An assessment of the attainability of the designated uses for the Harbour, an estimate of the potential costs (summarized in Table xx Page xx, an assessment of the benefits of such a Plan, and a gauge of the cost-effectiveness of the individual measures or sets of measures are detailed in Section V. Continual reassessment of the Plan will be required to take account of new technological developments and re-assessments of Harbour conditions.

Public consultation has formed an important component of the planning process and these are detailed in Section VII. The full report on the consultation concerning the Draft Remedial Action Plan is included in Appendix G, and recent letters submitted by key Stakeholders regarding the direction and intent of the Plan are included in Appendix F.

Finally, a set of criteria or objectives have been established that will allow us to gauge when we have achieved the objectives or goals that have been identified (Section IX). These were developed by the Technical Team and discussed with the Stakeholders in detail before they were finalized. To the extent feasible, they are quantitative in nature. The remainder are in the nature of defined tests that would allow current or future standards to be applied.

The ecosystem approach, if it is to address the full range of human and environmental conditions for the effective region - the watershed - that has impact on the Harbour, or alternatively, that the Harbour can influence in surrounding communities (natural and human) requires a comprehensive assessment. Encompassing even the most significant social, economic and environmental conditions and their interactions is a formidable challenge. Understanding the 'System" as a whole will call for constant attention to new developments in the social and economic realms, as well as a need to further our understanding of the natural aquatic regime.

I INTRODUCTION

The process leading to this report began with the release of an Ontario Ministry of the Environment (OMOE) report (Technical Summary, 1985) summarizing the water and sediment quality problems and their potential solutions. This report was based on the investigation of Hamilton Harbour carried out by OMOE in the 1970s and early 1980s, and on a series of industrial and municipal pollution control programs that were carried out in parallel with these studies. The improvements have been substantial but some problems remain (see Chapter IV). In the spring of 1986, the Minister of the Environment for Ontario called for public consultation on the remedial program, at which time a Stakeholders Group was formed by OMOE and Environment Canada to discuss and advise on the Plan to be undertaken (see Appendix H).

The Stakeholders Group met in a briefing workshop and several follow-up meetings in the spring and fall of 1986 and early 1987. Following a public meeting, the Stakeholders submitted an Interim Report to both the provincial and federal Ministers of the Environment in September 1986, outlining the principles, water uses, and goals they wished to see addressed in the Plan.

At the same time as the Stakeholders Group was formed, a Coordinator for the Plan was appointed and a Technical Writing Team was named to assist in the preparation of the report. Their first interim report was released in March 1987 and included preliminary estimates of costs (subject to detailed engineering investigations) and identification of the remaining information gaps that had to be addressed before a substantive plan could be submitted. The information gaps related primarily to the requirement for better fisheries and other biological information, and to the need for a more detailed assessment of contaminated bottom sediments in the Harbour.

A public meeting was again held to explain the content of the report and to hear public reaction to it.

In 1987 and 1988, the Technical Writing Team prepared a draft Plan incorporating the latest information describing the environmental problems, reviewing the goals of the work and submitting greater detail on the remedial actions to be taken. This was also followed by a public meeting.

During the period when this report was being developed the Remedial Action Plan (RAP) Program for the 43 Areas of Concern in the Great Lakes, which includes Hamilton Harbour, became the subject of a Protocol signed between Canada and the United States. With this Agreement (Annex 2, November 1987 Protocol) came new requirements for reporting to the Canada-Ontario Agreement Review Board (COA) and to the institutions of the International Joint Commission (IJC).

Hence, following the comments received on the 1988 draft Plan, the first stage of the RAP program was completed describing the environmental problems, the beneficial uses that are still impaired, the standards that are not yet being met, and the cause of the remaining impairment of uses of the Harbour (Stage I report entitled, 'Environmental Conditions and Problem Definition, March 1989', COA). This report encompasses biological, chemical, and physical factors affecting the aquatic system that includes both Hamilton Harbour and Cootes Paradise. The Stage I report was submitted for IJC comment in 1989. Notice of its acceptance by the IJC was received in June 1990 (Appendix E), following review by the COA Review Board and review at several levels within the IJC committees and Boards. The report of 1989 will require regular revision as new information and refinements in our data come forward. A second edition of the Stage 1 Report (COA, 1992) is available.

The technical options for remediation were intensively reviewed by the Stakeholders Group in a four-day workshop in the summer of 1989. Based on that workshop and advice on ancillary matters and on the public comments received up to that point, a draft set of recommendations was prepared for the Stakeholders in January 1990 (the draft 'Preferred Options Report'). Those recommendations have been reviewed, extended, and reworded by the Stakeholders over a period ending in July 1990, and finalized in 1992.

This Stage II report outlines in detail the proposed Remedial Action Plan, the options considered in reaching that Plan, and the goals and recommendations of the Plan. It has been developed with advice from the public garnered during a three month consultation at the beginning of 1992.

This report does not contain commitments for the work on the proposed Plan. While some agency commitments have already been made, new commitments for major measures will be required to make further progress to clean up the Harbour and to realize its full potential benefit to the citizens in the communities that surround it. When these commitments have been received, the Plan will be submitted to the International Joint Commission as Ontario's and Canada's plan to meet a major provision of the agreement between Canada and the United States to carry out our responsibilities in cleaning up the Great Lakes.

Citizens should be aware that industries and the municipalities responsible for dealing with pollution have not stopped to wait for this Plan. Where existing initiatives, such as the Municipal-Industrial Strategy for Abatement (MISA) of persistent toxic substances, were already in place, that work has gone forward. Municipalities have also taken steps to abate nutrient discharges to the Harbour in anticipation of this Plan. The details of all these programs and their impact are detailed in this report and in the Second Edition of the Stage 1 Report (COA, 1992).

While the focus of the RAP was initially on the loss of beneficial uses based solely on water quality problems, the roots of the problems go much deeper. In fact, the solution to the problems will reflect how all citizens, businesses, industries, and the governing councils view the Harbour and its potential to be a centre-piece and symbol of an environmentally sustainable community. The communities should take pride in what has already been accomplished, take hope for future improvements based on the effectiveness of past efforts, and look forward to seeing the restoration of a natural resource right at our front door that will give us greater opportunities for enjoyment and greater peace of mind.

I.1 Background

Concern for pollution problems in the Harbour is not new. The problems were identified in a formal way in the early 1970s, leading to the Harbour's designation by the International Joint Commission (IJC) as one of the 43 Areas of Concern in the Great Lakes. But even in the 1850s, when a new water supply was being considered for the small but growing city of Hamilton, the engineer-in-charge, Mr. Thomas Keefer, recognized that the bay was already contaminated, that growth of the city could make it worse (there was no treatment of sewage at that time and all sewage just drained down to the waterfront), and that he had to find a better source of drinking water out at the beach on Lake Ontario.

Recognition of further problems following the Second World War led to the establishment of water quality standards and a cleanup of discharges of pollution to the Harbour to restore better water quality conditions. In the past 20 years, an estimated $600 Million (1990 dollars) has been spent by industry ($500M) and the regional municipalities ($100M) to reduce the discharge of nutrients and contaminants to the Harbour. These measures have resulted in major improvements that are documented in the RAP report entitled, 'Remedial Action Plan for Hamilton Harbour - Environmental Conditions and Problem Definition' (March, 1989). The second edition of this report was published in 1992.

I.2 The Remedial Action Plan Program

Inauguration of the Remedial Action Plan program under the Great Lakes Water Quality Agreement is a recent initiative (formalized in the Revised Great Lakes Water Quality Agreement of 1978 - as amended by a Protocol signed November 18, 1987) that requires the Canadian and U.S. governments to develop plans explaining how the remaining problems in each of the Areas of Concern, like Hamilton Harbour, will be addressed.

This Remedial Action Plan for Hamilton Harbour is designed to meet part of Canada's and Ontario's obligations under that agreement.

I.3 The Purpose of This Report

This report is the next stage in the RAP process. It is to provide;

a) clear and precise goals consistent with the general and specific objectives of the Great Lakes Water Quality Agreement,

b) an evaluation of remedial measures already in place,

c) an evaluation of alternative, additional remedial measures required to restore beneficial uses with a schedule for their implementation (at this stage only the technically feasible schedule is described, rather than a firmly committed and funded schedule),

d) the beneficial uses that **will not** be restored (if any) and why they will not be restored,

e) the description of a monitoring program to track the effectiveness of the remedial works, and a

f) listing of the agencies or persons responsible for implementation of the measures that make up the Plan.

I.4 The Approval Process for the RAP

This Plan has been the subject of consultation with the public that is affected - that is, everyone in the watershed.

Following receipt of the comments from the public, the Technical Writing Team and the Stakeholders have considered the comments and have appended the results of the survey in this report.

This report is being sent to the Canada-Ontario Board of Review.

Following Review Board approval and their statement of commitment, the report will be submitted to the International Joint Ccommission for comment. The IJC serves as an auditor for all Canadian and U.S. RAPs to ensure consistency between the two countries in their programs to eliminate water quality problems in the Great Lakes, and to ensure that the Plan meets the terms of the Great Lakes Water Quality Agreement between the United States and Canada.

II DESCRIPTION OF THE AREA

II.1 The Watershed and its Hydrology

Hamilton Harbour is a 2,150 hectare embayment of Lake Ontario connected to the Lake by a single ship canal across the sandbar that forms the bay. The conditions in the Harbour reflect natural inputs, human activities, land uses, and drainage from the complete watershed of 49,400 hectares (Figure 1 and Figure 2).

This watershed is drained by three main tributaries: Grindstone Creek draining the north central area of the watershed (14% of the natural flow); Redhill Creek draining the south-east sector of the basin (15%); and Spencer Creek draining the north-west and western parts of the watershed (54%).

Spencer Creek reaches the main part of the Harbour through a 250 hectare, shallow area of both marsh and open water called Cootes Paradise, discharging at an artificial opening into the Harbour called the Desjardins Canal.

The Harbour in the eastern part of the basin is the main recipient of the urban runoff (11% of the total natural flow) from the cities of Hamilton and Burlington.

The Harbour also receives the treated sewage from all of Stoney Creek and Burlington - large portions of which are not in the natural watershed of the Harbour. Hence, the recommendations of this report will have to be addressed by all the citizens of these communities - not just those in the natural watershed. The areas affected are shown in Figure 2.

The natural annual flow into the Harbour ranges between 1.1 and 2.1 X 10^8 m^3. Since the water supply systems for the city of Burlington and Hamilton-Wentworth Region draw their water from Lake Ontario and discharge the sewage into the Harbour, an artificial supply of inflow to the Harbour has been generated approximately equal to the natural inflow. In addition, a less well measured flow of water enters the Harbour from Lake Ontario. Surging of the currents back-and-forth in the Burlington Ship Canal in winter, and a distinct inflow along the bottom of the Canal in summer means that Lake Ontario water of generally good quality is a major component of Harbour water. For the main Harbour, it is estimated that at any one time, approximately 10 percent of the Harbour water is natural water runoff, 10 percent is water from the sewerage systems and 80 percent is water from Lake Ontario. These proportions vary widely from one part of the Harbour to another.

II.2 Topography and Geology

The Niagara Escarpment is the most outstanding physiographic feature of the area, dividing the area of the watershed in half. The area above the escarpment is generally very flat

Figure 1: Harbour/The Bay - Location Map

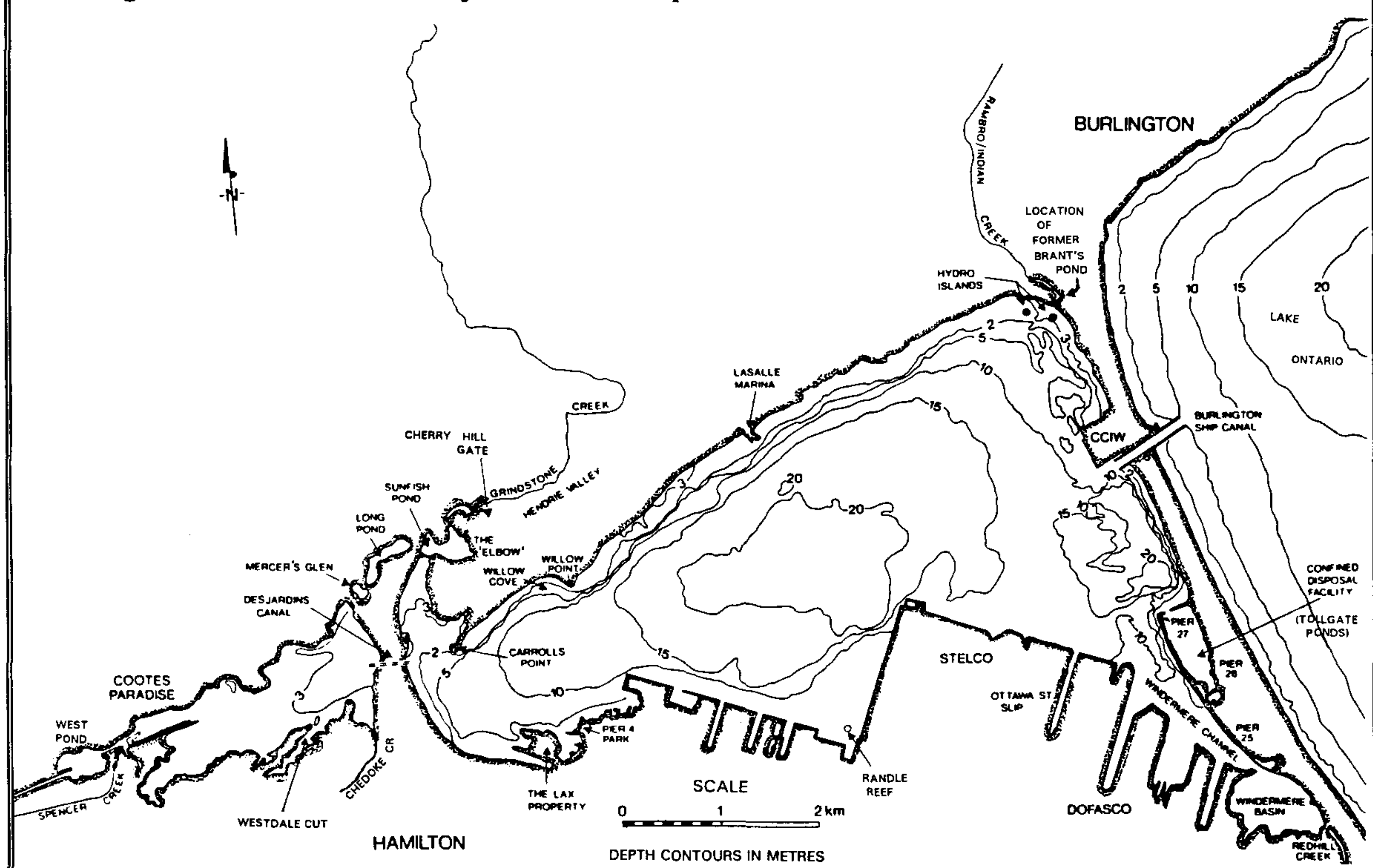
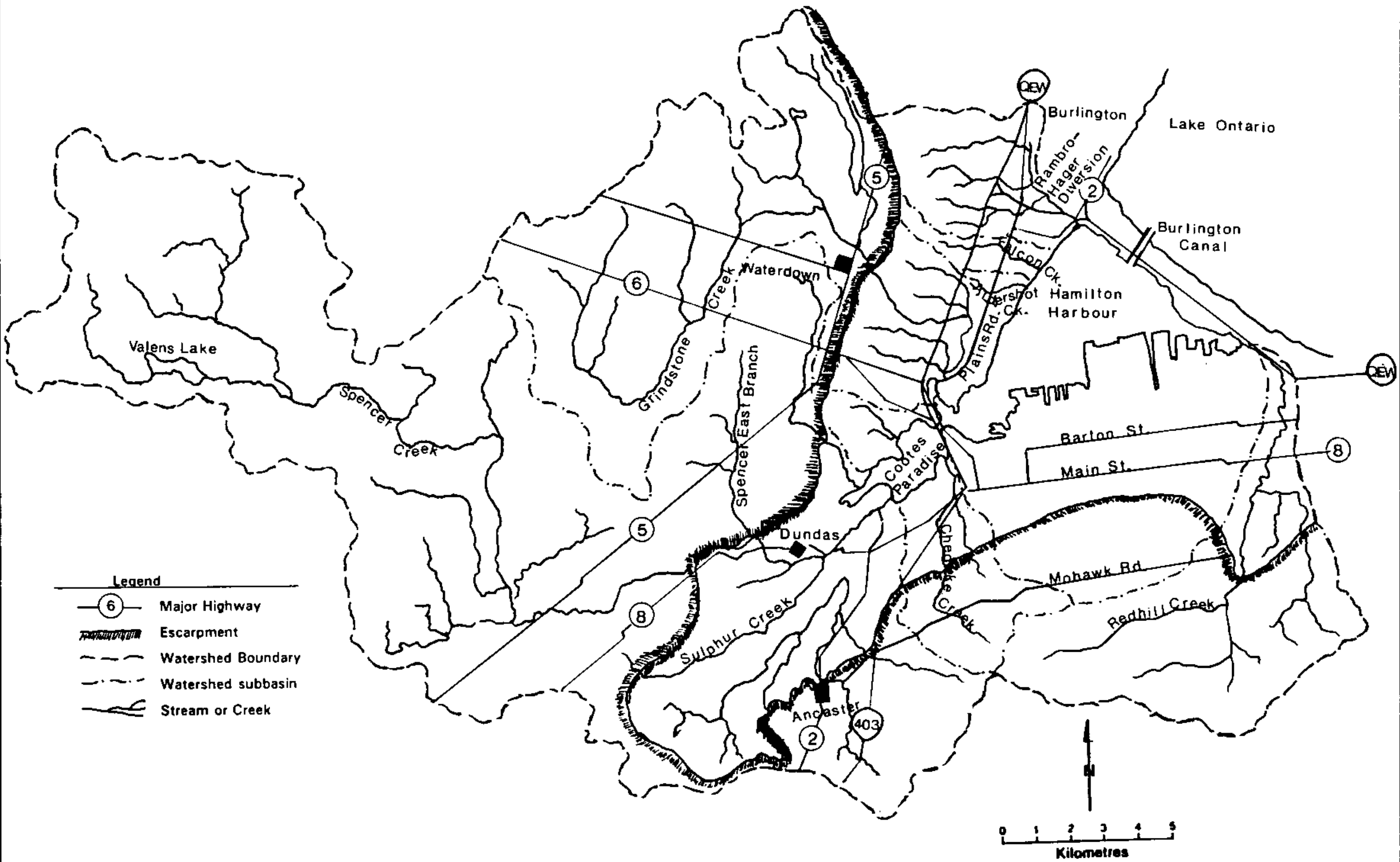


Figure 2: Hamilton Harbour Watershed



Source: H. Ng, NWRI

(typical gradients of 1 in 2,000). The escarpment itself gives rise to stream gradients of up to 1 in 20 with several scenic waterfalls. Below the escarpment, with stream gradients in the order of 1 in 100, streams move across plains of clay and sand, or down the Dundas Valley.

Reservoirs in each of the main tributaries near the lip of the escarpment dampen the effects of erosion on the tablelands above the escarpment. Erosion in the river valleys below the escarpment is a matter of general concern, although concern for erosion from construction sites is greater.

II.3 Current Land Uses

Urban centres located in the watershed are Hamilton (pop. 306,000), Burlington (120,000), Stoney Creek (43,000), Dundas (20,000), and Ancaster (15,000). Projected population increases for the basin are approximately 10 percent from these 1986 estimates to the turn of the century. Urban growth within the watershed has historically centred on the City of Hamilton. Development has resulted in a nearly continuous urban area surrounding the Harbour. The urban centres are largely below the Niagara Escarpment. The greatest pressure for development is in the eastern and north-eastern parts of the watershed.

A few small towns exist above the escarpment. Waterdown (pop. 4,000) has a 2,400 m^3/day sewage treatment plant discharging into Grindstone Creek.

The Harbour's deep water port supports the largest concentration of heavy industry in Canada. The port and the associated industries are located along the south shore of the Harbour. The major industries are iron and steel. Direct and indirect employment related to the port facilities is estimated at 30 percent of the total area employment.

In addition to being a major shipping centre, the Harbour is ringed by major highways which have an impact on water quality and habitat in the Harbour.

Eight municipal landfill sites have been closed in the last 20 years. Four privately operated non-hazardous solid industrial waste sites are located in the watershed. No detrimental effect on receiving waters has been found at any of these sites. Eight of these 12 sites are being monitored routinely, and the remainder have been or are being carefully assessed.

About 65 percent of the watershed is agricultural, primarily with mixed farms (livestock, hay, grains, corn) and fruit and vegetable farms.

Recreational areas include 13 conservation areas (2,000 ha), the Royal Botanical Gardens (including a 835 ha nature preserve) and the natural areas and trails associated with the Niagara Escarpment.

Twelve thousand hectares (or 25% of the watershed) are designated as Environmentally Sensitive Areas. Development in these areas is regulated in an attempt to prevent or minimize damage to plants, animals, landforms, forests, and to retain the educational, research or aesthetic values embodied in these locations.

From the time when Governor Simcoe built a military road from Ancaster (1793) on Burlington Bay to the Thames River, the present physical basin of the Harbour has been irreversibly altered.

Canals and infilling of the Harbour have had major environmental impacts. In 1823 a ship canal was built through the sandbar separating the Harbour from Lake Ontario. It was placed south of the natural outlet and was wider and deeper. This channel is now 88 m wide and 10 m deep - a situation that makes possible the massive inflow of Lake Ontario water into the Harbour as well as accommodating the largest seaway vessels.

The abortive attempt to canalize Cootes Paradise to move shipping up to Dundas in 1853 resulted in a change to the location of the outlet in that major marsh area, from a location near the Valley Inn Road on Grindstone Creek to the artificial cut called the Desjardins Canal under the Thomas B. McQueston bridge on York Boulevard.

The south and east shores of the Harbour are now all infill areas developed for industrial activities (primarily the iron and steel industries), marine terminals, and railway or highway construction. Twenty-five percent of the area of the original bay has been 'reclaimed', eliminating 75 percent of the wetlands, protected inlets and shallow areas that served as the nursery habitat for the largest fishery that existed on Lake Ontario until the first decade of this century.

The City of Hamilton has had an economic structure based primarily on the iron and steel industry and other heavy industry. The Harbour is a key element in its development, and in its continuance here. The Harbour is the second largest Canadian port (in terms of tonnage handled) in the Great Lakes region, and 80 percent of the tonnage is iron ore and coal for the two major steel industries. In addition, the Hamilton Harbour Commissioners have almost autonomous control over all of the Harbour waters, almost all of the remaining water lots, and the major industrial land holdings around the Harbour. The Commissioner's revenue from tenants on their land holdings exceed revenue from port facility operations.

The north shore of the Harbour in the Aldershot district of the City of Burlington consists largely of private homes. Some cemeteries, one large park, and a private golf course comprise most of the remainder. Hence the character of the north shore stands in marked contrast to the south shore, although public access is almost as poorly served as on the south. The western shore is railway land, and the eastern shore is highway, canal or institutional lands that prevent any general public access.

In terms of the 45 kilometres of shoreline available, space is utilized as follows:

52% - Industrial, including proposed developments on existing piers
15% - Transportation
11% - Residential
10% - Institutional (cemeteries, public buildings)
5% - Uncommitted
5% - Private open space (private marinas, golf courses)
2% - Public open space (public marinas and parkland)

Of this, only 7 percent of the shoreline is publicly accessible and green. More recently, local governments have adopted new environmental ethics, and have attempted to protect remaining greenspace using a preservationist approach, establishing islands of greenspace for public recreational use. But the amount of space currently being considered for public access is small in comparison with the continued industrial/marine development. This situation is mitigated somewhat by the access provided in the nature preserve in Cootes Paradise.

The Stakeholders Group for the RAP considers substantial increased public access to the Harbour proper to be essential for realizing the full potential for a body of water such as the Harbour with restored water quality and with an improved healthy fish and wildlife population.

Jurisdiction over matters affecting water quality, the potential for future costs of monitoring the environment, and land use in the watershed or around the Harbour are complex, to say the least. Regional planning for new housing, industrial development and open spaces can have an important bearing on how the Harbour is affected. Equally important is the diligent enforcement of by-laws that are designed to minimize the impact of construction activities, and to monitor business or other regionally-operated services to see that they are carried out effectively.

Jurisdiction for controlling waterfront land uses are divided, although shipping and navigation take precedence over all other uses by virtue of the fact that these regulatory/operation functions are vested in federal authority. Other waterfront planning authorities include the Regional Municipalities of Hamilton-Wentworth and Halton, the Cities of Hamilton and Burlington, the towns of Dundas, Ancaster, and Flamborough, the Royal Botanical Gardens, and local Conservation Authorities.

II.4 Socio-Economic Conditions

This section is based on a recent report by Schaefer and Robinson (1991).

II.4.1 Population and Demographics

II.4.1.1 Hamilton-Wentworth

The population of Hamilton-Wentworth is expected to increase by 12.5 percent from 1989, to about 483,000 by 2006, based on recent forecasts prepared by the Region's planning department. The rate of growth within the Region is expected to remain below the provincial average, which will likely continue to slow down over the 1988 to 2006 period. This is consistent with historical growth patterns from 1956 to 1988, and reflects the particular age structure and migration patterns which characterize the Region. Table 1A shows population growth to 2006 for the two Regions, under the "most likely" scenario, which assumes that moderate fertility and migration patterns prevail.

Table 1A: Population Profile - Hamilton Harbour

	1921	1931	1956	1976	1981	1986	2001	2011
H-W	124,715	190,019	312,924	409,490	411,445	423,398	476,560	507,830
Halton	25,540	26,558	71,611	228,495	253,885	271,389	350,070	398,100

Overall, migration into Hamilton-Wentworth is expected to remain positive, stimulated by the higher real estate prices in Toronto, and sustained by the future availability of development infrastructure locally. International migration is expected to account for almost 60 percent of future population growth in the Region.

The number of households is projected to increase from 161,100 in 1986, to about 193,500 by 2006. About 87 percent of this household growth is expected to occur in the periphery of the City of Hamilton.

II.4.1.2 Halton (Burlington)

The Regional Municipality of Halton has experienced steady growth both in absolute terms, and in terms of its size as a percent of total Greater Toronto Area (GTA) population. It increased from 5.6 percent of the GTA total in 1961, to 7.5 percent in 1986. Population growth in Halton is expected to exceed that for Hamilton and for the province as a whole, according to projections by the Ontario Ministry of Treasury and Economics (OMTE). This aggressive outlook reflects the Region's strategic location near to Toronto, strong transport links, relatively low cost land, and other environmental amenities.

For Burlington, the only Halton area municipality located in the Hamilton Harbour watershed, population growth has historically exceeded that for the Region, averaging 2.9 percent annually over the period from 1967 to 1986. Future growth in the Halton Region is expected to focus on urban Milton however, and Burlington's growth is expected to average only 1.5 percent annually from 1987 to 2011. From 1986, population is expected to increase by 51,300 to reach 168,000 by 2011. As a percent of Halton's total population, Burlington will therefore account for roughly 39 percent in 2011, compared to 43 percent in 1986. For residents living around the Harbour, population growth will add even more pressure to develop suitable public access to the waterfront.

II.4.2 Age Structure

Another widely recognized demographic feature, the aging population phenomenon, applies particularly to Hamilton and Burlington. The Hamilton Census Metropolitan area, which includes both areas, was identified in the 1986 census as having the third oldest average population of the 33 Canadian cities listed (33.4 years). This "aging" phenomenon obviously comes as the result of fewer babies and more seniors living longer.

II.4.3 Regional Growth Patterns

One widespread transition experienced in the Hamilton Harbour area, as in many communities throughout North America, is a substantial increase in peripheral development and suburban sprawl. Since 1931, in Halton Region alone, 45 percent of the total farmland has been replaced by urban development. While there are substantive advantages in terms of individual land and property ownership, there are, from a more holistic or sustainable perspective, a number of limitations. As with many North American communities, the spilling of development outside of the urban framework has resulted in: lost open space; reductions in agricultural land; an increase reliance on the automobile, yielding increased traffic congestion, air pollution and ultimately, water pollution; increased flooding activity during heavy rainfall; costly infrastructure expansion.

II.4.3.1 Implications for Harbour Remediation

An increase in population in the Hamilton Harbour area has at least two implications for remediation. First, there will be increased stress on existing sewage treatment plants, most of which are near capacity. From a socio-economic perspective, this highlights the enormous potential for water demand management (water conservation, pricing mechanisms, leak detection, pressure reductions, etc.) in the Halton and Hamilton-Wentworth area to reduce the quantity of water being used, thereby extending the life of treatment plants and potentially reducing the concentrations of certain contaminants in plant effluent.

Secondly, as the population around the Harbour continues to grow, there will undoubtedly be an increase in the demand for water-based recreational activity. This warrants a closer look at the anticipated growth of the existing and potential uses in the Harbour to facilitate in the allocation of waterfront land. This point will become increasingly important as waterfront land becomes available in an already intensely used waterfront on the main Harbour (Figure 1).

The aging phenomenon may be most significant in the context of RAP plans for waterfront recreational use. For planning future remedial options, it suggests relatively more demand for passive uses like trail-walking and bird-watching, and less demand for strenuous water sports and other active uses. This implies that passive multi-use greenspace might be given higher priority among competing foreshore uses.

Given the comprehensive nature of remedial action planning, as outlined in the Great Lakes Water Quality Agreement, there is some merit in investigating the implications of changing development patterns for improving water quality in Hamilton Harbour. In fact, as outlined above, the linkages are very inherent. A decentralized development pattern, from an environmental perspective, can be quite unsustainable. To alleviate many of the problems of decentralization and to make more efficient use of existing land, more attention can be directed at strengthening metropolitan districts, largely through more diverse housing (for all ages and income groups), improved public transportation (increased number of links with employment hubs, etc.), and strengthened commerce. In short, there is a greater need to integrate the various 'people activities' (i.e. working, shopping, entertainment, etc.). These suggestions provide little help for immediate water-related problems in the Harbour, but can go a long way to facilitating the maintenance of restored beneficial uses, in the long term.

II.4.4 Employment and Industry Outlook

On a combined basis, employment growth within the Greater Hamilton Census Metropolitan Area (CMA) has been strong between 1980 and 1988, with the total labour force increasing by 20.5 percent from 268,000 to 323,000. Meanwhile, unemployment rates have fallen annually in the post-recession period after a peak of over 11.0 percent in 1982 to 6.1 percent in 1988. The expanding labour force and a declining unemployment rate suggests that job creation in the CMA has been sufficient to absorb the annual increase in those employed or looking for work. For 1989, unemployment in the area averaged 5.9 percent, but is has risen in the current recession.

Underlying this recent employment growth is a fundamental shift in the nature of local employment, away from manufacturing and towards the service sector. Changes in industry employment from 1981 to 1986 are indicated in Table 1B. In 1986, business services

Table 1B: Labour Force Employment by Industrial Sector

Industry Sector	1981	1986	% Change 1981-1986
Primary	3,905	4,595	17.7
Manufacturing	69,945	61,575	-12.0
Construction	12,715	13,200	3.8
Transportation(1)	10,955	11,325	3.4
Trade	32,900	37,610	14.3
FIRE(2)	8,875	10,375	16.9
Government	7,725	7,635	-1.2
Other Services	59,000	68,580	16.2
TOTAL	**206,020**	**214,895**	**4.3**

(1) Transportation includes Communications and utilities
(2) FIRE refers to Finance, Insurance and Real Estate.

overtook manufacturing as the single largest industry sector; it now accounts for 37 percent of total employment, up from 33 percent in 1981. Also, the aging population is expected to create substantial new job opportunities in the service sector, ranging from tourism services to nursing-home care. Meanwhile, manufacturing employment in the area declined by approximately 12.0 percent from 1981 levels. This shift from high paying manufacturing jobs has apparently had a positive impact on real wages in the community. From 1981 to 1986, average employment income for males increased from $18,337 to $32,737 ($24,430 in constant 1981 dollars), and for females, it increased from $8,316 to $19,697 ($14,699 in constant 1981 dollars).

One scenario, based on international changes in the quantity and types of steel sought, a strengthening of the European community, and the changing of production techniques, suggests that the quantity of waterfront land required by the two main steel producers may be reduced. (Currently, the two steel producers and allied infrastructure occupy approximately 32 percent of the main Harbour: waterfront.) Trends within the steel industry towards continuous casting and mini-mills indicate more concentrated production lines and less intensive use of land in the steel-making process. Already there is restructuring taking place, with continuous casting having made the intermediate operations like the ingot floor virtually obsolete. With the onset of direct reduction technologies by the end of the first quarter of the next century, there may no longer be a need for coke ovens or the coke byproducts areas.

II.4.4.1 Implications for Harbour Remediation

The steady growth in business services since 1971 is a trend that will likely continue into the future. To some extent it depends on whether the local mix of labour skills continues to meet the demands of new highly paid business service occupations. But more importantly perhaps, it depends on the ability of regional policy-makers to ensure a healthy working environment for attracting more skilled labour into the area. This means not only providing affordable office space with suitable access, but also implies a willingness to control pollution and to create additional recreation amenities. In this way, the region can promote a well diversified labour force which will minimize the risk of depending too much on one economic sector.

With respect to the large 'footprint' of the industrial uses of the waterfront land, it seems difficult to foresee how public access could be realized in the face of proven safety and security concerns. However, access is such an important public issue that consideration should be given to establishing a community committee to explore the practical potential for providing access through existing industrial or Harbour Commissioner properties.

II.4.5 Summary

This section is not exhaustive in its description of socio-economic conditions in the Hamilton Harbour watershed. It has, however, discussed the importance of including social and economic information in the remedial action planning process, and has provided some illustrations of its relevance in facilitating the selection of remedial options to ensure the maintenance of restored beneficial uses. Some of these observations are summarized below.

Increases in population levels will continue to put stress on existing water supply and wastewater infrastructure, and exacerbate the pressure for improved access to the Harbour. Specifically, demographic trends point towards an aging population base for the future, with more leisure time on their hands. This suggests a relatively strong future demand for passive recreational uses like trail walking and bird watching and improved employment opportunities in the tourism, recreational, and other service sector industries.

The Area of Concern's economic structure is becoming increasingly diverse. With the adoption of new technologies, more automation, and increased international competitiveness, the area's main manufacturers may become less labour and land intensive. Steelmaking may no longer be the engine of growth for Hamilton. Employment in business services has recently overtaken manufacturing as the single largest industrial sector and will continue to grow. Skilled service sector occupations have grown substantially in the recent past and this trend is expected to continue into the foreseeable future, with the growth of small business.

Successfully adapting the local economy to this structural change will depend on regional policy makers' ability to create a healthy working and living environment and the creation of new and improved recreation amenities to attract more skilled labour into the area.

Perhaps the most pressing issue is increased public access to the Harbour. A potentially smaller industrial footprint on the Bayfront lands will offer greater opportunity for greenspace and other uses along the waterfront.

Finally, there is a real need to examine water demand management and effluent charges as a cost effective approach for improving water quality and for extending the sewage carrying capacity of the Harbour.

II.5 Environmental Conditions and Problem Definition

A summary of the scientific and technical information available on Hamilton Harbour and areas draining into the Harbour has been prepared with the assistance of several agencies. Building upon the earlier Ontario Ministry of Environment summary report on sediment and water quality (OMOE, 1985), recent investigations have updated that material. New information has been added in regard to fish and wildlife populations, and marsh and other habitat considerations in light of the goals stipulated for the Harbour by the Hamilton Harbour Remedial Action Plan Stakeholders, and the beneficial uses listed in the 1987 Protocol for the Great Lakes Water Quality Agreement between Canada and the United States in Annex 2. These are detailed in the Stage I reports for Hamilton Harbour (Environmental Conditions: Hamilton Harbour RAP, 1989 and 1992, COA).

Documentation now exists on the substantial improvements in water quality, in the abundance of fish, the increased and more diverse waterbird populations, and improvements in the contaminant content of both fish and birds. These are the results of remedial actions taken to date. The funds expended in this effort locally have been in the order of $600 Million (in 1990 dollars).

Some problems remain, largely because the Harbour receives all industrial and municipal waste, as well as urban and rural runoff from the complete watershed - no discharges are made directly to Lake Ontario. All municipal and industrial 'point sources' presently meet the provincial standards, and go beyond them in several respects. The difficulty lies in the small size of the Harbour receiving these wastewaters. This situation calls for more stringent standards specific to this watershed.

Hence, there remains a substantial water quality stress on this body of water, and serious habitat stresses for fish and wildlife, as follows:

1. **Contamination of bottom sediments** is a principal concern. The contamination present is largely the result of past industrial discharges. Recent deposits are much improved as a result of remedial programs in industries discharging directly to the Harbour. Yet the most recent deposits and the suspended material in the water column still do not meet the guidelines for open water disposal if dredging were required. Hence, navigational dredging still requires use of a confined disposal facility. The confined disposal facility currently in use will be filled by the year 2010. Construction of new confined disposal facilities could result in additional loss of shallow water habitat.

   The current guidelines for contaminated sediment have been recently revised. Major assessments are required before advice on remedial action for *in situ* sediments can be given. Remediation of Windermere Basin has begun through a dredging and confinement program. This work will be completed in 1992. Following the preliminary protocols for chemical testing and bioassays, a second area of high polynuclear aromatic hydrocarbon (PAH) concentrations and high toxicity near Randle Reef is actively being assessed for remediation. The PAH source is no longer active and the material resides in a shallow zone where there is greater potential for disturbance by ships or wave action.

   As for the remainder of the Harbour, several remedial measures are under consideration as evidence for the efficacy and environmental impact of each is compiled. Before action is taken on this larger area, however, we will have to ensure that the discharge of contaminants has been reduced to the point where we can be reasonably sure that future deposits of sediment will meet the new guidelines.

2. **Contaminants in the water column** have been well addressed in the control programs of the past 20 years. Metal concentrations only occasionally exceed objectives. However, un-ionized ammonia exceeds the objective along the south shore about 50 percent of the time although a major improvement was noted in 1990. The area of non-compliance for ammonia has extended over at least one third of the Harbour area in the late winter and spring.

   Spills have been observed to cause fish kills, and efforts must be continued to identify the potential for accidental discharges to the Harbour and ways to control them.

   The polychlorinated biphenyl (PCB) concentrations in the water column are now established to be largely the result of past discharges and probably the result of Great Lakes Basin atmospheric loadings and resuspension of the PCBs remaining in sediment. But they do not meet the water quality standard.

3. **Eutrophication** is severe, with nuisance algal growths, reduction in water clarity, and dissolved oxygen levels in the hypolimnion in summer hovering around 0.5 to 1 mg/L. This is a consequence of having four sewage treatment plants discharging into the Harbour and tributary areas. Phosphorus in combined sewer overflows and in streams adds to the problem.

   Low hypolimnetic oxygen concentrations are alleviated somewhat by periodic injections of cold oxygenated water from Lake Ontario which enters the Harbour along the bottom of the Ship Canal - a process controlled by summer heating of the water and wind surges.

   Reduced phosphorus loadings are required to control excess algal production, but remedial action to improve the dissolved oxygen condition also requires major reductions in oxygen-demanding ammonia loadings.

4. **Poor water clarity** is a particular aspect of eutrophication. As well as being a factor in the aesthetics of water quality, it gives rise to problems for potential swimming areas (the guideline is 1.2 m Secchi depth, where actual values are usually 0.5 to 1.0 m at best), and for the extent of submerged weed habitat, which is important for fish.

   Inorganic suspended material is the major factor affecting the extent of aquatic vegetation. This murky water is caused by erosion, wind-wave action (resuspension), and carp activity. Algae (see Eutrophication) and dissolved material which imparts colour to the water are also factors that predominate in the central part of the Harbour. Measures to deal with erosion, carp populations, and phosphorus control are key ingredients for remediation.

5. Widespread **bacterial contamination** violates the criteria for swimming, although the situation has improved over the past 15 years. Programs to disinfect sewage treatment plant effluent (or to improve the efficacy of the disinfection), and to reduce combined sewer overflows, contribute to the improvement. The principal problem will be, however, to deal with the high levels of pathogens during and after the runoff from rainfall. Animal and bird faecal material is washed from the watershed, and since there is little circulation to move it away from shores in the Harbour, the bacteria levels could remain high for several days after a rainstorm.

   During dry spells, the levels on the north shore and at the west end generally meet the criteria, based on the limited data available. The feasibility of ensuring a reasonable nearshore water quality requires more detailed investigation.

6. The **warmwater fishery population** of Hamilton Harbour indicates an environmentally stressed community. Although 59 species have been caught in the Harbour, the fishery is dominated by only four species. Carp, white perch, brown bullhead, and gizzard shad make up 70 percent of the total biomass. Carp, bullhead, and shad thrive under conditions of low dissolved oxygen and high concentrations of suspended solids. They can tolerate contaminated sediments and are frequently found in heavily contaminated environments. Their spawning and feeding activities uproot

vegetation and resuspend bottom sediments. They prey on juvenile fish and benthos, and eliminate desirable fisheries through predation, competition, and habitat destruction. Populations of carp, bullheads, and white perch increase as habitat deteriorates until the balanced fish community collapses into a stable community dominated by pollution tolerant species.

Most of the historic marsh in Hamilton Harbour disappeared as a result of landfilling along the south shore, and cannot be regained. However, the extensive Cootes Paradise and Grindstone Creek marshes disappeared because of the combined effects of sustained high water levels, uprooting of new plants by carp, and poor water clarity. Remedial actions could improve habitat for fisheries along the north and west shores of the Harbour and in Cootes Paradise.

Restructuring fish communities involves habitat development, introductions of desirable species, and control of problem species. Application of this approach has been successful in more easily controlled reservoirs but is largely experimental in the Great Lakes.

7. Through bioaccumulation or contact, **fish have accumulated body burdens of contaminants.** In some cases, particularly for the larger, older fish, this results in fish consumption advisories stipulated by the health authorities. These centre around mercury, PCB, and Mirex contamination.

Fish health is also a concern. Liver lesions on internal organs and papillomas on the skin are present with frequencies that indicate fish health is not normal. Both heavy metals and organic contaminants are implicated in the lesions. A biological origin (likely virus) is postulated for the papillomas. Both problems may indicate a stressed fish population, although the fish populations are not different from all the other fish populations in western Lake Ontario.

Colonial **waterbird** populations in the Harbour experienced serious **reproduction problems** in the 1970s. These problems have largely subsided with the reduction in body burdens of trace organic contaminants. Reproduction rates are now considered normal and increased nesting habitat has resulted in dramatic population increases in such birds as gulls, cormorants and herons. However, ducks and colonial waterbirds still carry fairly **large body burdens of contaminants.**

While specific remedial measures are difficult to target at this time, the general reduction of pollution and habitat stress should be helpful, particularly those measures dealing with toxic contaminants.

8. **Wildlife Populations - Harbour:** At present, colonial waterbird habitat exists at Piers 26 and 27 and at the Hydro Islands. The Pier 26 and 27 habitat is in a state of redevelopment. The provincially significant waterbird colonies are the largest and only nesting locations in western Lake Ontario. Complete loss of the herring gull colony would mean the loss of a monitoring tool for organic contaminants in western Lake Ontario. The colonial waterbirds are probably significant predators of the

forage pelagic fish in the Harbour. Rare colonial species have also nested in the present habitat locations.

Certain species, particularly the ring-billed gulls, are considered to be a nuisance at the present population levels.

The overall answer to the question of numbers of birds lies in controlling the amount of suitable habitat for each species.

Wildlife Populations - Cootes Paradise: The number and diversity of waterbirds and wildlife in Cootes Paradise is limited by the amount of marsh vegetation now available. Until the 1940s, the wetland was a well established, self-sustaining marsh. Though it remains a very important wildlife habitat on the Lake Ontario shoreline, it has been in serious decline for the past 45 years, losing more than 85 percent of the emergent vegetation cover and over 90 percent of the submergent plant species.

The problem consists of significant loss or reduction of resident wetland-dependent wildlife, and reduced good quality food supply for migrant waterfowl and other waterbirds, reducing the stopover/staging value of a strategic region in the lower Great Lakes.

The source of the problem lies partly with Spencer Creek. This principal tributary has carried increased loadings of suspended solids to Cootes Paradise since the 1940s, reducing the depth and changing the substrate. Wind and waves resuspend the sediment creating highly turbid conditions in the water which in turn reduce light penetration. Carp directly impact the plant community as noted above. The timing of the annual water-level regime of Lake Ontario is "out of synchronization" with the normal growth cycle of aquatic plants, thereby restricting them to small amounts of littoral habitat which fringe the basin. Finally, one sewage treatment plant effluent, CSO discharges and contaminated tributary creeks add nutrients to such an extent that serious eutrophication occurs.

II.5.1 Institutional Problems

The multiplicity of agencies responsible for, or having a stake in, the outcome of a complete rehabilitation program is daunting. While several formal mechanisms (e.g. environmental assessments) link agencies or the public in dealing with parts of the system, no formal mechanism exists which links these agencies and community interests in a comprehensive way - a way which we are trying to achieve with the Stakeholders Group. Nevertheless, it will be necessary for these groups to work together closely to achieve the multiple uses of the Harbour envisaged in the goals developed by the Hamilton Harbour Stakeholders Group and the public.

The means to achieve this cooperation will necessarily be a major concern for the continuity and effectiveness of the Remedial Action Plan program and will include planning at several levels throughout the Harbour watershed.

II.5.2 Sources of the Water, Sediment, and Biological Problems

Major efforts are continually being made to update and improve our measurements of the sources of contaminants in order to ensure that the control measures being implemented lead to the desired improvement. For some concerns, like the relation between a dissolved contaminant in the water and a distinct wastewater discharge, the relation may be direct and unequivocal. In others, such as concern for an adverse fish health outcome like a liver tumour, the connection to a source can be very complicated. In such a case the question of which chemical (or chemicals) might cause the tumours has to be established and then the food chain connections to the chemicals need to be understood. Where fish or birds migrate, or where their food migrate to/from areas outside of the Harbour, some particular care in interpretation is necessary.

These concerns are reflected in the following table (Table 2), and the text of the report addresses source loadings in so far as they are understood at this time.

II.5.3 Summary

The conditions in the Harbour are summarized according to the fourteen 'beneficial uses' specified in Annex 2 of the Great Lakes Water Quality Agreement. Table 2, which follows, identifies the current state of conditions in the Harbour and in Cootes Paradise along with the substances causing the problem, their sources, and the elements of the remedial action program which pertain to each.

Table 2: **Summary of impairment of beneficial uses as outlined in Annex 2 of the Great Lakes Water Quality Agreement.**

	USE IMPAIRMENT	SIGNIFICANCE TO THE HAMILTON HARBOUR RAP	CAUSES OF IMPAIRMENT	SOURCE OF PROBLEM	INFORMATION DEFICIENCIES
(i)	Restriction on fish and wildlife consumption	(a) Fish: Although there are current consumption advisories (mercury (Hg), Polychlorinated biphenyls (PCBs) and Mirex) on five of twelve fish species listed for the Harbour, four of the species accumulate contaminants Lake-wide because they migrate into the Harbour from Lake Ontario. It is unlikely that reduced loadings to the Harbour alone will result in elimination of fish consumption advisories since Lake Ontario conditions, atmospheric sources (not primarily local sources) as well as local contaminated sediment are all possible sources. In addition, smelt, alewife and gizzard shad - valuable food fish for harbour predators - also move contaminants from Lake Ontario into the Harbour and its food chain.	- Mercury (Hg), PCB, Mirex - Pesticides - very low levels of the insecticide DDT and DDE (breakdown of product of DDT).	- Sediments - Sewage Treatment Plants (STPs), (PCBs - origin may be by atmospheric and/or urban non-point sources). - Lake Ontario - in prey species and in top predators that move contaminants into the Harbour and its tributaries. - Atmospheric deposition	The connection between the many possible sources of the contaminants and the contaminants found in fish is unclear since current judgement is based on relatively weak circumstantial evidence.

	USE IMPAIRMENT	SIGNIFICANCE TO THE HAMILTON HARBOUR RAP	CAUSES OF IMPAIRMENT	SOURCE OF PROBLEM	INFORMATION DEFICIENCIES
		(b) <u>Wildlife</u>: Generally hunting is not permitted in the area. PCB concentrations in mallard ducks and snapping turtles are well above U.S. and N.Y. standards. There may be risk to hunters in other areas from migrating birds that spend time in this Harbour.	PCBs in food for birds.	Potentially PCBs in sediments in feeding areas or feeding on higher levels of the food chain that are contaminated from more general PCB distributions.	Wildlife should be examined more thoroughly. PCB and mercury distributions and links to local regional sources should be identified more precisely. Canadian standards for wildlife consumption are required. Standard methods for establishing more clearly that local sources are not significantly contributing to the problem need to be established and incorporated into the surveillance program.
(ii)	Tainting of fish and wildlife flavour	(a) <u>Fish</u>: No impairment is known to exist for fish. Fishing occurs in the Harbour but there have been no complaints regarding the tainting of fish flavour. (b) <u>Wildlife</u>: Tainting of wildlife flavour is not observed for Hamilton Harbour. Hunting is not permitted in the area.			No formal study of tainting of fish and wildlife has yet been undertaken.
(iii)	Degraded fish and wildlife	a) <u>Fish</u>: Prior to initiation of the Remedial Action Plan (RAP) there were no objectives for desired fish population densities. A reduction in the carp	- Loss of spawning, nursery and adult habitats - Low dissolved oxygen (DO),	- High algal blooms - Contaminated sediments - Shoreline filling - Introduction of	Storm loadings of suspended solids from watersheds. Information on fish and wildlife regarding habitat requirements for various life stages of fish and wildlife (see (iv)).

	USE IMPAIRMENT	SIGNIFICANCE TO THE HAMILTON HARBOUR RAP	CAUSES OF IMPAIRMENT	SOURCE OF PROBLEM	INFORMATION DEFICIENCIES
		population has been proposed in order to minimize the negative impact on the macrophyte communities and other species that depend on this type of habitat. Pike have been stocked in order to increase the population of top predators in the warmwater fishery. Fifty-nine species of fish have been found in the Harbour, forty-two of which are reproducing here. However, these populations indicate a highly degraded eutrophic system. (b) Wildlife: Two of the four recommended objectives for numbers of colonial waterbirds have been exceeded. Numbers of double-crested cormorants and black-crowned night herons are slightly below target levels. A reduction in the population of ring-billed gulls has been proposed.	ammonia toxicity - Degraded benthos (see (vi)) - Low aquatic plant diversity and abundance	exotic species - Poor light penetration	
(iv)	Fish tumours or other deformities	Liver and skin neoplasms and epidermal papillomas have been reported on several species of fish. Carcinogens	- Polyaromatic hydrocarbons (PAH) in contaminated sediment.	- Contaminated sediment from historical sources in	- Cause of tumours not clearly established. - Role of virus' not yet confirmed.

	USE IMPAIRMENT	SIGNIFICANCE TO THE HAMILTON HARBOUR RAP	CAUSES OF IMPAIRMENT	SOURCE OF PROBLEM	INFORMATION DEFICIENCIES
		are present in Harbour sediments. These sediments have induced liver tumours in fish in laboratory studies. Overall tumour frequency for Harbour fish is similar to the frequency of tumours found in fish from other sites in western Lake Ontario. The occurrence of hepatocellular carcinomas at low levels in white suckers strongly suggests chemical carcinogens in western Lake Ontario.	- Viruses may be responsible for epidermal papillomas.	the steel industry and general combustion products. - Urban runoff - Sewer system - Lake Ontario (perhaps)	
(v)	Bird or animal deformities or reproductive problems	To date, control sites have not been selected for bird or animal populations, and selection of sentinel wildlife species has not been made. There are no active bald eagle nests in the area although eagles have recently been sighted (1991). Reproduction rates for colonial bird populations are considered normal. Bird populations are being monitored. Higher levels of PCBs, organochlorines, and reproductive anomalies have been observed in snapping turtles in Cookes Paradise relative to a control site in Algonquin Park. The significance of this information is under study.	- Organochlorines, metals - DDT and its metabolites	- Historical deposits of contaminants in sediment - Contaminants in Lake Ontario	High concentrations of contaminants in turtles are poorly understood; other animals not yet studied. Acceptable control populations need to be better established.

	USE IMPAIRMENT	SIGNIFICANCE TO THE HAMILTON HARBOUR RAP	CAUSES OF IMPAIRMENT	SOURCE OF PROBLEM	INFORMATION DEFICIENCIES
(vi)	Degradation of benthos	The composition of the benthic community is characteristic of a highly eutrophic and urban/industrial contaminated environment. Both contaminants in sediment and low oxygen conditions (0.5-1.0 mg/1) in the hypolimnion in summer contribute to the problem.	- High nutrient levels - Decomposition of organic material in sediments releasing ammonia and hydrogen sulphide - Low dissolved oxygen - Trace contaminants in sediments	- STPs - Historical deposits of organic material in the bottom sediments.	Storm loadings of sediment. Time for end of sediment phosphorus reflux. Natural burial time for effective capping of contaminated sediments. Redistribution of sediment by ship traffic. Bioassays need to be standardized to define the end point.
(vii)	Restrictions on dredging activities	Hamilton Harbour sediments exceed acceptable limits for open water disposal of dredgeate under Provincial Guidelines. One cannot employ open water disposal for sediment dredged in the Harbour. Present CDF capacity is only adequate to the year 2010.	- PCBs in sediment - Metals, PAHs exceed guidelines in sediment	- STPs - Industry - Urban and rural runoff - Steel Industry - Combined Sewer Overflows (CSOs)	Quality of current deposits. Source control limits need to be set related to desired sediment quality.
(viii)	Eutrophication or undesirable algae	Ammonia and phosphorus concentrations exceed the requirements for the growth of algae at reasonable levels in the Harbour. The algae present an aesthetic problem as they reduce water clarity and foul beaches and rocks.	- High Phosphorous - High ammonia	- CSOs - STPs - Steel Industry - Runoff	Non Point Source contribution not known accurately enough. Update estimates of impact from phosphorous and ammonia loadings.

	USE IMPAIRMENT	SIGNIFICANCE TO THE HAMILTON HARBOUR RAP	CAUSES OF IMPAIRMENT	SOURCE OF PROBLEM	INFORMATION DEFICIENCIES
		The ammonia and decomposing algae create an oxygen demand that lowers summer hypolimnetic dissolved oxygen to levels averaging 0.5-1.0 mg/1. This, in turn, reduces fish habit, interferes with the normal food chain operation and increases the release of some contaminants from the bottom sediments. Major improvements in water clarity, and in total phosphorus and chlorophyll concentrations have been observed in the past three years, apparently as the result of new phosphorus control measures. But little change in dissolved oxygen conditions has been recorded in this period.			
(ix)	Restrictions on drinking water consumption or taste and odour problems	The drinking water supply for the residents of the Hamilton area and Burlington is Lake Ontario, not the Harbour. No drinking water supply is taken from the Harbour. However, existing water quality conditions in the main body of the Harbour now meet all objectives for a potable water supply. The Harbour water discharges to Lake Ontario through the Burlington Ship Canal which is 4 to 5 km from both the Burlington and	Not used for drinking water.	Not used for drinking water.	

	USE IMPAIRMENT	SIGNIFICANCE TO THE HAMILTON HARBOUR RAP	CAUSES OF IMPAIRMENT	SOURCE OF PROBLEM	INFORMATION DEFICIENCIES
		Hamilton water supply intakes to the northeast and southeast of the Canal, respectively. Intake water quality data to date indicate no problems related to the Harbour discharge.			
(x)	Beach closings	In the 1940's, on the advice of the Medical Officer of Health, the Hamilton Harbour Commissioners enacted a by-law prohibiting swimming in the whole Harbour. The basis of the ban was unacceptably high levels of faecal bacteria. There may also be some risk to recreational boaters where capsizing of small sailing craft often occurs. Results of sampling carried out in 1988, 1990 and 1991 indicate that remedial programs might be effective in bringing some specific areas of the Harbour within bacterial standards. Further investigation is required if swimming is to be considered for the Harbour, in terms of bacterial contamination, water clarity, beach sediment contamination and water quality conditions.	- High faecal bacteria levels during and after storms	- Raw sewage overflows (CSOs, STPs) - Streams and related urban and rural runoff.	Detailed bacterial data. Other sediment and water quality standards for swimming requested of the health authorities if they deem this necessary.

	USE IMPAIRMENT	SIGNIFICANCE TO THE HAMILTON HARBOUR RAP	CAUSES OF IMPAIRMENT	SOURCE OF PROBLEM	INFORMATION DEFICIENCIES
(xi)	Degradation of aesthetics	Oil sheens are observed occasionally and, there are periodic occurrences of objectionable turbidity, floating scum, debris, and putrid material. Reduced water clarity persists in shallow areas particularly. This is due primarily to discharge of suspended solids from tributaries, resuspension of bottom sediments by waves and by carp, and to some extent, by algal production.	- Occasional oil sheens - algal blooms - suspended solids - debris and putrid matter.	- Spills - industrial, highway, shipping - Runoff - Resuspension of sediment - Inadequately treated sewage (STPs, CSOs)	
(xii)	Added cost to agriculture or industry	(a) <u>Agriculture</u>: Hamilton Harbour water is not used for agricultural purposes. Lawn watering using Harbour water probably benefits from the nutrient content. (b) <u>Industry</u>: Treatment of the Harbour water for industrial use is routine, and includes the addition of chlorine to rid pipes of algal build-up, travelling screens to remove debris and fish, water strainers to remove suspended material for some uses, and bacterial control for special uses. Industry considers this source of water to be	- Algae - Debris - Fish - Suspended material - Bacteria	- CSOs - STPs - Storm runoff	

	USE IMPAIRMENT	SIGNIFICANCE TO THE HAMILTON HARBOUR RAP	CAUSES OF IMPAIRMENT	SOURCE OF PROBLEM	INFORMATION DEFICIENCIES
		adequate or good compared with other areas in the Great Lakes.			
(xiii)	Degradation of phytoplankton and zooplankton	With the exception of one species (Moina brachiata), zooplankton populations are similar in composition to populations in the Bay of Quinte. Abundance is high, reflecting eutrophication and increased productivity. Moina brachiata populations are high in Cootes Paradise and lower in the Harbour. This species is absent from Lake Ontario and from the Bay of Quinte. Zooplankton sizes are small, indicating heavy predation by zooplankton and feeding fish such as alewife. A new investigation of the zooplankton and phytoplankton assemblage is planned. Earlier studies of the toxicity of Harbour water to phytoplankton and zooplankton indicated no unusual toxicity. This situation is under review through application of new bioassays.	- High organic carbon - Nutrients - Light limitation - Low dissolved oxygen in bottom layers - Contaminated sediment - Predation by alewife	- Self-shading - Municipal and Industrial sources, generally - STPs, CSOs - No submerged plants for habitat	Assess toxicity of Harbour water to phytoplankton and zooplankton. Target numbers and test protocols have to be established.

	USE IMPAIRMENT	SIGNIFICANCE TO THE HAMILTON HARBOUR RAP	CAUSES OF IMPAIRMENT	SOURCE OF PROBLEM	INFORMATION DEFICIENCIES
(xiv)	Loss of fish and wildlife habitat	Fish and wildlife management goals are being developed which will define the amount and quality of physical, chemical, and biological habitat. There are very obvious water-quality-related habitat problems for fish that must be addressed. These include the general loss of submerged vegetation due to the water clarity problems as detailed in (xi), and the low oxygen conditions observed in the summer hypolimnion. Other habitat problems relate to loss of marsh areas due to high water levels, poor water quality, the uprooting activities of carp and siltation in Cootes Paradise and in shallow stream estuaries in the Harbour. Infilling of key habitat through past industrial, transportation and urban development activities has destroyed major portions of the habitat (i.e. 26% of the surface area of the Harbour and 80% of the Harbour shoreline have been altered since the early 1800's). Wildlife marsh habitat has been both destroyed (marsh and creeks on south shore for animals and waterbirds) and created (CDFs serving as nesting habitat for colonial waterbirds).	- Low dissolved oxygen (DO) - Loss of submerged and marsh vegetation - Shoreline development and redevelopment - Turbidity in the water	- High lake levels - Filling from urban development - Heavy algal blooms caused by nutrients STPs and CSOs - Resuspension of bottom sediments from high energy shores or from carp activity.	The impact of shoreline development and redevelopment needs to be assessed and controlled.

III GOALS AND OBJECTIVES

III.1 Background

The International Joint Commission (IJC), and its Water Quality Board have expressed a strong commitment to involving the public, and affected groups and organizations (Stakeholders), in the development of water quality enhancement strategies. In the preparation of Remedial Action Plans, the IJC has requested public involvement throughout the process, with a view to developing plans which are accepted by the community. Community commitment is essential, as responsibility for remedial actions lies primarily with local agencies and industries, as well as with the provincial and federal governments.

The Hamilton Harbour watershed supports a population in excess of 500,000. The Harbour has played a vital role in the area's development and, because of this, watershed residents and businesses are very aware of and interested in the Harbour's future. For decades, local governments and industries have been committed to restoration of the Harbour for beneficial uses.

In developing remedial actions for the Harbour, it was important to collect the views and opinions of Stakeholders and the general public to determine the community's desired use goals for the Harbour. During the research and data collection phases in the RAP's development (1985-1987), Environment Canada and the Ontario Ministry of the Environment launched a broad based public involvement program to help the RAP Technical Writing Team plan remedial measures and future controls needed to restore acceptable water quality in Hamilton Harbour. Once these goals were identified, the 49 member Stakeholders Group reviewed the Technical Writing Team's approach to remedial actions, costs and implementation framework.

The following approach to water quality enhancement is reported in "The Stakeholders's Interim Report (September 8, 1986). Rationales used for the setting of goals are explained fully in that report.

III.2 General Principles and Approaches

The Stakeholders' Interim Report presented a general approach to the development of the Remedial Action Plan. The goals and assumptions included in that report were previously reviewed with the public at a meeting held in July 1986. Further insight was gained through the public meeting held in March 1987.

In December 1986, Stakeholders were requested to provide their constituent group responses to the September Interim Report. As well, information supplied by the Technical Writing Team on the costs and timing necessary to achieve the Stakeholders' September goals was provided. When reviewed in the context of individual Stakeholders goals, the views of their constituents and in light of information presented by the Technical Writing Team on the feasibility of certain goals and principles, the Stakeholders Group adopted sets of overriding primary and secondary principles. These principles form the backdrop to the Remedial Action Plan.

III.3 Primary Principles
III.3.1 The Ecosystem Approach

In 1986, the Stakeholders identified the principle:

> "THAT effective water quality management is best achieved through application of an ecosystem approach".

The Great Lakes Water Quality Agreement as amended in 1987 calls for embodiment of "...a systematic and comprehensive ecosystem approach to restoring and protecting beneficial uses in Areas of Concern...".

The ecosystem approach may be applied at several levels. In the case of the Hamilton Harbour RAP it is applied in the scientific work at the level of the aquatic ecosystem in our attempts to integrate the biology, chemistry and physics of the Harbour. It is reflected, as well, in the consideration of multi-media, multi-substance consequences of the remedial options as more intense treatment of water pollution sources may have landfill or atmospheric consequences, or (in many cases) consequences for Lake Ontario as a whole.

The ecosystem approach is also intended to integrate social, economic, and environmental matters. Human health aspects of any changes made were especially identified by the Stakeholders.

"An ecosystem approach calls for a functional rearrangement of the organizations and interests as equal members of a team" (Hartig and Vallentyne, 1989). The Hamilton Harbour RAP Stakeholders Group consists of representatives of citizen groups, public interest groups, regional and area municipalities, and the provincial and federal government agencies. Across this breadth of community interests the RAP can therefore come to grips with such things as:

- fisheries and wildlife management
- land use planning
- atmospheric emissions
- groundwater
- municipal wastewater treatment
- stormwater management
- industrial wastewater treatment
- hazardous waste management
- water management
- recreation
- harbour operations and maintenance

The idea of a community 'round-table' is central to the development of the Stakeholders Group assembled to consider the Remedial Action Plan and reflects the process suggested in the ecosystem approach.

The Stakeholders also recognized that there were potential water use conflicts (e.g. waste discharge and swimming) but nevertheless wished to push forward in order to realize as much of the totality of their vision as could be achieved.

"Here, (an) ecosystem approach means a set of behavioural practices that, in so far as is humanly possible, takes account of the consequences of human actions and inactions at all levels of integration from personal to planetary" (Vallentyne, 1982).

Three propositions underpin the ecosystem approach:

1. **knowledge** that our species and its associated technology originated in the Biosphere and hence is part of Nature,

2. **ecological behaviour** that takes account of feedback at diverse levels, from personal to planetary, and

3. **ethical behaviour** based on an ethic of respect for other systems of Nature, comparable to an ethic of respect for other persons. (Vallentyne, op cit).

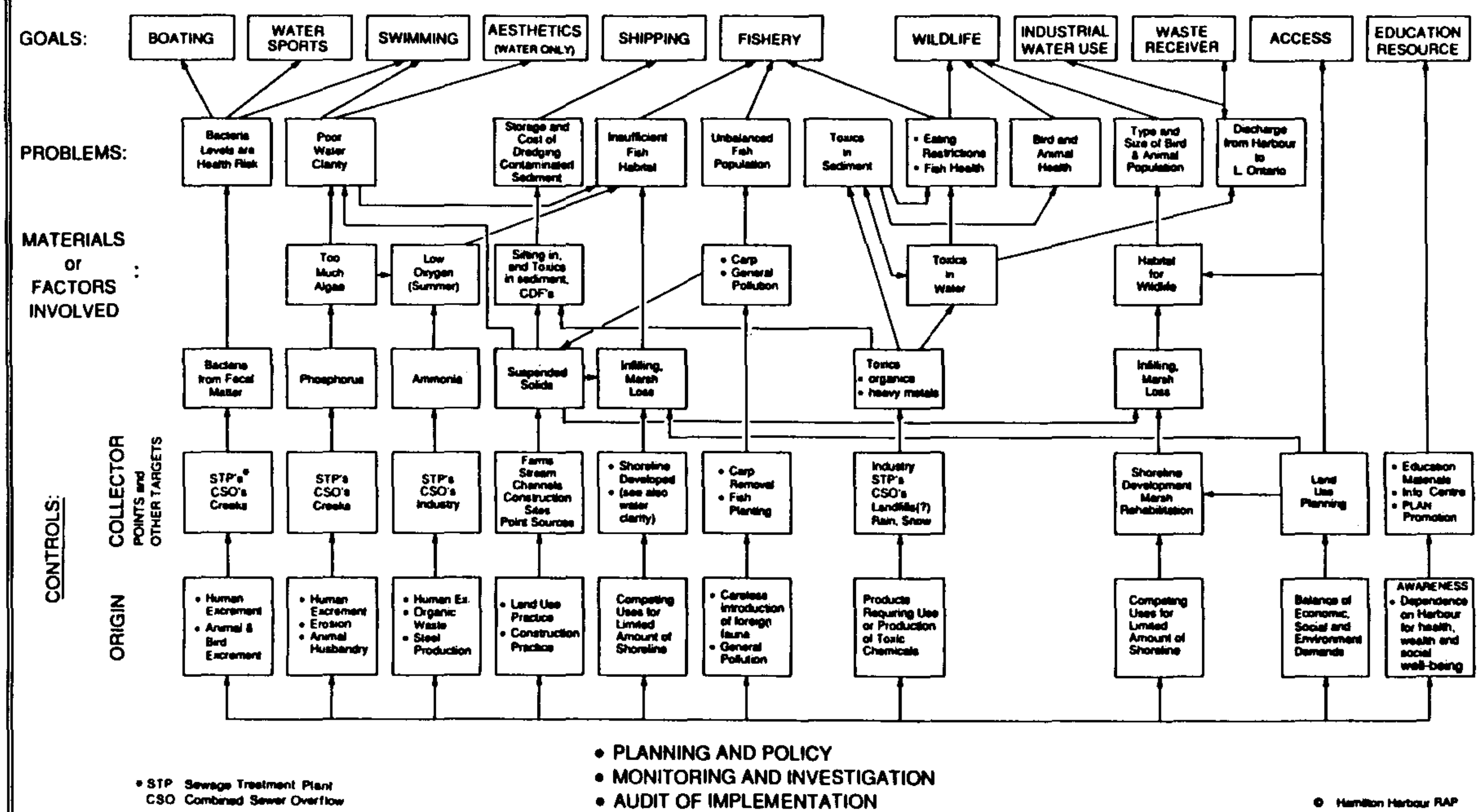
The nature of the decisions to be made can be ranked with respect to whether they tackle a problem in a sustainable or systemic way. The following Table 3 has been found helpful in making distinctions amongst types of solutions to problems. One could use this to rate the degree to which each of the options put forward reflects an ecosystemic approach.

As an aid to illustrating the Hamilton Harbour situation, its problems and their origins in an ecosystemic way, a chart has been developed linking goals, and the problems with their origin (Figure 3). Generally speaking, remedial measures that tackle the problem close to its source are more ecosystemic in nature than those that are applied further down the waste stream (Tables 3 and 4).

The Interim Report of the Stakeholders (September 1986) discusses the ecosystem approach. When viewed in the context of their constituents' responses, and in light of the unanimity of the group on this issue, Stakeholders elaborated on the principle as follows:

> "The eight use goals, which collectively are necessary for the rehabilitation of Hamilton Harbour, be developed within the context of an ecosystem approach that encompasses social, economic, and environmental issues...".
>
> And,
>
> "Economic, social, and environmental goals must be viewed in an integrated manner, so that not one of the three can or should take precedence over another" (Hamilton Harbour RAP Stakeholders, Interim Report, 1986).

Figure 3: Clean Habitable, Useful Harbour



Source: Drawing provided by G.K. Rodgers, NWRI

Table 3: Comparison of Approaches to Resolving Man-made Ecosystem Problems

APPROACH				
Problem	Egosystemic	Piecemeal	Environmental	Ecosystemic
Infectious disease	Patent medicines, quarantine	Conduits, pills	Public health programs	Prevention
Organic waste	Hold your nose	Discharge downstream	Reduce BOD	Energy recycling
Eutrophication	Stay away	Discharge downstream	Phosphorus removal	Nutrient recycling
Acid rain	deny it	Discharge permits	Use clean fuel on bad days	Alternative energy sources
Energy shortages	Hunt a scapegoat	Increase supply	Expand grid, conservation	Renewable energy
Toxic	Hide, disperse	Treat one-by-one pollution havens	Recover, re-use	Nontoxic alternatives
Greenhouse effect	Ignore problem	Invest in air conditioners	Breed new crops	Carbon recycling, hydrogen fuel
Pests	Broad spectrum of insecticides	Selective pesticides application	Integrated pest management	Ecological control
Traffic congestion	More roads through cities	More super highways	Staggered hours	Public transport, decentralize
Demotechnic growth	Shift disbenefits	Technofix	Zoned development	Conserver society
Attitude to nature	Dominate, exploit	Cost/benefit	Environmental management	Ecosystem ethic
View of the future	Egocentric	Linear, predictable	Wary of surprises	Emergent, adaptive evolving

Source: Modified from Vallentyne and Hamilton (1987).

Table 4: Policy Framework

NEEDED SHIFT IN POLICY FRAMEWORK FROM > > > TO	
Point individual analysis	Analysis of cumulative effects
Short time-frame	Long time-frame
Competitive	Cooperative
Negotiated	Consensual
Consultative	Partnerships
Direct involvement of few	Direct involvement of many
Distrust	Based on trust

Source: Sonntag et al., (1991).

In this report, the ecosystem approach is reflected in the rating of technical measures by the Stakeholders Ecosystem Committee, in the specification of loading limits (or the capacity of the Harbour), and in discussion of land use planning for the watershed. In this context it is worth noting that both Hamilton-Wentworth Region and the City of Burlington are exploring the issues of environmentally sustainable development in of the current review of their official Plans. The official Plan review for Halton Region also makes many references to the types of changes that will be necessary to work towards a more sustainable community.

III.3.2 Zero Discharge

As a subset to the ecosystem approach, the issue of zero discharge was discussed at length. The Stakeholders agreed that while any statement on zero discharge should be consistent with the Ontario Municipal and Industrial Strategy for Abatement (MISA) definitions, zero discharge is a philosophy and not a standard. Therefore, the Stakeholders resolved that:

> "The philosophy be adopted whereas control of inputs of persistent toxic substances shall be zero discharge, and therefore, the discharge of any or all persistent toxic substances be virtually eliminated".

III.4 Secondary Principles
III.4.1 Human Health

Contaminated areas of water are associated with potential human health risks. In Hamilton, the outflow of contaminated Harbour plumes into Lake Ontario may impact on the drinking water supply in Hamilton and Burlington. The Stakeholders therefore recommended:

> "THAT the water quality in Hamilton Harbour's drainage basin be improved to ensure continued human health and well-being.
>
> And,
>
> "THAT through an ecosystem approach, the water quality be improved to support a multiplicity of uses, both in the short and long term".

III.4.2 Public Acceptance and Support

In order to achieve public acceptance and support for remedial actions in Hamilton Harbour, which may be extremely costly from a purely economic standpoint, the Stakeholders held the view that the principles of public access and aesthetic improvements are essential to the successful implementation of the RAP. The Stakeholders recommended that the final RAP should include:

> "A shoreline management strategy, which would integrate, in a comprehensive fashion, the following four concerns:
>
> 1) Visual access
> 2) Major and minor nodes and areas of physical access
> 3) Fish and wildlife habitat
> 4) Existing industrial, residential, and recreational land uses".
>
> "Underscoring this strategy is the assumption that:
>
> > Public access is an important factor in achieving public awareness and support for Hamilton Harbour remedial actions;
> >
> > That public support for these actions will result in water quality improvements, leading to community benefits; and,
> >
> > That increased access is a key to achieving remedial actions and should become part of the overall solution whilst recognizing that access is a local authority concern".

III.4.3 Aesthetics

The Stakeholders recognize the importance of ensuring broadened opportunities for the general public to enjoy the benefits of an improved Harbour resource on a continuing basis.

III.4.3.1 Access (Physical and Visual)

It is the position of the Stakeholders Group that significant improvement is required in terms both of quantity and quality, to the opportunities and locations for physical and visual access to Hamilton Harbour.

III.4.3.2 Land Use

That the issue of the character and appropriateness of the land uses situated adjacent and in close proximity to the Harbour is of major consequence and must be addressed if a successful and comprehensive plan for the remediation of Hamilton Harbour is to be achieved.

III.4.3.3 Aesthetics

Shoreline and water aesthetics improvements are important in the public's perception of the Harbour.

The Stakeholders agreed that aesthetic improvements on a Harbour-wide basis provide the public with a genuine belief that water quality can be improved.

III.5 Water Quality Enhancement

A number of issues technically outside of the RAP's terms of reference were considered since they are important when implementing the ecosystem approach.

III.5.1 Impacts on Lake Ontario

Since drinking water intake pipes for Burlington and Hamilton are located in Lake Ontario, water quality in the Harbour does not need to support drinking water as a use.

However, as it is a possibility that Harbour water quality may detrimentally affect Lake Ontario, the issue was considered to be serious enough to be seen as an overriding, general goal, which all Harbour-wide uses and remedial actions should address.

STAKEHOLDERS'
GOAL: "To remove the potential negative impact of Hamilton Harbour's water quality on Lake Ontario Hamilton Harbour's water quality; with particular attention to areas of nearshore public uses and drinking water intake pipes for the Cities of Hamilton and Burlington".

III.5.2 Windermere Basin

In 1986, a preferred option was selected for the cleanup of Windermere Basin. There exists a strong commitment from the various levels of government to proceed to implementation. In light of the progress of the RAP, the Stakeholders recommend:

> "THAT the Windermere Basin study (1986) and recommended remedial actions be considered separately from and proceed in advance of the overall Harbour RAP, providing that the Ontario and Federal Environment Ministers ensure full public consultation and hearing on the alternatives".

III.6 Restricted Use

In order to achieve the overall objectives for Hamilton Harbour's water quality in such a way as to provide an enhanced ecosystem, certain water uses and actions need to be restricted, in that their continuation, in general terms, would negatively affect remedial actions designed to improve water quality.

III.6.1 Shoreline Filling

Shoreline filling could detrimentally affect water quality but could also benefit the social, economic, and environmental quality of the Harbour. The Stakeholders suggested for future consideration;

> THAT any filling for environmental or access enhancement purposes should:
>
> - meet the objectives established in the RAP;
> - contain fill of an acceptable quality to meet provincial guidelines;
> - be subject to environmental assessment.

It is noted that fill, for purposes other than environmental and access enhancement, will require separate consideration.

III.6.2 Wastewater Receiving Body

In order to achieve desired uses, its current use as a wastewater receiving body in the total Harbour should be restricted to certain areas or zones of the Harbour. For example, sewage treatment plant outfalls would not be acceptable in a proposed swimming area; where habitat may be damaged; or where body contact sports are proposed.

III.7 Water Use Goals
III.7.1 Introduction

Within the overall context of the ecosystem approach, and the general water quality goals established earlier, and taking into account restricted uses and peripheral issues, 11 current and desired uses in the Harbour were identified. A number of these uses are, to some degree, currently in place.

III.7.2 Enhancement of Existing Uses
III.7.2.1 Recreational Boating

Recreational boating is one of the preferred uses for the Harbour. Since increased boating may affect water quality, the Stakeholders considered that tighter control of motor boats and enforcement of regulations be a prerequisite.

STAKEHOLDERS'
GOAL — "Immediate action should be taken to improve water quality for recreational boating, on a continuing basis, for the total Harbour".

III.7.2.2 Water Sports

Activities in this category include: windsurfing, kayaking, ice-boating, or any other activities which involve the human body being in direct contact with the Harbour water.

STAKEHOLDERS'
GOAL — "THAT, on an area specific basis, water quality should be improved to permit increased use of the Harbour for water sports on a continuing basis".

III.7.2.3 Shipping and Navigation

Shipping and navigation uses are seen as an essential ongoing use of the Harbour's surface water. Activities integral to the continuation of this use include occasional dredging to maintain navigational channels.

STAKEHOLDERS'
GOAL — "THAT shipping, navigation and related uses should continue and be operated in a manner consistent with sound environmental principles and practices."

III.7.2.4 Industrial Uses

Water quality for industrial uses was reviewed from two perspectives - the first relating to a quality sufficient to supply industry with its water requirements; the second relating to the quality of the water re-entering the Harbour, subsequent to its use.

STAKEHOLDERS'
GOAL #1: "Improve water quality to levels appropriate to supporting industrial operations that draw water from the Harbour."

STAKEHOLDERS'
GOAL #2: "THAT industrial water uses should continue in certain areas of the Harbour, and that effluent discharges should meet Ministry of the Environment guidelines (MISA).

III.7.2.5 Wastewater Receiving Body

The Stakeholders recognized that wastewater inputs will continue to enter the Harbour.

STAKEHOLDERS'
GOAL #1: "THAT the Harbour's current status as a wastewater receiving body be changed, so that it becomes a recipient of acceptable effluent, in specific areas; and

STAKEHOLDERS'
GOAL #2: "THAT a loadings target approach be established for point and non-point pollutant sources, and linked to all other uses to ensure effluent quality does not impede other uses".

III.7.3 Enhancement of Future Uses
III.7.3.1 Fisheries

Historically, the Harbour has supported a generous and diverse fishery. Industrialization, other developments and miscellaneous other uses have despoiled or destroyed habitats and spawning areas. However, a limited warmwater fishery has survived and is expanding with improvements in water quality. While provincial consumption guidelines are not exceeded, tumour growths on certain species are widespread in the Harbour (and in other Great Lakes areas). This situation has led to general public antipathy regarding sport fish consumption. Public perception of high water and sediment contaminant levels has recently been confused and intensified by the death and disappearance of a number of Peking ducks which were placed, for a test, in Windermere Basin.

Fish and wildlife coexist in the same warm water and littoral marsh habitats. Sufficient marsh habitat restoration to ensure an improved reproducing, self-sustaining warmwater fishery would also encourage increases in wildlife habitats. Improved wildlife habitats further lead to improved aesthetics and wildlife appreciation.

STAKEHOLDERS'
GOAL: "THAT water quality and fish habitat should be improved to permit an edible, naturally reproducing fishery for warmwater species. Water and habitat conditions in Hamilton Harbour should not limit natural reproduction and the edibility of coldwater species.

III.7.3.2 Wildlife Appreciation and Habitat Protection

Habitat and natural protection areas, in the short term, would contribute to a greater appreciation of wildlife and the Harbour itself. This is another example where enhancement would build public acceptance of improved water quality, leading to public support for financing of remedial measures.

STAKEHOLDERS' GOAL: "THAT healthy self-sustaining resident and non-resident wildlife populations should be enhanced on a Harbour-wide basis through water quality improvements and habitat rehabilitation and protection".

III.7.3.3 Swimming

The Stakeholders agreed that swimming is a desirable goal for specific, restricted areas of the Harbour (e.g. west end and north shore).

STAKEHOLDERS' GOAL #1: Providing that water quality meets appropriate health standards in the west end to support swimming as a use, water quality be enhanced to permit swimming, in the short term; and

STAKEHOLDERS' GOAL #2: In the event that faecal coliform counts exceed water quality objectives for human contact, consideration should be given to using disinfectants and suitable membrane barriers to permit swimming, in the short term; and

STAKEHOLDERS' GOAL #3: Hamilton Harbour water quality should be improved so that it (a) provides for swimming in certain areas of the Harbour over the long term; and (b) has no impact on water quality for swimming in nearshore Lake Ontario.

III.7.3.4 Educational Resources

Hamilton Harbour, its watershed, ecosystem, and multiple uses is seen as an educational resource for students of all ages and community populations. The Stakeholders recommended:

1) "That educators be represented as a Stakeholders Group; and

2) That OMOE and DOE should work separately with formal and informal education groups to promote the Harbour as an educational resource; and

3) Educational programs be developed to change public perception of the current condition of the Harbour in support of efforts made by Stakeholders, towards remedial actions".

III.8 Plan Development and Implementation

The Stakeholders agreed and recommended:

1) That the Stakeholders Group continue to meet until the plan is completed; and

2) That the Group will review its role at the time of plan completion; and

3) That it requests funding from the Ministry of the Environment and the Federal Department of the Environment to continue its deliberations until the plan has been submitted to the IJC.

When reviewing its future role, during its agreed tenure, the Stakeholders Group decided that the following activities could be considered appropriate:

1) address implications for official plans;

2) review of water quality enhancement plans in progress, spearheaded by individual Stakeholders groups to identify the implications of RAP goals on these plans;

3) identify long-term RAP goals, and steps needed to achieve these goals;

4) identify the appropriate technical, political, economic sequence for achieving RAP goals;

5) identify available funds and promote agency commitment for remedial actions;

6) involve and hear from the general public relating to:

   - Stakeholders goals and actions;
   - RAP goals and actions.

In addition to an expressed desire to continue as a Group (Recommendation #44) there is deep concern about how we shall collectively be able to manage the total Harbour, as regards accommodating uses which may be in conflict in certain areas,
It was resolved by a majority:

> "THAT the Stakeholders advise the several levels of government with jurisdiction or interest in the Harbour, that there is a need to more adequately reflect the needs of Harbour users", and
>
> "THAT a new institution be formed to more adequately reflect these needs".

III.9 Linkages

III.9.1 Relation Among Control Strategies, Water Uses, Beneficial Uses (GLWQA) and Other Goals

The Stakeholders detailed water uses to be maintained or enhanced (Table 5). The 1987 revisions to the GLWQA list 14 beneficial uses to be reinstated as a condition of delisting an Area of Concern such as Hamilton Harbour (Table 6). In Table 7, these are linked among themselves and then with the categories of strategies recommended in this report (metals and organics, eutrophication, biota, and habitat). Many linkages are evident, hence the need for a comprehensive program which will ensure that the more sensitive uses are addressed.

The emphasis in the GLWQA beneficial uses has been placed on the proper functioning of populations of fish, aquatic birds, and wildlife dependent on the aquatic habitat. The proper functioning of the aquatic system to allow natural reproduction of a healthy, well-balanced biota which does not accumulate metals and organics is the key measure of the achievement of a clean body of water. Hence, it is the most sensitive use.

III.10 A Future for Hamilton Harbour

With hope based on the success of clean-up measures taken to date, and on the prospect of an achievable improved level of water quality and of an improved fish, bird, and wildlife community, the Stakeholders have held out a vision of the Harbour that is both a centrepiece for the surrounding communities and the face of a self-sustaining, healthy aquatic ecosystem.

The Harbour is seen as more of a people place. There is to be a high degree of integration amongst all activities on the Harbour, from the major shipping facilities and steel-making to enhanced wildlife and recreational opportunities. There were corridors for integrating the Harbour with the hinterland through green valley spaces along major tributaries - corridors for both people and wildlife. People corridors are required to break down the present barriers to easy and pleasant contact with the Harbour waters. So too, a people link was envisaged between the Hamilton City Centre and the Harbour with a grand promenade.

The Port of Hamilton and steel production will continue to be a major part of life in the Harbour but in a more environmentally friendly way.

Adjectives that Stakeholders have used to describe this vision include diverse, accessible, quiet, clean, friendly, balanced, connected, green, enhanced, and integrated. There was a greater focus on culture and recreation. They want to achieve greater public access through non-automobile options such as bicycles, walkways, and people movers, leading to greater enjoyment of the water. Buildings surrounding the Harbour were set back and terraced back towards the escarpment.

The beach strip became a part of the total Harbour. Some Stakeholders saw a Harbour 'centrepiece' made of anchored 'lakers' or some other form of floating island. All were to be linked with a water taxi or tour boat system.

Table 5: Principles, Water Use Goals, and Recommendations Specified by the Stakeholders Group for Hamilton Harbour.

Primary Principles:

1. Ecosystem approach
2. Zero discharge

Secondary Principles:

1. Human health protection with multiple use.
2. Public support requires access - land use planning.
3. Aesthetics improvement essential.

Special Issues:

1. Removal of potential negative impact of Harbour discharge on water intakes and beaches in Lake Ontario.
2. Windermere Basin clean-up requiring full public consultation.
3. Infilling must meet RAP objectives, meet guidelines, and be subject to environmental assessment.
4. Restricted use of the Harbour for waste discharges to avoid use conflicts.
5. Land use adjacent or close to the Harbour must be addressed.

Water Uses to be Enhanced:

1. **Recreational Boating:** for the whole Harbour.
2. **Water Sports:** for specific areas.
3. **Shipping and Navigation:** to continue in certain areas of the Harbour.
4. **Industrial Use:** to continue in certain areas, and be subject to OMOE regulations.
5. **Waste-water Receiving Body:** subject to acceptable standards, assigned to certain areas and subject (where appropriate) to loading targets so as not to impede other uses.
6. **Fisheries:** permit edible, naturally reproducing warmwater fishery, with no impact on coldwater species reproduction or edibility.
7. **Wildlife:** healthy, self-sustaining resident and non-resident wildlife populations to be enhanced.
8. **Swimming:** water quality to permit swimming in west end (near term) and certain other areas of the Harbour (long term); all with no impact on swimming in nearshore Lake Ontario.
9. **Educational Resources:** for all ages to be informed of the current (improved) conditions in the Harbour, enhancing awareness of the program.
10. **Access:** improve quality and quantity for visual and physical access.
11. **Aesthetics:** improve shoreline and water aesthetics.

Plan Development and Implementation:

1. Continuation of the Stakeholders Group through each stage of the development of the Plan, in order to:

   - consider the relation between official plans and the RAP
   - review current plans of the RAP
   - review goals of the RAP
   - promote remedial actions
   - audit and integrate public comment into the RAP.

Table 6: Remedial Action Plans as Characterized in the Great Lakes Water Quality Agreement of 1978, and Amended by the Protocol of 1987 (Annex 2).

General Principles:

1. Systemic and comprehensive ecosystem approach.
2. "Plan shall provide a continuing historical record of...assessment...remedial action...methods...changes in environmental conditions and milestones."
3. Build on existing strategies.
4. Reduce "point source impact zones to the maximum extent possible...pending the achievement of the virtual elimination of persistent toxic substances."
5. "Ensure that the public is consulted in all actions undertaken."

Plans to Include:

1. "A definition and detailed description of the environmental problem."
2. "A definition of the causes of use impairment."
3. "An evaluation of remedial measures in place."
4. "An evaluation of alternative additional measures."
5. "A selection of additional...measures...and a schedule."
6. "Identification of...(those)...responsible for implementation of remedial measures."
7. "A process for evaluating remedial measure implementation and effectiveness."
8. "A surveillance and monitoring process to track effectiveness of...measures and confirmation...of restoration of uses."

Impairment of a Beneficial Use:

This is intended to mean a change in the chemical, physical, or biological integrity of the Great Lakes System sufficient to cause any of the following:

1. Restrictions on fish and wildlife consumption.
2. Tainting of fish and wildlife flavour.
3. Degradation of fish and wildlife populations.
4. Fish tumours or other deformities.
5. Bird and animal deformities or reproduction problems.
6. Degradation of benthos.
7. Restrictions of dredging activities.
8. Eutrophication or undesirable activities.
9. Restrictions on drinking water consumption, or taste and odour problems.
10. Beach closings.
11. Degradation of aesthetics.
12. Added costs to agriculture or industry.
13. Degradation of phytoplankton and zooplankton populations.
14. Loss of fish and wildlife habitat.

Source: Annex 2, Great Lakes Water Quality Agreement, as amended by the Protocol of 1987.

Table 7: Relation Amongst Stakeholders Water Use Goals, GLWQA Beneficial Uses, and RAP Strategies.

Stakeholders Recommendations			
Water Use/Goal	**Related Uses/Goals**	**GLWQA Beneficial Use**	**Related RAP Strategy**
Recreational Boating	Swimming Access Aesthetics	Degradation of aesthetics	Eutrophication
Water Sports	Swimming Access Aesthetics	Beach closings Degradation of Aesthetics	Eutrophication Bacteria
Shipping and navigation	Potential for Use Conflicts (Area Designations)	Restriction of dredging activities	Metals and Organics Eutrophication
Industrial Use	Potential for Use Conflicts (Area Designations)	Added costs to agriculture or industry	Metals & Organics Eutrophication
Wastewater Receiving Body	Potential for Use Conflicts (Area Designations)	Source controls Zero discharge/virtual elimination	Metals & Organics Eutrophication
Fisheries	Aesthetics	Restrictions on fish consumption Tainting of fish flavour Degradation of fish populations Fish tumours or other deformities Degradation of benthos Eutrophication or undesirable algae Degradation of plankton populations Loss of fish habitat	Metals & Organics Phenols Biota Habitat
Wildlife	Fisheries	Restrictions on wildlife consumption Tainting of wildlife flavour Degradation of wildlife populations Bird or animal deformities or reproduction problems Loss of wildlife habitat	Metals & Organics Phenols Biota Habitat
Swimming	Access	Eutrophication or undesirable algae Beach Closings	Metals & Organics Eutrophication Bacteria
Educational Resource	All	All	All
Access	Use Conflicts		
Aesthetics	General	Degradation of aesthetics	Eutrophication Biota Habitat

Source: G.K. Rodgers, NWRI

Cootes Paradise was seen to be more of a natural area with limited public access so as to preserve wildlife values in the area. Yet this development was matched by addition of several wildlife viewing stations around both Cootes Paradise and the Harbour.

The Lax property and waterfront park as well as the area beside the railway lands became another focal point for recreation. The vision included much 'greening' along the waters edge, integrating the industrial area with the city centre, and along natural stream valleys and street corridors in the built-up areas.

The City of Hamilton would become much more of a cultural centre and focal point as the Harbour became better integrated with the city, and the city became an extension and reflection of the Harbour ecosystem.

Finally, the undeveloped lands about the regions' urban population continued to be reserved for farming and natural uses as the cities of Burlington and Hamilton became sustainable through carefully planned growth and social development that placed paramount value on the integration of social, economic, and environmental goals.

IV ANALYSIS OF OPTIONS

IV.1 Introduction

Since the 1970s, major improvements have occurred in the Harbour's condition.

- colonial waterbird populations have increased in the Harbour;
- provincial water quality objectives for the protection of aquatic life have generally been met throughout most of the Harbour, (except for ammonia, cadmium, iron and zinc in localized areas);
- fish-eating birds are no longer experiencing breeding failures and deformities in their young;
- there are signs that the number and diversity of fish species are increasing;
- improvements have been documented in the number and type of aquatic worms inhabiting the Harbour sediment;
- 42 species of fish are successfully reproducing in the Harbour;
- there are 7 out of 12 fish species in the Harbour which do not now have fish consumption guideline restrictions.

These improvements are the result of the $600 Million (1990 dollars) that has been spent by industries and municipal governments to meet the water quality standards established by the IJC and the Ontario Ministry of the Environment.

While significant improvements have been made to the Harbour's water quality, a number of other problems still must be resolved:

- waterfowl habitat in the Harbour has been lost;
- there have been isolated incidents of lead contamination and botulism among waterfowl;
- colonial waterbird habitat may be lost again due to development;
- ammonia concentrations in the Harbour exceed the Great Lakes Water Quality objectives;
- for two to three months in the summer, fish do not inhabit the deeper waters of the Harbour because oxygen concentrations are too low. These concentrations do not meet the IJC and Provincial Water Quality objectives;
- there are fish consumption guideline restrictions for larger specimens of five species of fish in the Harbour;
- water clarity is restricting the potential of shallow water areas to become fish habitats by hindering aquatic plant growth;
- algae concentrations in the surface waters are deemed to be a nuisance, causing unsightly clumps, turbid water, and odours when it decomposes.
- water turbidity and bacteria levels are occasionally too high to permit swimming.

The Stakeholders identified a series of enhanced and future use goals that have been described in Chapter III. The three key use goals are entitled Fisheries, Wildlife, and

Swimming. Meeting these three goals will meet the requirements for the remaining goals that have water quality, sediment quality, or habitat improvement aspects.

The purpose of this chapter is:

1. to describe past improvements in water quality due to loading reductions;
2. to describe completed or nearly completed loading reductions and anticipated water quality improvements;
3. to describe options to improve water quality in compliance with IJC and Provincial Water Quality Objectives;
4. to describe further measures that can be taken to attain the goals for enhanced and future uses of the Harbour and Cootes Paradise.

IV.2 Water Quality

IV.2.1 Problem Summary

The water quality problems in Hamilton Harbour and Cootes Paradise embraced in this category include:

1. A major factor in the depletion of oxygen is the excessive ammonia loading from sewage treatment plants (primarily) which may account for 35 to 45 percent of the oxygen demand. In addition, this same ammonia loading gives rise to un-ionized ammonia concentrations above the Provincial objective designed to prevent toxic effects on biota (acute toxicity but not persistent or bioaccumulative) in late winter, spring, and early summer.

2. Excessive abundance of algae and a consequent reduction in water clarity is due to phosphorus loading from several sources. Algal decay gives rise to 30 to 35 percent of the demand on oxygen in the bottom waters in summer, so that dissolved oxygen is depleted below the Provincial guideline of 4 ppm.

3. In addition to algae, water clarity is adversely affected by discharge of high levels of suspended solids from streams, industries, sewage treatment plants, and sewer overflows.

The means by which one may seek to reduce loadings of phosphorus, ammonia, and suspended solids can improve other conditions as well. For example, control of combined sewer overflows for phosphorus reduces suspended solids loading, discharge of some toxics, discharge of objectionable debris, oils and scums, and discharge of bacterial contamination. The potential of each remedial action to affect the full range of contaminants is detailed in Section V.1 (following).

IV.3 Overview of Loading Reductions: Hamilton Harbour
IV.3.1 Ammonia Loading
IV.3.1.1 Historical Actions

Major reductions in industrial discharges of ammonia have been achieved. The industrial loadings have been reduced from about 24,000 kg/day of ammonia as nitrogen in 1967 to about 352 kg/day in 1989. However, there has been little change in the loadings of ammonia from the municipal STPs. Regular monitoring for ammonia in the effluents from the STPs was started in 1978.

Figure 4 shows the total loadings of ammonia as nitrogen from both industrial and municipal sources since 1978, including estimates of loadings in Hamilton's combined sewer overflows (CSOs), and the concentration of ammonia found in the Harbour. The concentration trend in the Harbour is seasonally cyclical with the highest concentration occurring in the early spring and the lowest in the summer. The cyclical pattern is caused by the inhibition of nitrifying bacteria, which oxidize ammonia, by cold temperatures. As a result, the concentrations build up in the Harbour during the winter. In 1989, the winter concentration peaked at 1.5 mg/L. When the water temperature warms above 6°C in spring, the nitrifying bacteria become active again and very rapidly oxidize the accumulated ammonia. In so doing, the oxygen level in the Harbour water is reduced. The oxidation of each mg of ammonia, as nitrogen, requires about 4.6 mg of oxygen.

Not all of the ammonia discharged to the Harbour is oxidized. Ammonia is also flushed to Lake Ontario through the canal. As well, some ammonia is used by the aquatic biota as a nutrient. It is initially taken up by aquatic plants, including algae, and by bacteria. A small portion of this nitrogen makes its way through the food chain, ending up as protein in fish and in waterfowl.

A plot of ammonia loadings to the Harbour versus maximum early spring concentrations in the Harbour is shown in Figure 5. Extrapolation of the best fit straight line through the points in the plot to the 0 mg/L ammonia concentration indicates that during the winter about 3,300 kg/day of ammonia is utilized by algae or flushed out into Lake Ontario (assuming a linear response between loading and peak concentration). Therefore, at the present rate of removal (see Figure 6), a further 1,200 kg/day reduction in ammonia loading may prevent the build-up of ammonia in the Harbour during the winter.

Ammonia in the un-ionized form is toxic to some aquatic organisms. The percent of ammonia present in the un-ionized form is dependent on the pH and the temperature of the water.

The Provincial water quality objective for un-ionized ammonia is 0.02 mg/L. The concentration of un-ionized ammonia in the Harbour water from winter, 1984 to fall, 1989 is shown in Figure 7. Concentrations exceeding of the objective occur in late spring and summer when the percent ammonia present in the un-ionized form increases ten-fold as a result of a rise in temperature and pH. The rise in pH from about 8 to 8.4 in the surface

Figure 4: Hamilton Harbour - Ammonia Loading and Concentration

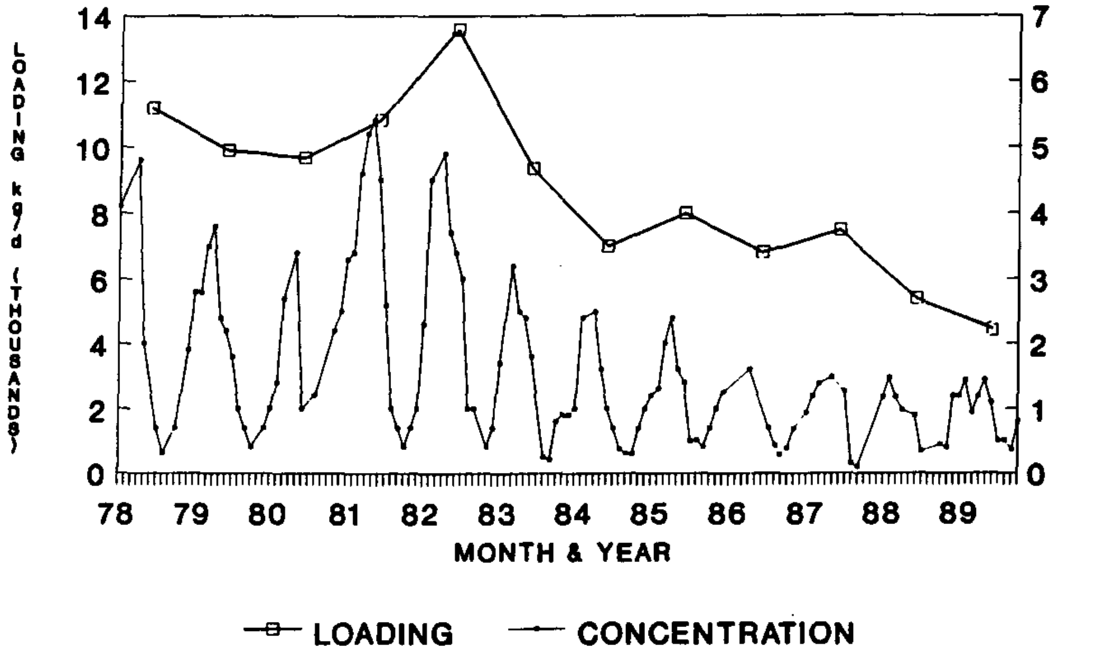
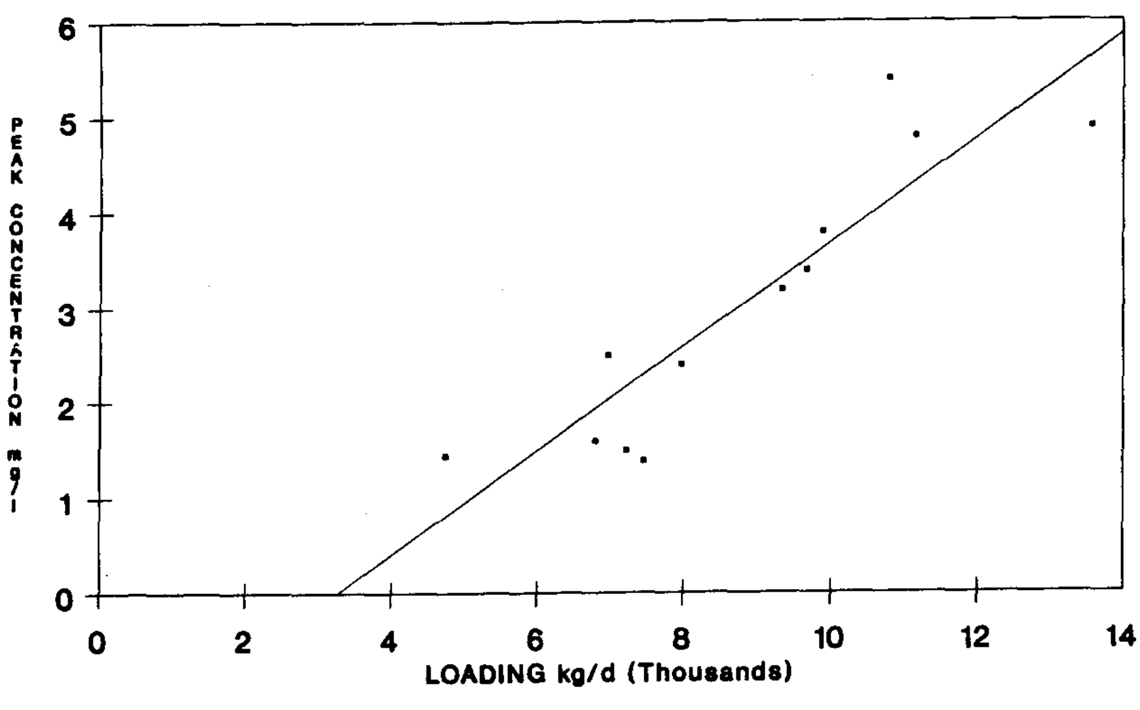


Figure 5: **Hamilton Harbour - Ammonia Peak Concentration vs Loading**



Source: **J. Vogt, MOE/WCR**

Figure 6: Hamilton Harbour - % Ammonia Contribution by Source (1989)

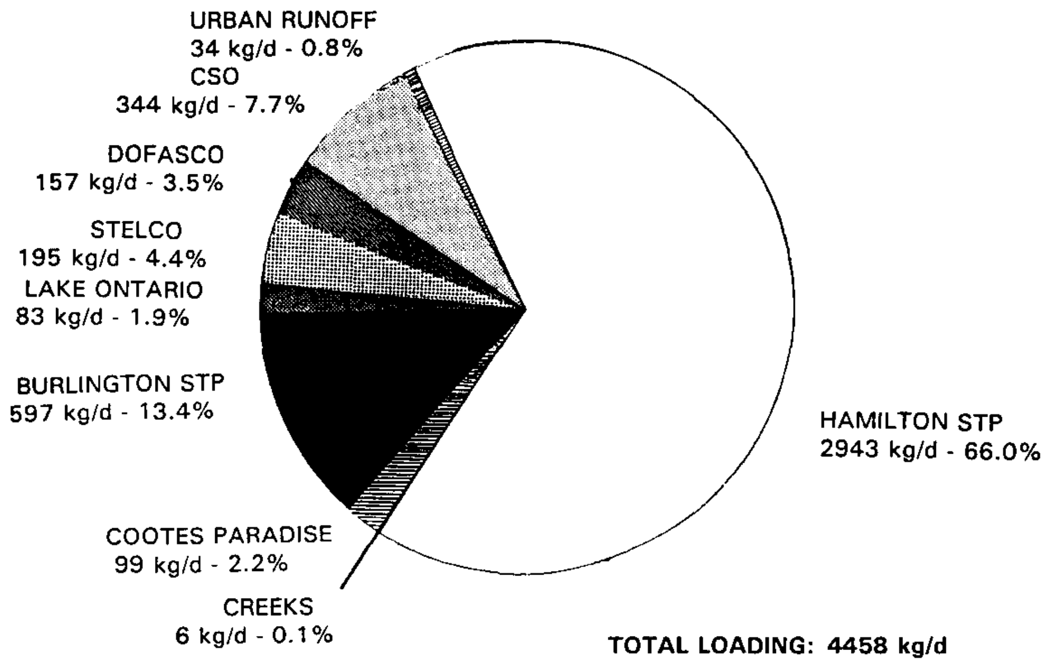
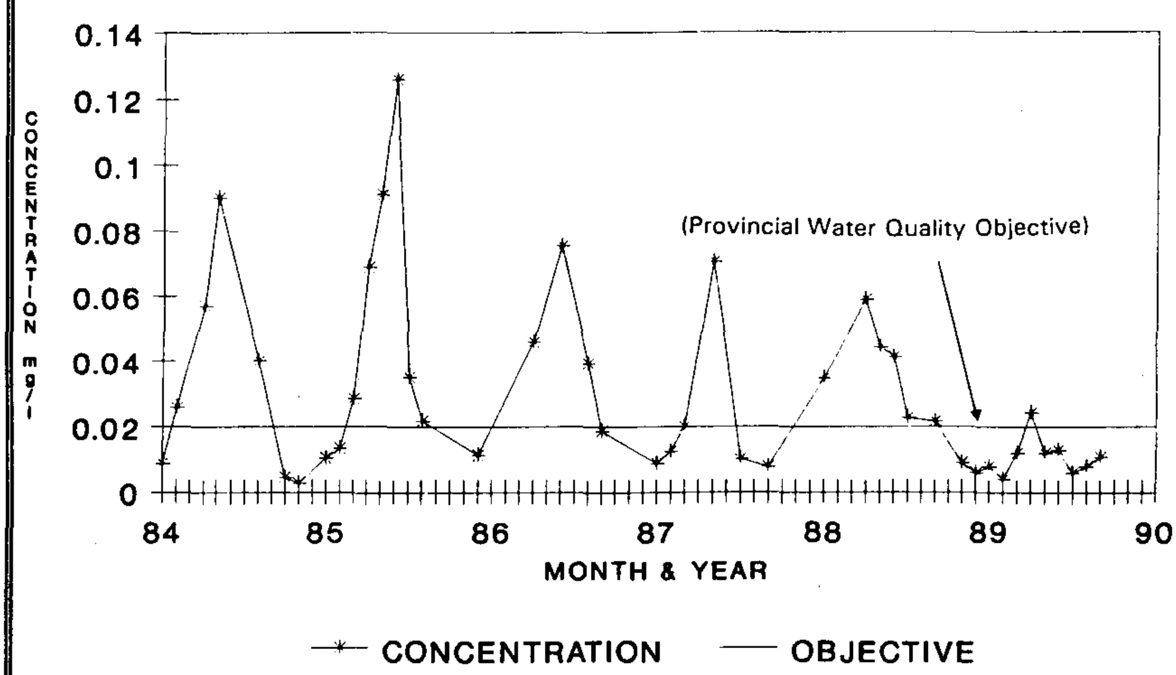


Figure 7: Hamilton Harbour - Un-ionized Ammonia Concentration



Source: J. Vogt, MOE/WCR

waters is believed to be caused by the removal of carbon dioxide from the water column as a result of algal photosynthesis. The low levels in 1989 were associated with lower pH and lower chlorophyll concentrations.

IV.3.1.2 Current and Proposed Actions

The sources of ammonia to the Harbour include the Hamilton and Burlington STPs, the CSOs in Hamilton, and the two integrated steel mills. The relative contribution of each source in 1989 is shown in Figure 6.

By far the largest source of ammonia input to the Harbour is the Hamilton municipal STP which discharged 2,900 kg/day in 1989, or about 66 percent of the total loading. About 90 percent of the ammonia is produced in the sewage treatment plant from the decomposition of plant and animal protein in the wastewater. The efficiency of removal in the STP can be improved by increasing the sludge age. The nitrifying bacteria which oxidize ammonia are slow growers and therefore require a reduction in the wasting rate of the activated sludge to maintain a suitable biomass of nitrifying bacteria. This can be achieved by increasing the activated sludge concentration in the aeration basin and/or the hydraulic capacity of the STP aeration basin.

The Hamilton municipal STP has spare aeration basin capacity. Thus, increasing the total Kjeldahl nitrogen (i.e. ammonia plus organic N) removal efficiency should be possible with minimal capital expenditure. Large-scale pilot studies are being carried out at the plant to determine the maximum removal efficiency that can be attained without affecting the removal efficiency of suspended solids, BOD, and phosphorus. These studies should be completed in 1992, although a 2,400 kg/day reduction took place between 1987 and 1989 and even further reductions are being attempted for 1990/91 using existing facilities.

The Burlington municipal STP represents the second largest source of ammonia being discharged to the Harbour, with a loading of 600 kg/day in 1989, or about 13 percent of the total loading. As with the Hamilton STP, the efficiency of ammonia removal can be improved by increasing the sludge age through operating with a higher mixed liquor suspended solids concentration and/or increasing the hydraulic capacity of the aeration basin. The Regional Municipality of Halton is upgrading the municipal STP including changes to enhance ammonia removal. As well, a consultant has been retained to audit the plant to recommend ways to optimize its operation.

The total ammonia in the municipal STP effluents will probably have to be reduced to 3,000 kg/day or a concentration of about 7.5 mg/L at present sewage flows to prevent build-up of ammonia in the Harbour during the winter and to prevent concentrations above the un-ionized ammonia objective in late spring and summer.

The third largest source of ammonia to the Harbour in 1989 are the CSOs with an estimated average loading of 350 kg/day. There are 26 CSOs in Hamilton. The Regional Municipality of Hamilton-Wentworth has installed a retention basin at one of the larger sewers to collect the overflow for conveying back into the sewer system for treatment after storm occurrences. Construction of the facility has been completed at a cost of $6.3 Million and was put into operation in 1989. The cost of installing storage basins to control all CSOs is estimated to be about $80 million. The construction of the retention basins could be completed in five years but current plans are for completion over a 20 to 40 year period. The Regional Municipality is also proposing to develop a computerized system to optimize the capacity of the existing sewers. Such a system may reduce the overall cost of controlling CSOs. If major renovations of the sewer system are required, the CSO problem may be addressed in a broader program of sewer system renovation that could cost between $100 and $250 million.

The fourth largest source of ammonia discharged in 1989 was Stelco, with an average loading of 195 kg/day or about 4 percent of the total loading. Stelco completed installation of indirect final coolers in 1987 which reduced their loading considerably.

The fifth largest discharger of ammonia in 1989 was Dofasco with a loading of 157 kg/day, representing 3.5 percent of the total. With the installation of a blast furnace water recycle system, some additional reduction in ammonia loadings will be realized.

IV.3.1.3 Potential Remedial Actions for Ammonia Control

Action #1 Do nothing.

Action #2 Diversion of the STP effluent from the Harbour or Harbour tributaries directly to Lake Ontario.

Action #3 Reduce loading of waste plant and human protein material to the sewers, treatment plants, or Harbour.

Action #4 Separate the existing combined sewers to prevent overflow of domestic sewage.

Action #5 Further divert potential Combined Sewer Overflows into retention basins to be treated after rainstorm flows abate.

Action #6 Divert remaining residual industrial ammonia discharges from the Harbour to the sewage treatment plants to take advantage of the efficiency of scale in the STPs.

Action #7 Review of treatment processes at all sewage treatment plants to optimize operations in such a way as to reduce ammonia loadings without major plant facility expansion.

Action #8 Add additional capacity to existing sewage treatment plants to increase sludge aging in order to reduce ammonia discharges.

IV.3.1.4 Evaluation of Potential Remedial Actions to Address Ammonia Loadings

The nature and consequences of potential actions that might be taken to reduce ammonia loadings are outlined below.

Potential Action #1 Do Nothing

The continuance of current (1988) practices leading to ammonia loadings to the Harbour will ensure that target loadings will be exceeded by 100 to 200 percent. The consequence of this is continued toxic levels of un-ionized ammonia in one-third to one-half of the south and east portions of the Harbour during up to one-half of the year, and the continuance of low oxygen conditions in the hypolimnion in summer. While the former is due almost entirely to ammonia discharge alone, it should be noted that alleviation of the dissolved oxygen situation will require action on both ammonia and phosphorus.

Ammonia is one of only three water quality parameters that do not meet water quality standards in significant portions of the Harbour.

This measure has been rejected.

Potential Action #2 Diversion of STP Effluent Directly to Lake Ontario

Diversion of the STP effluents would alleviate 80 percent of the problem in the Harbour. The Lake with its larger oxygen supply and dilutional capability could absorb this particular material with minor consequences since the toxic effects are acute in nature and not a persistent, bioaccumulative effect.

However, this measure involves diverting more than just ammonia and has to take into account the other contaminants in the STP effluent. Such a measure will not negate the need for CSO remediation either - again, for reasons of other associated contaminants.

Furthermore, the public at large and the advisors on the Stakeholders Group, have rejected this option except as a last resort. Reasons are varied, but it seems that a large majority want to see that every means short of diversion is undertaken to correct the Harbour problem, and only then, if the Harbour is not satisfactory, will they consider reassessment of the situation.

Therefore, this measure has been rejected at this juncture (see Recommendation #50).

Potential Action #3 Reduction in Loading of Plant and Animal Protein to the STP

Food waste and human waste are the major components of this loading to the STP. Food industry discharges to the sewer system and food waste from homes should be minimized. Garburators could be banned (as is done in Burlington already). Food wastes from homes should ideally be composted or, where this is not possible, put into the regular garbage.

Human waste reduction in an urban setting is problematical. Composting toilets that can be used in rural or cottage areas are not yet deemed by authorities to be acceptable in the urban setting. This type of technology, if further developed and tested, might serve to reduce human waste loadings by 20 to 30 percent - but only if householders are prepared to take the extra care and attention that such devices now require for maintenance. There is also an energy cost to this technology (a heater to ensure aerobic degradation processes) of about 900 kwH/year for each toilet.

This approach may have future potential, but it needs study and cannot address the immediate problem in a timely fashion.

It is recommended that this approach be given further study (see Recommendations #47 and #48).

Potential Action #4 — Sanitary and Storm Sewer Separation to Prevent Overflows of Raw Sewage into the Harbour

This measure would address 13 percent of the loading (1989) and would be very costly for retrofit of the large older urban areas if ammonia were the only problem associated with combined sewer overflows.

Therefore, this measure is not recommended for dealing with the ammonia problem alone.

Potential Action #5 — Reduction of Combined Sewer Overflows

This measure again addresses 13 percent of the loading. Since other contaminants are more important in the CSOs, the decision on such a measure hinges more critically on other factors.

This measure is not recommended on the basis of ammonia alone, but would be helpful if other factors dictate such a measure (see Recommendation #1).

Potential Action #6 — Divert Remaining Residual Industrial Discharges from the Harbour to the Municipal Sewer System

This is an attractive option with the caution that other contaminants in the industrial discharge must meet sewer use regulations. The industrial discharge of ammonia directly to the Harbour is now only 8 percent of the total. Previously, it was 70 percent of the total, so industry has made great strides in eliminating their discharge.

Therefore, it is recommended that this option be considered taking into account the small portion of the total loading that it constitutes at the present time and the correlative factors noted above.

Potential Action #7 **Optimization of STP Operations to Reduce Ammonia Loadings**

The predominance of ammonia (80%) discharged to the Harbour in 1989 came from the two large STPs situated at the east side of the Harbour. These plants have not been required to treat their effluent for ammonia. Modest modifications to the plants may make it possible for these plants to meet a large portion of the recommended ammonia loading reductions. The details cannot be specified here because each plant has its own characteristics. Generally, a computerized process audit and hydraulic investigation will identify the points at which the plant can be altered to effect the changes necessary, in conjunction with the suspended solids and phosphorus loading targets specified in this plan.

This process audit and the possible associated changes in chemical treatment strategies, hydraulic changes, or improvements in aeration efficiencies, are strongly recommended as a first step in improving treatment to meet the targets (see Recommendation #1).

Potential Action #8 **Add Capacity to the STPs to Accommodate Increased Treatment for Ammonia**

It may be necessary, if action #7 is not adequate, to make major modifications to the existing STPs to meet the target loadings. This will, in all likelihood be less cost efficient than the potential for remediation in action #7, and should undergo more detailed analysis before it is implemented (see Recommendation #48).

IV.3.2 Phosphorus Loading

IV.3.2.1 Historical Actions

With the installation of wastewater treatment facilities and elimination of manufacturing processes discharging phosphorus at the steel mills, the industrial discharges of phosphorus to the Harbour have been reduced from about 1,200 kg/day in 1967 to less than 10 kg/day in 1989. The phosphorus loadings from the STPs have also been reduced through the use of chemical treatment. In addition, in the early 1970s, the restriction placed on phosphorus content of laundry detergents reduced the concentration of phosphorus in the waste stream entering sewage treatment plants from 9 to 10 mg/L to 5.5 to 6.5 mg/L. For 1989, the estimated loadings are shown in Figure 8.

Total phosphorus loadings to the Harbour since 1974, including estimates of loadings from creeks and Hamilton's CSOs, are shown in Figure 9, along with the phosphorus concentrations in the Harbour. The total loading has been reduced from about 1,500 kg/day in the mid-1970s to about 330 kg/day in 1989. Recent data summary of chlorophyll a and secchi depth (Figure 10) show very recent improvements in the water quality related to phosphorus loading.

Figure 8: Hamilton Harbour - % Phosphorus Contribution by Source (1989)

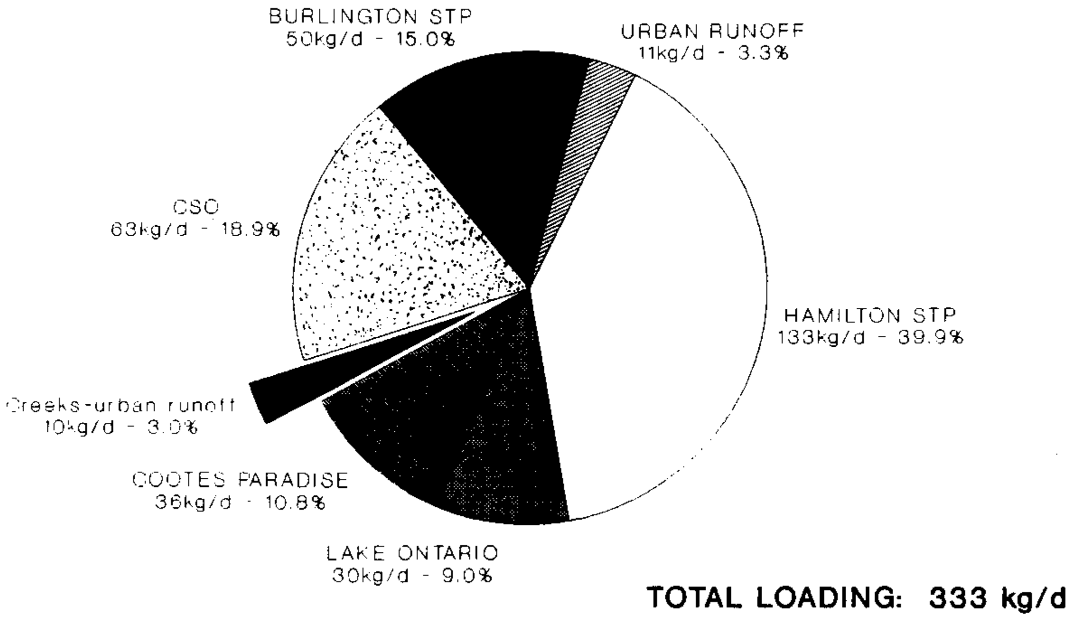
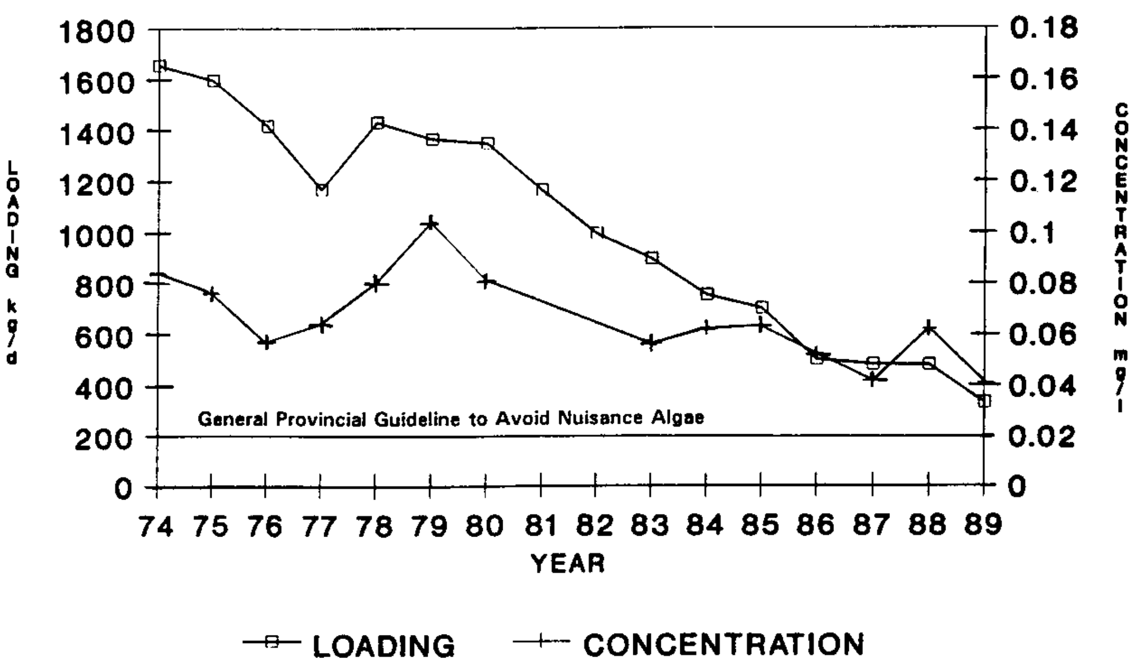


Figure 9: Hamilton Harbour - Phosphorus Loading and Concentration



Source: J. Vogt, MOE/WCR

In Figure 11, the annual average phosphorus loadings to the Harbour are plotted against the annual average total phosphorus concentrations found in the Harbour. Also included in Figure 11 is a plot of the phosphorus concentrations that would have been predicted using the Janus-Vollenweider model for annual average concentrations.

The actual concentrations are lower than predicted by the model. The difference between predicted and observed concentrations may be partly the result of 'short circuiting' (flushing of phosphorus from the Harbour to Lake Ontario before it becomes completely mixed in the Harbour) but is believed to be mainly caused by the removal of phosphorus from the water column by the iron discharges from the steel mills through precipitation and settling of the precipitate to the bottom sediments.

IV.3.2.2 Total versus Available Phosphorus

Measures to mitigate the impact of phosphorus loadings are approached in this report, in terms of total phosphorus. There are reasons to consider the question of what is 'available' phosphorus in each of these loadings if it might influence the efficacy of any particular abatement strategy to reduce algal growths. In general, the question of availability has to be considered in the light of the sensitivity and flushing characteristics of the specific area one wishes to protect.

Our analysis to date suggests that the strategy we propose is insensitive to the question of phosphorus availability, either because the scale of contributions to any particular part of the Harbour or the marshes usually has a predominant source, or that the proposed priorities in the strategy for phosphorus control has additional benefits that override the distinction between total and available phosphorus.

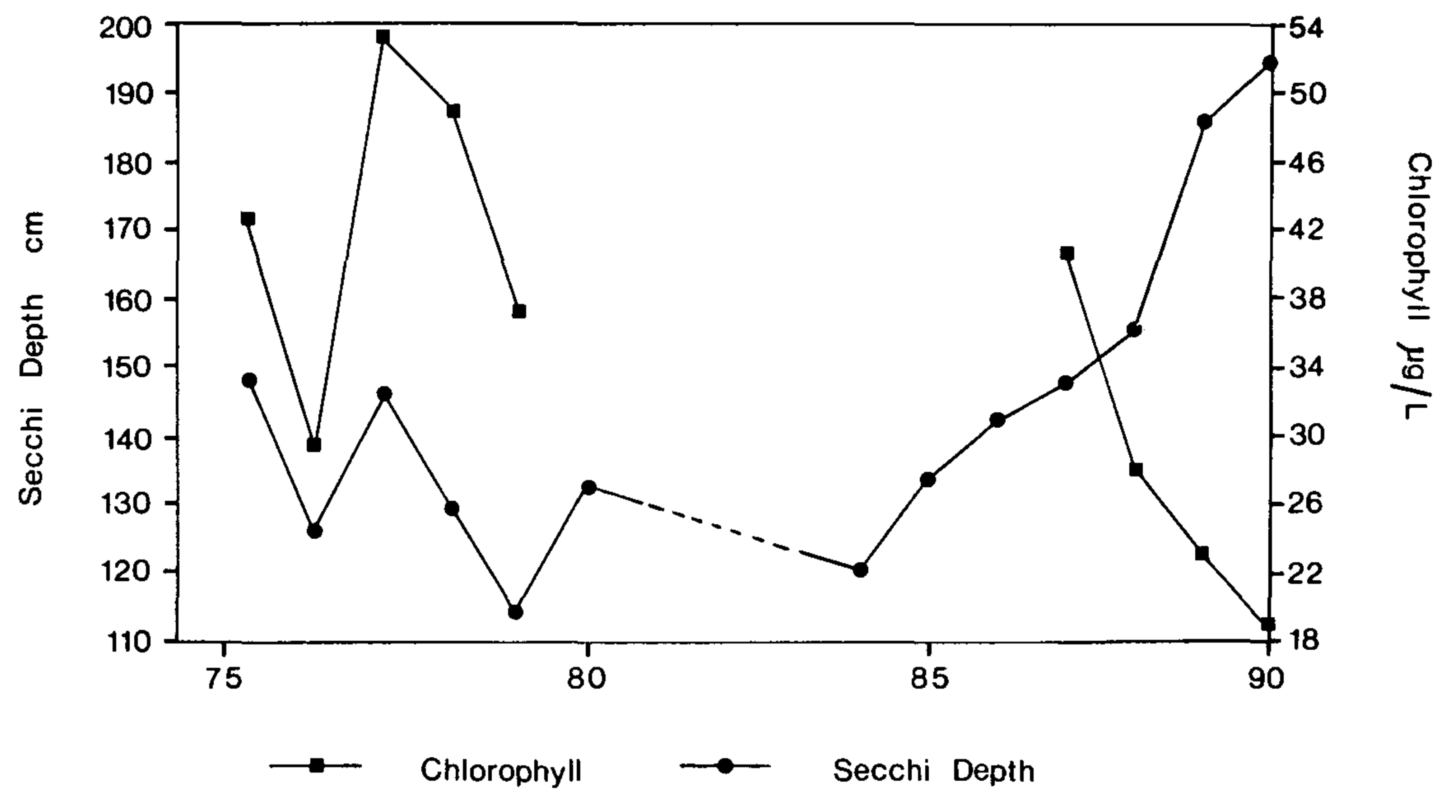
IV.3.2.3 Current and Proposed Actions

The sources of phosphorus being discharged to the Harbour and their relative contributions in 1989 are shown in Figure 8. The annual average total loading to the Harbour in 1989 was 333 kg/day as phosphorus.

The largest source of phosphorus being discharged to the Harbour in 1989 was the Hamilton municipal STP with a loading of 133 kg/day or 40 percent of the total loading. Studies are being carried out at the Hamilton plant to optimize the treatment for removal of phosphorus. It is believed that with such optimization, the effluent concentrations from the existing plant can be reduced below 0.5 mg/L now being achieved, as compared to an average concentration in 1987 of 0.9 mg/L. It is believed that similar reductions may also be achieved by optimizing the operation of the Burlington municipal STP which discharged 50 kg/day or 15 percent of the total in 1989.

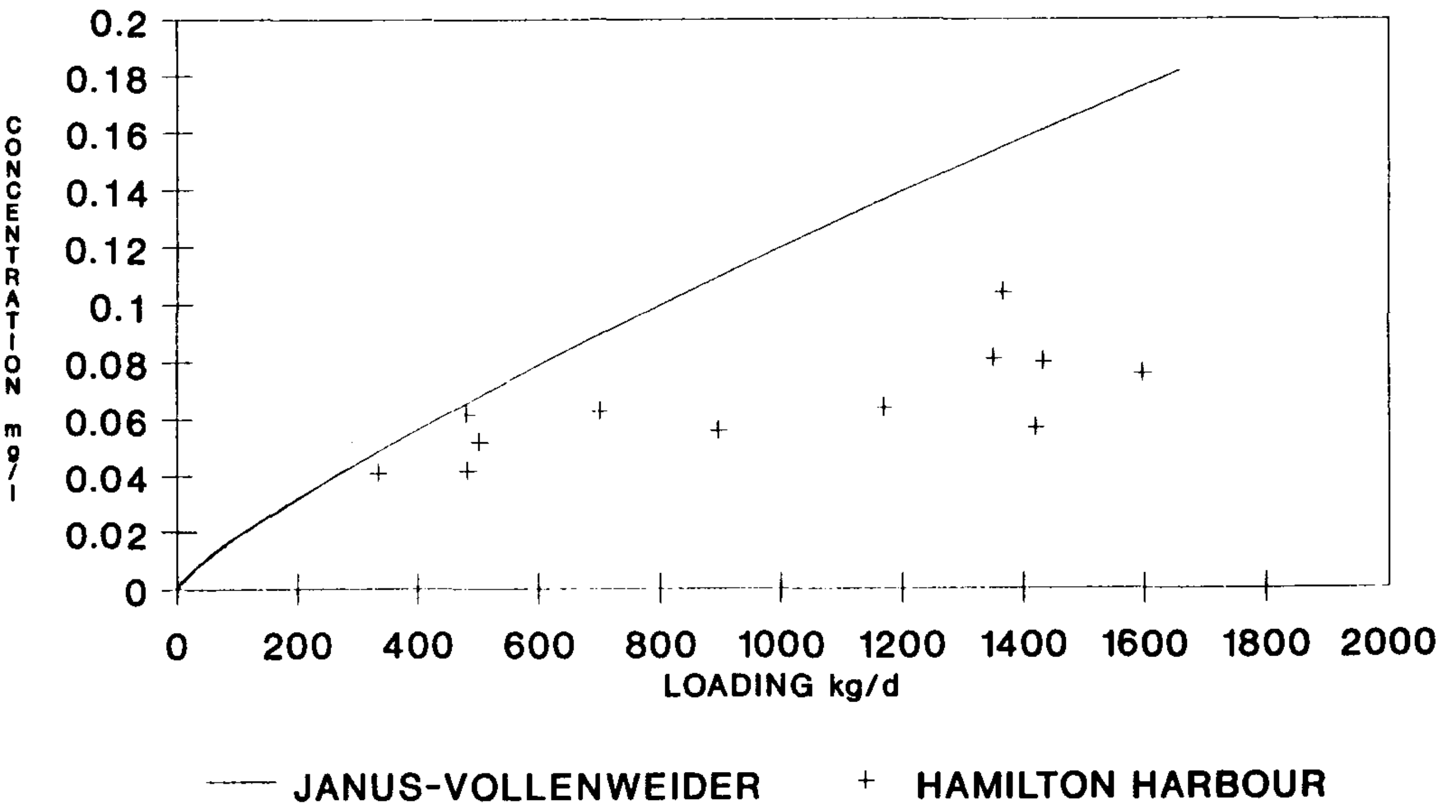
Other sources of phosphorus input to the Harbour include CSOs, creeks, and storm sewer discharges. It is estimated that an average of 63 kg/day of phosphorus is being discharged

Figure 10: Hamilton Harbour - Station 258



Source: Painter, <u>et al</u>., 1990.

Figure 11: Harbour Harbour - Phosphorus Concentration vs Loading



Source: J. Vogt, OMOE/WCR

by way of CSOs. The provision of sewage storage facilities at all 26 CSOs as described earlier, should reduce the phosphorus loading from this source to about 5 kg/day as phosphorus.

Phosphorus in the creeks is believed to be mostly from soil erosion at construction sites, along stream banks, and off farm land. It is possible that reduction of erosion through more stringent controls at construction sites, installation of retention devices to minimize peak stream flows and/or structures to protect stream banks, and changing farm practices could reduce the phosphorus input from these sources by one-half. More field work is needed to determine the significance of each of these sources before an estimate can be made of the actual reduction attainable, and its cost. A preliminary study was completed in 1989.

With reductions of the phosphorus concentrations in municipal STP effluents to 0.5 mg/L, elimination of CSOs in Hamilton and reduction of non-point sources by 50 percent, the total phosphorus loading to the Harbour would be reduced to about 240 kg/day. From Figure 12, the phosphorus concentration in the Harbour at a loading of 240 kg/day would be about 0.028 mg/L. If the concentrations in the municipal STP effluents can be reduced to 0.4 mg/L, the total loading to the Harbour would be reduced to 200 kg/day and the concentrations in the Harbour water to about 0.023 mg/L.

The sources of phosphorus noted above include fertilizers used on rural and urban properties, phosphorus in soil eroded from land or stream banks, animal waste, combined sewer overflows, and sewage treatment plants. In accordance with the ecosystem approach, the source of the material must be investigated further.

Combined sewer overflow volumes consist largely of urban stormwater which can carry phosphorus from lawn fertilizers, and animal waste (pets, urban wildlife). A smaller portion of the CSO flow is from the 'sanitary' sewer system which needs to be examined separately.

The regular sewer system receives waste from the industrial/commercial sector and from homes. The industrial/commercial sector uses some cleaning agents with phosphorus content ranging up to 30 percent (as P_2O_5) compared with regulated laundry detergents that range from 1 to 5 percent. If there is a problem with this sector, a municipality would regulate them individually because the number of such sources is limited. One report puts this typically at about 15 percent of the phosphorus in raw sewage (as of 1978).

Domestic sources account, typically, for 85 percent of the phosphorus sources to the sewage treatment plant. Human waste accounts for 40 to 45 percent; kitchen waste and laundry detergents (regulated content) each contribute 10 percent; and other domestic cleaning compounds (particularly dishwasher detergents that are **not** regulated) contribute 20 to 25 percent.

Product formulation controls for cleaning agents could further be applied to reduce the phosphorus load to the sewage treatment plants. Alternatively, public pressure on manufacturers to supply lower phosphorus alternatives as cleaning agents through such programs as the 'Environmental Choice' program may have an affect. The costs and benefits comparing further product controls and improvements at the sewage treatment plants, are required.

Kitchen waste could be reduced by restricting garburator use, and encouraging more inclusive use of composter disposal of some kitchen wastes.

Human waste is the largest source of phosphorus in sewage systems. Alternatives to a central sewage treatment plant for disposal of this waste in an urban setting are not yet adequately tested. Package sewage treatment systems may be suitable in some situations. For more rural sites, composting toilets have sometimes been found to be more suitable than septic tank systems. However odour problems (inside and outside of the home), the need for regular maintenance procedures, and greater energy use per household are detrimental factors especially in an urban setting.

Reduction in the loading of the total amount of organic material to the sewage treatment plant is an attractive strategy if the waste goes back to the land (without causing pollution). However, the current practice of using a central sewage treatment plant operating at full efficiency, with return of sludge/fertilizer to the land and recovery of energy from the methane produced in the sludge digesters, has many advantages as well as proven performance characteristics.

IV.3.2.4 Further Actions

If the phosphorus loading to the Harbour cannot be reduced adequately by optimizing chemical treatment in the existing STPs, then an option would be to install filters to further treat the final effluent. The cost of a filtration system for the Hamilton municipal STP and the Burlington municipal STP would be about $60 Million and $20 Million, respectively. With filtration and using dual point chemical addition, the phosphorus concentration in the municipal STP effluents can be reduced to as low as 0.1 mg/L. Tests at the small Dundas STP have confirmed the potential for this level of control (1990) though whether it can be maintained consistently is a matter for further assessment. It should be noted that sand filters have recently been installed on the Dundas and Waterdown STPs to better protect the more sensitive parts of the watershed that they affect - namely Cootes Paradise and Grindstone Creek, respectively.

Finally, sewage treatment plants operate less efficiently when wastewater flows to the plant exceed design levels. Also, they are less efficient when waste concentrations are lower. Both conditions arise when there are combined sewers (which give rise to the need for sewer overflow 'relief' gates), substantial infiltration/inflow, or where excessive water use dilutes the waste.

A separated sewer system is deemed more desirable if attention is paid to the need for treatment of the stormwater runoff.

A program to track down infiltration/inflow sources may also be beneficial.

Most importantly, water use in Canada is high - double the use (per capita) in the U.S.A., and four times as much as in Europe. A concerted program to reduce water use would also take the strain off the existing water pipe, sewer pipe, and treatment plant infrastructure. Demand management with payment for the full cost of water/sewer services being presented to the user has many benefits. More water efficient plumbing fixtures are available and could be included in building codes. Rainwater falling on roofs and driveways can be collected to reduce storm flood peaks and for later use in garden watering or car washing.

IV.3.2.5 Potential Remedial Actions for Phosphorus Control

Action #1 Do nothing.

Action #2 Diversion of the STP effluent from the Harbour or Harbour tributaries directly to Lake Ontario.

Action #3 Reduce organic waste from food entering the sewage system.

Action #4 Ensure that fertilizer use in urban and rural areas is reduced to only the essential levels.

Action #5 Place further restrictions on the use of phosphorus in domestic and industrial/institutional cleaning agents.

Action #6 Embark on a more intensive public information program leading to identification of more environmentally friendly cleaning agents containing less phosphorus (and along with no other environmental disadvantages).

Action #7 Reduce erosion in rural areas.

Action #8 Reduce stream bank erosion.

Action #9 Reduce erosion losses from construction sites and other locations with bare soil.

Action #10 Undertake a pilot study of strategies and techniques that might be used to reduce nutrient loading to streams, lakes, and harbours, with or without a central sewage collection/treatment system. This should be followed with a demonstration of how this can be done in the face of increased population, with the requirement of fixed loading limits for the aquatic environment.

Action #11 Undertake a comprehensive water conservation program to reduce the volume of wastewater flow entering STPs, including financial and regulatory incentives.

Action #12 Undertake measures to improve stormwater management so as to maximize infiltration into the soil and re-use at the householder level.

Action #13 Undertake a program to identify and correct infiltration/inflow problems in sewer systems.

Action #14 Separate storm and sanitary sewers in all future developments or redevelopments while considering the need for treatment of the storm flows.

Action #15 Further divert combined sewer overflows into retention basins to be treated after the rainstorm flows abate.

Action #16 Review of treatment processes at all the sewage treatment plants in such a way as to reduce phosphorus discharges without major plant expansion.

Action #17 Add final effluent filters as another stage in the sewage treatment process at sewage treatment plants for Hamilton and Burlington.

IV.3.2.6 Evaluation of Potential Remedial Actions for Phosphorus Control

The nature and consequences of potential actions that might be taken to reduce phosphorus loadings are outlined below.

Potential Action #1 Do Nothing

The continuance of current (1988) practices leading to phosphorus loadings to the Harbour will ensure that target loadings will be exceeded by 100 to 150 percent. The consequences of this are continued algae production at pre-1988 levels, associated poor water clarity, algae on rocks and beaches in undesirable concentrations, and the continuance of low oxygen conditions in the hypolimnion in the summer. It should be noted that alleviation of the dissolved oxygen situation will require action on both ammonia and phosphorus.

Phosphorus is one of only three water quality parameters that do not meet water quality guidelines in significant portions of the Harbour, although some leeway is permitted in its application if the community is satisfied that conditions are acceptable.

Potential Action #2 Diversion of STP Effluent Directly to Lake Ontario

Diversion of the STP effluents would alleviate 55 percent of the problem in the Harbour. The Lake with its larger oxygen supply and dilutional capability could absorb the particular material with only minor consequences since no other plant discharging to Lake Ontario is required to reduce effluent concentrations by more than is already done in Hamilton and Burlington plants.

However, this measure involves diverting more than just phosphorus and has to take into account the other contaminants in the STP effluent. Such a measure will not negate the need for CSO remediation either - again, for reasons of other associated contaminants.

Furthermore, the public at large, and the advisors on the Stakeholders Group have rejected this option except as a last resort. Reasons are varied, but it seems that a large majority want to see that every means short of diversion are undertaken to correct the Harbour problem, and only then, if the Harbour condition is not satisfactory, will they consider reassessment of the situation.

Therefore, this measure has been rejected at this juncture (see Recommendation #50).

The following potential actions refer to ways in which phosphorus loading can be reduced by tackling it at the source. Note that reduction of these sources translates into reduced need for coagulant chemicals at the treatment plant and reduced sludge production at the treatment plant. Under current regulations (1 ppm phosphorus in effluent of STP), only 15 percent of the phosphorus entering the STP goes into the Harbour. At the level of the technically feasible treatment implied in this plan, (0.15 ppm phosphorus in effluent), only 2 percent of the phosphorus entering the STP would go into the Harbour.

Potential Action #3 Reduce Food Wastes Entering Sewer System

At both the household and food industry levels, the amount of food waste entering the sewer system could be reduced. Garburators could be banned through municipal action (as is the case now in Burlington) and the food industry could be asked to take measures to minimize the discharge of this material to the system.

There is no consensus on this issue, partly because we lack good information on its significance. Occasional 'spills' by industry have caused serious problems, and further action on these types of conditions should be addressed in the spill control program (see Recommendation #38).

Potential Action #4 Reduction of Fertilizer Use in Urban and Rural Areas

In rural areas it is feasible to optimize phosphorus use so that nearly 100 percent of the phosphorus used in fertilization of crops is taken off with the crop. A reduction of 2 to 5 percent of the 1989 load could be achieved.

In urban areas, particularly in areas where 'grass cultivation' is carried out (golf courses and parks), fertilizer use should be reviewed with a view to its minimization. Householders can either use mulching mowers and reduced fertilizer applications to minimize use, or eliminate the need by shifting to 'dry-land' xeriscaping which reduces water requirements as well. Perhaps 1 to 3 percent of phosphorus entering the Harbour is affected this way. Their main impact may be seen in the quality of the creek waters that drain into the Harbour.

It is recommended that all large-acreage landowners/operators review their use of fertilizers to see if it cannot be reduced substantially. Householders are also asked to eliminate unnecessary lawn fertilization (see Recommendation #38).

Potential Actions #5 and #6 — **Further Restrictions on the Phosphorus Content of Household Laundry Detergents, Laundry Detergents, Industrial Detergents and Dishwasher Detergents**

Laundry detergents and regular industrial detergents are already regulated with respect to phosphorus content (2% as P). Special industrial detergents are sometimes regulated under sewer-use bylaws, as alternatives are usually available.

Dishwasher detergents are not regulated.

In all cases, low phosphorus content alternatives are available to the buyer.

It is not recommended that further regulation of detergents be undertaken, since this is a measure that would affect products sold across Canada and should be reviewed in that context.

Consumers are asked to look for and use products with low phosphorus content - environmentally friendly products - that reduce the cost and the use of chemicals in the sewage treatment plants (see Recommendation #38).

The following three actions address the phosphorus content of suspended solids carried to the Harbour as the result of erosion. They are described in greater detail in the section following this which deals with suspended sediments loading specifically.

A large fraction of the phosphorus in suspended solids loading is not readily available for the aquatic food chain. However, some will be available or released over a long time in areas where vegetation is rooted in bottom sediments or in areas where overlying water conditions promote the leaching of the phosphorus from the sediments.

Note that Cootes Paradise is more sensitive to this type of loading than the Harbour proper.

Potential Actions #7, #8 and #9 — **Soil Erosion**

Addressed below in section IV.3.3 (see Recommendations #4, #5 and #6).

Potential Action #10 — **New Strategies and Technologies to Reduce Nutrient Loads to STPs**

Central sewage collection/sewage treatment systems and septic tanks are the current means to deal with human waste. The central system is being pushed to the limit with Harbour requirements, and septic tank systems are causing problems in some areas of the watershed. Yet there is pressure to permit the population in the watershed to expand.

Ways and means to balance the population growth with alternative ecosystemic ways to deal with human waste have not been adequately investigated and/or authorized by licensing bodies.

This Action is strongly recommended (see Recommendations #47 and #48).

Potential Action #11 Water Conservation

Programs to reduce the demand for (or use of) treated water will have beneficial effects. Reduced water use will reduce water pumping costs and reduce the cost of sewage treatment. The reduced requirement for hydraulic capacity in the treatment and delivery system for water supplies, and in the sewage system will also reduce costs. Reduced flow volumes improves the efficiency of sewage treatment systems allowing us to increase the population load without increasing the phosphorus load to the Harbour.

Several methods have been recommended to reduce water use. These include:

a) Promotion of efficient water use. Water saving devices, such as toilet reservoir dams, efficient shower heads, etc., could be provided at or below cost, and combined with a public information program.

b) Legislation of a new plumbing code that mandates the installation of water saving features in all new homes.

c) Installation of water meters for all users so that their water/sewer bill reflects their use of water directly.

d) Changes in the water rates to encourage water saving, with a general rate increase plus a rate structure that includes increasing rates for greater water usage for beach homes and, especially, industry or business.

Water conservation programs are strongly recommended (see Recommendation #40).

Such programs have been shown to reduce water use by 8 to 12 percent. Greater reductions, up to 20 to 25 percent are possible if the program is pursued vigorously and continuously (see Recommendation #40).

Water conservation and application of the user-pay system in the supply of water treatment and wastewater treatment services, are the subject of recent reports from the province of Ontario and agencies concerned with this issue (MISA Advisory Committee, 1991; OMNR, 1992; Metropolitan Toronto, 1991; Rivers et al., 1991). This last report addressed the Hamilton Harbour RAP specifically.

The analysis of savings associated with implementing a water conservation program are not yet detailed. However, the overall situation is that water is sold to customers and wastewater service is provided, at less than cost. Thus leads to water over use, increased pollution, further deterioration of the pipes and treatment facilities of the sewer system, non-productive spending of the taxpayer's money, and unfairness in the pricing of the service.

In principle it is strongly recommended on the understanding that a more detailed analysis of facility operation and capital costs (to be expended or foregone) will be necessary to complete our understanding of the actual savings, our potential to cover costs more efficiently or raise revenue, and the resulting reduction of pollution.

Potential Action #12 Stormwater Management

A major aspect of combined sewers and of the erosional load to any body of water is the volume of water in the peak flows associated with rain storms or spring snow melt. There are ways and means to mitigate erosion by reducing the very erosive peak flows. Detention basins in stream courses, dry wells to aid infiltration into the soil, reduced use of eavestroughs and increased use of rain-barrels (or rain-water cisterns) for later re-use are measures that could be used systematically to retain the water in the groundwater system. This provides greater re-use and added filtration for removal of materials that are undesirable for discharge to streams and the Harbour.

This type of measure is strongly recommended.

Potential Action #13 Reduction of Infiltration and Inflow to Sewer Systems

Even where there are separate systems for stormwater and sewers, the volume of flow to the sewage treatment plant increases markedly during rain storms. This is due either to infiltration into the pipelines or to rainfall collection systems being hooked up (unintentionally or illegally) to the sanitary sewer system.

Where this type of problem exists to the detriment of the efficiency and capacity of existing sewage treatment plants, it is recommended that the responsible authorities investigate means to reduce inflow and infiltrations to the sanitary sewer system.

Potential Action #14 Sewer Separation

Where good stormwater management is practised, storm and sanitary sewer systems can be separated to reduce the potential to overload the sewage treatment plant.

It is recommended that separate sewer systems be installed in new developments on the conditions that stormwater flows are properly managed to reduce peak flows in creeks and that water quality is not compromised.

Up to this point, we have dealt primarily with ways to modify the volume of water and quantity of waste introduced into the existing sewer systems. We now turn to means to improve the operation of the existing sewer collection and sewage treatment systems themselves.

Potential Action #15 Retention Basins for Combined Sewer Systems

Combined sewer overflows (CSOs) during rain storms are responsible for 19 percent of the phosphorus entering the Harbour. In combination with the bacterial contamination and toxic chemical additions that this represents, there is a very strong case for dealing with this problem. There are over 20 combined sewer overflows discharging directly to the Harbour and Cootes Paradise, as well as to streams that enter their southern shores.

Hamilton-Wentworth Region has already begun to address this problem by reducing by 25 percent the volume of overflow which discharged originally into Redhill Creek. This is one of the most cost-effective ways to start on the problem, and to better ensure that the Windermere Basin clean-up becomes permanent.

Plans have also been approved by the Hamilton-Wentworth Regional Council to address two CSOs in the western area - one of four in the Cootes Paradise watershed and two discharging into the channel behind the proposed park in the southwest corner of the Harbour. This strategy is completely in accordance with the priorities for this plan. First priority is given here for remediation of CSOs in the western sector of the Harbour and in Cootes Paradise. This will give relief to areas that have the greatest potential for recreational and environmental benefits.

Reduction of CSOs in the central and eastern parts of the Harbour, besides being a natural complement to industrial effluent improvements, will reduce the need for dredging in the marine and docking areas.

It should be noted that the less CSO volume there is, the more stormwater that will require treatment in the sewage treatment plant. This will require adequate capacity in the Woodward Avenue STP to accommodate the increased volume of wastewater.

The remediation of combined sewer overflows on the south shore of the Harbour has been deemed of the highest priority by both the technical team and the Stakeholders Advisory Group (see Recommendation #1).

Potential Action #16 Operational Audit of Sewage Treatment Plants

Treatment processes in sewage works tend to be unique to each plant, because although the basic processes are similar, each has been designed or modified in different ways. While the current objective for phosphorus is 1 ppm concentration, the targets in this plan call for a concentration of 0.10 to 0.15 ppm at current wastewater volumes. The two major plants in the area implemented different coagulant introductions and have achieved, on average, a concentration of about 0.5 ppm with reasonable consistency. Some ammonia removal was also achieved.

To go further, a detailed audit is required to assess the hydraulics of the plants, the efficiency of the clarifiers, and the optimization of chemical additions, etc. It should be possible to achieve at least 0.3 ppm with such alterations in plant structure and operations. A component of these investigations should be the degree to which bypassing (primary or secondary) can be minimized. For example, step feed control has been installed at the Dundas STP to reduce bypassing, and (as this is being written) a major component of the Woodward Avenue plant is being altered to achieve the same flexibility in operation (see Recommendation #1).

Potential Action #17 Effluent Filtration for STPs

The next degree of phosphorus control can be achieved by using final effluent filtration. Such technology should bring STPs close to the final targets set for the Harbour in this plan. Sand filters have already been installed at the Dundas and Waterdown STPs, because these plants discharge into Cootes Paradise and Grindstone Creek respectively, and these are more sensitive bodies of water.

The installation of such treatment at the Skyway (City of Burlington) and Woodward Avenue (Hamilton-Wentworth Region) plants is a major cost.

Therefore, it is recommended that every measure short of final filtration, be implemented. Then there should be time to assess the response of the Harbour before embarking on final effluent filtration. This way the uncertainty in models predicting the response of the Harbour can be reduced and the cost-effectiveness of this final step can be better assessed (see Recommendation #1).

IV.3.3 Suspended Solids Loading

IV.3.3.1 Historical Actions

The total suspended solids loading to the Harbour from all sources since 1978 is shown in Figure 12. The loadings from industry alone in 1967 were 150,000 kg/day and were approximately 8,450 kg/day in 1989 or 18.8 percent of the total loadings.

The sources of suspended solids and their relative contributions to loadings in 1989 are shown in Figure 13. One should probably not point to a single dominant source from this perspective since the impact tends to be most evident close to the entry point of each individual source. While reduction of any one of the sources could benefit the Harbour as a whole, the improvement in the nearshore areas close to where it is injected into the Harbour will be the most noticeable.

Ancillary issues sometimes concern the organic or inorganic composition of the material and sometimes they concern not just the bulk of the solids but the contaminants that they may carry with them (e.g. reductions in total phosphorus loadings are effectively achieved by reducing suspended solids discharge).

Figure 12: Hamilton Harbour - Suspended Solids Loading

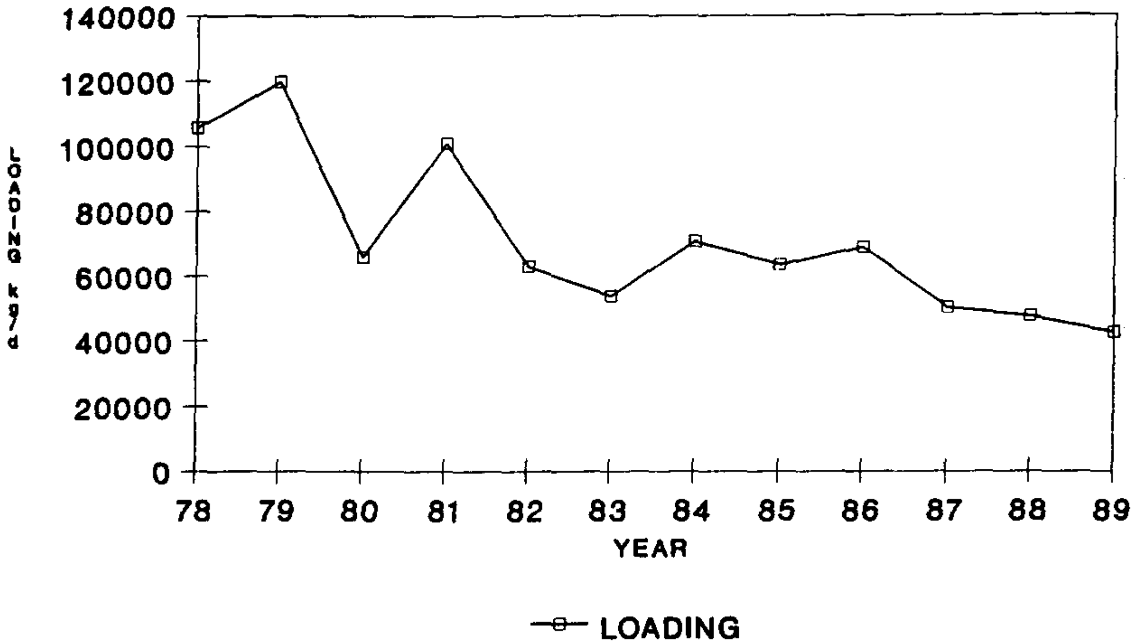
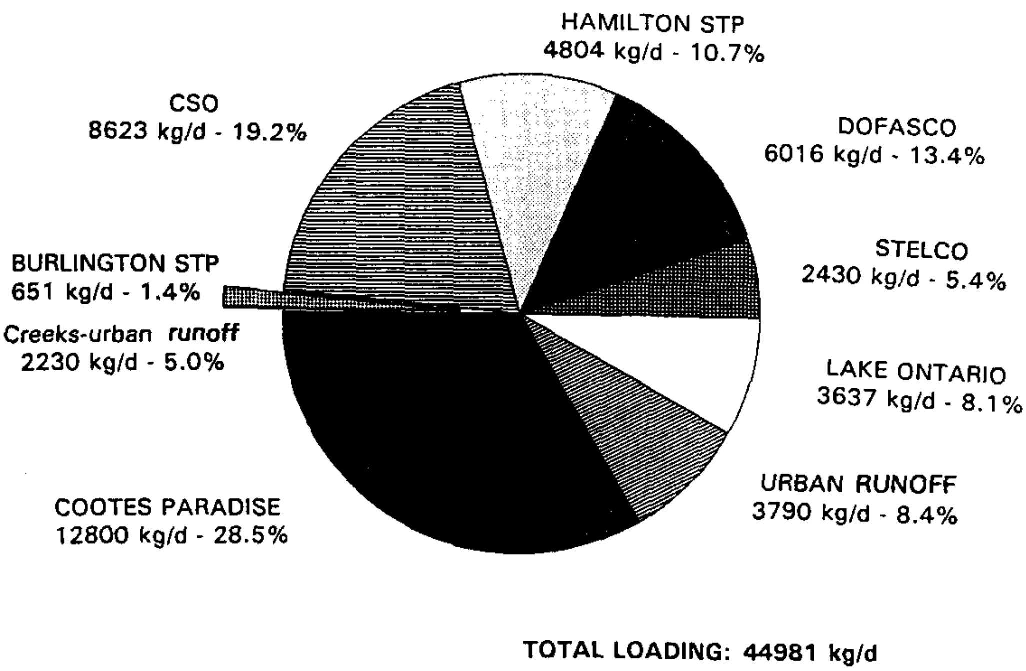


Figure 13: Hamilton Harbour - Contribution by Source (1989)



Source: J. Vogt, OMOE/WCR

Hence, while creeks, urban runoff, and Cootes Paradise loadings are sometimes smaller units, their area of impact is critical and thus they probably should receive higher priority.

IV.3.3.2 Current Actions

Sewage treatment plants, Stelco, and Dofasco have undertaken measures to address a variety of pollutants. Those actions have also resulted in lower suspended solids loadings.

IV.3.3.3 Potential Remedial Actions for Suspended Solids Control

Action #1	Do nothing.
Action #2	Improve stormwater management through use of detention ponds or other measures to reduce the peak flows and retain the suspended load back in the watershed.
Action #3	Better training for certification of construction supervisors for housing and other construction developments as regards the implementation and maintenance of erosion control measures.
Action #4	Better enforcement by municipalities of erosion control requirements in subdivision agreements at construction sites of all types (housing, industry, etc.)
Action #5	Programs to aid the farming community in soil conservation.
Action #6	Programs to reduce stream bank erosion where it is most serious, including 'soft' flood control measures.
Action #7	Reduction of combined sewer overflows, especially in Cootes Paradise and in the western half of the Harbour.
Action #8	Further reductions in the suspended solids loading from sewage treatment plants to be realized in conjunction with phosphorus and ammonia control.
Action #9	Further reductions in the industrial discharge of suspended solids.
Action #10	Implement better street cleaning in general, and at construction sites to reduce the sediment load in storm runoff.

IV.3.3.4 Evaluation of Potential Remedial Actions for Suspended Solids Control

Measures to reduce toxic chemical loadings, ammonia loadings and phosphorus loadings are achieved by removing suspended solids from the wastewater flow. Hence, attention to these factors provides a large measure of relief from 50 percent of the suspended solids loading estimated for 1989. Indications are that implementing phosphorus control as described in the previous section will remove 50 to 70 percent of the loading from the STPs.

Suspended sediment loading from creeks and resuspended sediments in shallow areas were more prominent in earlier data than noted in the 1989 estimates. However, it is clear that siltation of estuaries and marsh areas is a major consequence of loadings from the creeks and streams. In these locations they damage the habitat and then are available for resuspension by wind or carp activity. Strategically, the discharge of suspended solids into these shallow areas may be more critical than other discharges.

Potential Action #1 Do Nothing

Failure to reduce the loading of suspended solids to the Harbour, especially in the loadings from the creeks, will negate any efforts to achieve a viable water quality for swimming, and will counteract most efforts to re-establish fish habitat in the Harbour. The most sensitive areas are those around the mouth of Indian Creek (northeast part of the Harbour) and the area at the west end affected by discharges from Grindstone Creek and Cootes Paradise (see loading factors in Figure 13). Potential swimming areas at LaSalle Park and around the Lax property are also affected by local creeks that need remediation.

Doing nothing about suspended sediment loading would likely give rise to faster burial of contaminated sediment in the Harbour but some of the loading is of dubious quality itself, and it is not yet established whether or not sediment burial is an appropriate way to address the trace metal and trace organic contaminants in the existing bottom sediments.

As noted in previous sections, failure to address reductions of loading of silt discharged into the Harbour near navigation areas generates greater need for dredging and consequent infilling of habitat through the construction of more and larger confined disposal facilities.

This option is not recommended.

Potential Action #2 Improved Stormwater Management

Better stormwater management should reduce erosion in creeks.

This measure is strongly recommended, especially when combined with measures to address sewer overflows associated with storms in areas with combined sewers (Refers to Recommendation #6 in a general sense).

Potential Action #3 Improved Erosion Control at Construction Sites

Studies have established that a major portion of the suspended sediments in streams arises from erosion at construction sites. While plans for construction projects include erosion control, these are not sufficiently effective, due, in part, to lack of understanding of the reason for such control, and in part due to lack of understanding of the techniques necessary to ensure good erosion control.

It is therefore recommended that inspectors and construction foremen be provided the opportunity to be certified in the technical aspects of erosion control at construction sites (see Recommendation #5).

Potential Action #4 Enforcement of Erosion Control Regulations

Better enforcement of erosion control measures is required at all construction sites.

This is strongly recommended (see Recommendation #5).

Potential Action #5 Soil Conservation in the Rural Communities of the Watershed

Erosion in urban areas and in developing areas is probably the major source of suspended sediments to the Harbour. The reason is that most of the main rivers and streams in the watershed form reservoirs near the brow of the Niagara escarpment. These reservoirs, while serving other recreational and conservation goals, act as traps for upstream erosion and as regulators of high flows downstream.

Premature filling of these reservoirs is counter productive, however.

Therefore, it is recommended that the farming community employ soil conservation measures and be aided through such programs as the OMAF Land Stewardship program (see Recommendation #4).

Potential Action #6 Reduction of Stream Bank Erosion

Below the escarpment there are certain areas that are particularly prone to erosion. These need to be identified and assessed for potential to use 'hard' and 'soft' measures to reduce erosion from stream banks.

This is recommended (see Recommendation #6).

Potential Action #7 Reduction of Combined Sewer Overflows

This has been discussed above (option #1) and in the sections on phosphorus and ammonia controls. This is one further reason to address this major problem, and is again highly recommended (see Recommendation #1).

Potential Action #8 **Reduction of Suspended Solids Loadings to the Harbour from STPs**

Reduction of STP loadings of suspended solids by 50 to 70 percent is likely to occur with phosphorus controls. This is a useful side-effect of the more stringent phosphorus conditions on STPs (see Recommendation #1).

Potential Action #9 **Reduction of Suspended Solids from Industrial Discharges**

Like CSOs, navigation benefits will accrue to a reduction of industrial discharges of suspended solids. In general, this is accompanied by a reduction in trace metal and trace organic loadings.

This will be addressed in the Municipal and Industrial Strategy for Abatement (MISA) of persistent toxic chemical discharges (see Recommendation #28).

Potential Action #10 **Street Cleaning**

Tracking of soil from construction sites to local roads is unavoidable, as is the build-up of silt that washes from roads into storm sewers that drain into the creeks and Harbour.

It is recommended that some care be taken to clean streets on a regular basis in areas where there are unusual amounts of mud or silt build-up (see Recommendation #5).

IV.4 Overview of Loading Reductions: Cootes Paradise
IV.4.1 Phosphorus Loading
IV.4.1.1 Historical Actions

Phosphorus inputs must be reduced to control algal growth. The average retention time in Cootes Paradise is only 2.7 days during the year. However, about a 20-day retention time occurs during the summer low-flow period. Control of available phosphorus inputs during the peak algal growing season of mid-April to mid-September is important.

The total loading of phosphorus to Cootes Paradise during the peak algal growing season has decreased from about 55 kg/day in the mid-1970s to about 42 kg/day in 1989 as a result of improvements at the Dundas municipal STP. The average loadings of phosphorus to Cootes Paradise, from mid-April to mid-September, are shown in Figure 14 for the years since 1975. Also shown in Figure 14 are the concentrations of phosphorus measured in Cootes Paradise. The sources of phosphorus inputs and their relative contributions in 1989 are shown in Figure 15 for the peak algal growing season.

Figure 14: Cootes Paradise - Phosphorus Loading & Concentration

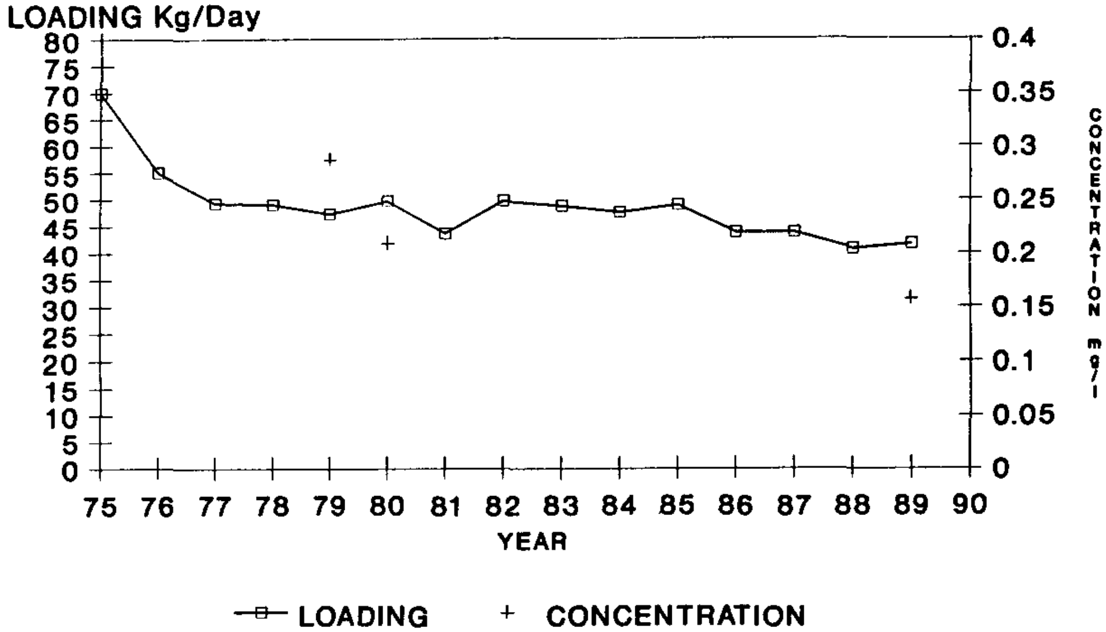
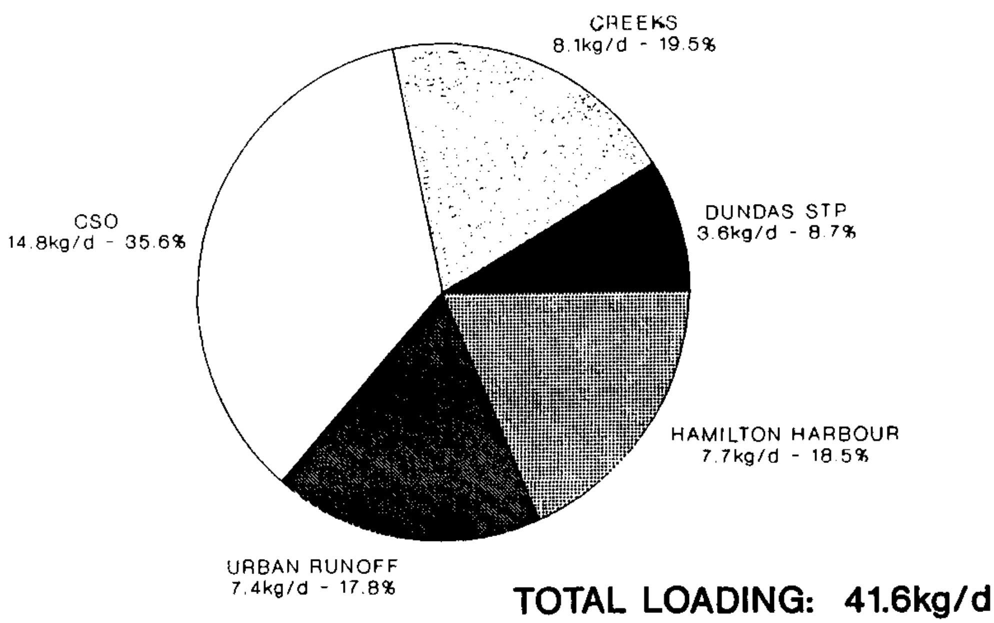


Figure 15: Cootes Paradise - % Phosphorus Contribution by Source (1989)



Source: J. Vogt, OMOE/WCR

IV.4.1.2 Current and Proposed Actions

The combined sewer overflows are the largest source of phosphorus input to Cootes Paradise during the peak algal growth season with 15 kg/day being discharged in 1989. The Regional Municipality of Hamilton-Wentworth has design work under way to reduce the CSO loading by installing a retention basin at one of the five CSOs discharging to Cootes Paradise, and in addition, has installed filters at the Dundas plant which have reduced the phosphorus loading. Demonstration of step-feed control techniques are currently under way to maintain efficiency of treatment during peak flow periods. As well, modifications are being made to optimize chemical treatment for further phosphorus reductions.

The creeks represent a large source of phosphorus with a loading of 8.1 kg/day in 1989. Studies to identify the sources and the possible abatement measures indicate that erosion in housing development construction may be a major source. It is reasonable to expect, however, that at least a 30 percent reduction can be attained. The contribution from creeks therefore can probably be reduced to about 6 kg/day.

With filters at the Dundas municipal STP and the step feed control system that reduces the frequency of STP bypassing incidents, reduction of inputs from creeks by one third and elimination of CSOs, the available phosphorus loading to Cootes Paradise during the peak algal growing season would be substantially reduced. The phosphorus concentration in Cootes Paradise would be reduced to about 58 μg/L. The turbidity caused by algae would therefore be reduced by 40 percent. Algal chlorophyll accounted for less than 10 percent of the variability of turbidity during 1987. Turbidity in Cootes Paradise is mainly impaired by silt.

IV.4.2 Suspended Solids Loadings
IV.4.2.1 Historical Actions

The sources of suspended solids and their relative contributions to Cootes Paradise are shown in Figure 16. By far the largest source of suspended solids loading is from the creeks, which represent 50 percent of the total loading to Cootes Paradise in 1989.

Soil erosion adds to turbidity in Cootes Paradise. The most common practice in the construction of subdivisions is to first strip off the top soil. Sewers and water mains are then installed and the homes and streets constructed. The top soil is then replaced and the lots are sodded. Between the stripping of the top soil and resodding, the erosion rates are very high. With development, the water retention capabilities are reduced resulting in more rapid precipitation runoff. The more rapid runoff, in turn, causes higher peak stream flows which result in increased erosion of stream beds and banks.

The larger stream bed gradients in the hilly areas now under development make the problem more serious. As well, the trend in the farming community has been towards the planting of more row crops such as corn. Soil is less protected from erosion with these crops. Measures to control soil erosion include: settling basins for runoff from construction sites; storm retention basins to reduce peak storm flows; installing riprap on creek beds and banks susceptible to erosion and modifying farm practices to minimize soil loss. Two studies have been carried out demonstrating the potential for improvement in both types of erosion control.

Carp also cause turbidity by stirring up the bottom sediments during their activities. They also uproot aquatic plants. The loss of aquatic plants results in wind and wave energy reaching further down into the water column and perhaps reaching the sediments. Cootes Paradise is shallow and approximately 70 percent of its sediment surface is susceptible to wind and wave resuspension of silt since the aquatic plants are missing. Carp control by commercial fishermen was promoted by the Royal Botanical Gardens during the 1950s and aquatic plants returned. Means of controlling carp will have to be determined if aquatic plants are ever to return to the open waters of Cootes Paradise (see Section IV.10.7.3).

IV.4.3 Ammonia Loadings

Ammonia loadings to Cootes Paradise for 1989 are shown in Figure 17. Ammonia is not considered a serious problem here except possibly very near the STP and CSO effluents. Generally the entire area is shallow and well aerated and this mitigates ammonia problems.

IV.4.4 Evaluation of Potential Remedial Actions for Cootes Paradise - Eutrophication

The generic methods for reducing the pollution stress on Cootes Paradise are covered already in the sections on Hamilton Harbour. Restoration of marsh habitat is crucial in this area. The options to deal with marsh redevelopment are:

a) to isolate areas from water pollution and carp stress, and

b) to reduce the stress by both water pollution and carp on the area to see if it can be re-established in a more natural balance with normal drainage processes.

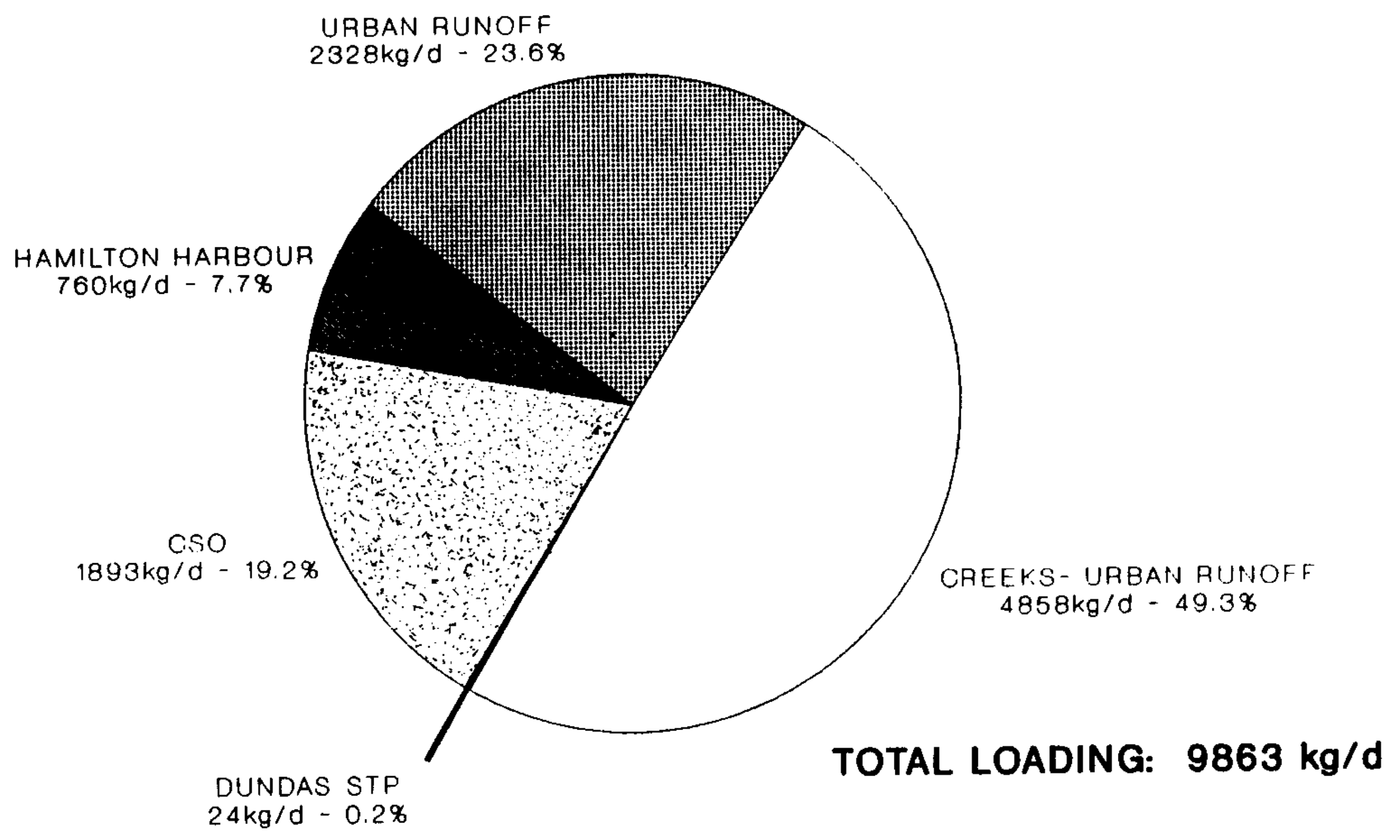
The second is the preferred option. Hence, a priority is recommended on reducing the stress on the marsh from combined sewer overflows, the suspended sediment load from the creeks (particularly Spencer Creek), and the pollutants from the Dundas STP.

IV.5 Toxic Contamination: Trace Metals and Trace Organics

IV.5.1 Background

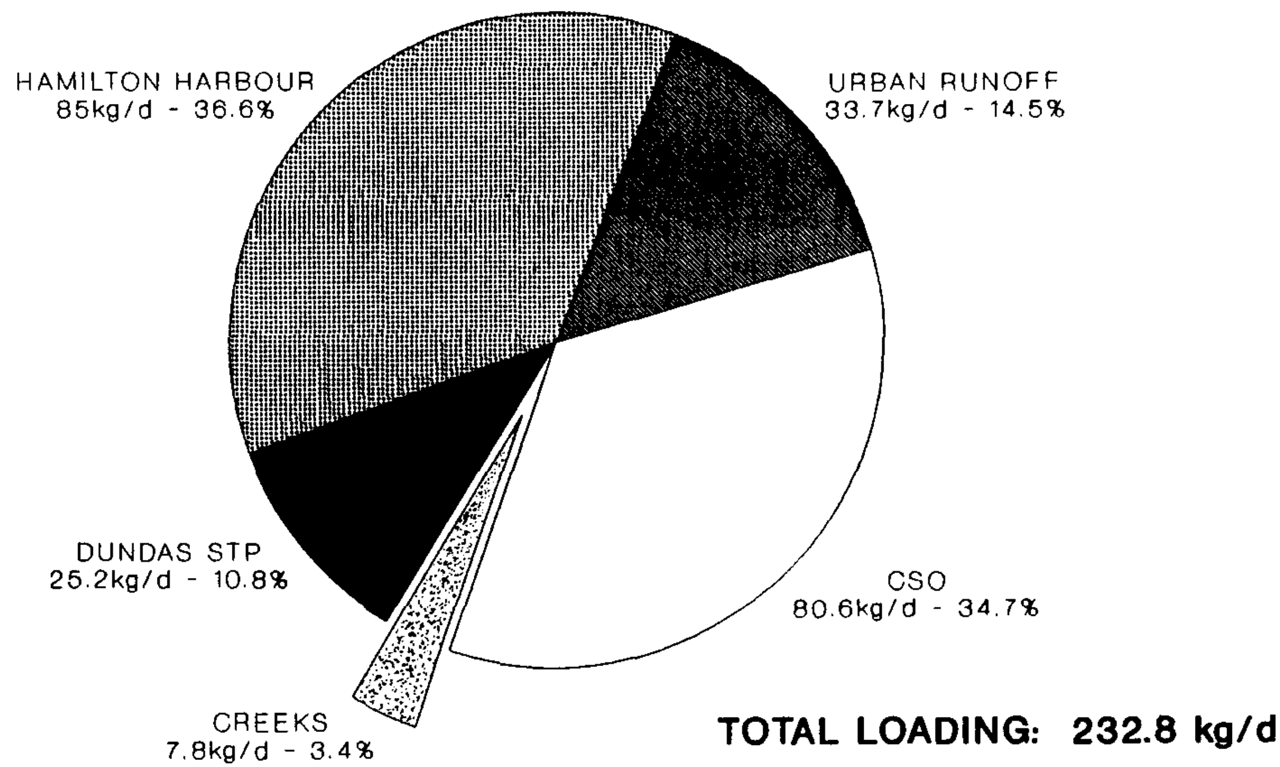
The goal of the Hamilton Harbour RAP is an environment that allows the presence and natural reproduction of the most sensitive native species of aquatic and terrestrial life, and that prevents any contaminant-related restrictions on fish consumption.

Figure 16: Cootes Paradise - % Contribution Suspended Solids by Source (1989)



Source: J. Vogt, OMOE/WCR

Figure 17: **Cootes Paradise - % Contribution Ammonia by Source (1989)**



Source: **J. Vogt, OMOE/WCR**

Current local concerns are related to impacts associated with the presence in the Harbour water and sediment of:

1. metals such as cadmium, zinc, iron, nickel, and lead,
2. organochlorine compounds such as PCBs, Mirex, and DDT metabolites,
3. PAHs such as benzo(a)pyrene and naphthalene.

The main reasons for concern are toxic effects on desirable aquatic biota, particularly benthic macroinvertebrates (see for example, Figure 18), and food web uptake and transfer leading to potential health effects (such as tumours and deformities) in top predator species such as fish-eating birds, reptiles, and mammals (including humans).

IV.5.2 Water

Recent data demonstrate that, in general, water column concentrations of trace metals and organics either comply with the Provincial Water Quality Objectives (PWQO) or are seldom detectable at currently measurable concentrations. Much of the Harbour exhibits concentrations of metals and organics similar to those observed in the nearby open Lake, and it is likely that the Harbour is influenced by the same range of indirect sources such as atmospheric deposition and lake-wide recycling from sediment and biota.

Future concerns may emerge as the result of the ongoing development of additional water quality objectives for chlorinated organics and PAHs, and the improvement of routinely available detection limits for these, or similar, compounds. However, current local water quality concerns associated with trace metals and organics cannot easily be separated from the larger issue of lake-wide conditions and impacts.

IV.5.3 Sediment

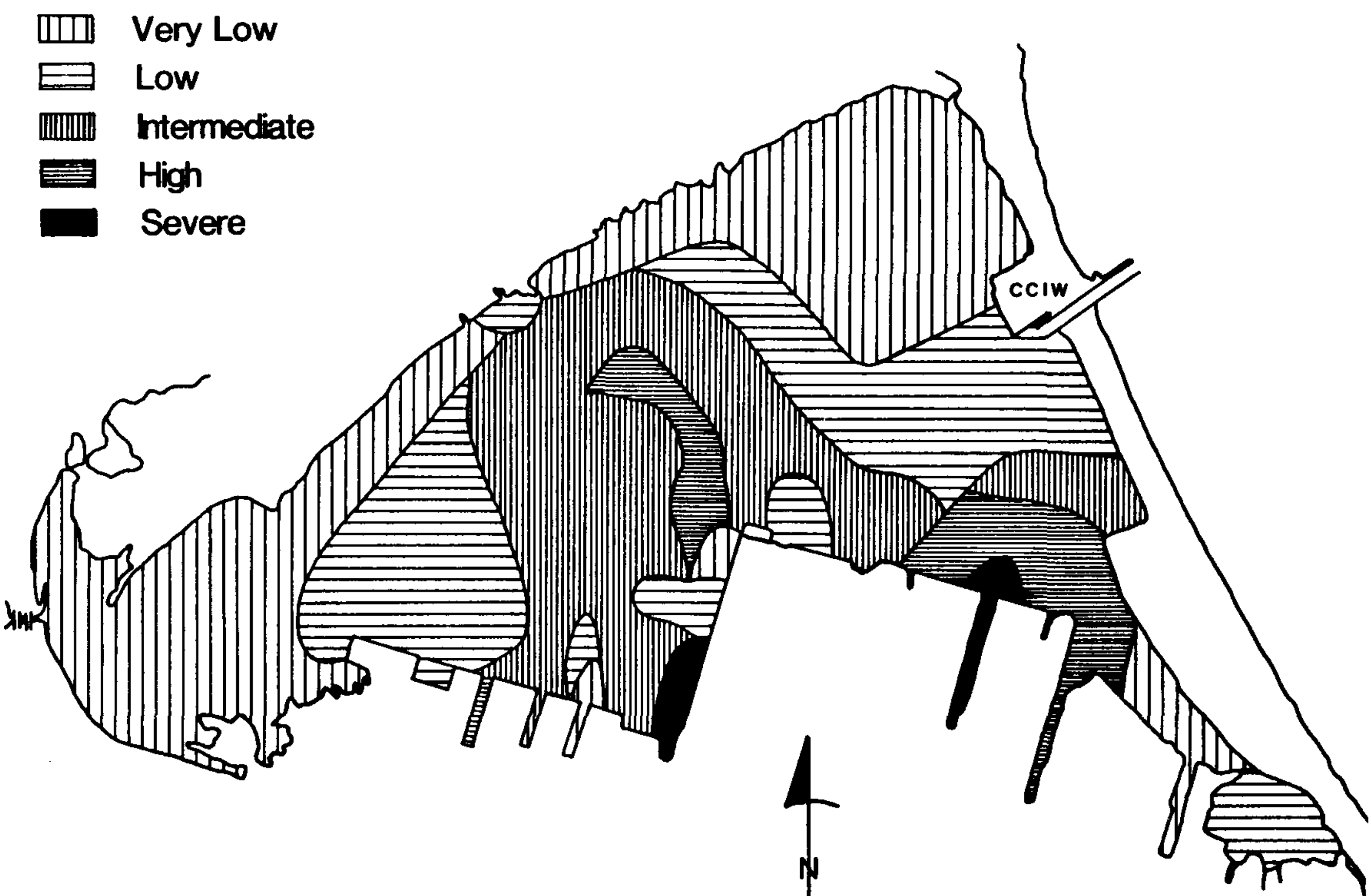
Sediment conditions can be summarized as follows:

1. metals and PCBs throughout the Harbour sediments are generally found at concentrations greatly in excess of draft provincial sediment guidelines.

2. *in situ* assessment of benthos indicates a stressed community structure dominated by pollution-tolerant species.

3. laboratory bioassessment of sediments using oligochaetes, bacteria, Daphnia, and mayfly larvae have identified a large zone where, under oxygenated conditions, the sediment causes significant mortality, inhibits growth, and interferes with reproductive success (depending on the test organism).

Figure 18: Acute Toxicity of Hamilton Harbour Sediments February 1, 1989



Source: T. Murphy, NWRI.

These results have led to the general conclusion that trace metals and organics associated with sediment, and the processes that perpetuate continued contamination of sediments, are currently of greater concern than those associated with the water column. Since no significant mortality to Daphnia or mayfly larvae was observed in sediment from the western portion of the Harbour, the contaminant levels in these sediments have been designated as interim local targets for abatement of the contaminated portion of the Harbour.

Assessment of both chemical and biological information currently available allows the contaminated sediment problem to be divided into:

1. a high priority problem associated with sediment "hot spots", where acute biological effects and grossly elevated concentrations of metals and PAHs may warrant a clean-up operation, and

2. a more general problem associated with a large zone of sediment, chiefly affected by historical accumulations of metals and PAHs resulting from previously elevated industrial loadings.

IV.5.4 Biota

Available information on trace contaminant concentrations in the tissues of algae, macroinvertebrates, and fish demonstrates uptake of trace metals and organics from water and sediment. There are currently consumption advisories for several fish species due to one or more of mercury, Mirex, and PCBs; and liver and skin neoplasms and epidermal papillomas have been reported on several species.

There are presently no tissue concentration guidelines for species other than fish, and interpretation of biological tissue information is difficult due to the potential for exposure to contaminants in the open Lake, from historical accumulations in Harbour sediment, as well as from current discharges from municipal and industrial sources.

IV.6 Hamilton Harbour: Water Column
IV.6.1 Zinc Loading
IV.6.1.1 Historical Actions

Annual average zinc loadings to the Harbour are shown in Figure 19, along with the zinc concentrations in the Harbour water. A major reduction in zinc loading to the Harbour occurred in the early 1980s when Stelco completed installation of a system for recirculation of blast furnace wastewaters. This improvement reduced the zinc loading to the Harbour from about 800 to 200 kg/day. As a result of this reduction, the zinc concentration in the Harbour dropped from about 0.05 to 0.018 mg/L. Since then, further improvements at the steel mills have reduced the total loading to the Harbour to about 110 kg/day in 1989, with the concentration in the Harbour water at about 0.017 mg/L.

IV.6.1.2 Recent Actions

The zinc concentration is now within the Provincial water quality objective of 0.03 mg/L on virtually all occasions, even in the vicinity of point source discharges. The sources of zinc discharged to the Harbour and their contributions in 1989 are shown in Figure 20.

Dofasco has recently installed blast furnace wastewater recirculation. As well, Stelco has been making improvements to minimize equipment breakdowns and to improve the efficiency of the filtration plant. With these changes, the loading from Dofasco is expected to be reduced to 19 kg/day and the loading from Stelco to about 30 kg/day. Thus, the total zinc loading to the Harbour is expected to be reduced to 73 kg/day with an average concentration of zinc in the water column of 0.01 mg/L.

IV.6.2 Phenols Loading
IV.6.2.1 Historical Actions

The annual average total loading of phenols discharged to Hamilton Harbour since 1974 is shown in Figure 21 along with phenols concentrations measured in the Harbour water. The loading has been reduced from about 2,600 kg/day in the early 1970s to about 15 kg/day in 1989 as a result of controls installed by the steel mills. The concentration of phenols in the Harbour water was less than 0.4 well within the Provincial water quality objective of 1 μg/L. In the past two years μg/L in 1987, this has risen above the objective, to 2.3 μg/L. The reason for this has not yet been discovered. No deleterious impact of these increases has been noted in the Harbour.

IV.6.2.2 Recent Actions

The sources of phenols discharged to the Harbour are shown in Figure 22 along with 1989 relative contributions. Essentially all of the phenols originate from the steel mills with Stelco representing 43 percent of the total load in 1989.

Stelco completed its major programs for control of discharges of phenols in mid-1987.

IV.6.3 Polynuclear Aromatic Hydrocarbon (PAH) Loading
IV.6.3.1 Historical Actions

Knowledge of the historical loadings for PAHs is limited since technology for monitoring these chemicals in the concentrations found in the effluents (ng/L range) is a relatively recent development. The total PAH loading to the Harbour from point sources was found to be 1.8 kg/day in 1986 and 0.89 kg/day in 1988, with the loading for benzo(a)pyrene being 0.068 kg/day in 1986.

Figure 19: Hamilton Harbour - Zinc Loading and Concentration

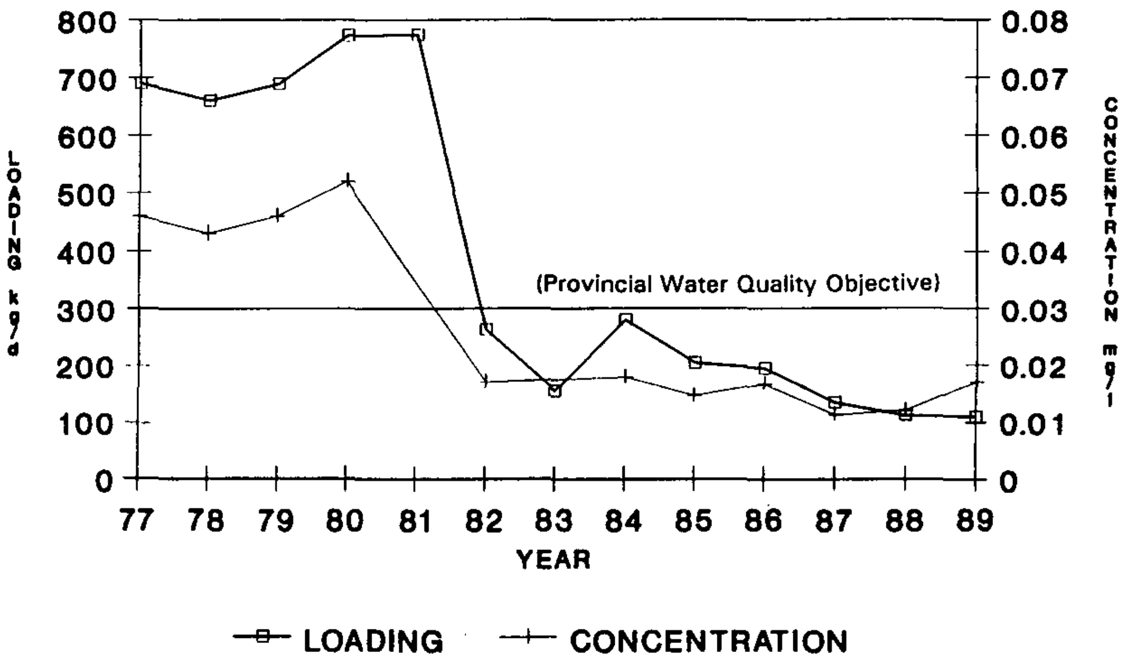
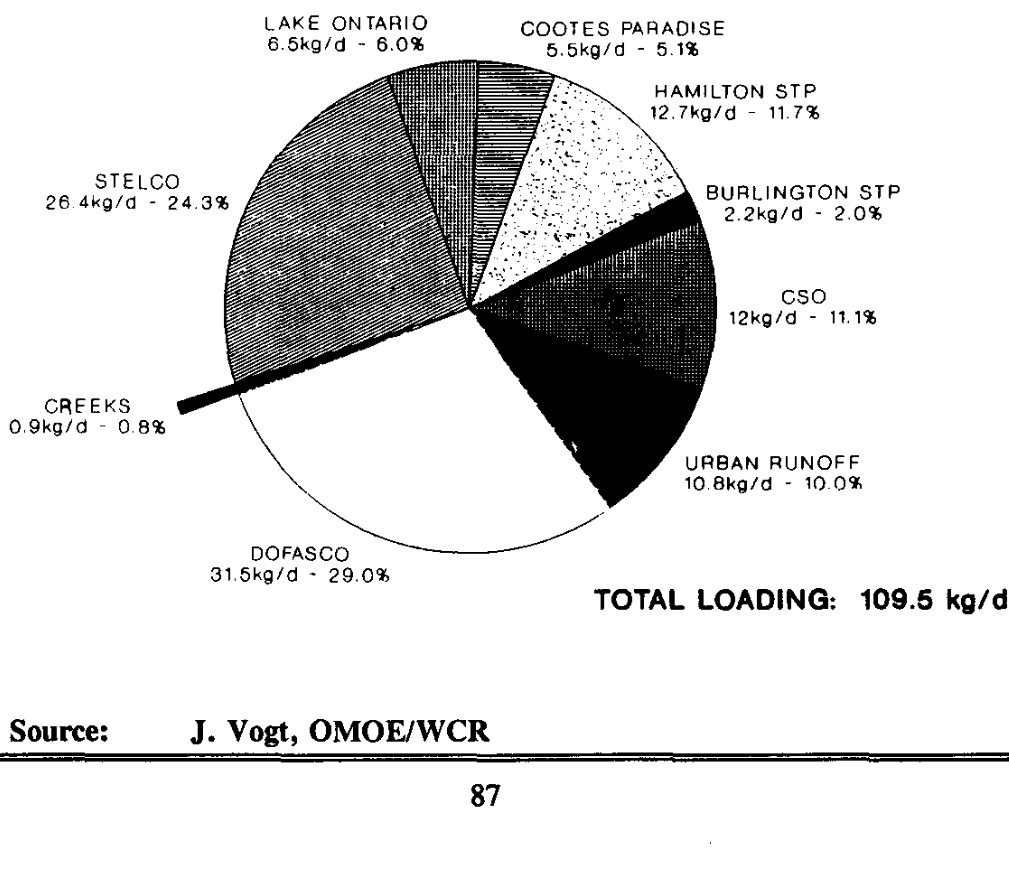
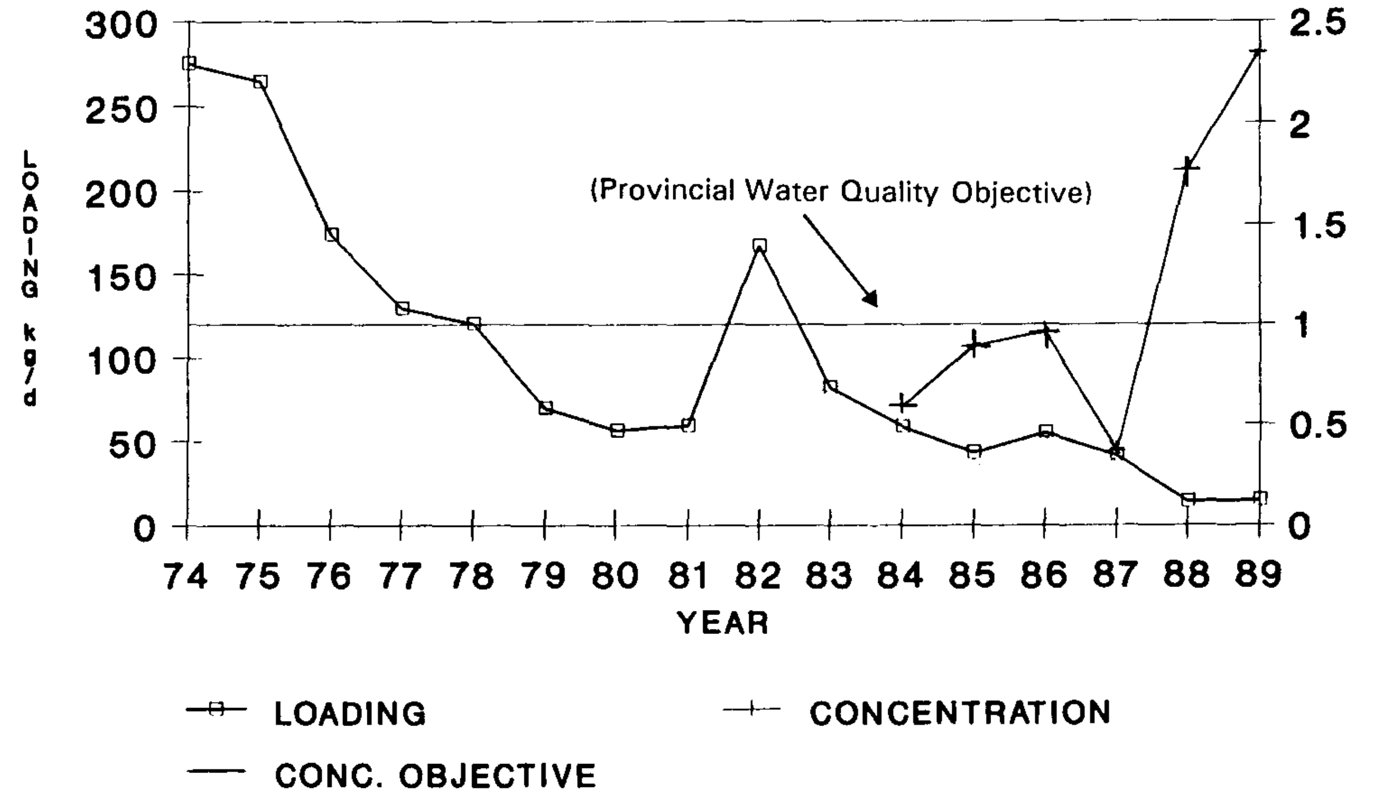


Figure 20: Hamilton Harbour - % Zinc Contribution by Source (1989)



Source: J. Vogt, OMOE/WCR

Figure 21: **Hamilton Harbour - Phenols Loading and Concentration**



Source: J. Vogt, OMOE/WCR

IV.6.3.2 Current Actions

The wastewater treatment facilities installed to control conventional parameters are also efficiently removing PAHs. The current PAH loading is probably a fraction of a percent of what they were 20 years ago. The sources of the present discharges and their relative contributions to the total loading are shown in Figure 23. The control works installed by the steel mills in 1987 and in 1988 are expected to reduce the PAH loading to the Harbour from point sources to less than 1 kg/day.

PAHs are not easily detected in the Harbour water column but some data are about to be published. They are, however, found extensively in bottom sediments. Historical sediments in some parts of the Harbour are found to contain greater than 1400 $\mu g/g$ of total PAHs as compared to 4 $\mu g/g$ in sediment deposited in 1987. The loadings from all sources are deemed to be low enough that PAH-contaminated sediment may be removed without too much concern that they will be re-contaminated.

IV.6.4 Cyanide Loading
IV.6.4.1 Historical Actions

Essentially all of the inputs of cyanide to the Harbour are from the steel mills. With the installation of pollution control facilities, the cyanide loading to the Harbour has been reduced from about 850 kg/day in 1978 to about 50 kg/day in 1989. The total loadings of cyanide to the Harbour since 1974 are shown in Figure 24. The sources of cyanide and their relative contributions in 1989 are shown in Figure 25.

IV.6.4.2 Current Actions

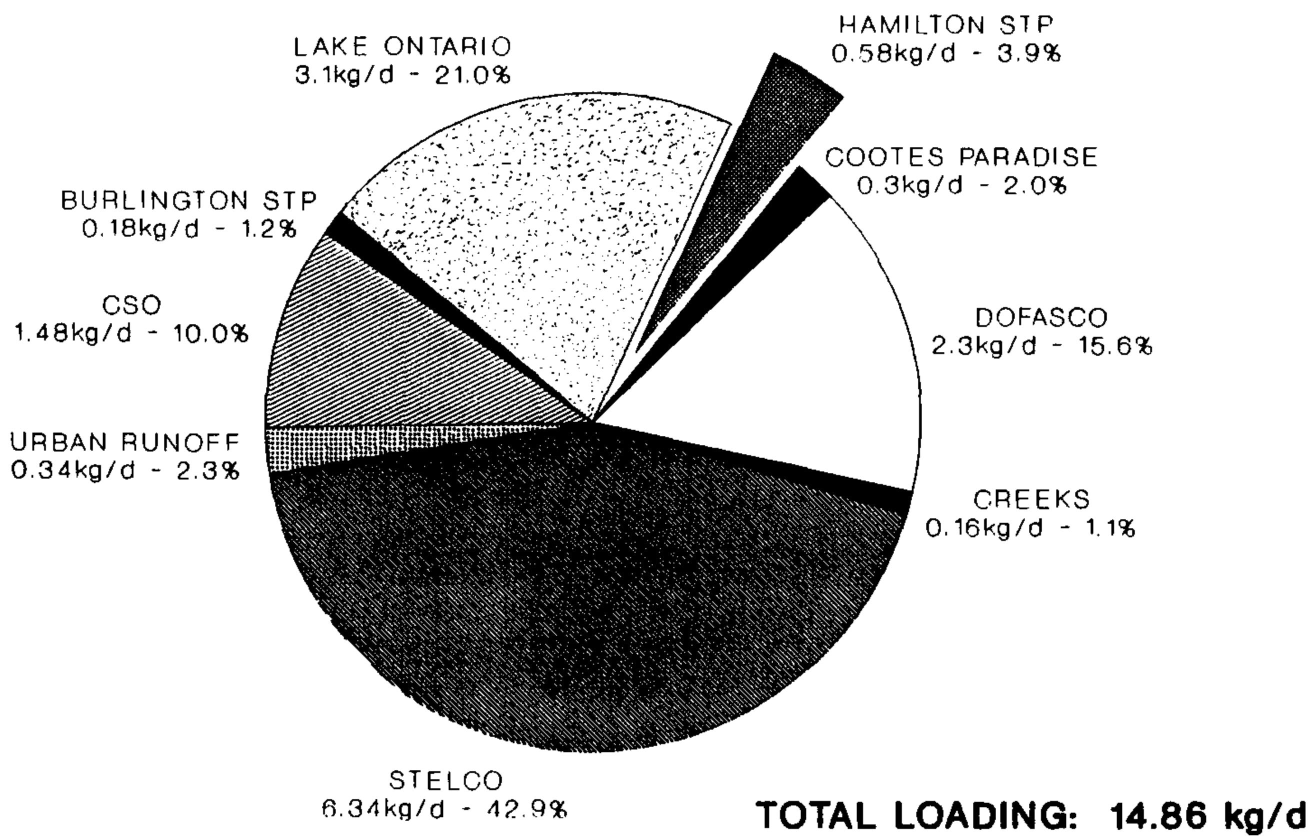
The completion of further control works by Stelco in 1987, and by Dofasco in 1988 have reduced the total cyanide loading to less than 50 kg/day.

In the latter 1970s, when the loadings to the Harbour were in the order of 850 kg/day, occasional concentrations exceeding the 0.005 mg/L Provincial Water Quality Objective for cyanide were found in the Harbour water column. With the reduced loadings, this would no longer be expected.

IV.6.5 Iron Loading Reductions
IV.6.5.1 Historical Actions

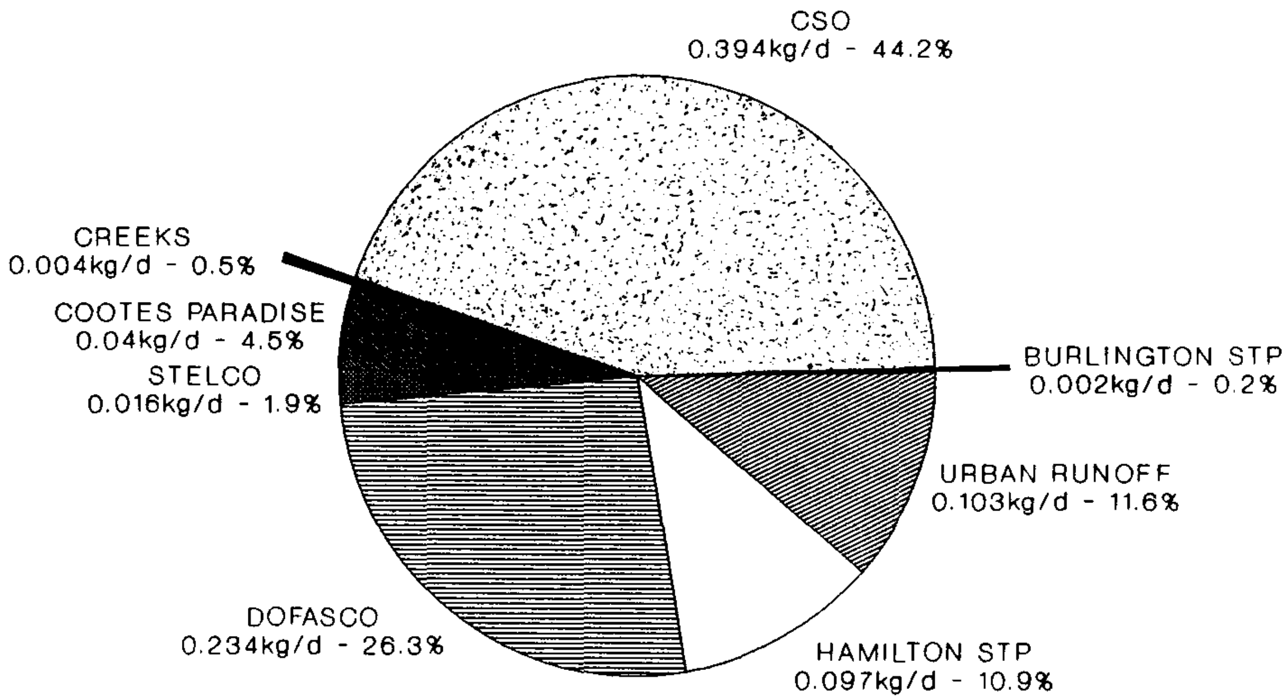
The iron loading to the Harbour in 1989 was about 3,000 kg/day, compared to about 20,000 kg/day in the early 1970s. The reductions have occurred as a result of installation of improved pollution control facilities by the steel mills. The total loading to the Harbour since 1974 is shown in Figure 26 along with the concentrations in the Harbour water column. The sources of the iron input and their relative contributions are shown in Figure 27.

Figure 22: Hamilton Harbour - % Phenols Contribution by Source (1989)



Source: J. Vogt, OMOE/WCR

Figure 23: **Hamilton Harbour - % Contribution by Source Polynuclear Aromatic Hydrocarbons (1988)**



TOTAL LOADING: 0.891 kg/d

Source: **J. Vogt, OMOE/WCR**

Figure 24: Hamilton Harbour - Cyanide Loading and Concentration

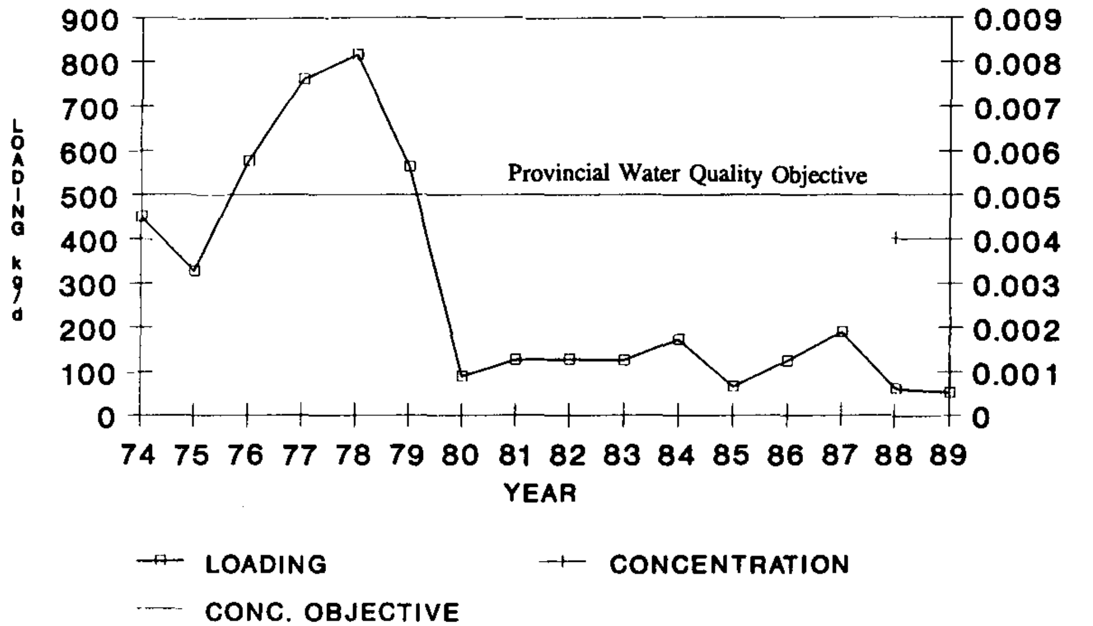
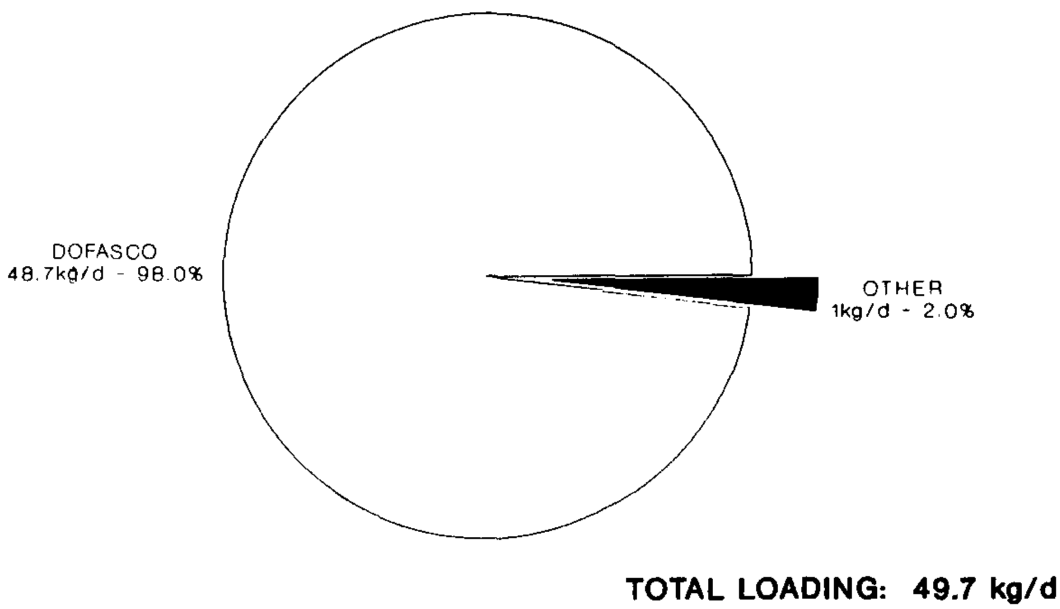
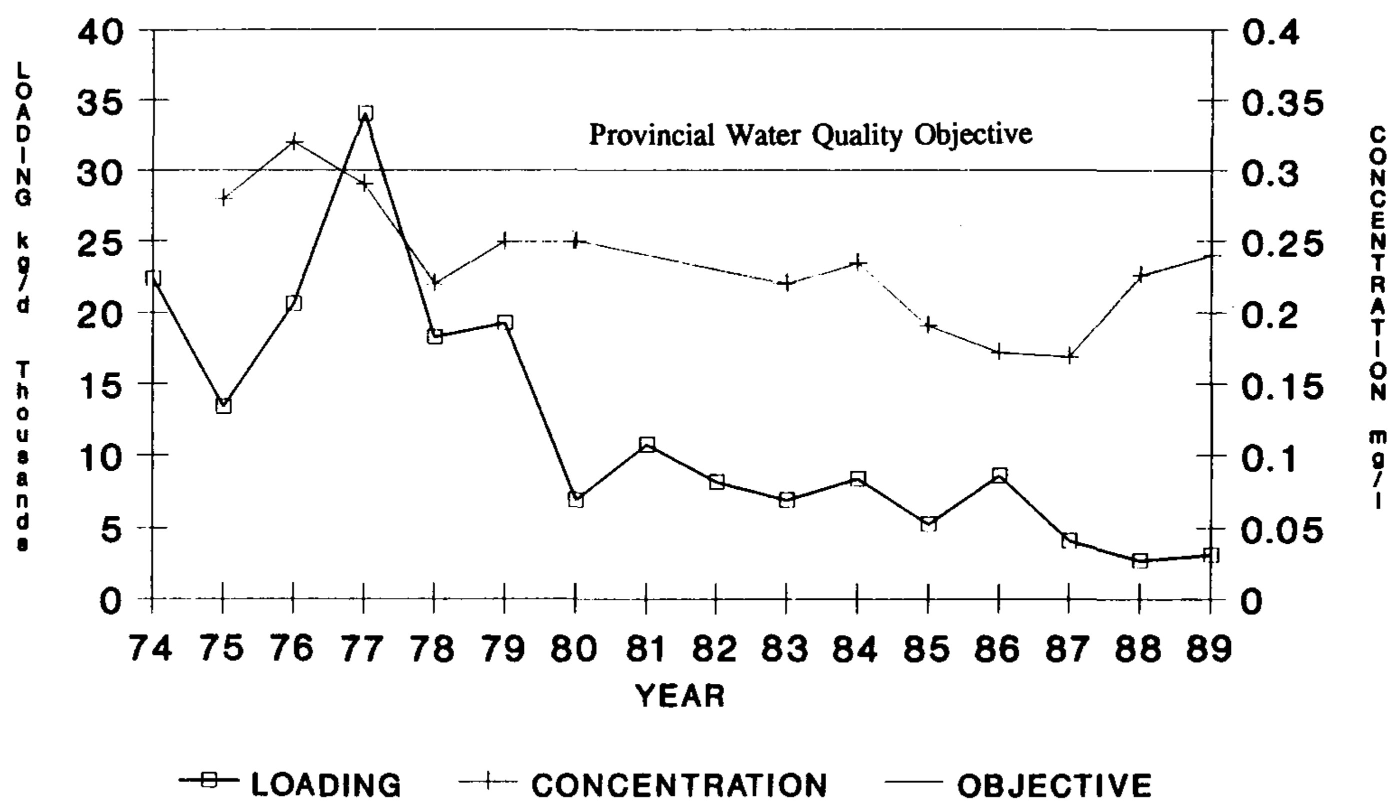


Figure 25: Hamilton Harbour - % Cyanide Contribution by Source (1989)



Source: J. Vogt, OMOE/WCR

Figure 26: Hamilton Harbour - Iron Loading and Concentration



Source: J. Vogt, OMOE/WCR

In the late 1970s, occasional concentrations above the Provincial Water Quality Objective for iron (0.3 mg/L) were found. With the reductions of inputs that have occurred since then, such values are not now found except in the extreme south-east corner of the Harbour on a few occasions each year.

IV.6.6 Other Trace Contaminants

IV.6.6.1 Introduction

A series of other trace contaminants have been tracked in some detail as methods are sought to continually reduce trace contaminant loadings even though, in many cases, the water quality objectives may already be met. These loading objectives are currently being reviewed with not only water quality, but also sediment quality in mind. Remediation of contaminated sediment can be rendered ineffective if the new sediment surface material being laid down does not meet the standard. This standard would have to be met whether removal or *in situ* treatment or capping is to be carried out, or whether we depend on new sediment to inactivate old contaminated sediments with natural burial.

IV.6.6.2 Lead

Reference to the estimates for lead loading to the Harbour in 1989 (Figure 27) illustrates the predominance of the combination of combined sewer overflows, urban runoff and Cootes Paradise discharge. These strongly suggest that the origin of the lead is from street runoff and its source is gasoline. Restrictions have been put in place banning the use of leaded gasoline and after another year these lead loadings should be re-assessed based on additional direct measurements.

IV.6.6.3 Copper and Chromium

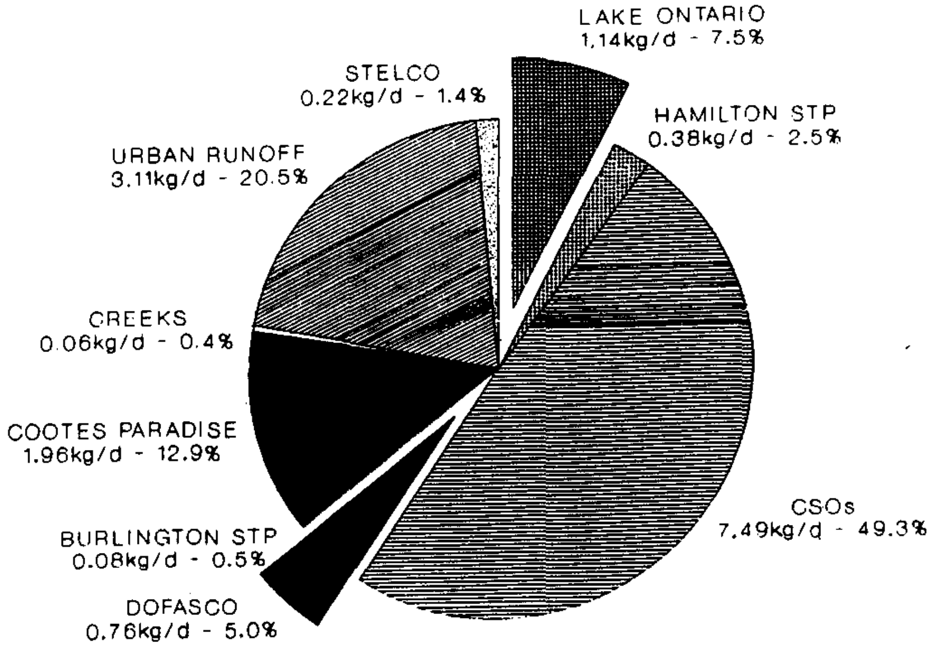
Of copper and chromium, only copper periodically (15% of observations in 1987) exceeds the water quality objectives. Copper is also concentrated in sediments near some STP effluents such as in West Pond in Cootes Paradise. One major source of copper is leaching from copper plumbing - a difficult source to 'turn off'. Copper, like zinc, iron and chromium is also one of the essential nutrients at very low levels.

Both the copper and chromium source charts (Figures 27 and 28) show the predominance of Lake Ontario water as a source. Clearly the concentration in the main body of the Harbour, which is 80 percent Lake Ontario water, will be heavily influenced by the concentrations of these trace metals in Lake Ontario water. In the case of copper, the Lake water is so close to the objective that any small sources at concentrations just above the objective are not readily diluted below the objective in the Harbour.

IV.6.6.4 Current Actions

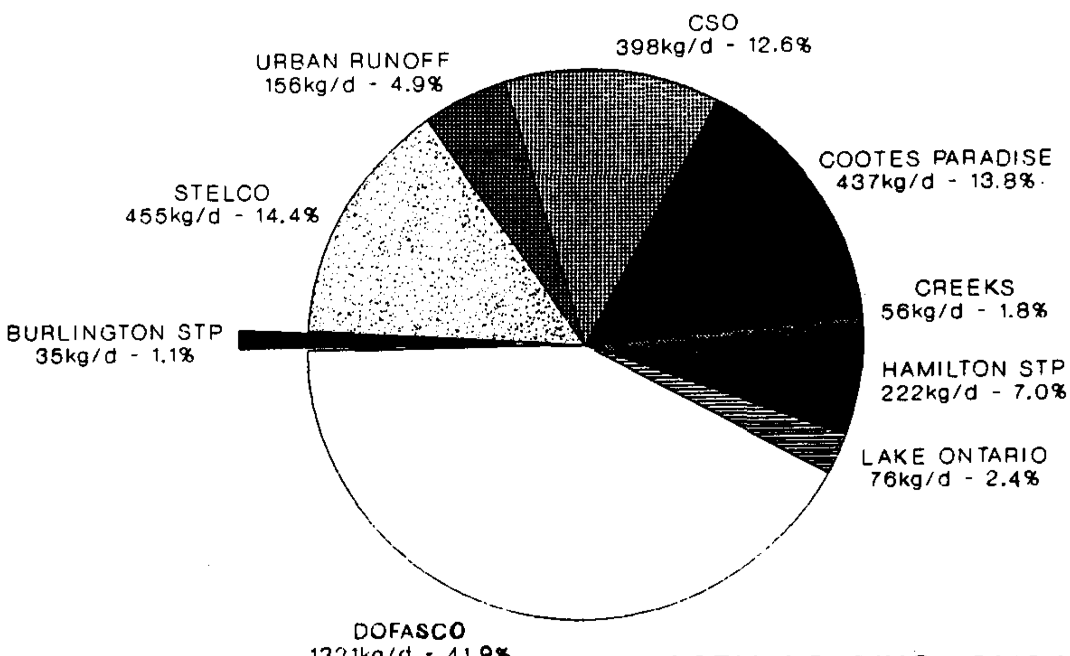
Persistent trace metals and trace organics are targeted in the Provincial program designated the Municipal-Industrial Strategy for Abatement (MISA). The Iron and Steel sector of the MISA program includes the only two industrial direct dischargers to the Harbour.

Figure 27: Hamilton Harbour - % Lead Contribution by Source



TOTAL LOADING: 15.20 kg/d

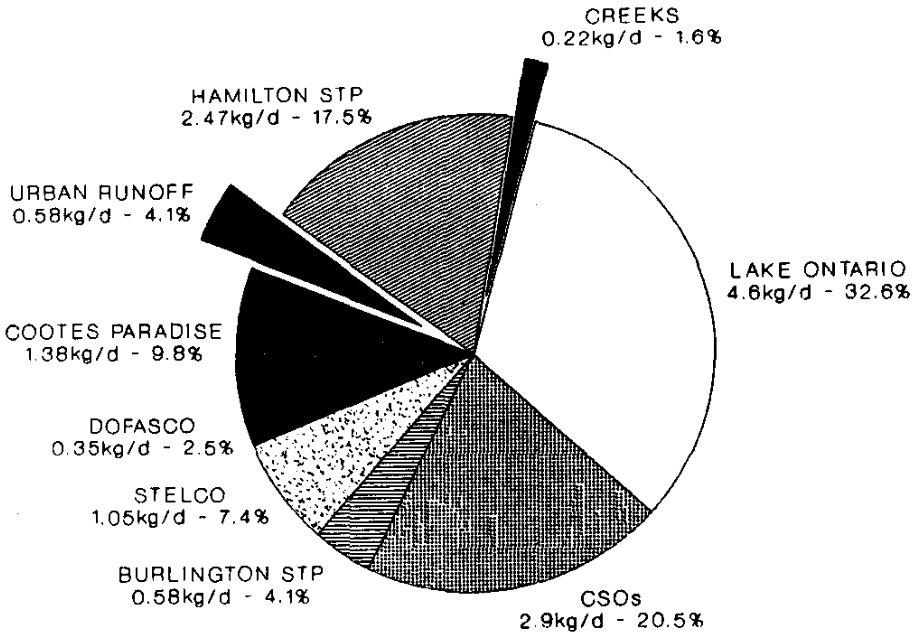
Figure 28: Hamilton Harbour - % Iron Contribution by Source (1989)



TOTAL LOADING: 3156 kg/d

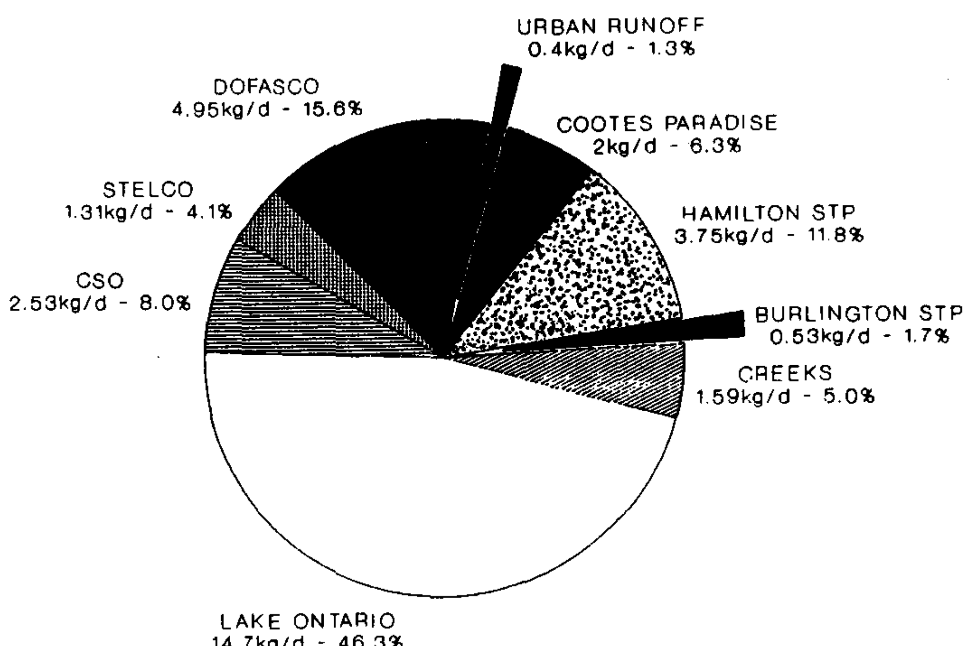
Source: J. Vogt, OMOE/WCR

Figure 29: Hamilton Harbour - % Copper Contribution by Source



TOTAL LOADING: 15.1 kg/d

Figure 30: Hamilton Harbour - % Chromium Contribution by Source



TOTAL LOADING: 31.9 kg/d

Source: **J. Vogt, OMOE/WCR**

Monitoring has been completed and is now being assessed along with designation of the best available technology that is economically achievable (BATEA). Results are due in 1991 and 1992, respectively.

Research and development is exploring suitable technologies for this industry and environmental research is charged with developing the minimum environmental site requirements to see where priority may lay in moving towards virtual elimination.

The largest Regional Municipality in the watershed, Hamilton-Wentworth, has been chosen as a pilot site for development and application of a new sewer use by-law under the MISA program. The Region, with the support of the province, has established the laboratory capability and inspection staff to identify industries and businesses contributing up to 90 percent of the loading of trace metals and trace organics. The report for this analysis and the consequent control program (depending on prevention, re-use, or pre-treatment technology) is due later in 1991.

IV.6.6.5 Potential Remedial Actions for Trace Metals and Trace Organics Loading Reductions

In general terms the priority for dealing with these substances is:

1. Reduce the use of the material or reduce its production if it is generated in an industrial process.

2. Re-use the material in the same or another application.

3. Treatment of the discharge by changing it to a less harmful form, or find a secure containment facility for historical accumulation (and/or sewage sludge).

Within this context, the specific options that may be considered are:

Action #1 Do nothing.

Action #2 Expedite the MISA program for the Iron and Steel Sector.

Action #3 Expedite the MISA program for control of discharge of trace contaminants to the sewer system.

Action #4 Mount or expand programs to inform citizens on the careful and minimal use of toxic materials, pesticides, etc., and, where the use of solvents, paints, and cleaners is unavoidable, to employ proper disposal methods.

Action #5 Operate an expanded program of toxic chemical disposal centres to make it easier for citizens to deal with residues of toxic materials.

Action #6 Optimize sewage treatment plant operations for their maximum potential to extract persistent toxic chemicals from the effluent.

Action #7 Further control on spills and carry out procedures to ensure constant vigilance in dealing with the potential for spills.

Action #8 Find the means to reduce the use of chlorine in disinfecting sewage treatment plant effluent.

IV.6.6.6 Evaluation of Potential Remedial Actions for Trace Metals and Organics

Potential Action #1 Do Nothing

Doing nothing further, and assuming that production and process do not change in those industries discharging directly to the Harbour or to the sewer systems, will not change the fact that current violations of water quality criteria are due to STP discharges and 'recycling' of contaminants inside the Harbour through resuspension of sediments.

However, in such a scenario, no further progress would be made towards virtual elimination/zero discharge. And there is potential to move further with that objective if we elect to do so.

It is not recommended that we do nothing further. We make a small, but measurable contribution to the persistent toxic chemical loading to Lake Ontario, and unless we match the efforts of other U.S. and Canadian communities we will not be doing our share to clean up the larger part of the basin that supplies us with drinking water and could supply us with cleaner fish.

Potential Action #2 MISA - Iron and Steel Sector

Under the MISA program, Best Available Technology that is Economically Achievable (BATEA) is to be the standard in Phase 1. Monitoring has been completed and specifications for the treatment/source reduction methods will be set in 1992.

It is recommended that this component of the MISA program be expedited (see Recommendation #28).

Potential Action #3 MISA - Industrial and Commercial Establishment Discharges to the Sewer Systems

Further controls are to be placed on the discharge of persistent toxic substances to the municipal sewer systems. A pilot study has just been completed by Hamilton-Wentworth Region and the Ontario Ministry of the Environment. The study assessed the major contributors of the toxic substance load to the system and develop a strategy, with business, to prevent or pre-treat the discharges causing the most serious problems with the contaminant loading to the STP.

It is recommended that this program be expedited in both Hamilton-Wentworth and Halton Regions, building on the initial work that has been done in both Regional Municipalities (see Recommendation #28).

Potential Action #4 and #5 — Citizen Program to Reduce the Release of Toxic Chemicals to the Watershed

Every citizen can play a part in reducing the release of toxic chemicals to the watershed. Reduced or eliminated usage is paramount in our homes. Where use is still deemed necessary, making use of the Regional toxic waste disposal facilities is the final alternative.

Citizens can also play a part in the workplace by carrying out their responsibilities in the programs for the industrial and commercial sectors.

This program, already operating in both Regional Municipalities should look to means to develop greater participation, and is strongly recommended (see Recommendations #30, 31, 38, 39).

Potential Action #6 — Sewage Treatment Plant Operation to Optimize for Removal of Persistent Toxic Chemicals

Sewage treatment plants remove toxic chemicals from the treated wastewater. They are not designed for this purpose, but do so by virtue of the fact that most treatment processes remove suspended sediments to which the chemicals adhere. While the efficacy of the processes and their impact on the quality of the sludge (determining its suitability for farmland or silvicultural land disposal) from the sewage treatment plant, are not well established, additional importance has been given to the advanced STP processes because it has this beneficial effect on toxic chemical discharges.

While this cannot, and should not, replace source control or prevention it is well to note this added benefit to the use of more sophisticated sewage treatment technology (Follows from Recommendation #1).

Potential Action #7 — Spill Control

Substantial reductions in spills and improvement in mitigation of spills have been achieved through current programs of the Province and through continuance of industries with the Harbour Commissioners operating as the Port of Hamilton Spill Control Group.

Since spills often have such visible and sometimes drastic effects, we endorse the Control Group's target of zero volume of spill material from shipping uses. It is recommended that targets for spill volume reductions be set for industry and municipal sewer systems and efforts bent towards prevention of spills.

Biennial reports on the amount and type of spills and corrective actions taken are recommended (see Recommendation #7).

Potential Action #8 Reduced Use of Chlorine

Chlorine is used extensively as a method of disinfecting wastewater carrying human pathogens like bacteria and viruses. The efficacy of chlorine is currently under scrutiny and there is concern that chlorination may give rise to chlorinated organics.

At present, STP effluents are chlorinated only in the summer season when human contact with Harbour waters is most likely.

Alternative methods of disinfecting wastewater should be considered in any redevelopment of STP facilities (see Recommendation #26).

IV.7 Hamilton Harbour: Contaminated Sediment

IV.7.1 Overview

The amounts and concentrations of heavy metals, PAHs and PCBs in the Harbour are not surprising, given the fact that a major iron and steel industry has been situated here for decades, and the fact that the Harbour is an excellent sediment 'trap', retaining about 85 percent of all suspended sediment discharged into it.

As shown in Figure 18, toxicity tests indicate high priority areas for remediation. Already the contaminated sediment in Windermere Basin has been dredged and placed into confined disposal cells for dewatering and capping. In dealing with the two remaining areas, consideration has been given to:

1. the depth of water (shallower sediments are more easily disturbed by winds),

2. the potential for disturbance by ships or navigational dredging,

3. whether the material is being redistributed in the Harbour,

4. whether the source of the contamination has been eliminated (to avoid re-contamination).

On this basis, priority has been given to establishing standards, dredging techniques, risk analysis and treatment technology for the area near Randle Reef where PAH concentrations are of greatest concern. Considering that this area meets all four criteria gives impetus to correction of the problem at this site. PAHs are implicated in fish health problems in the Harbour and are considered responsible for the high acute toxicity of the sediment to all bottom dwelling organisms. Naphthalene may be the specific agent.

The next site of concern being assessed is the Ottawa St. slip and the area near the mouth of the slip. The greater depth of water in the open Harbour area of the zone, quiescence in the narrow slip, uncertainty as to what the principle causes of the toxicity are (and whether the material causing the problem is now being discharged) all point to the need for better assessment before remedial action can be specified.

The whole Harbour is generally contaminated, with levels of zinc and PAHs, the ones of most concern, and with some lesser concern for lead and copper. These levels are such that serious consideration has to be given to whether there is a need to take some measures over large parts of the Harbour to mitigate impacts. These concentrations of contaminants are well above what has been established as 'no effect levels' according to the Provincial Sediment Quality Guidelines (PSQG), although some of the natural levels of contaminants from pre-colonization days also exceed these standards. Large areas exceed the 'lowest effect level' and 85 percent of the Harbour has one or more substances above the 'severe effect level' (PSQG).

The great depth of water probably means that the warmwater fish don't regularly inhabit some areas of greatest sediment contamination, although the bottom-dwelling organisms take up some of the contaminants and by this route the contaminants could enter the food chain. In addition, there are seasonal changes in toxicity that could implicate dissolved oxygen levels (and related sulphide chemistry). Ammonia levels or other factors also need to be understood well enough to provide confidence that any possible mitigative measure will have the desired effect.

IV.7.2 Potential Remedial Actions to Address Problems

Action #1 Do nothing.

Action #2 Expedite designation of the size of the Randle Reef area requiring remediation, and the acceptable removal and treatment techniques to be used.

Action #3 Complete the assessment of the Ottawa Street slip site and designate the remedial action.

Action #4 Complete the assessment of the remaining Harbour-wide levels of contamination and potential remedial measures (along with their environmental impact) including allowing the present material to be buried with cleaner sediment.

Action #5 Establish the limitations on discharges into the Harbour that would allow new sediments being laid down to meet environmental quality requirements.

IV.7.3 Evaluation of Potential Actions for Cleaning Up Contaminated Sediment

Potential Action #1 Do Nothing

To do nothing further than confine any materials dredged for navigation purposes will be inadequate if only because some of the sediment probably qualifies as hazardous material. Some of the sediments, which are shown to be most toxic in bioassays, are located where they are easily disturbed by wave action and shipping activities. Hence, they are resuspended and moved out into the rest of the Harbour by currents. Inattention to these 'hot spots' in shallow water, even though they are getting no worse, will ensure wider distribution of these very contaminated sediments throughout the Harbour.

For the largest part of the Harbour that has toxicity that is not the best, but not bad enough to dictate urgent action, there is less understanding of the consequences of leaving it alone or making some attempt to detoxify it *in situ*. The concern is for the degree to which this material restricts the development of viable benthic organisms or the degree to which the contaminants enter the food chain for bioaccumulation in fish, birds or wildlife.

It is recommended that we do something to sort out this historical legacy of contaminants discharged over the past 100 years.

Potential Action #2 Randle Reef Contamination

Bioassays indicate that this area, which is contaminated with polynuclear aromatic hydrocarbons (PAHs), is the worst remaining area in the Harbour. The area is subject to disturbance for dredging, by large ships and by wave action. The only option is to remove the material (and treat it, if necessary). Standards need to be established (recommendations have been made) and acceptable removal and treatment methods specified.

It is recommended that action be taken as soon as possible to remove and treat the 50,000 to 100,000 m^3 of material in this area (see Recommendations #29, 47, 48).

Potential Action #3 Ottawa Street Slip Contamination

Currently this area is the next most serious area requiring attention because of highly contaminated sediment. Two factors are holding up specification of the cleanup strategy.

a) Uncertainty as to what is causing the toxicity, and hence

b) Whether the causative discharge has been reduced sufficiently to ensure no re-occurrence of the problem once the contaminated sediment has been dealt with.

Therefore, it is recommended that these issues be addressed quickly and be immediately followed by specification of the remedial strategy (see Recommendations #29, 47, 48).

Potential Action #4 **Assessment of Remaining Harbour-wide Sediment Contamination**

In the absence of any clear strategy for how to deal with this problem, it is recommended that a Task Force be formed to develop just such a strategy by 1993. Many assessment data have been collected and there are current studies of alternate ways to mitigate this problem, should it be deemed necessary (see Recommendation #29).

Potential Action #5 **Establish Further Discharge Limitations That May Be Required to Ensure Future Deposits in the Bottom of the Harbour Will Not Require Removal or Treatment**

In the absence of a clear understanding of what actions may additionally be required to protect the Harbour, it is recommended that a separate Task Force be set up to investigate ways and means of specifying discharge limits or other remedial actions required to maintain adequate sediment quality in perpetuity (see Recommendation #29).

IV.8 Cootes Paradise: Contaminated Sediment

IV.8.1 Current Situation

Generally, the contaminant content of water in Cootes Paradise is better than that of the Harbour proper. Examination of the contaminant content of the bottom sediments suggest that two areas tend to have contaminants well above background levels of 100 to 150 years ago.

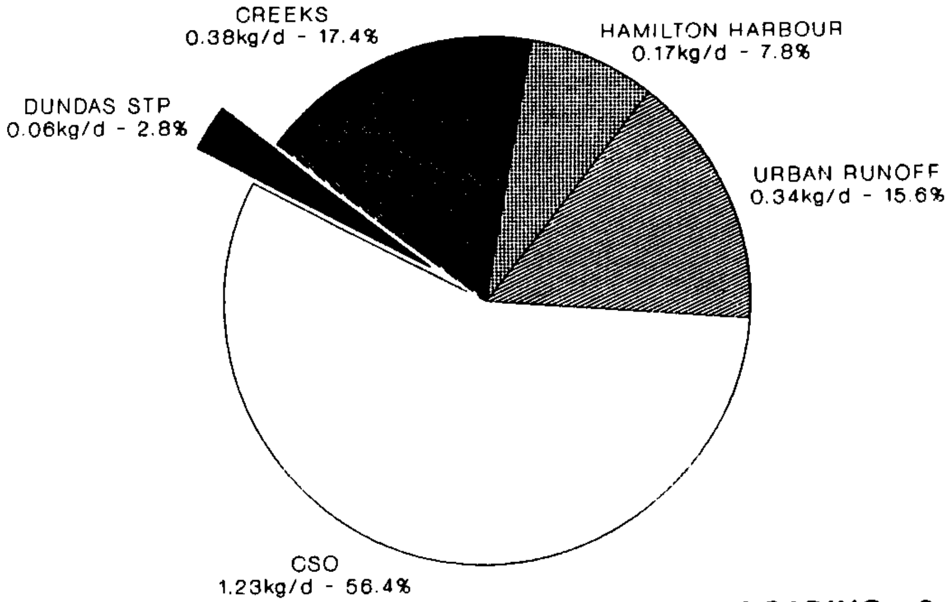
While no contaminants have been found at the severe effect level (where a serious problem would exist) several contaminants do exceed the next lowest guide - the 'lowest effect level'.

Two locations can be singled out. They are West Pond and the area at the mouth of Chedoke Creek between Highway 403 and Princess Point Park. Cadmium and PCBs exceed the 'lowest effect level' at both locations. Also, zinc and copper, probably associated with leaching from plumbing as it is discharged from the Dundas STP, are above the 'lowest effect level' in West Pond. Mercury is above the 'lowest effect level' in the Chedoke Creek area.

IV.8.2 Programs Proposed or in Place

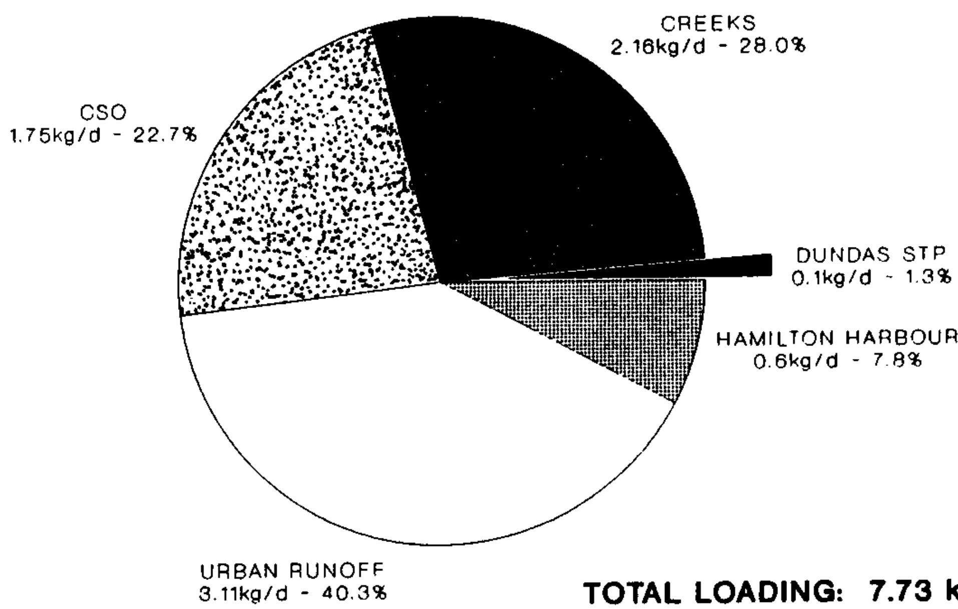
The programs designed to reduce the entry of persistent toxic chemicals into the sewer system (MISA), to reduce or eliminate combined sewer overflow into Chedoke Creek, and the program to reduce suspended sediment loading from Spencer Creek, will all serve to mitigate major components of the sources. Materials for which loading data are available are shown in Figures 31, 32, 33, 34, 35 and 36. Assessment of potential for seepage from landfill sites has also been carried out.

Figure 31: Cootes Paradise - % Phenols Contribution by Source



TOTAL LOADING: 2.18 kg/d

Figure 32: Cootes Paradise - % Lead Contribution by Source



TOTAL LOADING: 7.73 kg/d

Source: J. Vogt, OMOE/WCR

Figure 33: Cootes Paradise - % Chromium Contribution by Source (1989)

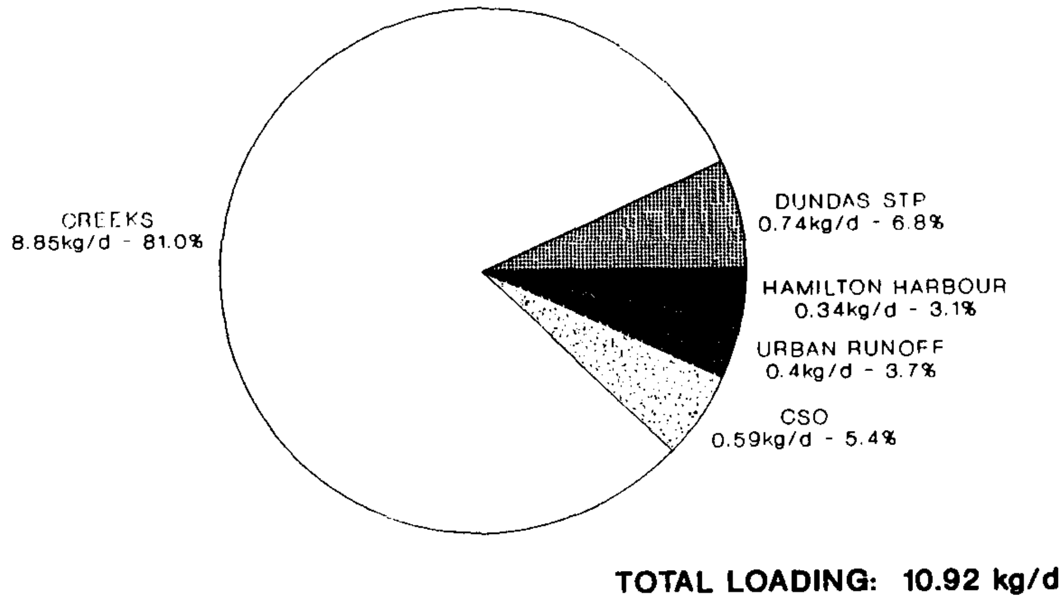
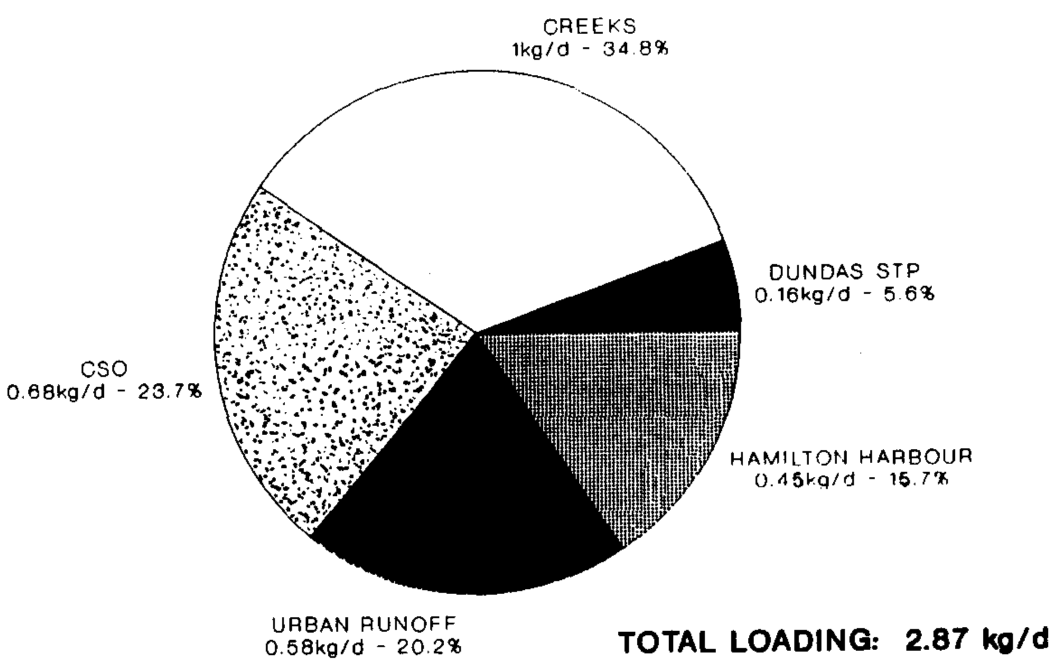
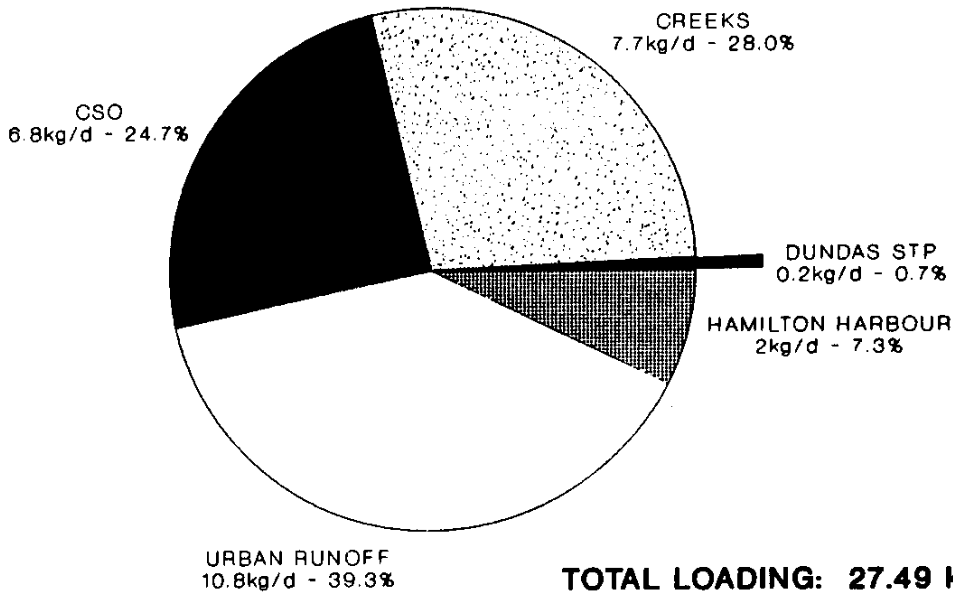


Figure 34: Cootes Paradise - % Copper Contribution by Source (1989)



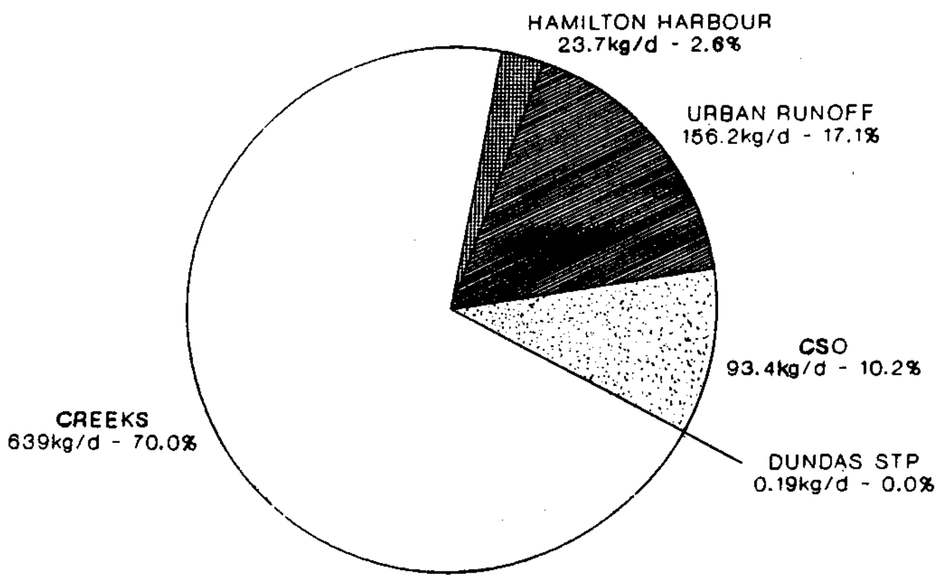
Source: J. Vogt, OMOE/WCR

Figure 35: Cootes Paradise - % Zinc Contribution by Source (1989)



TOTAL LOADING: 27.49 kg/d

Figure 36: Cootes Paradise - % Iron Contribution by Source (1989)



TOTAL LOADING: 912.5 kg/d

Source: J. Vogt, OMOE/WCR

IV.8.3 Potential Remedial Actions to Address Problems

Action #1 Do nothing.

Action #2 Eliminate the combined sewer overflows into Cootes Paradise.

Action #3 Implement erosion control programs to reduce suspended solids loading into Cootes Paradise.

IV.8.4 Evaluation of Potential Remedial Actions to Address Concerns in Cootes Paradise

The basic strategy for remediating Cootes Paradise and re-instating a viable marsh with its attendant wildlife and fish populations is to remove pollution stresses. The significance of this shallow sensitive tributary area is great. Hence we have indicated in previous sections dealing with phosphorus, suspended sediment and other contaminants that priority should be given to this area in programs addressing CSOs, creeks and STPs. The current efforts already implemented or approved (sand filters and step feed control at the Dundas STP, and designation of one of the most serious CSOs for remediation on Chedoke Creek) are the direction we have to move.

Priority for additional measures to address suspended sediments in Spencer Creek, and the remaining CSOs is indicated.

IV.9 Bacterial Contamination and Swimming

IV.9.1 Current Status - Swimming

Swimming is not normally practised in Hamilton Harbour or Cootes Paradise due to limited public access, the Hamilton Harbour Commissioners' by-law prohibiting swimming in the Harbour based on the advice of the Medical Officer of Health for Hamilton-Wentworth Region. The bacteria counts have been assumed to be too high to permit swimming.

The Lake Ontario beaches immediately adjacent to the ship canal, on both the Burlington and Hamilton side, occasionally experience high bacterial counts which result in beach closures.

The Hamilton area beach is presently less extensively used than before, with the area known as Confederation Park now experiencing greater use. While periodic bacteriological problems are experienced in this latter area, they are almost certainly not due to impingement by water from Hamilton Harbour.

IV.9.2 Limitations on Swimming

IV.9.2.1 Legal

Swimming is presently illegal in Hamilton Harbour in accordance with a by-law of the Hamilton Harbour Commissioners based on the advice of the Medical Officer of Health.

IV.9.2.2 Access

At present, there exist few, suitable shore-based safe access points for swimming in the Harbour. There are areas with potential as sites for swimming: the former Lax property on the Hamilton side in the west end of the Harbour; the waterfront area adjoining LaSalle Park on the Burlington side in the east-central area of the Harbour; the northeast portion of the Harbour adjacent to the Canada Centre for Inland Waters in Burlington; and, along the north shore in the western third of the Harbour.

IV.9.2.3 Water Clarity

The water clarity guideline for swimming is 1.2 metres. The Secchi disc depth averaged 1.9 m in 1990 from April through to October in the middle of the Harbour. Secchi disc readings taken by Fisheries and Oceans Canada along the north shore, in shallow water during the summer of 1987 had a mean transparency of 0.95 metres. Once a water depth of 2 m was reached, the Secchi disc depth increased to 1.3-1.4 metres. The causes of the shallow light penetration are a combination of non-living solids, phytoplankton and a background absorption due to dissolved organics in the water. The decrease in water clarity inshore relative to offshore is probably due to wave action. General improvement of water clarity in the Harbour (Section IV) combined with suppression of wave action will allow almost any site on the west, southwest or north shores to meet the guideline.

IV.9.2.4 Bacteria

The most crucial factor for swimming is reduction of the risk of contamination by human pathogens that is represented by bacteriological standards. The sampling programs in the past provide insufficient information in nearshore areas in the western end of the Harbour to indicate its feasibility for swimming. The open water sampling, although infrequent, indicates that bacteria counts in the centre of the Harbour would not restrict swimming. Results of a 1990 survey in the extreme nearshore zone near LaSalle Park, Willow Point, and the Lax property showed that Harbour stations fell in the middle of the range exhibited by existing Lake Ontario beach stations for faecal coliform densities, both in terms of mean bacterial densities, and the frequency of observations above the MOE objective of 100 organisms/100 ml. These findings indicate that it may well be feasible to establish bathing beaches within the Harbour.

Swimming is not recommended, allowed, or proposed to be allowed for Cootes Paradise.

IV.9.3 Current Actions

The primary sources of bacterial contamination are the sewage treatment plant effluents, the combined sewer overflows and the general drainage from both urban and rural areas.

The effluent from sewage treatment plants is chlorinated during the summer season. Though the effectiveness of this treatment has been questioned, it appears to be responsible for the general improvement in bacterial water quality in the Harbour over the past 15 years, as measured at stations in the middle of the Harbour.

Twenty-five percent of the combined sewer overflow is now under control. It formerly discharged into Redhill Creek which subsequently discharges to the southeast corner of the Harbour. The effect of this measure has not yet been assessed fully. Plans are under way, supported by Hamilton-Wentworth Regional Council, to deal with a combined sewer overflow to Cootes Paradise, and to areas around the proposed waterfront park in the southwest part of the Harbour. These should have a very beneficial effect on areas where there is a potential for beaches.

IV.9.4 Potential Remedial Actions for Bacterial Contamination Control

Action #1 Do nothing.

Action #2 Continue disinfection of STP effluents.

Action #3 Prevent combined sewer overflows throughout the Harbour, with first priority on areas in the western half of the Harbour and in Cootes Paradise.

Action #4 Ensure that sources of bacteria entering via streams are identified and addressed - especially as they affect potential beach sites.

Action #5 Reduce sewage treatment plant by-passes.

Action #6 Protect beach areas for swimming with membrane barriers and by disinfecting the water.

IV.9.5 Evaluation of Potential Remedial Actions for Bacterial Contamination Control

Potential Action #1 Do Nothing

Current conditions for bacterial contamination are marginal. They used to be far worse. Bacterial counts are high for a few days after rainfall at most likely swimming locations. It seems unlikely that conditions would ever be adequate along the south shore if nothing further were done. Things may not be too bad on the north shore, but there has been inadequate sampling yet to assure health authorities that conditions are satisfactory.

Since we are very close to achieving swimming conditions in the Harbour, it is recommended that we take the final steps to complete the job.

Potential Action #2 Continue Disinfection of STP Effluents in Summer

Chlorination of STP effluents during the summer months is probably responsible for the improved conditions that we have now.

It is recommended that disinfection of the effluents be continued (see Recommendation #26).

Potential Action #3 CSO Control

The discharge of raw sewage in overflows of the combined sewers in rain storms is affecting the levels of bacteria in potential swimming areas on the west and south shores of the Harbour.

It is recommended that Hamilton-Wentworth Region continue to pursue its program of CSO remediation with priority on CSOs that are likely to affect potential swimming areas (west end of Harbour) and in Cootes Paradise (see Recommendation #1).

Potential Action #4 Bacteria in Streams

While data are spotty, there is a strong likelihood that streams carrying storm water runoff carry bacteria to the Harbour.

It is recommended, with priority on streams close to potential bathing sites, that these streams be checked for bacteriological quality. If that quality is inadequate, measures should be taken to correct the problem (see Recommendations #25, 27).

Potential Action #5 STP Bypasses

Sewage treatment plants, when overloaded, will bypass all or part of the wastewater flow and this will bring bacteria to the Harbour.

It is recommended that the magnitude of this contribution be assessed and corrective action taken where warranted (see Recommendation #1).

Potential Action #6 Swimming Enclosures

Some jurisdictions have constructed enclosures in small embayments to serve as pools for swimming within the larger body of water. The water inside the enclosure can then be disinfected on a continual basis as with swimming pools.

It is recommended that this option be used only if other measures are not adequate (Refer to Section III.7.3.3 - Stakeholders Goal #2).

IV.10 Restoration of Fish and Wildlife Habitat in Hamilton Harbour

IV.10.1 Background

Apart from its obvious historical value as an industrial centre and shipping port, Hamilton Harbour was recognized in the 1800s as a unique fish and wildlife habitat that contributed significantly to commercial and recreational fishing, trapping, and hunting.

Almost all of Cootes Paradise and the south and west shores of Hamilton Harbour consisted of shallow water marshes that supported immense flocks of ducks, wildfowl, otter, beaver, fisher, mink, muskrats and many species of amphibians and reptiles. The marsh also provided essential spawning, nursery, and adult habitats for the warmwater fish community. The diverse warmwater fishery included pike, bass, yellow perch, sunfish, muskellunge, walleye, drum, burbot, channel catfish, brown bullhead, and white sucker.

IV.10.1.1 Fisheries

Prior to 1900, Cootes Paradise and Hamilton Harbour were renowned for their thriving fisheries resources (see Stage I report). Only remnants of the historical fishery remain today. Remedial actions have significantly reduced phosphorus, ammonia, organic and metal loadings to the Harbour and additional measures are proposed that will restore water quality to support fish and wildlife. Unfortunately, much of the habitat damage, particularly along the south and east shores (65% of the littoral habitat in the Harbour), is irreversible. As a result, remedial actions to restore habitat are confined to areas along the east, north and west shores of the Harbour and in Cootes Paradise.

Irreversible habitat loss, combined with conflicting use goals for navigation, sewage disposal and property development, preclude a return to the environment of 1900. Fisheries populations will never reach historic levels and some cold water species such as lake trout, whitefish, herring and sturgeon will probably not return to the Harbour. Future opportunities for recreational fishing are limited to pike, bass, perch and crappies, and spring and fall fishing for rainbow and brown trout and Pacific salmon. The remedial options outlined in this report are intended to restore fish communities to a level indicative of a healthy and productive environment, whose value lies in education and non-destructive use.

Although the abundance and distribution of fish in the Harbour has changed dramatically since 1900, at least 59 fish species remain in the Harbour. Many of the desirable warmwater species such as pike, bass, perch, crappies, sunfish and channel catfish are still present in low numbers. Successive changes in the fish community of Hamilton Harbour reflect the characteristic transition from a moderately enriched (mesotrophic) environment dominated by top predators, such as pike and bass to a nutrient enriched (eutrophic) ecosystem dominated by benthivores such as carp and white perch, and planktivores such as alewife and gizzard shad. Based on this observation, habitat requirements were developed for a fish community similar to the warmwater fish community of 1900. Pike and largemouth bass, apart from their importance in the historical fishery, were chosen because of their sensitivity to some of the obvious stresses impacting the Harbour ecosystem. For example, pike require flooded terrestrial vegetation as spawning habitat. The decline of wetlands in Cootes Paradise and Grindstone Creek is clearly a limiting factor for pike and for other species that depend on flooded emergent vegetation. Largemouth bass have similar requirements for submerged vegetation at all life stages.

The overall strategy for restoring fish communities relies on the timely implementation of recommended options. There is little point creating physical habitat if water quality remains a limiting factor, or introducing top predators if there is no suitable habitat available. Clearly, implementation of remedial options must first deal with source control of phosphorus, ammonia, toxic chemicals, and suspended solids. The next logical step is habitat restructuring and carp control (simultaneously), followed by species introductions.

IV.10.1.2 Wildlife

There is little information about historical wildlife populations in the Harbour, making it difficult to establish what wildlife resources have been lost. Many migrant and resident water birds used the original marshes, as did several species of aquatic mammals, (fisher, mink, beaver, muskrat, and a large number of amphibian and reptile species). The marsh fauna is now drastically reduced, but open water areas are still used by migrating loons, grebes and ducks, including large numbers of common mergansers, especially in Cootes Paradise and the west end of the bay (Carrolls Point area).

Historically, the Harbour's main attraction for migratory waterfowl was as a stopover and staging area, rather than as nesting habitat. The same is true today. Colonial nesting birds (gulls, terns, herons, and cormorants), on the other hand, are not native to the Harbour and are here as a result of range extensions. These species are attracted to the man-made habitats in Windermere Basin, the berms around the Confined Disposal Facility, and the Hydro islands. Some of these species may have used the Lake Ontario shoreline, although related species (black tern, rails, marsh wrens, gallinaceous birds) used the original marshes. Large flocks of ducks, mainly diving ducks, overwinter in Windermere Basin, and the bay proper is used by wintering divers, especially greater scaup and lesser scaup.

The Stakeholders realize that much of the historical habitat has been irretrievably lost, but their desire, as stated in their goals, is that "healthy, self-sustaining resident and non-resident wildlife populations should be enhanced on a Harbour-wide basis through water quality improvements and habitat rehabilitation and protection". In their goals and ancillary objectives, the Stakeholders have highlighted several issues:

1. wildlife health and contaminant monitoring,

2. enhanced wildlife populations through the preservation and rehabilitation of habitat and the establishment of habitat and population targets,

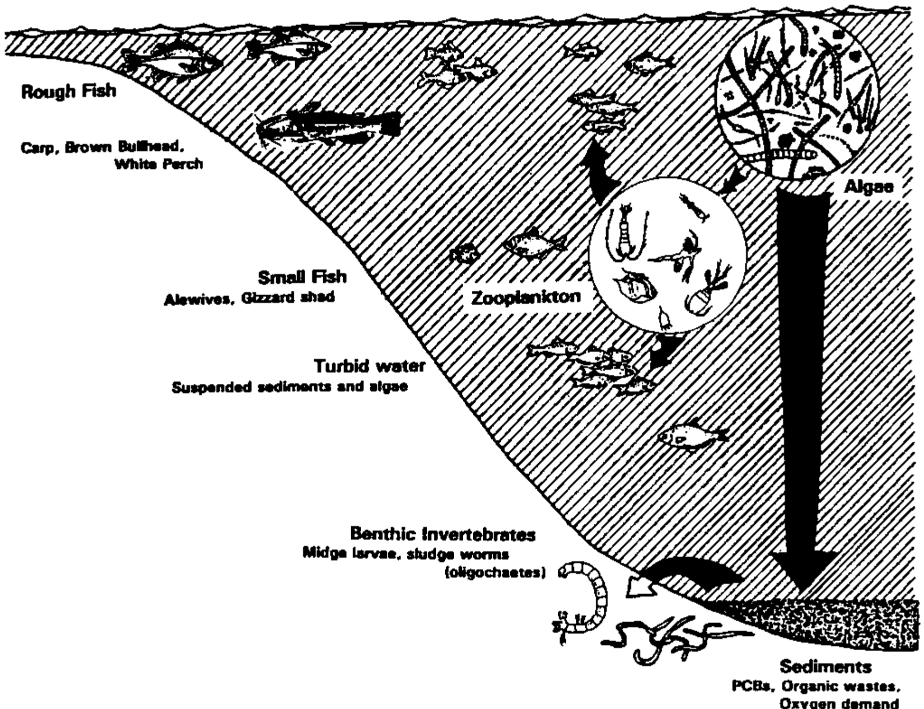
3. integrated management of fish and wildlife populations throughout the Harbour, and

4. improved wildlife appreciation and educational opportunities.

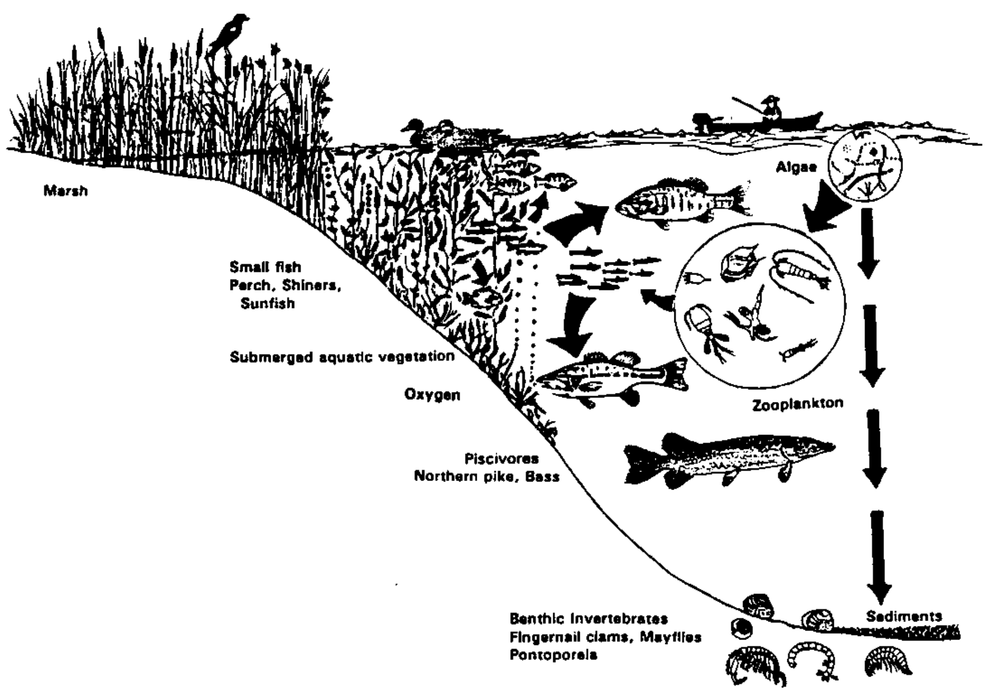
IV.10.2 Wildlife Health

Much of the research on wildlife health in Hamilton Harbour has focused on colonial waterbirds, waterfowl, and snapping turtles. Contaminant levels in colonial waterbirds are similar to those in other areas in Lake Ontario, and are not eliciting an acute effect or affecting reproductive success. However, fish-eating birds in Lake Ontario are showing biochemical responses to organochlorine contaminants. These responses include increases in enzyme levels and a liver disorder known as porphyria. Field studies are continuing to confirm these relationships in Hamilton Harbour. Over time, levels of most contaminants have decreased, e.g. in herring gull eggs.

Figure 37: Hamilton Harbour - Present State



Hamilton Harbour - Future State



Source: Concept courtesy Green Bay, RAP report.

Instances of waterfowl death have been attributed to lead contamination and botulism. PCB levels in some waterfowl samples from the Harbour exceed current human consumption guidelines in New York and Wisconsin.

IV.10.3 Wildlife Management

Fish and wildlife appreciation, and preserving and creating habitat for an enhanced wildlife community are important issues for the Hamilton Harbour Stakeholders. The public is also becoming increasingly aware of the importance of green space in an urban environment. Green space not only provides ready access for nature appreciation for the urban population, but it must also be large enough to function as habitat for the wildlife to permit nature appreciation in the first place. Pockets of natural areas are inadequate if biogeographical isolation of the species therein is the ultimate result. Wildlife corridors or linkages that connect our natural areas are critical if they are to be viable. Increasing pressure to partake in nature appreciation is also threatening the viability of our natural areas. Even the extensive Royal Botanical Gardens natural areas are feeling "people pressure."

Management of natural areas throughout the Harbour area is fragmented. A comprehensive land use planning exercise for the natural areas is required. Priority areas need to be identified and additional lands adjacent to the Harbour must be acquired. Projects affecting the shoreline, such as the Perimeter Road, GO-expansion Route, the Waterfront Park, Expressways, and the Windermere Basin Dredging project, must consider incorporation of public access, aesthetic concerns, and fish and wildlife habitat in their planning.

IV.10.4 Summary of Issues Impeding the Restoration of Fish and Wildlife Populations

IV.10.4.1 Wildlife

- Present colonial bird habitat is man-made and temporary and will probably be affected by commercial development of the Confined Disposal Facility, which is anticipated around the year 2000.

- Waterfowl and shorebirds are exposed to potentially toxic contaminants in the uncapped Confined Disposal Facility and the uncapped cells surrounding the recently dredged Windermere basin.

- There is no suitable habitat available in the Harbour for colonial nesting birds (terns, cormorants, herons) to relocate when the CDF property is developed. Also, there are few places that provide suitable opportunities for wildlife viewing.

- Populations of ring-bill gulls are excessive in the vicinity of Windermere Basin and along Eastport Drive. Similarly, there are nuisance populations of Canada geese, skunks and raccoons in Cootes Paradise.

- Common Terns require specialized habitat and management considerations to co-exist with currently large numbers of ring-bill gulls.

- The night-heron colony is being adversely affected by the cormorant colony on the CDF.

- Legislation protects colonial nesting bird habitat only during the period when the birds are actually nesting. Failure to protect these critical habitats throughout the year jeopardizes the future of colonial nesting birds in the Harbour.

IV.10.4.2 Fish

- Concentrations of suspended sediments, chlorophyll, and phosphorus contribute to poor water quality in Hamilton Harbour and Cootes Paradise.

- The hypolimnion in the Harbour has low oxygen levels during the summer.

- The warmwater fishery is dominated by alewife, white perch, carp, bullhead and gizzard shad. These are species indicative of poor water quality and degraded habitats. These fish adversely impact desirable species through predation, competition, and habitat destruction.

IV.10.4.3 Fish and Wildlife

- More than 85 percent of the productive wetlands have disappeared from the Harbour, Cootes Paradise and the tributaries. The disappearing wetland has been accompanied by reduced plant abundance and diversity, substantial declines in spawning and nursery habitat for fish (abundance and diversity), and dwindling populations of marsh dependent waterfowl, mammals, reptiles and amphibians from Cootes Paradise.

- Harbour sediments are toxic to desirable benthic species, and may impact the health of resident fish and waterfowl.

- Littoral habitat along the south shore has been irreversibly lost because of landfilling.

- Most of the sloping shoreline along the north and east shores has been reinforced with concrete or steel to prevent erosion. The resulting high energy shore contributes to increased turbidity and poor plant growth.

- Carp contribute 70 percent of the littoral fish biomass in the Harbour. Their feeding and spawning activities destroy emergent and submerged vegetation, and are responsible for increased turbidity.

- Habitat management is fragmented and requires comprehensive land use and fish and wildlife habitat management plans.

IV.10.5 Recent Activities

Previous attempts to identify remedial options for restoring fish and wildlife populations failed to consider the two goals together. Although many of the recommendations had elements in common, efforts were not made in the early stages to combine the two and develop a joint strategy. It was apparent during the preparation of the Stage 2 report, that a more comprehensive approach would accomplish the fish and wildlife goals and also enhance human enjoyment of these resources by improving access, wildlife viewing, fishing opportunities, and aesthetics.

The Fish and Wildlife Committee convened two workshops late in 1990 to discuss remedial options that would meet the Stakeholders goals for both fish and wildlife and other goals related to access, and education. Experts in marsh restoration and fisheries/wildlife enhancement participated in the development of remedial options for Cootes Paradise and the Harbour. Workshop recommendations were presented to the RAP Stakeholders in a report prepared by Dr. Murray Johnson entitled, "A plan for restoration of fish and wildlife habitat in Hamilton Harbour and Cootes Paradise".

This report was used extensively to prepare a fish and wildlife habitat restoration proposal to the Great Lakes Cleanup Fund. The proposal was successful. The federal government approved $4.2 Million over 3 years (1991-1993) to restore fish and wildlife populations in Hamilton Harbour and Cootes Paradise. Partner contributions for approximately $9.3 Million is committed or promised.

In the preface to the report, Dr. Johnson identified eight criteria for selecting and implementing remedial options. These criteria, which are listed below, form a conceptual basis for habitat improvement in Hamilton Harbour and Cootes Paradise.

IV.10.5.1 A Conceptual Basis for Habitat Improvement

1. Highest priority should go to preventing further habitat loss.

2. Pollution clean-up and habitat improvement should be concurrent.

3. Habitat improvements for fish and wildlife should be compatible and, whenever feasible, mutually beneficial.

4. Habitat improvement should not jeopardize health of fish and wildlife populations.

5. Habitat restoration programs need an experimental management approach.

6. Habitat projects should capitalize on new opportunities and new developments.

7. Projects should be ecologically sound, self-sustaining and permanent.

8. Habitat improvement should provide a high diversity of benefits.

Habitat creation is both a goal and a remedial action that will sustain the newly established ecosystem year after year. For example, restoration of the Cootes Paradise marsh will do more than house wildlife and fish. It will also provide a sink for nutrients and contaminants from the Dundas STP, trap sediments from the Spencer Creek watershed, reduce fetch which will minimize wind driven resuspension of sediments, and stabilize the loose silt bottom - in effect, modifying the factors that contribute to marsh loss.

There are two parts to the restoration program. The first addresses habitat restoration in Hamilton Harbour which is further separated into the following five sub-areas: colonial bird habitat on Pier 27, creation of an island chain in the north east shore that would become a fish and wildlife conservation area, island creation along the north shore off LaSalle Park and the cemetery properties between Carrolls Point and Willow Point, and littoral habitat development off the CN property in the proposed waterfront park. The second part of the plan addresses marsh restoration in Cootes Paradise and Grindstone Creek.

IV.10.6 Potential Remedial Actions to Restore Fish and Wildlife Populations

IV.10.6.1 Fish

Action #1 Do nothing

Action #2 Preserve existing habitat through:

a) Enforcement of the habitat provisions of the Fisheries Act.

b) Development of a fish habitat management plan for Hamilton Harbour.

Action #3 Introduce adult pike and bass in an experimental management approach to restructure the fish community that will meet the goal for a desirable warmwater fishery.

IV.10.6.2 Wildlife

Action #4 Do nothing

Action #5 Operate the Confined Disposal Facility and created cells in Windermere Basin to minimize wildlife exposure to contaminated sediments.

Action #6 Establish objectives for contaminant levels in wildlife.

Action #7 Develop legislation and habitat plans that protect wildlife nesting habitats throughout the year.

Action #8 Establish management plan to effectively manage desirable and undesirable populations of wildlife in Hamilton Harbour and Cootes Paradise.

IV.10.6.3 Fish and Wildlife

Action #9 Capitalize on opportunities to create habitat in projects that involve construction on or near the Harbour shore.

Action #10 Restore 200 ha of marsh vegetation in Cootes Paradise and the Grindstone Creek estuary, including Sunfish Pond, the "elbow", and the pike spawning marsh (Cherry Hill Gate marsh).

Action #11 Take measures (in addition to removing pollution stress) to reduce the impact of carp in Cootes Paradise, the tributaries, and in the littoral zone of the Harbour.

Action #12 Create opportunities for fish and wildlife viewing and habitat in Windermere Basin.

Action #13 Create approximately 5 km of island habitat to enhance fish and wildlife populations in Hamilton Harbour. Islands will be created in the vicinity of Pier 27, on the federal water lot north of CCIW, at LaSalle Park, off the cemetery properties between Willow Point and Carrolls Point, and off the CN property in the area of the proposed Waterfront Park and Pier 4 Park.

Action #14 Construct wildlife viewing platforms, a canoe launch, an interpretive centre, and fishing piers to enhance beneficial uses for access, recreation, and education.

IV.10.7 Evaluation of Potential Remedial Measures to Restore Fish and Wildlife Populations

IV.10.7.1 Fisheries

Potential Action #1 Do Nothing

Even if all the current pollution stresses are removed from the Harbour and Cootes Paradise, to the maximum extent possible, there would still be inadequate habitat to support a self-sustaining, edible warmwater fishery. Although the north and east shores of the Harbour and Cootes Paradise/Grindstone Creek are the only locations suitable for habitat restoration, they are still degraded areas characterized by high turbidity and few aquatic plants.

Change is unlikely without major intervention. Degraded ecosystems, such as Hamilton Harbour, have internal mechanisms for maintaining their existence. For example, the high concentrations of suspended sediments that enter the Harbour from the watershed cause high turbidity and poor light penetration which limits plant growth in the littoral zone. Poor plant growth discourages predators, which in turn encourages greater numbers of undesirable species such as carp. The feeding activities of carp contribute further to increased turbidity and further plant loss. In effect, the littoral zone has achieved a new and stable equilibrium that perpetuates itself. Altering the community composition requires a multiple strategy that simultaneously creates habitat, controls undesirable species and introduces desirable species. Direct intervention is necessary in all three areas before restoration will be accomplished.

Potential Action #2 Preservation of Existing Habitat

Historically, little or no effort has been made to protect the Harbour shoreline. Water and sediment quality has deteriorated, marshes have been filled, boulders and sand removed for construction, and most of the shoreline has been reinforced with concrete or steel. Until recently, regulatory efforts have not preserved shoreline habitat in any part of the Harbour.

We cannot expect that fish and wildlife managers can re-create habitat of value equal to what was lost. It is essential, therefore, to use all possible legal and planning methods to save any threatened existing habitat. Better results at restoring habitats should be expected from enlargement of surviving habitat than starting from scratch.

It is recommended that recent efforts to rigorously enforce the habitat provisions of the Canada Fisheries Act be extended to preserve the remaining habitat in the Harbour and Cootes Paradise. Similarly, legislation to protect wildlife habitat during the non-breeding season is urgently needed.

Development of a fish and wildlife habitat management plan for Hamilton Harbour will take a proactive role in habitat protection by identifying opportunities for habitat enhancement and sites where habitat must not be altered (see Recommendations #15, 16, 17).

Potential Action #3 Introduce Top Predators

Although 59 species have been caught in the Harbour, the fishery is dominated by few species (carp, white perch, bullhead, alewife, and shad). These species thrive under conditions of low dissolved oxygen and high concentrations of suspended solids. They can tolerate contaminated sediments and are frequently found in heavily contaminated environments. Their spawning and feeding activities uproot vegetation and stir up bottom sediments. They prey on benthos and juvenile fish, and eliminate desirable fisheries through predation, competition, and habitat destruction. Populations of carp, bullheads and white perch increase as habitat deteriorates until the existing fish community collapses into a stable fish community dominated by pollution tolerant species.

Top predators like pike and bass are indigenous to the Harbour and likely to find habitat suitable for survival and reproduction. Introduction of adult fish will be necessary to shift the fish community from its' present stable condition to a more balanced community controlled by top predators. Introductions of adult fish will immediately exert some biological control by feeding on juvenile carp, white perch, and shad, and more quickly establish self-sustaining populations by utilizing available spawning habitats.

This measure is recommended, but habitat restructuring is an unproven technology with a high degree of experimental management. Monitoring must be conducted to ensure that introduced fish are reproducing successfully in the Harbour and contributing to a self-sustaining fish community (see Recommendations #14, 15).

IV.10.7.2 Wildlife

Potential Action #4 Do Nothing

Clearly, matters relating to wildlife habitat in the Harbour have developed haphazardly, though generally positively up to the present. It is doubtful, however, that the desirable future state of waterfowl and colonial birds will be achieved without intervention.

Colonial nesting birds on the CDFs and in Windermere Basin will probably be displaced in the future by commercial development some time after the year 2000. However, the birds are not secure in the short term. Colonial nesting birds occupying the man-made berms are subject to disturbance by people, their pets and wild predators. In addition, their nesting sites are not adequately protected by law and they presently cannot relocate elsewhere in Hamilton Harbour. Nesting habitats for colonial birds will disappear from the Harbour unless active steps are taken to relocate them from Windermere Basin and the CDF to newly created habitat elsewhere in the Harbour.

Cootes Paradise has reached a stable and undesirable configuration characterized by turbid water, thin ribbons of emergent vegetation in sheltered bays and no submerged vegetation. The absence of plants to consolidate bottom sediments, and trap nutrients provides excellent habitat for large populations of carp and ensures that sediment entering the marsh from the watershed is continually suspended in the water column from wind and carp activities. The marsh has degraded to the point where it can not recover without significant intervention.

Potential Action #5 CDF Operation

Some evidence exists indicating that ducks, terns and shorebirds have been lost to botulism and suspected lead poisoning in Windermere Basin. This threat remains there and if the CDF ponds become warm, organically rich waters are susceptible to invasion by the pathogen and metal inputs will continue (from disposal of contaminated sediments). Most of the water entering Windermere Basin is sewage treatment plant and storm sewer effluent, and the basin is reduced to one half of its original size.

Colonial nesting waterbirds and waterfowl should have suitable habitat in designated areas where continuity of use is ensured. If 'colonials' are to use Confined Disposal Facilities (CDFs) and the newly created cells beside Windermere Basin, then the cells should be quickly capped with clean fill and present no hazard to wildlife (see Recommendation #20).

Potential Action #6 Objectives for Contaminant Content in Wildlife

Contaminant advisories are available to assist consumers of Great Lakes fish to select fish that will minimize contaminant uptake. Similarly, there are national contaminant standards for several organochlorines, pesticides, dioxins and some metals in fish. Surprisingly, there are no national standards or consumption advisories to protect wildlife and consumers of wildlife.

There is good evidence that wildlife (herring gulls, cormorants, ducks, and snapping turtles) have elevated contaminant levels in their flesh. Acute mortality, and a variety of sublethal effects have been observed in wildlife from Hamilton Harbour. The source of contaminants is uncertain, but exposure to contaminated fish from Lake Ontario, and exposure to sediments in Windermere Basin and the CDFs are probably major contributing factors.

It is difficult to judge the edibility of wildfowl or the health of birds and wildlife from contaminant concentrations in their flesh. Therefore, it is recommended that national standards be established for contaminant levels in wildlife that protect wildlife and consumers of wildlife (see Recommendations #17, 18, 19, 21).

Potential Action #7 Legislation to Protect Wildlife Nesting Habitat Throughout the Year

Wildlife habitat for migratory birds, (e.g. ducks and colonial waterbirds) is only protected by legislation while the birds are nesting. Clearly, important habitat for the rare and desirable species that nest in the Harbour should be protected throughout the year.

Therefore it is recommended that CWS, through the Great Lakes Action Plan for Wetlands, encourage legislation that provides continuity of habitat protection. This policy also provides much needed protection of wetland habitat that may not be protected under the Fisheries Act (see Recommendation #23).

Potential Action #8 Plan to Manage Desirable and Undesirable Wildlife Populations

With the exception of some conservation and habitat development efforts in Windermere Basin and the CDF berm, wildlife populations in Hamilton Harbour (colonial birds and waterfowl) have not been purposefully managed. Tern habitat has been created in Windermere Basin. Cormorant and night-heron habitat has been created on the CDF berms. However, there have been no programs to control ring-bill gulls or to move birds to safer, more secure habitats in the Harbour. There are no provisions for colonial bird habitat after the CDF is capped and developed.

The RBG has a long term management plan for the fauna and flora of Cootes Paradise. The Plan is based on a recreated marsh with a high diversity of plant species that creates ecological niches for greater diversity of wildlife. Components of the plan include purposeful introductions of emergent and submerged plant species, control of exotic plants (purple loosestrife, milfoil), and animals (carp, white perch). Encouragement of rare indigenous fauna and flora (wild rice, spiny softshell turtle, least bittern) and control of nuisance populations (Canada goose, muskrat, raccoons, skunks, and squirrels).

We recommend the development of an overall plan to manage the combined wildlife resources of Hamilton Harbour and Cootes Paradise. The plan will include habitat and population targets, agency responsibilities, and contingencies for long-term maintenance.

IV.10.7.3 Fish and Wildlife

Potential Action #9 Capitalize on Opportunities to Create Habitat

When a new development occurs, the normal objective is to allow no net loss of habitat. Yet there may be opportunities to obtain a net gain. Front end project funds may be obtained more easily than after-completion costs. Some projects may provide material needs. An alternative to shoreline protection, which degrades the littoral zone, is development of island breakwaters which extend and protect littoral areas. There are several proposed projects that have potential to create fish and wildlife habitat (repairing the LaSalle Park Pier, Eastport construction, development of Pier 4 and the Waterfront Park, expansion of the James St. Marina, development of the Burlington Waterfront Plan and the new Science Centre, construction of the Perimeter Road, and erosion control off the cemetery properties). Each activity has the potential to create fish and wildlife habitat.

It is recommended that the Bay Area Restoration Council become aware of projects in the Harbour and capitalize on opportunities to create/enhance fish and wildlife habitat (see Appendix J).

Potential Action #10 Restoration of the Cootes Paradise Marsh and the Grindstone Estuary

Participants at the marsh restoration workshop reviewed a number of options ranging from low technology conservation measures such as planting and protecting existing vegetation, to construction of bermed marsh cells isolated from the adverse effects of sediment, carp, nutrients and water level fluctuations. The resulting recommendations represent an integrated approach to marsh restoration.

The integrated approach incorporated the most desirable features of other options suggested to date, in a strategy to rehabilitate all of Cootes Paradise as one system. It consisted of:

(i) pollutant reduction at source, with an emphasis on reducing sediment inputs,

(ii) carp control at Desjardins Canal, in addition to other manipulations of the fish community,
(iii) reduction of fetch and provision of shelter with berms and islands, and,
(iv) plantings of aquatic plants and measures to extend existing macrophyte beds. This will be accomplished as follows:

Stabilization of mudflats with emergent vegetation

Sites adjacent to existing marshes should colonize naturally if protected from carp and high concentrations of silt. Other sites will be selected for suitability for planting of emergent plants. Sites selected for either natural colonization or planting must be protected from wave action and resuspension of sediments.

Promote colonization by submergents and emergents by changing morphometry

Shelter for aquatic plants, protection of the shoreline and sedimentation (to provide shallow water for emergents) can be obtained by installing groynes at strategic points along the shoreline. Islands would be desirable to provide not only shelter for aquatic plants but also provide dry, protected sites for nesting and protect leeward shorelines and marshes. Creation of an inlet marsh in western Cootes Paradise is recommended to trap sediment from Spencer Creek and become somewhat shallower and more suitable for plants. The marsh at the boardwalk site would expand westward.

Restoration of marsh in the eastern half of Cootes Paradise may be restricted to the near shore. However, submergent plant colonies may develop in open water areas, particularly if planting of emergents in the western half of Cootes Paradise is successful and the inputs of sediment from the watershed are reduced and new inputs of sediment to the open water areas are curtailed.

Restoration of Grindstone Creek

The four areas of concern are the Cherry Hill Gate marsh, Long Pond, the "elbow" and Sunfish Pond. Carp likely are the main stress in the latter three areas where little marsh remains. The 4 ha Cherry Hill Gate marsh runs parallel to Grindstone Creek and it is connected to the creek at the downstream end. Pike have spawned in the marsh but it dewaters so early in the spring that larval fish are killed. The three downstream ponds (about 20 hectares) would be suitable nursery areas for pike and other species if carp could be controlled. Spawning and nursery areas do not have to be large to support a strong pike population. Largemouth bass probably would spawn in the three downstream ponds.

The following projects are recommended:

Water level control in the Cherry Hill Gate marsh

A low dam (0.5 m) should be built spanning approximately 5 m across the mouth of the marsh to maintain a minimum water level suitable to sustain spawning pike and emergent fry. The marsh could be dewatered at the appropriate time by lowering the dam. A small flow could be maintained through the marsh by tapping into the creek upstream, and channelling water to the head of the marsh.

Restoration of marsh in the "elbow", Long Pond and Sunfish Pond

Because fetch is low, these sheltered ponds should be colonized by emergents and submergents when carp are excluded. Mudflats remaining over part of the "elbow" in late summer and fall are well suited for shore birds and turtles and an RBG trail provides access there. The Grindstone Creek marsh is a very popular tourist attraction. Efforts to restore marsh habitat will have a high educational potential and benefit the large number of naturalists who visit the area (see Recommendations #9, 10).

Potential Action #11 Carp Control

Recommendations to control carp assumed that carp could not be excluded or eradicated from the Harbour. Realistic alternatives focused on measures to reduce the large numbers of adult carp in the Harbour and restrict their access to Cootes and Grindstone Creek. Priorities focused on temporary solutions to control carp until a balanced fish community could be established that would eventually lead to some measure of biological control.

Carp control grates

The writing team discussed methods to exclude adult carp from Cootes Paradise by constructing a dam or grate in Desjardins Canal. Carp will also be excluded from Grindstone Creek by constructing a carp grate between the Valley Inn Road and Sunfish Pond. The dam option prevents all undesirable species such as alewife, carp, and white perch from entering Cootes Paradise and Grindstone Creek and offers an opportunity to control water levels to restore emergent vegetation. However, the option was rejected because it prevented the movement of juvenile fish between Cootes Paradise and the Harbour and because of the possibility that a dam may interfere with sediment transport and hydraulics in Cootes Paradise.

The grate is the least expensive and the easiest to construct. However, grates small enough to restrict the movement of large carp will also prevent the movement of desirable top predators such as pike and channel catfish. Fish movement can be accomplished by constructing a fish trap at the grate and physically moving fish from one side to the other during spawning migrations (early April-June, and late September-November). Juvenile fish of all species could move at will between the

Harbour and Cootes Paradise and the barrier would have minimal effects on sediment transport. The barrier would only be used from early April to October.

Placement of grates in the Desjardins Canal and at the mouth of Grindstone Creek are not viewed as permanent solutions. Rather, carp control is proposed as a temporary measure to keep carp out of Cootes Paradise and Grindstone Creek until submerged vegetation recovers and a desirable fish community is established. The option has several advantages: it is low cost; it has minimal environmental impact; it is reversible and can be installed as required, and involves no irreversible habitat alteration. Carp control without planting, reshaping the underwater slope, and protecting plants from wave action will not lead to a restored marsh. It is only one of several strategies in the integrated program.

Carp exclusion is impractical in Hamilton Harbour and carp removal is the only feasible alternative to reduce the number of carp sufficiently to improve light penetration and encourage revegetation. The recommended option is to operate a trap netting program during the summer months to remove carp from the Harbour. This is a temporary measure designed to reduce habitat destruction and competition during the transition period before stocked fish have become self-sustaining (see Recommendation #11).

Potential Action #12 Wildlife Habitat in Windermere Basin

Windermere Basin, in its present form, is not good fish and wildlife habitat. However, we anticipate that other remedial options to reduce contaminant inputs to the STP and improved treatment efficiency will result in the discharge of uncontaminated effluent into Windermere Basin. At that time, dredging should stop and the basin should be allowed to fill with clean sediment and resume its proper function as estuary for to Redhill Creek. This is especially important if remedial actions are implemented to improve fish and wildlife habitat upstream. In the meantime, it probably will be necessary, in order to sustain dwindling numbers of common terns in the lower Great Lakes to maintain the nesting colonies of terns on the Windermere dykes (see Recommendations #22, 23, 24).

Potential Action #13 Creation of 5 km of Island Habitat in the Harbour for Fish and Wildlife

Infilling along the south and east shores of the Harbour has claimed 5 to 10 percent of the volume of the Harbour and 25 percent of the surface area. At the same time, the littoral zone has been reduced to approximately 199 ha. Submerged vegetation is absent or sparse in 109 ha leaving only 90 ha of suitable habitat for fish and waterfowl. Most of the littoral habitat along the shore is exposed to wind and wave action which stirs up bottom sediments and reduces water clarity. Apart from submerged vegetation, there are no underwater structures that can be used by fish. Similarly, apart from Windermere, the CDFs and the two small hydro islands, there is no suitable habitat for colonial waterbirds in Hamilton Harbour. The creation of islands parallel to shore will reduce turbidity, encourage plants in the newly created lagoons, and provide loafing and nesting sites for colonial nesting birds and feeding sites for waterfowl. In addition, islands with connections to shore increase access, and provide opportunities for fishing and wildlife viewing.

All islands recommended for the Harbour will comply with Hamilton Harbour Commissioners' specifications for navigational safety and construction. They will consist of a large rubble exterior and an inner core suitable for supporting tree growth. The berms will be 4 to 12 m wide at the top with at least a 2:1 slope on the windward side and a longer slope on the lee side. Large boulders will be placed at the base of the slope on both sides to provide adult fish habitat.

Creation of colonial bird habitat on Pier 27

Pier 27 is an extension of the Confined Disposal Facility used by the Hamilton Harbour Commissioners to dispose of contaminated dredge spoils. The area has been colonized by colonial nesting birds (Caspian terns, common terns, double-crested cormorants and black-crowned night-herons) and represents an important nesting site on Lake Ontario. Unfortunately, the birds are nesting on land that will eventually be developed, and their habitat, which is not protected by law, will be destroyed.

We recommend the creation of a 250 m x 12 m island to the north of Pier 27 specifically as habitat for colonial nesting birds. This location will afford excellent viewing opportunities from Pier 27, and from the shore and at the same time, protect the birds from predators and visitors. Nesting habitat (cottonwoods and willows) and platforms will be provided to encourage nesting of desired species. The island will shelter part of the east shore from the prevailing westerly winds and encourage submerged plants, an excellent habitat for ducks and fish.

Creation of a Fish and Wildlife Conservation Area north of CCIW

The north east shore is one of the widest littoral zones in the present Harbour (approximately 18.4 ha). It is exposed to the full five mile fetch of Hamilton Harbour, and turbidity from resuspended sediments is preventing plant growth and limiting fish and waterfowl habitat. The site contains two small islands that are already used by colonial nesting birds. We recommend expanding these islands by approximately 1,250 m along the east shore to enhance some of the beneficial uses of the Harbour, particularly for fish habitat and waterfowl use, and protection of colonial nesting birds. Specific nesting sites will be created to encourage some species and discourage others. The site offers considerable potential for restoration of fish and wildlife habitat. Public access will be provided to the first island only by means of a bridge or fishing pier.

Habitat development along the north shore

The north shore of Hamilton Harbour has a high potential for restoration of fish and wildlife habitat. There is no landfilling, but breakwalls have been constructed along most of the shore to prevent erosion. The area between Carrolls Point and Willow Point is the only stretch of unprotected shoreline on the north shore. The clay banks at this site show recent signs of erosion by wave action confirming its' role as a source of sediments to the Harbour.

LaSalle Marina is the only location on the north shore that is protected by a floating tire barrier. The barrier reduces wave action, resulting in good water clarity and excellent plant growth. The disparity between this site and unprotected sites on both sides of Lasalle Park is a clear indication of the beneficial effects of shelter. Not surprisingly, fish and wildlife communities have responded to the increased plant growth. Fish biomass and species diversity are greater in this location than at any other site in the Harbour, and the combination of plentiful food and island-like habitat attracts night-herons, blue herons, terns, and cormorants.

Three types of improvements along the north shore are recommended; these are: (1) islands (3000 m), (2) groynes (400 m), and (3) fishing piers. All will be confined to public lands. Initial suggestions are to locate islands off LaSalle Park since this is the only access point along the north shore, and off the cemetery property to protect the last remaining natural shore and reduce sediment input into the Harbour. The islands will improve aesthetics, provide waterfront access, protect shorelines from erosion, and promote submergent aquatics at depths of 1 to 2 m.

Habitat creation at the waterfront park

The 2.1 km of shoreline between the proposed Waterfront Park property and the Desjardins Canal represents 14 percent of the total littoral shoreline in Hamilton Harbour. More importantly, it is the last remaining shallow water habitat on the south shore. Although the area is an important spawning and nursery habitat for bass, its real value lies in its potential for rehabilitation. The uncontaminated sand and gravel substrate along the CNR shore is preferred spawning material for largemouth bass.

We recommend creation of islands along the CN property (1,120 m) and the Pier 4 Park in the 2 to 3 m depth. As along the north shore, the islands will promote plant growth, provide habitat for colonial nesting birds, and provide increased access to the waterfront. A fishing pier is also proposed for this site. Island creation will occur in conjunction with the Waterfront Park and Pier 4 development. In addition, proper placement of islands will provide sheltered rowing areas for the Leander Rowing Club, an important user of the west Harbour (see Recommendation #12).

Potential Action #14 Enhanced Beneficial Uses for Access, Recreation and Education

Remedial options to restore fish and wildlife populations emphasize the creation of marsh and littoral habitats at several locations in Hamilton Harbour and Cootes Paradise. Throughout, we have considered the diverse needs of a complex urban setting, which is why the options include fishing piers, a canoe launch, access, an interpretive centre, enhanced aesthetics, and wildlife viewing platforms. In addition to creating new opportunities for sport fishing and wildlife appreciation, these options will improve access to the waterfront, increase opportunities for public education, develop a strong public advocacy through public participation in marsh restoration, improve aesthetics, and eventually lead to further improvements in water quality (see Recommendations #24, 36).

IV.11 Urbanization and Land Management

It must be evident, in spite of discussion up to this point that focuses on the more obvious 'pipes' which discharge to the Harbour, that urbanization and industrialization of the watershed is the underlying reason for the past degradation of water quality and the loss of natural habitat for fish and wildlife.

What has been proposed up to this point is to apply every reasonable known or developable technology to take stress off the system - with the judgement that this will be sufficient (if pursued vigorously) to restore a reasonable degree of integrity to the functioning of the aquatic ecosystem. Although matters look very hopeful, we must be aware that we are not restoring the system to its original pristine state. The system is degraded now, was in a worse state 15 to 20 years ago, but is retrievable to a reasonable degree.

To deal with the current situation, and particularly to address ways to maintain the aquatic system in its restored state for the decades to come, will require the combined efforts of several jurisdictions and agencies. The first strategic element will have to address, at the most senior planning levels in the watershed, the overall goals for the watershed and the acceptance of the specific targets that relate to those goals (e.g. the limited capacity of the Harbour to accept phosphorus loadings). These goals need to be reflected in Regional and Area Municipal Official Plans, the plans of the Conservation Authorities, the regulatory actions of the enforcement agencies, and the goals of the community, industry and Harbour Commissioners generally. This degree of collaboration can be achieved in a variety of ways.

Integrated land use planning and Harbour use planning will be crucial to maintaining a viable aquatic ecosystem and the closely linked terrestrial and stream ecosystems throughout the watershed. The connections between planning decisions and environmental quality on the one hand and between environmental quality and community well-being on the other hand are many and diverse. They include:

- population growth and its consequent additional loading of nutrients to the sewage treatment plants,

- urban development and its impact on flood flows and soil erosion,

- industrial development with its employment opportunities alongside waste generation potential,

- achieving an acceptable balance amongst industrial, shipping, recreational, transportation, commercial, environmental and private interests in use of the Harbour and Cootes Paradise shoreline,

- the relation between the previously listed interests and habitat for animals, birds and fish,

- the relation between having a healthy aquatic or natural environmental system and the community's perception of risk to its own health, or its opportunity for enjoyment of accessible green space or for enjoyment of water-based activities,

- the relation between the current quality of life and that which we bequeath to future generations.

Collaboration on the scale envisaged here has, in the past, been partly successful. It is probably inevitable that agencies or jurisdictions with different goals might come into conflict. However, if we are to achieve the distinction of rehabilitating Hamilton Harbour and its watershed in a socially and economically acceptable way, collaboration amongst several agencies and three or four levels of government will be essential.

Also, as is evident from the sources of pollution listed in earlier sections of this report, each and every citizen can play a part through their individual actions to reduce pollution or pollution-causing activities, or through their participation in community-wide efforts to provide direction to the developments in our cities and the surrounding countryside.

IV.11.1 Potential Remedial Actions to Address Problems

Action #1 Do nothing.

Action #2 Incorporate Harbour capacity limits for wastewater loading and habitat requirements into planning goals for the affected Regional and Area Municipalities.

Action #3 Incorporate RAP goals into the regulatory activities of the Region, Provincial and Federal agencies responsible for any aspect of the Plan.

Action #4 Establish a management team and director for the implementation of the Plan.

Action #5 Establish a mechanism for regular, knowledgeable public scrutiny of the Plan in all of its implications.

Action #6 Establish contractual or other agreements amongst the various jurisdictions to carry out coordinated funding, planning and operations as required in the Plan.

Action #7 Provide materials and incentives to disseminate information about the Plan, the state of the environment and the progress of the communities around the Harbour in achieving the goals established and agreed.

Action #8 Incorporate better procedures for control and enforcement of regulations pertaining to erosion in the watershed, particularly for urban development areas.

IV.11.2 Comments on Potential Remedial Actions

We have 'caught' the situation in the Harbour where mostly technical measures are available to correct many of the problems that we face due to the population and industry that is present in the watershed at this time. Doing nothing to capitalize on this opportunity is to close the door on the future.

The limits on what 'load' the Harbour can carry need to be part of the planning in all jurisdictions having an impact on the Harbour (Action items #2 and 3 - Recommendations #1, 2 and 36).

The management direction of the Plan, and means to have public scrutiny of the implementation of the Plan are requirements of the Canada-Ontario Agreement Review Board (Action items #4 and 5 - Recommendations 45 and 46).

The arrangement that has been developed in discussions with the COA RAP Steering Committee and the Stakeholders is described in Section IV.14.2.

The organizational structure that has been developed is presented in Figure 38.

Funding arrangements will be required for the Stage 2 report to go forward with a commitment as designated in the Great Lakes Water Quality Agreement (Action #6).

Essential to the complete Plan is access to information about the Harbour in both a reactive and proactive sense. Provision must be made to ensure that information is readily available (see Recommendations #34 and 35).

IV.12 Access and Aesthetics

As the Stakeholders stated early in their deliberations:

> "Public access is an important factor in achieving public awareness and support for Hamilton Harbour remedial actions ... leading to community benefits", and "aesthetic improvements ... provide the public with a basis for genuine belief that water quality can be improved".

Public use of the Harbour requires an increase in the opportunity for the public to be beside or on the water. This, in turn, calls for ensuring that the water experience is aesthetically pleasing.

The aesthetics of the shore and water experience include the clarity, smell and appearance of the water and shore. It also includes the bird life, odours, noise and landscaping around the shores.

In addition to the measures to address algae, water clarity, spills and combined sewer overflows, the following actions could be considered:

IV.12.1 Potential Remedial Actions to Address Problems

Action #1 Institute public information and education programs as a means of encouraging public use (see Recommendations #34 and 35).

Action #2 Municipalities or other authorities to acquire and develop land for public use, to use existing lands or identify new sites as they become available (see Recommendations #36, 43 and 44).

Action #3 Re-examine present zoning by-laws and official plans and recommend changes to improve access potential (see Recommendations #36, 37, 43 and 44).

Action #4 Develop and implement a comprehensive Green Belt plan to cover unsightly terrain and to encourage natural indigenous vegetative cover for industrial and marine areas and for the north and east shores.

Action #5 In a coordinated fashion, institute physical clean-up programs for litter and refuse in all parts of the Harbour, in Cootes Paradise and in tributary streams and valleys, supplementing existing city programs where necessary (see Recommendation #39).

IV.13 Institutional Arrangements

A number of discussions have centred on existing environmental assessment procedures and the means to oversee the implementation of this Remedial Action Plan. While there will undoubtedly be changes to environmental assessment procedures, it is strongly recommended that the RAP ***not*** be considered a substitute for the regular assessment procedures now in place.

In order to ensure political and public acceptance of the Plan, it was recommended by the Stakeholders that a Council on the Harbour be maintained. This proposal, first made in 1986, has been the subject of intense discussion both in the Stakeholders meetings and among the agencies involved. The following is abstracted from the Stakeholders meeting minutes (June 1991).

IV.13.1 Goals for Implementation

There are three major goals for the implementation strategies and structures:

1. To ensure that the RAP remains a **continuous priority** for government agencies and Stakeholders organizations.

2. To provide a comprehensive process for the **coordination, evolution and monitoring** of the RAP by agencies, Stakeholders, and the general public.

3. To ensure that governmental agencies remain publicly responsible for carrying out their **specific activities as lead agencies** for implementing the Plan.

The structure recommended in Figure 38 is the result of discussions between Stakeholders representatives and the two lead RAP agencies, MOE and DOE.

IV.13.2 Structures

1. The Hamilton Harbour Stakeholders have helped to set goals and review technical options for the RAP. As the RAP moves into its implementation phase, the Stakeholders will need to meet at least twice a year to monitor and help revise the Plan.

2. The general public has been involved in the RAP process through the dissemination of Fact Sheets to over 2,000 persons as well as through public meetings. Public education programs will need to be developed and delivered to supplement these activities.

3. The relationship between the Stakeholders and the agencies will need to be strengthened and regularized for effective and open implementation. We envisage the process to correspond with the structure outlined in Figure 38.

4. We propose that the management group be named the Bay Area Implementation Team for the Remedial Action Plan (BAIT). We also propose that the principal consultative organization for the Remedial Action Plan be known as the Bay Area Restoration Council (BARC). In addition to these two groups, we propose Secretariats, a number of committees of each group, and a Foundation for handling financial support from a variety of agencies.

5. The establishment and operation of BARC for the purposes of:

   a) assuring protection and appreciation of the ecosystem of Hamilton Harbour;

   b) promoting, monitoring and assessing the implementation of plans for the environmental protection and restoration of the Hamilton Harbour area including the Hamilton Harbour Remedial Action Plan;

   c) assessing the public's perceptions of the environmental status of the Hamilton Harbour area, and promoting and developing related public information and education programs to heighten public awareness;

d) providing advice and making representations to the relevant government bodies, including the Canada-Ontario Agreement Review Board, in support of environmental protection and restoration plans for the Hamilton Harbour area;

e) coordinating the activities of the corporation with those of other organizations, societies and individuals with complementary objectives;

f) to solicit, receive, acquire and hold donations, gifts, and legacies for the objects of the association, to enjoy all the benefits of ownership thereof, to sell or convert any property into money from time to time; to invest and re-invest any principal in such manner as may from time to time be determined; and to disburse and distribute such money and property in the furtherance of the objects of the association.

6. The roles of the President of the BARC would be:

   a) To chair the biannual Council meetings.

   b) To supervise the Secretariat and its activities and organization.

   c) To regularly communicate to the Implementation Team the concerns of the BARC and the general public, and to reciprocate those concerns developed in the BAIT.
   d) To chair the Board of the BARC.

7. The Board is elected from any of the members of BARC. The President of the Board of BARC will be a member of the Board and elected by the Board. These positions are unpaid, although any expenses associated with the BARC would be reimbursed.

   The Secretariat for BARC will coordinate material with the BAIT secretariat and carry out the duties assigned with respect to the BARC mandate.

8. Membership of the BARC is to be voluntary, but to be as representative of community interests as possible. The "round table" model is considered to be the ideal, with members present not just to represent special interests, but to consider matters in a manner that transcends those interests. The BARC will replace the current Stakeholders Group.

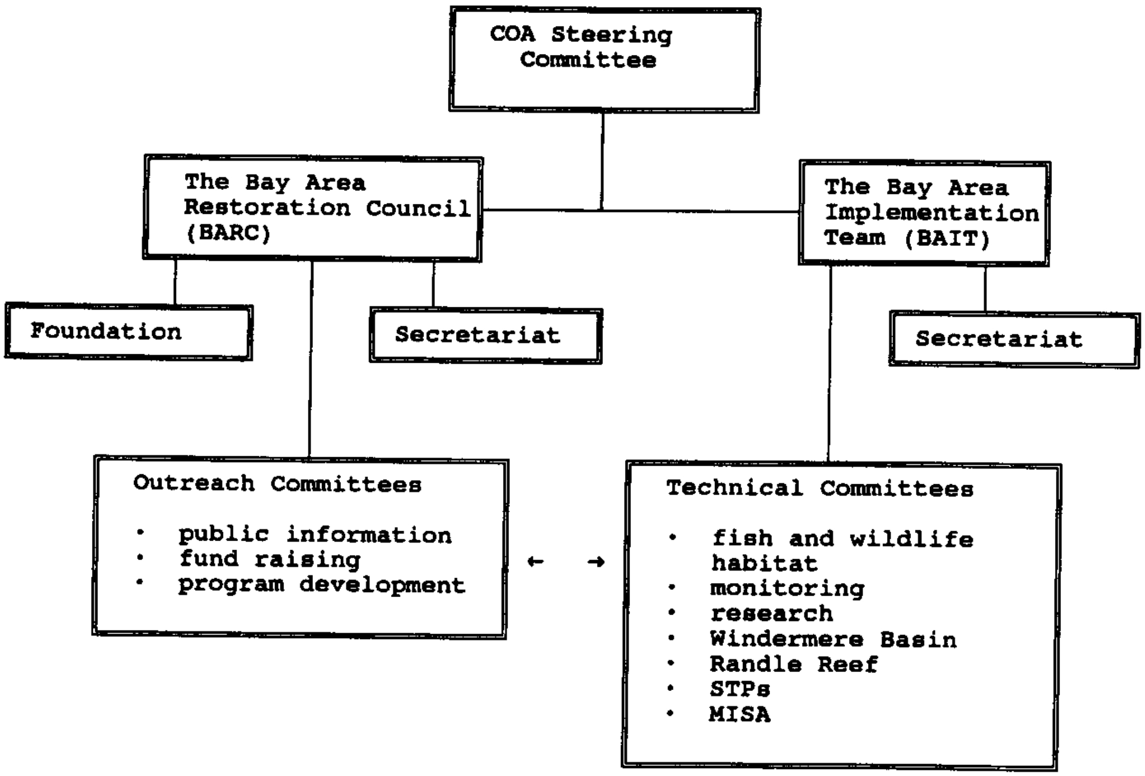
9. The responsibilities of the BAIT could be:

   a) To ensure implementation of the RAP.

   b) To ensure proper reporting of actions and progress.

   c) To ensure proper coordination and direction of Technical Committees.

Figure 38: Implementation Structure for the Hamilton Harbour RAP



Source: Hamilton Harbour Stakeholder Group

d) To communicate and consult with the BARC on all issues.

e) To refer reports to the BARC for their review.

f) To report status of the RAP to the Canada-Ontario Agreement Review Board through its RAP Steering Committee.

10. Membership of the BAIT would be the core group of implementing agencies. The Chairmanship of the BAIT could be shared between MOE and DOE with MOE taking the major lead.

11. The BAIT will probably need to meet monthly or bimonthly to review progress and solve new technical problems. They will also need to report progress to the BARC and the general public, as well as within their own agencies.

12. The Secretariat for BAIT would have the following roles:

    a) To provide secretarial, coordination and report preparation functions.

    b) To engage in public education programs and related public meetings and forums.

    c) To provide a focus for the RAP and a continuous linkage mechanism between the BARC, the BAIT, and the public.

13. Advisory/Technical committees are to be established as required. There has already been a call for a Fish and Wildlife Committee which has been established. Membership in these committees can come from the BARC, the BAIT, or from the community where special interest or knowledge could serve. Agency members of the technical committees have particular project responsibilities in reporting to the BAIT, but should do so with the full knowledge of their committees. A formal contact person from the BARC should also be identified for Technical Committees.

V SELECTION OF REMEDIAL ACTIONS AND RECOMMENDATIONS

Technical means to deal with pollution sources or wastewater were analyzed by the Writing Team and the Technical Options Committee of the Stakeholders. These options were presented to the Stakeholders in a workshop where the priorities for the different goals for the Harbour could be set individually and those priorities reflected in the composite of the priorities for the Plan. A resource book and work book were developed for use in their workshop and an outline of the process and criteria are presented below.

As the development of this Plan progressed, engineering studies of the promising options have been carried out and implemented in some cases. It is a matter of judgement when the Plan should be finalized, but even though not all detailed engineering plans have been developed this seems to be a propitious time to complete this stage of work for a report to the Canada-Ontario Agreement Review Board and the International Joint Commission.

Since the Plan development has taken place over four years while RAP guidelines and objectives were being developed, it is important to note that the general structure of the plan has been in place since 1986 (Hamilton Harbour RAP Stakeholders' Interim Report - September 1986). The details that have been added since that date have refined the target loadings or environmental objectives, refined the technological approaches to the problems, explored the literature for more ecosystemic ways to address the problems and prepared better substantiated cost estimates. Hence, the strategy to address fish and wildlife habitat for example, is a recent development arising out of the need to resolve a potential conflict between fisheries and wildlife goals. Also the cost estimates presented in this report are better refined than those presented in earlier discussion documents (e.g. Report of Goals, Problems and Options - A Discussion Document, 1988).

It has been encouraging to find the industries and agencies responsible for addressing problems proceeding well ahead of the finalization of the Plan even though it has sometimes made it difficult to keep up with the progress in our reports. An added benefit to this pre-emptive attack on the problems is that our intensive monitoring program seems to be recording the beneficial response in the Harbour itself. This lends further credence to the strategy and has allowed us to refine our targets. This, in turn will provide greater confidence in recommendations that entail much greater costs than the initial economical steps that have been taken.

Sometimes plans are taken as a hard-and-fast list against which to gauge future action. Our experience to date cautions against taking such a view. Provision has been made to officially record changes in the Plan where conditions or new information dictate better approaches. The reason for this suggestion arises from two perspectives on the work proposed.

a) The cost of these measures to society as a whole and to householders has engendered creative work to find more economical ways to achieve our goals. We wish to encourage that creativity and would be willing to revise the Plan if more effective and economical methods were to be found; and

b) In several ways the proposals are experimental in character and may require revision if the results do not prove to be beneficial as originally projected.

The ways and means by which we strive to achieve zero discharge or virtual elimination of persistent toxic chemicals, to achieve extremely low concentrations of nutrients or suspended solids in the effluents of municipal STPs or industrial effluents, or to reinstate habitat for fish and wildlife are somewhat new in North America, and should be recognized, when achieved, as a major advance in integrated resource restoration.

V.1 Stakeholders Review of Technical Remedial Actions

Measures that may be used to reduce the discharge of waste materials to the Harbour generally include those which address materials right where they are first used or produced, or at some place downstream in the line between the source and the discharge point into the Harbour. The measures addressed in this section, other than source reduction, are largely technical measures. That is, they involve treatment of wastewater or mitigation of the condition in the Harbour itself. Source reduction measures are addressed in later sections.

The measures reviewed in this section include:

Remedial Measure	**Title**
1.	Improved Chemical Treatment at Sewage Treatment Plants
2.	Nitrification at Woodward Avenue and Skyway STPs
3.	Ammonia Loadings from Steel Industries
4.	Installation of Sand Filters at the Skyway and Woodward Avenue STPs
5.	Diversion of STP Discharges to Lake Ontario (Halton and Hamilton-Wentworth)
6.	Remediation of Combined Sewer Overflows - Hamilton-Wentworth Region
7.	Rerouting of Dundas and Waterdown Sewers to the Woodward Avenue Plant (Hamilton)
8.	Phosphorus Control for Rural Runoff
9.	Erosion Control: Rural - Agricultural
10.	Erosion Loadings from Construction Activity
11.	Oxygenation of Hypolimnion in Summer
12.	Control of Bacterial Contamination from North Shore Streams or Resuspended Sediments
13.	MISA - Iron and Steel Sector (Dofasco and Stelco)
14.	MISA - Municipal STP Sector - Industries and businesses discharging to the municipal sewers

15. Remedial Action for the More Seriously Contaminated Sediments in the Harbour
16. General Sediment Contamination (less seriously contaminated sediments)
17. Spill Controls
18. Control and Creation of Colonial Bird Nesting Sites
19. Cootes Paradise Marsh Development (Dyking)
20. Restore Emergent Vegetation (Harbour)
21. Additional Littoral Habitat (Harbour and Cootes Paradise)
22. Restructuring the Fish Community - Plantings

These measures were rated by the Stakeholders in a major four day workshop. The format of the review was developed by the Technical Options Sub-committee of the Stakeholder Group. The details of the assessment method are given in Appendix L.

Initially each measure was gauged by the Technical Team as to its likely degree of impact on each water use specified by the Stakeholders (Section III.7). This in itself results in a ranking of the measures that assumes equal weight for each water use (see first Table in Appendix L). It also indicates which water uses are most sensitive to the overall program. Unfortunately it was not possible to rank the MISA measures (#13 and #14) since no information was available at the time (1989) on the cost or degree of impact of the remedial measures being developed under the program for virtual elimination of persistent toxic chemicals.

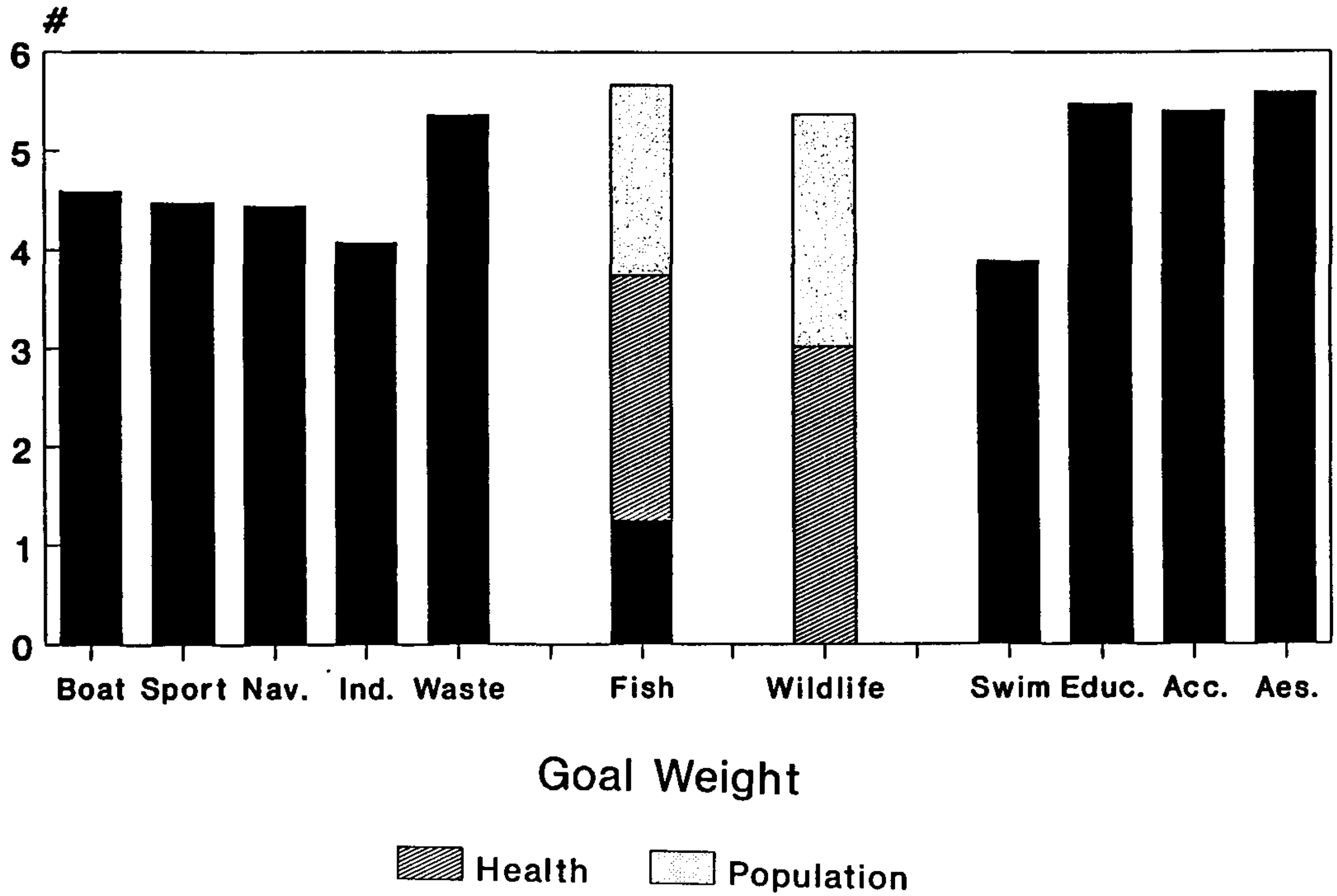
Equal weighting of water uses ranked CSOs and the sewage treatment plant improvements at the top of the list. Fisheries and wildlife concerns were found to be sensitive to a wide range of measures as were swimming, aesthetic concerns and the use of the Harbour as a receiving body for wastewater. This last item may need explanation. The wastewater receiving function was endorsed by the Stakeholders (in preference to diverting waste to the open Lake) but only in so far as these discharges met all of the requirements of maintaining or restoring the other water uses which they specified.

While ranking the measures without weighing uses was useful, the Stakeholders were given the means to assess the measures with their own weighing of water uses, with application of the degree to which measures met ecosystemic principles and with the opportunity to alter the assessment of the significance of the measures as originally presented by the Technical Team and Technical Options Committee.

V.1.1 Results

Thirty-one Stakeholders took part in the review and it was found that the Stakeholders do not collectively rank any of their goals as particularly low (Figure 39). Six of them are ranked somewhat higher than the others, however. These include use of the Harbour as a wastewater receiver, reinforcing their wish **not** to use Lake Ontario as the prime receptacle for wastewater discharges - albeit under conditions requiring all necessary effluent controls (1986 Interim Report of the Stakeholders). Others ranking somewhat higher are the fisheries, wildlife, educational, access and aesthetic goals. Recreational boating, navigation concerns, industrial uses and swimming uses ranked slightly lower.

Figure 39: Average Goal Weight



Source: Stakeholder Workshops - Summary Document, 1989.

With such an even ranking of water use goals (or 'beneficial uses', to use the terminology of the Great Lakes Water Quality Agreement), the rated effectiveness of each remedial measure is given below as a rank.

Samples of the ranking distributions of options are given in Appendix L.

Remedial Measure	Title	Rank
06	Combined Sewer Overflows	1
04	Sand Filters at STPs	2
09	Erosion Control - Rural	3
19	Cootes Paradise Marsh Restoration	4
10	Erosion of Construction Sites	5
01	Improved Chemical Treatment at STPs	6
17	Spills Control	8
20	Harbour Vegetation Enforcement	10
12	North Shore Bacterial Control	10
08	Rural Runoff-Nutrient Controls	10
22	Fish Community Restructuring - Carp Control	
05	Diversion of STPs to Lake Ontario (last resort)	12
07	Dundas STP Measures for Overload (overflow to Hamilton system)	13
21	Littoral Habitat Improvements	14
03	Industrial Ammonia Loadings Reduced	14
02	Ammonia Removal at STPs	16
16	General Sediment Contamination over Harbour	16
15	Hot Spots in Sediment - Contamination	17
18	Colonial Bird Habitat - Alterations	18
11	Oxygenation of Bottom Water	19

Notes:

1. Measures with a low rank were often those with the least "interconnectedness", that is, they did not affect as many other activities as the more highly-ranked options, but this does not mean that a lower-ranked measure would not be implemented in order to meet water quality goals.

2. Measure 5, STP effluent diversion to Lake Ontario, was given a low ecosystem approach score and three individuals rejected this measure and refused to rate it. This measure was discussed by the Stakeholders and Recommendation #50 reflected the majority view that diversion should only be considered as a last resort.

3. Where there was a 'tie' in ranking, the Ecosystem Committee rankings were used to break the tie.

4. Measure 19, Cootes Paradise Dyked Marsh, has undergone major revisions as noted in Section IV.10.

5. MISA program elements (numbers 13 and 14) were not ranked by Stakeholders because it was felt that too little information was available to address these measures at this stage. However, adoption by the Stakeholders of the Principle of Zero Discharge consistent with virtual elimination (see Section III.3.2) is one measure of the significance that is placed on the issue of persistent toxic chemicals.

These data need some interpretation in light of the discussion by Stakeholders of each of these measures. It is noted above that measure 19 dealing with wildlife habitat restoration using dyked cells received some concern as regards conflicts between fisheries and wildlife goals. These conflicts were resolved through a new strategy reflected in the final recommendations.

In addition, some measures only addressed one goal (i.e. oxygenation of Harbour water), but this one factor can be crucial in a way not well reflected in this analysis. In this instance the impact of dissolved oxygen on exclusion of fish from the coldest water of the Harbour in summer; on the toxicity of bottom sediments to benthic fauna; and on the release of contaminants from the sediments of the water column have to be considered in concert. Some measures are linked, such as the several measures dealing with sewage treatment plants. In this case it is necessary to address these measures in a way which reflects the logical sequence of measures that could be implemented at the plants, and the cost efficiency of each measure.

From these data, including the detailed comments made by Stakeholders in the workshop, the following rankings emerged:

1. Correction of combined sewer overflows with first priority to discharges in Cootes Paradise and the western half of the Harbour.

2. Improved efficacy of the sewage treatment plant operations through:

   a) process audits
   b) improved chemical treatment
   c) improved aeration and hydraulics and any necessary clarifier or recycle line capacity modifications
   d) computer aided automated operational control systems installed

3. Installation of filters as an additional step in sewage treatment at the Burlington and Hamilton-Wentworth Sewage Treatment Plants (after #2, and only if required).

4. Erosion control in the rural and urban areas, with emphasis on processes affecting channel erosion below the escarpment, on erosion from construction sites (housing

developments, highways, railroad and industrial) and potential nutrient discharges from farming operations.

5. Greater control on spills that can impact on the Harbour directly (such as a cargo spill or a direct industrial spill) or indirectly, such as spills into the sewer system that disrupts the operation of a sewage treatment plant.

6. Measures to address habitat restoration for fish and wildlife and to address needs for changes in the species composition of the fish population.

7. Control of bacterial contamination sources affecting the north shore of the Harbour.

8. Further controls on industrial discharges (details as yet incomplete but emphasizing in-plant recycling and source reductions).

9. Addressing the problems associated with bottom sediments contaminated by a variety of toxics from past and current discharges to the Harbour.

10. Mitigation of low hypolimnetic oxygen conditions (summer only) until causes of the dissolved oxygen depletion have been remediated as a short experiment.

These priorities should not be viewed entirely as a linear set of independent actions. Judgements about the sequence of serial or parallel measures need to consider such things as:

a) Remediation of combined sewer overflows requiring an increase in the sewage treatment plant capacity,

b) Tertiary sand filters should not necessarily be considered ahead of STP audits if the loading targets for the Harbour can be met by more cost effective methods,

c) The technology exists to proceed promptly with a number of STP measures, but must be viewed as part of a complete sewage system,

d) The potential for population and industrial development of different kinds, under various degrees of control, to affect future wastewater volumes and quality, and

e) While much 'end-of-pipe' technology exists, there has been little in-depth development of methods to reduce at multiple dispersed sources.

In viewing the fundamental objectives of reducing both toxic and nutrient contaminants, it is also fortunate that efforts to reduce either type of loading usually results in a corresponding benefit to the other type, especially in sewage treatment plants. This arises primarily because of the affinity of both types of contamination to particulate material. A major component of water improvement is aimed at physical removal of particulate materials, whether from industrial effluents, sewage treatment effluents or streams. This reduces loadings of both nutrients and trace contaminants.

V.2 Recommendations

Following the sequence of rankings listed in the previous section, and the surrounding discussions regarding other types of measures, planning concerns and a wide range of issues that are not technical in nature, the recommendations of the Stakeholders and the Writing Team were developed through careful study and discussion over a period of six or seven months. They are as follows:

Recommendation #1

(a) It is recommended that the key goal for the Harbour be,

That dissolved oxygen levels always be above 4 mg/L throughout the Harbour, to increase the fish habitat, improve benthic fauna diversity and amount, and to reduce the toxicity of bottom sediments.

(b) Since the above goal embodies remedial measures that will impact on water clarity, on bacterial contamination, on unacceptable levels of ammonia, on nuisance algae growth, on trace contaminants and on unsightly, putrescent or objectionable sludge deposits, it is recommended:

THAT these factors be addressed concurrently with the measures relating to the goal for restoration of dissolved oxygen in the Harbour.

(c) Based on these considerations, it is therefore recommended that measures be taken to remediate in order of priority:

i) The combined sewer overflows into Cootes Paradise and the western half of the Harbour,

ii) The remaining combined sewer overflows in the eastern half of the Harbour, on the condition that no increase in total phosphorus or ammonia loadings will result elsewhere in the Harbour,

iii) The net discharges of ammonia, phosphorus, and suspended solids in all sewage treatment plants in the Harbour to meet the loading capacities specified in Chapter 9; and

iv) Specifically to deal with nutrient enrichment problems in confined areas of the Harbour, that the phosphorus concentration in the effluent be reduced to less than 0.1 ppm at the Dundas and Waterdown sewage treatment plants.

(d) In order to properly gauge the impact of current and proposed remedial measures, it is recommended that the conditions (dissolved oxygen, clarity and algae) be monitored very carefully in the Harbour and Cootes Paradise, and that confidence in our ability to predict changes be improved by analysis of these data and by development of more comprehensive calibrated models.

Recommendation #2

That ambient water quality criteria and sewage treatment plant effluent criteria be reviewed for Cootes Paradise and Grindstone Creek to ensure that loadings from the sewage treatment plants have no further significant impact on the ecological value of these two areas.

Recommendation #3

That municipalities and other authorities develop a shoreline management strategy whereby they acquire and develop land for public use, use existing lands under their control, and identify new sites as they become available, in order to provide substantially more physical access to the shores of the Harbour.

Recommendation #4

That erosion be minimized through utilizing such measures as conservation tillage, buffer strips, cover crops, crop rotation and structural controls as appropriate.

Recommendation #5

That erosion be minimized during subdivision construction by utilizing best management practices. These management practices must be developed, adopted and enforced by municipalities and conservation authorities, and that training programs for inspectors and construction site supervisors be established by provincial authorities.

Recommendation #6

That further sources of erosion and contaminants be located and remedial measures suggested, by carrying out further studies on tributary streams.

Recommendation #7

That spills and near-spills into the Harbour and/or on surrounding areas are reported publicly, and their severity, frequency and potential for further reduction be monitored. The process of spill handling should be reviewed every two years.

Recommendation #8

To reduce stress on fish due to trace contaminants, lack of oxygen in the bottom waters, and lack of submerged weed habitat, it is recommended:

That light penetration be increased in Harbour waters, and that oxygen demand in the hypolimnion and possible exposure of fish to toxic substances be reduced by improving the water quality and sediment quality in the Harbour as recommended in other sections of this report.

Recommendation #9

As recommended in Section IV, that efforts be undertaken to restore 240 ha of submerged and emergent vegetation in Cootes Paradise, by controlling carp populations and introducing natural predators, or by other measures (subject to environmental assessment).

Recommendation #10

That emergent marsh vegetation in Grindstone Creek, including the pike spawning marsh be restored and that measures be adopted to exclude carp such as a carp barrier containing a fishway that will permit the passage of other fish species during their upstream and downstream migrations in Grindstone Creek.

Recommendation #11

That in order to mitigate the destructive effects of the existing large numbers of large carp on wildlife and fish habitat, carp control in Hamilton Harbour and Cootes Paradise be implemented. Studies are necessary to determine the effectiveness of methods of carp control, but preference is to be given wherever possible to techniques designed to exclude their access rather than by removal. Methods to exclude carp must not prohibit the movement of other fish species between Cootes Paradise and Hamilton Harbour.

Recommendation #12

That island structures be created at several locations offshore for various purposes such as the creation of lagoon habitats for fish and waterfowl, the provision of nesting and loafing habitats for colonial birds, increasing the amount of "sloping edge", the prevention of erosion of the shore and resuspension of bottom sediments, and where possible facilitate access, provide linkages to other green spaces along the Harbour, and improve aesthetics.

Recommendation #13

Encourage coordination among Lake Ontario, Harbour and Cootes Paradise shorelines projects such as the proposed habitat creation projects and the development of Pier 4 Park, the waterfront park on the former Lax property, and the waterfront park on Burlington's beach front.

Recommendation #14

That top predators be introduced to the Harbour to restructure the fish community.

Recommendation #15

That the status of the fish community and habitat improvements be monitored.

Recommendation #16

That regulatory agencies apply Canada's Fish Habitat Policy to ensure the regulation of "no net loss" of all fish habitat in Hamilton Harbour, and once the Fish Habitat Management Plan is developed, to ensure that developers, landowners, Conservation Authorities and other regulatory agencies comply with the development application guidelines for areas sensitive to development.

Recommendation #17

That one or more indicator species, solely indicative of the conditions within the Harbour, be established to monitor wildlife populations and contaminant levels in wildlife in the Harbour. A battery of appropriate biological responses should be developed and monitored.

Recommendation #18

That contaminant levels in the water, sediment and foodchain be reduced as much as possible to allow for the presence and natural reproduction of the most sensitive native species of aquatic and terrestrial life, and to prevent any contaminant-related restrictions on fish consumption.

Recommendation #19

That indicators of wildlife health and efficacy of remediation efforts to control contaminants be determined by developing contaminant concentration objectives for indicator wildlife species.

Recommendation #20

That steps be taken to minimize contaminant uptake by wildlife in CDFs.

Recommendation #21

That research be encouraged on the biological significance of environmental contaminants in Hamilton Harbour.

Recommendation #22

That BARC maintain a Fish and Wildlife committee which endorses the concept and principles of the 1990 Fish and Wildlife Restoration Project subject to detailed workplan development; development of partnerships as required for the DOE Cleanup Fund; ensuring BARC involvement and representation on the Steering Committee for the project; and augmentation of the EARP process through involvement of BARC in the planning and implementation of the project.

Recommendation #23

That habitat be maintained or created as necessary in the Harbour or in Lake Ontario immediately adjacent to the Harbour to support nesting populations of colonial waterbirds at selected areas, and that all development projects be reviewed by the Fish and Wildlife committee to ensure they comply with Canada's Fish Habitat Policy.

Recommendation #24

That marsh boardwalks and wildlife viewing platforms be created on Cootes Paradise marsh and in certain strategic Harbour locations, provide access, and opportunities for wetland appreciation and education of the surrounding area.

Recommendation #25

If urban storm runoff is determined to be a significant source of bacterial contamination to the Harbour, that the source of this bacteria be established in order to eliminate the transfer of bacteria to the Harbour.

Recommendation #26

While continuing to disinfect sewage effluent, that alternatives to chlorination be considered to reduce the risk of producing unwanted chlorinated organics.

Recommendation #27

That the improvement in bacteria quality be monitored and the existence of no new sources of bacteria be verified (i.e. north shore streams) by immediately conducting regular sampling for bacteria in candidate swimming areas of the Harbour.

Recommendation #28

To meet the goal of zero discharge or virtual elimination of trace metals and trace organics within as short a time as possible, it is recommended:

That remedial measures be implemented for industries discharging trace contaminants to the Harbour, to the watershed or to the municipal sewer systems under both the criteria for 'Best Available Technology that is Economically Achievable' (BATEA), and the criteria deemed necessary to ensure good water and sediment quality in the Harbour and its tributaries and reduction of contaminants in fish and biota to the maximum extent possible.

Recommendation #29

Standards and procedures have not been fully established for assessing the need or desirability of remediating contaminated sediments. For this situation, certain preparatory work is urgently needed, namely:

a) For the more severely contaminated areas of sediment, that biologically-based clean-up criteria be established; that three-dimensional chemical and bioassay mapping be carried out; that biological assessment of current suspended sediment loading be carried out (to ensure that potential new sediments would meet the standards); and that effluent sources for biologically available forms of trace organics be assessed.

b) For the general wide-spread sediment contamination in the Harbour, that a biological assessment of existing sediment following prolonged oxygenation be urgently carried out; that an assessment of contaminant transfer from the sediment to benthos and bottom-feeding fish be carried out; that cause-effect toxicity be carried out to allow development of more chemical-specific effluent limits; and that a model integrating all the information be developed to better relate contaminant sources and their effect, and to better predict the "recovery" period for the large mass of historically contaminated sediment in the Harbour.

Recommendation #30

That household hazardous waste collection services be continued and expanded by Regional Municipalities, and that citizens be further encouraged to use collection depots for the disposal of toxic chemicals.

Recommendation #31

That pesticide use (herbicides, insecticides, etc.) by all agencies and organizations responsible for parks, conservation areas, or other large tracts of land within the watershed be reviewed with the intent to substantially reduce the loading to the Harbour and its watershed.

Recommendation #32

That artificial oxygenation or aeration of the hypolimnion be considered as an interim measure:

a) to achieve the desired hypolimnetic dissolved oxygen concentration immediately while other options are being implemented; and,

b) to confirm that a diverse benthic invertebrate population can develop in the sediments of the Harbour without any toxicity, growth limitation or bioaccumulation problems.

Having completed their review of technical options, the Stakeholders addressed concerns about education, municipal and provincial planning that incorporates the goals of the RAP, and about the measures required to ensure that the RAP has a management focus and a closely linked public consultation component. Their recommendations are as follows:

Recommendation #33

To inform the public and students of the present conditions in the Harbour and to encourage them to support the efforts being made to clean up the Harbour; and

That the Stakeholders Group/BARC appoint a Task Force with the responsibility of forming a public information/education committee and an education liaison committee to develop and maintain public information and education programs and to open and staff an environmental information centre.

Recommendation #34

To highlight the Areas of Concern in the Great Lakes and Hamilton Harbour in particular, that existing and proposed centres, such as the RBG, Hamilton and Halton Region Conservation Authorities, Burlington and Hamilton City Halls, and the Great Lakes Science Centre be used as distribution points to disseminate information regarding Hamilton Harbour and the RAP, and to generally encourage a more informed ecosystem perspective in people's day-to-day lives.

Recommendation #35

That all owners, agencies, and governments having jurisdiction to plan and/or implement plans within the watershed, incorporate, in a co-operative and co-ordinated manner - within their respective plans, policies, programs and regulations - the relevant principles, goals and objectives for the Harbour, abutting properties and the watershed area set out in this Hamilton Harbour Remedial Action Plan, in addition to specific recommendations which may be set out elsewhere in the plan. Without detracting from the generality of the foregoing, the following matters specifically should be addressed:

- meet the loading targets and water quality standards for the Harbour;
- shoreline management encouraging natural vegetative cover;
- habitat management for fish and wildlife within and adjacent to the Harbour;
- physical access to the Harbour by wildlife and people;
- visual access to the Harbour from the surrounding land area; and,
- visual, aesthetic and experiential quality of the Harbour and environs.

And further, that as a long term objective and outcome to this process, to establish a single planning document which consolidates the accomplishments of the stated objectives for the Harbour and its watershed.

Recommendation #36

That the two Conservation Authorities collaborate on the preparation of guidelines for shoreline development that take into account aesthetic and habitat functions of the shore zone.

Recommendation #37

That the Ontario program to control air emission sources be continued in order to eliminate visual and odorous emissions, to make the Harbour area more aesthetically pleasing.

Recommendation #38

That individual citizens within the Harbour watershed take particular care to avoid polluting the Harbour and Lake, recognizing that everything we put down the drain, dump on our streets, use on our lawns or throw in a creek eventually reaches the Harbour.

Recommendation #39

That the appropriate agencies improve the availability of household hazardous waste facilities and that education programs be developed to aid citizens and businesses in reducing their use of environmentally damaging toxic chemicals.

Recommendation #40

To aid in improving Harbour water quality, that water conservation programs be encouraged. Strategies to achieve this could include, but are not limited to, the following:

a) That Regional Municipalities build on their existing programs to complete the coverage of water metering for all water customers, provide support for retrofitting older homes with water saving devices, and establish rate structures and set water rates to reflect the real cost of operating and improving the water treatment, water distribution, sewage collection and sewage treatment systems.

(b) That the Provincial Government change the building code to mandate the use of water conserving fixtures in new homes.

Recommendation #41

To maintain water quality conditions in Hamilton Harbour and the western end of Lake Ontario in the longer term, it is recommended that the Province of Ontario develop strategies to cope with projected increases in population and industry in the west end of the Lake, taking account of needs such as:

- technology development,
- drinking water intakes and waste effluent locations,
- regulations/certificates of approval/legislation,
- funding for municipalities faced with especially restrictive waste treatment requirements.

Recommendation #42

That existing environmental assessment procedures be maintained for all projects conceived within the area that may have an impact on the Harbour ecosystem or on the uses for which the Harbour water quality has been improved.

Recommendation #43

That the goals of the RAP be the recognized in all projects or developments impinging on the Harbour in the future, with greater emphasis on an ecosystem assessment.

Recommendation #44

That the Bay Area Restoration Council, the Bay Area Implementation Team, and associated Secretariat, Foundation and Committees as outlined in the Plan be endorsed by the Canada-Ontario Agreement Review Board as the formal institution for ensuring the continuity of reporting and public consultation throughout the period of implementation until such time as the area is delisted as an Area of Concern under the terms of the Great Lakes Water Quality Agreement.

Recommendation #45

That the Bay Area Implementation Team responsible for carrying out and auditing the Remedial Action Plan be required to make annual reports on the conditions in the Harbour and the schedule of remedial actions that will form the final Plan.

In order to address both the need for data to assess the improvements expected in the Harbour and to address the uncertainties that remain regarding environmental impacts and the potential for alternative solutions for the future, it has also been recommended:

Recommendation #46

That all agencies, municipalities and industries confirm their commitment to the collection of the surveillance and monitoring data that is required and to its analysis for presentation to the International Joint Commission and to the public.

Recommendation #47

That the management agencies (e.g. Federal and Provincial Governments, RBG) responsible for research and development provide an adequate level of research support addressing the specific problems of the Harbour and its watershed.

Recommendation #48

In order to reduce costs and ensure effectiveness in achieving a reduction in loadings of contaminants to the Harbour, that sediment, sewage sludge and wastewater treatment technology research be funded at an adequate level to improve remedial measures.

Recommendation #49

Recognizing the substantial funds involved to effect major remedial actions and the necessity for shared responsibility for implementation; the Hamilton Harbour Stakeholders Group supports the principal of multi-lateral partnership agreements as one means of achieving realistic solutions and recommends that serious and active consideration of such partnership agreements be pursued.

Recommendation #50

That diversion of STP effluent to Lake Ontario be considered only after all other technically feasible and practical options have been implemented.

Each of the above recommendations calls for action on the part of one or more agencies or groups. These are detailed in the following table (Table 8).

Table 8: List of Recommended Remedial Actions and Agencies Responsible

Recommendation	Agency Responsible	Task
1. To address loadings that arise from inadequacies in the sewer wastewater collection and treatment systems	Regional Municipality of Halton	That the discharge of the Skyway WPCP meet the target loadings (treated target loadings - treated and by-pass combines) for ammonia, phosphorus, and suspended solids that are specified in this plan.
	Regional Municipality of Hamilton-Wentworth	a) Undertake to eliminate or minimize combined sewer overflows to Cootes Paradise and Hamilton Harbour with first priority on Cootes Paradise and the western part of the Harbour, b) That the discharge of the Woodward Avenue WPCP meet the target loadings (treated and by-pass combined) set in this plan for ammonia, phosphorus, and suspended solids, and c) That every effort be made to reduce the concentration of phosphorus in the Dundas and Waterdown WPCPs to less than 0.1 ppm.
	OMOE and EC	Develop models based on recent data to gauge the impact of new ammonia, phosphorus, and suspended solids loadings reductions, to gauge the cost-effectiveness of each remedial measure as it is implemented.

Recommendation	Agency Responsible	Task
2. Review of criteria for Cootes Paradise and Grindstone Creek	OMOE, EC	To review with RBG staff, and with other scientists working on Cootes Paradise, the impact of the Dundas STP and other pollution sources on this wildlife sanctuary now and in the future, and to prepare a report on the results of this assessment.
3. Physical access to the Harbour	Regional and Area Municipality	Develop a shoreline management strategy in order to provide substantially more physical access to the shores of the Harbour.
4. Erosion control - soil conservation	OMAF, Farming Community	To aid the farming community in finding ways to reduce erosion. To implement measures to reduce suspended sediment loading from erosion in erosion-prone areas of the watershed.
5. Urban area erosion control	Conservation Authorities	To take the lead in coordinating the efforts of all agencies who have a role in reducing erosion from construction sites.
	Municipalities, OMOE, OMNR	To enact and enforce regulations dealing with erosion from construction sites.
	OMOE, OMNR	To provide the leadership, policy, and training skills required to aid the construction firms, municipalities and conservation authorities in developing a much more intensive erosion control program.
6. Tributary erosion sources	OMOE, Conservation Authorities	To support the investigation of erosion that will allow identification of priority areas for erosion control.
7. Spill occurrence control	Hamilton Harbour Commissioners, OMOE, TC, EC, Cooperating member companies and agencies as specified in the Plan for the Port of Hamilton Spill Control Group	To produce a biennial public report of spill instances that have affected or potentially could have affected the Harbour.
8. This will be addressed in the measures noted below for phosphorus, ammonia, and suspended sediment loading reductions (Recommendations 36, 41).		
9. 10. 11. Carp Exclusion habitat restoration	DFO, RBG, EC, OMOE, OMNR	To implement a program to remove the stress on Cootes Paradise and Grindstone Creek marshes due to carp (as well as through removing the water quality stresses due to discharges from STPs, CSOs and streams), preferably through measures designed to exclude the carp.
12. 13. Submerged and littoral habitat	DFO, OMNR, HHC	To implement a program to construct fish and bird habitat in the Lax Property area, along the southwest shoreline, along the north shore and in the northeast and eastern sections of the Harbour.
14. Fish plantings	OMNR, DFO	That these agencies implement a program to reinstate top predators into the Harbour in such a way as to result in their natural reproduction in the Harbour.

Table 8 - continued next page

Recommendation		Agency Responsible	Task
15.	Fish and fish habitat monitoring	OMNR, DFO	Monitor the fish populations for population structure, density, natural habitat reproduction and health to establish if and when it reaches the targets specified in this plan.
16.	Fish habitat policy	OMNR, DFO	To enforce the policy of "no net loss" of fish habitat in the Harbour and policy Cootes Paradise.
17.	Biological monitoring	DOE (CWS), OMNR	Establish effective monitoring programs for wildlife populations, their health monitoring and their contaminant content to track their health and populations and to compare with the targets indicated in this plan.
18.	Contaminant reductions	This is addressed in the measures outlined in the section dealing with trace metal and trace organic contaminants in loadings to the Harbour and in the sediments (Recommendations 20, 28, 29, 30, 31, 32, 38, 39).	
19.	Biological monitoring criteria	EC (CWS), NHW, OMNR	Develop contaminant criteria for Biological the health and edibility of wildlife.
20.	CDF operation	EC, DPW, HHC	Develop a plan for the management CDF operation of CDFs in the Harbour that minimizes contaminant uptake by plants and wildlife.
21.	Research	See Recommendation 48.	
22.	Fish and wildlife restoration project	BARC, EC, DFO, OMNR	Maintain a fish and wildlife committee to meet the goals of the fish and wildlife restoration project.
23.	Colonial bird habitat	EC (CWS), OMNR	To develop habitat to support nesting colonial waterbirds in conjunction habitat with fish habitat development.
24.	Viewing stations	EC, RBG, OMNR, Cons. Authorities, HHC	To construct six new wildlife viewing stations around the Harbour.
25. & 27.	Bacterial monitoring for potential beaches	Area municipalities	Urban storm runoff be controlled Municipalities through retention ponds, treatment monitoring systems or other means to prevent excessive bacterial and aesthetically deleterious discharges in sensitive areas of the Harbour (marshes, swimming areas, parks, etc.).
26.	Alternatives to chlorination	Regional Municipalities, OMOE	Consider the means to phase out chlorination as a means to disinfect effluent from sewage treatment plants.
28.	Program implementation for MISA	OMOE	To specify as soon as possible, the MISA regulations for the Iron and Steel Sector and for discharges to streams or to the municipal sewer systems.
		Industries and Business	To implement the MISA requirements as soon as possible.
		OMOE, EC	To develop the criteria for protection of the Harbour should BATEA be deemed inadequate.
29.	Contaminated sediment assessment	OMOE, EC, DFO, OMNR	To carry out the investigations necessary and to make the decisions required to proceed promptly with clean-up of the contaminated sediments in the Harbour.

Table 8 - continued next page

Recommendation	Agency Responsible	Task
30. Hazardous waste collection	Regional Municipalities	To continue the education programs already in place regarding the disposal of toxic waste. To expand the availability of household hazardous waste collection facilities.
31. Reduction of pesticide use	City Parks, Conservation Authorities, Golf Course operators, Industries, and Federal and Provincial Departments, Landowners in the watershed, OMAF	Reduce the use of pesticides to minimal levels and/or adopt alternative weed pesticide use and pest control strategies and to report annual use of these materials as a trend indicator.
32. Oxygenation of the hypolimnion	OMOE, EC	To implement artificial oxygenation or aeration of the hypolimnion (assuming source controls have not substantially altered the dissolved oxygen regime for the better) in summer for a period not to exceed 5 years for short-term remediation and to confirm the value of better oxygen values on benthos and the toxicity of sediments.
33. Education and information programs	BARC Citizens School Boards, Colleges and Universities	Set up Task Force to promote public education and school, college, or information university programs regarding environmental, social, and economic aspects of the Harbour and its watershed. Take the opportunity to become informed. Incorporate appropriate level of information into courses for students at all levels stressing the ecosystem approach.
34. Information programs	BARC RBG, Conservation Authorities	Promotion of Harbour and ecosystem information displays and information materials at sites around the Hamilton-Wentworth and Halton Regions. Provide appropriate displays and viewing.
35. Planning with RAP goals and basic criteria	OMOE	Establish conditions and programs for municipal and industrial wastewater treatment or source as reductions consistent with the goals and delisting criteria for Hamilton Harbour and Cootes Paradise. Encourage the landscaping programs already begun using native plants and trees where possible.

Table 8 - continued next page

Recommendation	Agency Responsible	Task
		Develop and demonstrate technology to meet the targets set for the Harbour for all contaminants in an efficient, economical, and effective way.
		Adopt development plans, policies, programs, and regulations to meet RAP goals, notably for all stormwater and wastewater handling, and development of physical and visual access to the Harbour.
	EC	Collaborate on a single plan to consolidate plans and accomplishments for the Harbour, its watershed, and areas outside the watershed that discharge sewage into the Harbour.
	All Municipalities	To promote improved public access at every opportunity.
		To make provision for substantially greater ***public*** access to the waterfront.
	All Agencies	
	BARC	
	Regional Municipalities, HHC, EC, Provincial Government	
36. Guidelines for shoreline development	Conservation Authorities, DFO, OMNR	Enforce shoreline Guidelines for modification regulations to ensure no net loss of habitat for fish, birds, other wildlife, or plant species (especially rare plants), and maintenance of aesthetic values.
37. Air pollution	OMOE	Develop and enforce regulations to limit even further the emissions which cause unsightly plumed foul odours which detract from the quality of the aquatic environment and its enjoyment by the citizens.
	Industries	To respond to regulations and to new opportunities to limit air emissions causing problems.
38. Citizen participation	Citizens	To take personal responsibility for minimizing the use of toxics, fertilizers, and pesticides; to dispose of toxic chemicals and contaminating materials (oil, paint, solvents, dry battery cells, etc.) at municipally operated collection sites; to collect pet waste for proper disposal; and to reduce litter.

Table 8 - continued next page

Recommendation	Agency Responsible	Task
39. Hazardous waste facilities	Regional Municipalities	To continue the education programs already in place regarding the disposal toxic waste. To expand the availability of household hazardous waste collection facilities.
40. Water conservation	Regional Municipalities OMOE, Provincial	To promote water conservation through comprehensive metering (where not yet installed), through setting of water/sewer rates reflecting the total cost of supplying water, and through programs to aid in retrofitting older houses with water-saving devices, or through other measures. To change the building code to mandate installation of water conserving fixtures in new developments.
41. Western Lake Ontario Concerns	Provincial Government	Implement longer term planning to encompass the impact of potential development in the west end of Lake Ontario on water supply and wastewater treatment in an integrated manner.
42. 43. Guidelines for environmental assessments in this area	Regional Municipalities, OMNR, OMOE, OMMA, MTO, EC, DFO, TC	In reviewing projects for environmental assessment in Hamilton Harbour, in the Harbour's watershed or for projects that could affect the habitat (infilling) or water/sediment quality in the Harbour, reference be made to the goals and conditions laid out in this Plan.
44. 45. Management of the program and regular review	Canada-Ontario Agreement Review Board	Endorse the management and consultative structure, the roles, and the operating public arrangements embodied in the Restoration Council and Implementation Team descriptions noted in this report.
46. Surveillance and monitoring	All agencies and governments identified in the monitoring plan	To carry out their portion of the surveillance and monitoring, working together to assemble an integrated ecosystemic report every two years on the state of the Harbour and the watershed for submission to the public, the COA Review Board, and the IJC.
47. Research	All agencies and governments	To periodically review research and study requirements that will impact most immediately on the major financial decisions to be made in implementing the plan (or implementing changes to the plan).
48. Technology Development	EC, Industry, OMOE	Develop and demonstrate relevant technology that will aid in identifying economical, efficient, and effective ways to meet the stringent requirements specified in the plan for current and future requirements.

Table 8 - continued next page

Recommendation	Agency Responsible	Task
49. Multi-lateral partnership agreements	All agencies and governments	Actively pursue the principal of multi-lateral partnership agreements as one means of achieving realistic solutions.
50. Diversion of STP effluent	Regional Municipalities, OMOE	Diversion to Lake Ontario should be considered an option only after all other technically feasible and practical options have been implemented.

VI ATTAINABILITY OF DESIGNATED USES

VI.1 Introduction

The analysis of impairment of the beneficial uses proposed for Hamilton Harbour shows that the Harbour would benefit from a coordinated remedial action program. The Plan is designed, ideally, to restore these beneficial uses and to maintain the conditions necessary for their continued use.

It is important, however, to make some assessment of whether these uses can be fully attained with reasonable certainty. While no specific study has been conducted to assess attainability, some issues can be identified based on an extrapolation of the existing information. Monetary constraints are not being considered at this juncture.

VI.2 Physical Characteristics

The flow of streams entering Cootes Paradise and Hamilton Harbour, and the depth and flushing characteristics of various parts of the Harbour system can affect fish habitat in these areas. The influence of stream flow volumes and temperature affect most seriously the habitat in the streams themselves - an important element of harbour habitat - as well as the estuary zones. Although the flow can be regulated with storage reservoirs, temperatures and natural flow regimes are distorted. It is possible that a year with low flow and hot weather could adversely affect any improvements made in water clarity or water quality for that year. Low flows for example, can result in reduced migration of certain species of fish as they move upstream into spawning habitat. While some habitat restoration projects address this type of issue, not all of natures' variability can or should be fully controlled.

Much of the habitat has water levels controlled primarily by water levels in Lake Ontario, which are themselves regulated artificially in the St. Lawrence River. Hence these levels have been 'smoothed out' to mitigate the extreme highs and lows which the Lake would normally undergo in a natural regime. It's hard to say whether this is beneficial to the marsh habitat or not. Often marsh habitats undergo rejuvenation during water level or flushing extremes. Lacking good predictive capability, it is concluded that a strategy that gives preeminence to stress removal needs to be monitored carefully and that it may be necessary to install structures to fully control water levels in the longer term.

The flow of streams and the location of storm runoff discharges can also affect water quality. In many places in the Harbour there are quiescent embayments that are poorly flushed by streams that have been diverted by storm drainage works, or that depend on major wind storms for their rejuvenation. While the former is subject to some intervention, the latter is not readily accommodated. Hence, there could be annual variability in water quality in these constricted areas in spite of remedial actions to improve general conditions in the Harbour.

The flushing of the Harbour by Lake Ontario water is a larger manifestation of the impact of natural forces on water quality. It has been estimated that, on average, 10 percent of the water in the Harbour is streamflow or runoff, 10 percent is treated sewage or combined sewer overflows while 80 percent is Lake Ontario water. These proportions vary seasonally and, while it has not been investigated, are likely to be very different from one year to the next. This could cause pollutant concentrations in the Harbour to vary from year to year even though the reduced loading remains constant.

Given the high percentage of colder, high-oxygen water coming into the hypolimnion of the Harbour from Lake Ontario in the summer, the dissolved oxygen in this layer of the Harbour is dependent on the natural forces affecting this inflow. This inflow, in turn, is dependent on the surface water temperature differences between the Harbour and the Lake (which depends on solar heating, on air temperature and on wind speed and direction) and on seiche activity in the Lake and Harbour (which depends on extreme wind-storm events).

Hence, concentrations of contaminants in Harbour water, and the dissolved oxygen in the summer hypolimnion will depend on both the remedial programs that reduce loadings of pollutants, and on the physical exchange and mixing processes. It is for these reasons that these physical processes require more intensive investigation at this time since no program yet exists to routinely assess the year-to-year variations that these physical processes affect.

The condition of the inflowing streams also requires some study because of the impoundments that have been installed on them. These impoundments provide recreational opportunities and control flooding. But in all likelihood they have some detrimental effect on water quality. Clearly there is a trade-off operating here amongst various uses. That trade-off should made explicit.

VI.3 Chemical Characteristics - Water

VI.3.1 Trace Organics and Metals

The general water quality conditions dependent upon physical processes affecting the dilution effects, and the processes affecting the supply of oxygen to the hypolimnion in summer have been discussed above. In addition, many contaminants reach the Harbour from a variety of urbanized areas for which it is very difficult to identify specific sources - whether they be lead in gasoline (which has now been regulated) or a contaminant like oil dripping onto roads from many cars. The implementation of measures to deal with CSOs and urban stormwater should be accompanied by an analysis of alternative management strategies given the large cost of some of these measures. This Plan was financed to carry out only a generic study of these issues. Hence alternatives need to be more carefully assessed to better define the potential benefits, the costs associated with each measure and the feasibility of attaining the uses desired.

PCB levels 6 to 75 times the standard of 1 ng/L have been found in STP effluent, in tributaries and in the Harbour. Even Lake Ontario has been found to have concentrations of 4 ng/L in the area around the west end. While methods do not always provide consistent data at these levels of concentration, all these data were analyzed in the same laboratory.

They suggest, along with the congener composition, that they are weathered PCBs and not fresh sources. That further suggests that remedial measures to address PCBs have to be implemented on a broad scale. In the absence of a clearer situation it is difficult to predict improvement to the recommended standard of 1 ng/L in the water column in this Harbour based on local measures alone.

Beside PCBs, the other two contaminants affecting the fish consumption guidelines in this area are Mirex and mercury. Mirex sources in the area have not been identified. Mercury was once discharged into the Harbour. Both mercury and Mirex are found in some Harbour sediments. But until it is much clearer how these two contaminants enter the Harbour and the food chain, there is no clear strategy available to **accelerate** the documented decrease in concentrations of these substances in fish tissue.

VI.3.2 Dissolved Salts (Water Hardness)

The total dissolved solids content of Harbour water has, for natural reasons, always exceeded the GLWQA objective of 200 mg/L. Undoubtedly, the addition of treated sewage increases the salt content of Harbour water, as does the use of salt to alleviate winter driving problems on area roads. These two uses are no different than urban centres generally, though the restricted circulation in the Harbour shows the effect of these loadings more acutely. Actually some communities around the Harbour have deliberately reduced road salt use in order to minimize its impact. Even so, their effect is partly obscured by the apparently natural high levels of salt in the waters of Redhill Creek, a major tributary of the Harbour that drains through gypsum deposits.

While the lakewide standard cannot apply in such a situation, and there are no known impacts on the beneficial uses of the Harbour, the matter requires clarification. There is no indication that dissolved salts in the Harbour are getting worse at this time although average dissolved salts in Lake Ontario are gradually increasing year by year.

VI.3.3 Nutrient Enrichment - Eutrophication

The loading targets for phosphorus, ammonia and suspended solids established for Hamilton Harbour in this plan require the sewage treatment plants to incorporate the very best treatment processes available to retrofit these plants. Adapting older plants is not always easy, and the target concentrations for phosphorus (between 0.10 and 0.15 ppm) will be particularly difficult to achieve and maintain simultaneously with ammonia controls.

The recent improvements in phosphorus control using improved chemical treatment has reduced loadings of phosphorus by one-half. Simultaneously the water clarity and algae conditions have improved. Therefore we have greater confidence that our target loadings will achieve the improvement anticipated even though our predictive capabilities lack high precision. However, our confidence in achieving the improved dissolved oxygen condition with only source controls is not great. It has also been suggested that even if source controls ultimately achieve this objective, it could be 10 or 20 years before the system responds adequately. This will require careful monitoring.

While correcting the current situation with existing hydraulic loadings of sewer wastewater looks optimistic - notwithstanding the difficulty of maintaining such cleanup (less than 2% of phosphorus would be left in the discharge) - the future is more problematic. Expansion of the population without either a reduction of per capita hydraulic and waste loading, or the application of even more technology (at likely greater cost) will result in a gradual re-establishment of the eutrophication problem. It will be necessary to incorporate such considerations into the planning for both Hamilton-Wentworth and Halton Regions. The Stakeholders and general public have expressed the desire not to divert treated sewage treatment plant effluent to Lake Ontario except as a last resort. Therefore, it seems prudent to carefully monitor the changes in the Harbour as the sewage treatment plants install each phase of their remedial program. Given the precision of current predictions, the observed conditions will be a better gauge of the effectiveness of the strategy and the first phases will sharpen the precision of our predictive capability for the generally more costly final stages.

VI.4 Chemical Characteristics - Sediment

The Harbour has served as a settling basin for particulates discharged to the Harbour or for organic deposits from algal growths in the Harbour over many decades. The particles have been partly organic with consequent oxygen demand and ammonia-producing potential. The inorganic fine particles have included trace metals from industry and other discharges, or have been the site of attachment of hydrophobic trace organics.

Iron in sediments has probably been beneficial to the Harbour, on balance. It is ironic that one of the metals of concern, zinc, is the result of recycling metal from cars - and the zinc is in that metal because of its rust-preventive action. Lead is another major trace metal of concern, and its principal source has probably been the lead used in gasoline.

Loading reductions by industry and the regulation of lead in gasoline has addressed the sources of this sort of contamination. The problem that remains is to establish the best way to ensure that such contamination does not re-occur, and to deal with the historic residue of past discharges. Both topics are the subject of intense investigation at the present time.

Biological methods of assessing sediments are still in the developmental stage and except where sediments are acutely toxic, some uncertainty exists as to the scale of integrated risk to the aquatic ecosystem that these situations present.

Techniques for 'inactivation' of bottom sediments containing a variety of trace metals or persistent organic toxic chemicals are also under investigation. Removal techniques have to be selected (if removal is essential) that do not cause more problems than they correct. There is one area of acutely toxic sediments in the Harbour due primarily to PAHs and zinc, where the source of the contaminants has been eliminated and where the potential for resuspension of the sediment is high (due to shallow water depths and wind exposure of the area, plus navigation traffic and related dredging). It has been difficult to complete a plan assessing the alternative ways to inactivate or remove and treat the material in this location. Final decisions are pending.

Even more difficult is the problem of dealing with the large (85%) area of the Harbour that does not meet the bulk chemical objectives that are being considered (these objectives themselves are under review). Resolution of the objectives, the test procedures and potential for various remedial measures is a long-standing subject of uncertainty.

VI.5 Biological Characteristics

Certain goals have been described to indicate habitat requirements, desirable biological diversity, and community structure for fish and colonial bird populations in a restored Harbour with its associated wetlands. In addition, certain health standards and toxic chemical content objectives are applicable to these and other wildlife in the area. Each of these factors may partly be dependent on circumstances outside the control of the local industries and populace.

The contaminant burdens in fish and birds in the Harbour and in Lake Ontario as a whole have declined. It should be noted that many fish we find in the Harbour spend time in both the Lake and the Harbour. Thus it is our expectation that the measures or conditions that have led to the decline of contaminant burdens in fish and birds in Lake Ontario as a whole, combined with further effluent controls in the Harbour itself, would result in declining contaminant burdens in the biota of Hamilton Harbour. Both sets of measures will be required to ensure further substantial reductions of these contaminant burdens. This will be particularly true for migratory fish and the types of birds that feed on fish.

Tumours (or hyperplasia) found in fish are one measure of population health that will be given considerable attention. Some portion of these tumours are caused by parasites and viruses. This portion of the fish health problem seems to occur at many sites in the Great Lakes irrespective of chemical contamination. However, controls we put into place to reduce exposure to known carcinogens will bring about changes in such things as chemically caused liver tumours. Clearly, controls on chemical pollution will only affect a portion of the tumour incidence.

Our efforts to improve the dissolved oxygen conditions in the Harbour may, according to some experts, result in higher contaminant burdens in fish - at least for a while - until conditions in the bottom sediments improve to the point where fish food organisms in the sediments have lower contaminant content. At the present time, these organisms are 'protected' from fish predation during the summer months by the overlying low oxygen conditions.

The fishery of Hamilton Harbour is dominated by plankton feeding and benthic feeding fish. There are few top predators. From this perspective, the Harbour fish community is typical of many stressed, warmwater eutrophic ecosystems. The Harbour, like most other embayments on the Great Lakes, has been impacted by a number of introduced fish species. Some, like the Pacific salmon and rainbow trout were introduced intentionally to encourage the recreational fishery. Others, such as the sea lamprey, carp and most recently the zebra mussel, were accidentally introduced to the Great Lakes. The combined effects of habitat destruction, toxic chemicals, and eutrophication have impacted indigenous fish communities and created opportunities for successful colonization by non-native species.

All such exotic introductions, whether deliberate or unplanned, have the potential to interfere with our overall objective of developing the conditions for a naturally reproducing, indigenous, healthy and productive warmwater fishery. Our efforts to reach such a goal are in the nature of a **necessary** major experiment, whose outcome, while viewed optimistically, is not fully assured.

VI.6 Water Contact Recreation

Contamination by faecal coliform bacteria is a problem common to any area in the Great Lakes impacted by urban runoff. The beaches of Lake Ontario on the east side of the sand bar separating the Harbour and Lake Ontario are periodically found to have unacceptable coliform counts - even though they are isolated from the direct discharges of STPs, CSOs, and most of the urban runoff in the area. It is not surprising that our Harbour areas are affected more seriously by this problem than areas more easily flushed by upwellings and coastal mixing along the open shores of the deep lakes.

Faecal coliform measurements supplemented by E. Coli measurements (a measurement considered to be a more direct indicator of human pathogenic organisms) indicate very high levels after rainfall. Faecal coliform measurements, unfortunately (the most common indicator data available) can originate from both human and animal sources. Control of human bacteriological contamination from CSOs and STPs may achieve objectives in some areas of the Harbour. Storm runoff may also have to be disinfected in other areas to supplement STP and CSO remedial programs.

VI.7 Navigation

Costs to navigation from pollution focus on the special requirements for proper disposal of contaminated dredgeate. There are practically no areas of the Harbour that meet all of the dredging guidelines.

Remedial measures to address CSOs will reduce the need for dredging (reduce the volume to be moved) since most of the remaining CSOs discharge into marine docking areas. The guidelines for moving any sediments are so restrictive that this will be a major cost to dredging activity and will result in even greater destruction of shore zone habitat unless alternatives can be found to avoid the use of CDFs.

VI.8 Aesthetics

Litter and debris as they relate to general aesthetic quality will be much improved by the CSO remedial program. However, a concerted effort on the part of the entire community will be required to address the whole problem. Stricter enforcement of litter by-laws and special volunteer clean-up efforts will have to be more effective.

Odours and visually unpleasant aspects of the shoreline will need measures that go beyond issues of water quality. There are currently few, if any, problems of odour or water clarity originating with water quality that are not addressed in the remedial measures proposed. Air emission control programs and shoreline landscaping can contribute as much or more to the aesthetic quality of viewing or recreational water uses as can remediation of water quality problems.

In some areas, weeds will be encouraged to grow as necessary habitat to ensure a suitable fish population. This may not be compatible with uses where weeds are considered an impediment to some beneficial uses such as viewing or boating.

VI.9 Summary

All of the remedial measures being proposed in this Plan will be a benefit to the various water uses for the Harbour and will result in the improvement of the functioning of the aquatic ecosystem. Some specific water quality objectives will be better met as a result of the remedial measures, but ammonia, chlorine and PCB water quality objectives will be difficult to achieve. Chlorine toxicity near STP discharges arises because of the need to control for human pathogens in STP effluent. A trade-off has been made here. Ammonia in toxic amounts arises from the degradation of natural protein from plant and animal sources (primarily human waste) in the sewage treatment plants. It may be difficult to eliminate this toxicity everywhere, though fortunately it is not a persistent toxic material. PCB water quality objectives will probably not be met in the foreseeable future because it is the residual of past PCB discharges. It cannot be attributed in any significant degree to new fresh sources in this watershed.

The origin of the mercury, PCBs and Mirex in fish in the Harbour is also a question that remains unanswered. PCBs in fish may be the result of the situation described above, or they could be the residue of PCBs picked up outside Hamilton Harbour (for migrating fish populations) or, in the case of older fish like the large carp, their PCB content could be PCBs that they picked up 15 or 20 years ago when PCBs were not regulated. Mercury and Mirex have been found here and there in the Harbour sediments, but not in amounts that seem to be a risk to the fish. While mercury was discharged into the Harbour in past years, the source of the Mirex is unknown. Both seem to be decreasing in concentration in fish tissue, but no strategy has been developed to accelerate its reduction in the absence of good knowledge about the likely source of the contamination.

Probably the largest scale of 'clean-up' that is in question, is the matter of the contaminants and a degree of toxicity of the sediments in the Harbour - the legacy of past discharges from industry, from cars and highways and from sewage. The Harbour has served as a catch basin or settling 'pond' for a large fraction of the contaminants in, or attached to, sediment particles. These sediments are under intense scrutiny. One location where the contaminants were not easily leached from the particles has been addressed with a dredging and containment program. Another highly contaminated location has been identified where removal or confinement is required, although the exact methods to be used have not yet been established.

There remains a large fraction (85%) of the Harbour that qualifies as having (primarily) zinc and lead levels exceeding the "Severe Effect Level" being proposed for new standards. Ways of assessing these sediments and their impact are still under development, as are methods for mitigating their impact (if there is an impact of significance) without dredging the whole Harbour (1,700 ha).

Notwithstanding these uncertainties, the direction and scale of remedial actions proposed will produce much additional benefit to the Harbour and the uses of the Harbour. We need not wait until all the answers are available.

VI.10 Estimating the Cost and Benefits of Remedial Measures

VI.10.1 Introduction

Throughout the discussion of the means by which the Harbour can be restored, cost estimates have been developed to aid the technical team, the public advisory group (the Stakeholders) and the public in judging the various options proposed. Earlier reports (The Interim Report of the Hamilton Harbour RAP Writing Team, 1987; Goals, Problems and Options - A Discussion Document for the Hamilton Harbour RAP, 1988) presented estimates based on the general concepts and not on detailed analysis of specific facilities.

Subsequently, two economic studies were carried out (Marshall, Macklin and Monaghan, 1988; Apogee Research International Ltd., 1990) using major portions of the cost data. Cost of remediating contaminated sediments was not included in this work.

In essence, these estimates have been what we would call 'Concept Plan Estimates'. Even now, the range in estimates for sites where we know that removal and treatment is required, is very broad. There are few locations for which well defined boundaries in the areas requiring treatment are set and acceptable technologies designated.

Even so, these cost-benefit analyses were attempted in order to obtain some sense of the scope of the Plan, though they are necessarily rather generic in nature. The Marshall, Macklin and Monaghan report had an added feature in that it incorporated a eutrophication model for the Harbour in such a way that it could take account of some secondary features (like water clarity and oxygen depletion) that have more than one causative loading factor.

Ideally we would like to see a more fully developed model of the cost and benefit aspects of remedial measures linked with the Harbour 'response' at several physical, chemical and biological levels. But that, necessarily, is in the future.

In any traditional cost and benefit analysis, efforts are made to put a price on benefits. Hence the fishery is often viewed as a resource that can be exploited by its removal, with associated economic implications for the sale of boats, fishing gear, etc. Less well developed are measures of 'value' that accrue from simply knowing that a healthy, balanced and naturally reproducing fishery is present and thriving in the Harbour. It is this latter view that seems to predominate in current public thinking about the fish population, either for its intrinsic value or for its value as a surrogate for the much less well understood effects of pollution on human health.

What price do we put on the 'image' of the area - changing its 'pollution' image to the image of an area that has met and conquered the problems that have beset the Region?

We conclude at this point in time that it is difficult to find ways to give expression to the benefits in a way that adequately reflects priorities. But we do need to have the best current estimates of projected costs.

VI.10.2 Current Cost Estimates

Current cost estimates exceed earlier information for three reasons. One is inflation. For example, the construction cost index for 1986/1990 is 1.36. Initial cost estimates were developed in 1986 dollars and, where still being used, have had to be adjusted to take account of this inflation. The second reason that the total of available estimates is rising is that some items could not be reliably estimable at earlier stages of the development of the Plan. A number of these are now included. Thirdly, the nature of some of the problems, with the sewer collection/sewage treatment systems are systemically linked with both maintenance and renovation requirements, and with requirements for projected expansion. Some of these costs are included in the Hamilton-Wentworth Region estimates, though not in the Halton Region/Burlington costs.

The table of cost estimates (Table 9) therefore reflects this uncertainty with the presentation of a range of possible costs.

The table still **does not include** four categories that need future clarification:

a) **The cost of dealing with the main body of contaminated Harbour sediments:**

Whether the sediments of intermediate 'toxicity' (not bad enough to require mandatory remediation, but not good enough to say with reasonable confidence that they are not in need of some degree of remediation) will require some form of treatment has not yet been established. The characteristics of Hamilton Harbour sediments have been documented, but an analysis of the pros and cons of various ways of dealing with the sediments is not yet possible. For example, it may be sufficient, and least disruptive of the aquatic biota to let the contaminated sediment be buried through sedimentation - in which case the solution is a slow one, but requires very little monetary outlay. Alternatively, physical or chemical treatment might be considered which would be more speedy, but affects the biota now present and may also be costly. As above, the methods to deal with this category of sediments have not yet been tested adequately and hence a cost cannot be placed on it.

b) The costs of potential future industrial and residential development:

The communities around the Harbour are in the midst of Official Plan Reviews. All of these reviews include population and industrial expansion 'projections'. These projections have both water supply and sewage treatment implications. More sewage means more nutrient loadings to the Harbour if the technology being applied is not upgraded or the volume of wastewater precipitation is not reduced and the current outfall locations are maintained. The Plan in this report points to the need to apply the best available technology to correct the existing problems with the current sewage volume. If that sewage volume increases, the treatment technology has to be correspondingly improved to meet the loading targets for such things as ammonia, phosphorus and suspended solids because these are fixed loading constants for the Harbour, independent of any development.

If diversion of wastewater to Lake Ontario is only acceptable as a last resort, maintaining the loading to the Harbour in the face of new development requires new technology to be developed and applied. At the levels at which we are currently asking the sewage plants to operate to correct Harbour problems, that additional treatment technology will likely be even more costly.

There will be added costs associated with any further development around the Harbour (highways, marinas, etc.). Modifications in infilling practices or runoff water treatment will be required to ensure that we meet the habitat and water quality goals.

A more systemic examination of planning and its implications for the community is required for social and economic conditions, as well as environmental conditions in the watershed.

c) New standards for water, sediment, fish and bird contamination levels:

As our understanding of environmental processes and their outcome increases, we can expect revised or additional standards to be developed. Seldom are new standards less stringent than the older standards. Consequently, if new standards are set, a number of these cost estimates would have to be revised.

d) Ancillary costs:

Enjoyment of the Harbour is affected by more than water quality. Air quality is a major concern of the public and the Stakeholders irrespective of the indirect effect it may have on water quality. The full benefits of recreational uses in the areas affected by industrial air emissions will not be realized unless air pollution (odours and dust) are addressed as well as the water quality concerns.

The advisory committee and the public have given expression to a vision for the Harbour that includes better developed public access. The costs of such development are not included in this Plan.

Table 9: Hamilton Harbour RAP Preliminary Cost Estimates (1990) (thousands of dollars)

Projects within the jurisdiction of HAMILTON-WENTWORTH REGION			
Item	**Capital Cost Range or One Time Development Cost**	**Annual Operating Cost Range**	**Comments**
Combined Sewer Overflows with expansion of primary at Woodward Ave. STP.[1]	Phase I (West) 40,000-55,000 Phase II (Central)[6] 80,000-93,000 Phase III (East)[6] 100,000-127,000	2,000-6,000	Cost very dependent upon final decision about frequency of overflows allowed, degree of stormwater treatment and trunk sewer twinning option. (Pollution Control Planning Study in progress with shared Region and MOE funding.)[4][5] Program already underway.
Effluent filtration (Woodward Ave.)	40,000-55,000	1,000-2,000	See audit below.
STP Audits and Technology Demonstrations (Woodward Ave., Dundas and Waterdown Plants)	2,000-3,000[3]	1,000-1,500	Audits and demonstrations underway with shared funding (Region, EC, MOE).[3]
New capital requirements for Ammonia Control	3,000-4,000		Engineering studies required to finalize design and costs.
MISA Sewer Use Bylaw Enforcement	2,500	2,300	Pilot study completed [3] in draft form.
Urban Erosion (Training/Enforcement)		30-50	See reports by Ecologistics and MOE. Municipal responsibility with assistance from, and coordination by Hamilton Region Conservation Authority.
Storm Runoff Control and Treatment (Dundas, Ancaster, Flamborough, Glanbrook) Erosion Control	5,000-10,000	200-300	
Water Conservation	14,000-18,000	500-700	Water meters. Promotion campaign. Revenue generation possible. Present Regional policy incorporates installation over 25 years.
Toxics Collection (additional)		3,000-5,000	Phase I Program in place. (One place open every Saturday for 1 year.) Substantial advertising in place. Satellite system being considered.
TOTALS:	**286,500-367,500**	**10,030-17,850**	

Table 9 - continued on next page

Projects within the jurisdiction of HAMILTON-WENTWORTH REGION			
Item	Capital Cost Range or One Time Development Cost	Annual Operating Cost Range	Comments

Notes: (1) Step Feed Control at Woodward Plant (North) - $270,000 to convert plant operations has been completed.

(2) Hamilton-Wentworth Region and the City of Hamilton have paid a share of the contaminated sediment cleanup already under way (e.g. see Windermere Basin Project).

(3) Report on "Sewer Use Demonstration Program, The Regional Municipality of Hamilton-Wentworth" 1992, recommends costs be recovered through user-pay, fees and individual agreements with industries. A major portion of the development costs has already been committed or completed.

(4) Refer to draft report, "Region of Hamilton-Wentworth Pollution Control Plan", May 1991, prepared for the Region.

(5) While the costs of expanding the primary treatment unit of the Woodward Avenue Plant are included in this list, it is undertaken here to deal with a hydraulic 'bottleneck' in the STP as well as to deal with anticipated population and industry growth. It makes sense to consider both in the design of this modification.

(6) Phase I (West) includes all CSOs in Cootes Paradise and all CSOs in the Harbour from the Desjardins Canal to Pier 9.

Phase II (Central) includes all CSOs from Pier 10 to the Sherman Inlet.

Phase III (East) includes all remaining CSOs in the industrial area, noting that the major (25% of all CSO volume) CSO originally entering the Redhill Creek has already been addressed with a retention basin.

N.B.: It should be noted that no costs or concepts have been developed (to our knowledge) to deal with the major long term conceptual plans being developed for places like the Town of Flamborough, with a population of 26,000 in (1986) and, with a projected population doubling some time in the next 20 years.

Projects within the jurisdiction of HALTON REGION and BURLINGTON			
Item	**Capital Cost Range or One Time Development Cost**	**Annual Operating Cost Range**	**Comments**
STP Audit (Skyway Plant) • Clarifiers • Ammonia Control • TP Control • Hydraulics	10,000-23,000	1,000-2,000	Audit underway.[1] Funding (EC/MOE/Region). Engineering studies completed in 1991.
Effluent Filtration (Skyway Plant)	10,000-22,000	1,000-2,000	Engineering studies yet to be done.[2]
MISA and Sewer Use Bylaw Enforcement	100-150	300-350	Preliminary work done by Region. Final Estimates will depend on Provincial directives.

Table 9 - continued on next page

Projects within the jurisdiction of HALTON REGION and BURLINGTON			
Item	**Capital Cost Range or One Time Development Cost**	**Annual Operating Cost Range**	**Comments**
Urban Erosion (Training/Enforcement) (Burlington Region)		20-30	Assistance from Conservation Authority
Storm Runoff Control Treatment and Erosion Control (Burlington)	5,000-10,000	200-300	Priority for streams affecting swimming and habitat projects.
Water Conservation (Burlington)		150-200	Promotion Campaign. Report due in 1991.
Toxics Collected		1,000-2,000	Expansion of existing programs, currently $500K/year at hazardous waste depot.
TOTALS:	**25,100-55,150**	**3,670-6,880**	

Notes: (1) All, or a major portion of these funds have already been committed.

(2) Refer to draft report, "Operational Audit of the Regional Municipality of Halton's Burlington Skyway Water Pollution Control Plant" March 1991 by CH2M Hill Engineering Ltd.

N.B.: No provision is made in these estimates to deal with the projected increase in water use that is being currently considered in the planning for an expanded water supply system (doubling the capacity by 2011) in the City of Burlington. Various strategies are currently in the initial stages of development.

INDUSTRIAL PROGRAMS			
Item	**Capital Cost Range or One Time Development Cost**	**Annual Operating Cost Range**	**Comments**
MISA (Iron and Steel Sector - including monitoring)(1)	70,000-140,000	3,000-6,000	Includes plant operations and monitoring. MISA Reports due in 1991 for more detailed estimates. Refers to Dofasco and Stelco plants in Hamilton. Refers only to BATEA.(2)
MISA (Sewer Use - including monitoring by industry)(1)	50,000-100,000(3)	2,000-4,000(3)	MISA Pilot Study due in 1992. Approximately 300 industries make significant discharges to the municipal sewers.
Share of contaminated sediments remediation costs (see other section).			
Developers/Construction (Erosion/Control)	-	500-600	See Report by Ecologistics Ltd. (1989) "Hamilton Harbour RAP - Non-Point Source Loading Study".
TOTAL	**120,000-240,000(3)**	**5,500-10,600(3)**	**Studies due in 1991 for MISA regulations.**

Table 9 - continued on next page

INDUSTRIAL PROGRAMS			
Item	**Capital Cost Range or One Time Development Cost**	**Annual Operating Cost Range**	**Comments**

Note: (1) Estimates provided by MISA staff in advance of detailed technical and economic analyses.

(2) BATEA is Best Available Technology Economically Achievable.

(3) Estimated.

CONTAMINATED SEDIMENT[1]/OXYGENATION			
Item	**Capital Cost Range or One Time Development Cost**	**Annual Operating Cost Range**	**Comments**
Randle Reef Contaminated Sediment			
• Removal	20,000-25,000		Pretreatment, mobilization, removal, monitoring, containment, handling and transportation included (conventional).
• Treatment	10,000-50,000		Basic assessment is completed. Treatment off site.[2]
Ottawa Street Slip - Contaminated Sediment	30,000-75,000		Second priority to Randle Reef Area.[2]
Main Harbour - Remaining Contaminated Sediment	Not determined at all. May be negligible. May be extensive.		Impact not yet assessed. Potential methods under investigation as well as fundamental strategy.
Oxygenation of Bottom Waters	300-4,000	400-250	Interim measures (5 year maximum duration).[3]
TOTALS	**60,300-154,000**	**400-250**	**Note uncertainties described above.**

Notes: (1) Windermere Basin work already funded and will be completed in 1992 ($5.5 M) - cost not included above. Costs for clean up of contaminated sediment in Windermere Basin shared among Federal, Provincial and Municipal Governments.

(2) Estimates provided by staff of Environmental Protection/Ontario Region/Environment Canada.

(3) Estimate provided by Dr. T. Murphy, NWRI/Environment Canada.

Table 9 - continued on next page

HABITAT AND WATERSHED RENOVATION			
Item	**Capital Cost Range or One Time Development Cost**	**Annual Operating Cost Range**	**Comments**
Fish & Wildlife Habitat Restoration	6,000-13,000	150-200	DFO, EC, RBG, OMNR, C.A.[1]
Urban Programs to Reduce Erosion	See Regional Municipal Programs.		
Rural Runoff • Tillage Practices • Manure Storage • Buffer Strips (to reduce erosion and pollutant release to streams)	300-500	30-50	OMAF Land Stewardship Program (LSII) has been renewed. National Soil Conservation Program (NSCP) started in 1990/1991. Runs for 3 years. Annual costs accrue to the farming industry.[3]
Landscaping	2,000-4,000	150-200	All Harbour shoreline owners. Some work already completed by Stelco, Dofasco and Hamilton Harbour Commissioners.[2]
TOTALS	**8,300-17,500**	**330-450**	

Notes: (1) Estimates included in submission to the Environment Canada Great Lakes Cleanup Fund in 1991 by DFO and the Royal Botanical Gardens. Funded to $4.6M level by Great Lakes Fund subject to development of partnerships with land owners and provincial agencies.

(2) Estimates based on advice of Hamilton Harbour RAP Writing Team members.

(3) Estimates provided by Ontario Ministry of Agriculture and Food.

ADMINISTRATION MANAGEMENT MONITORING R & D			
Item	**Capital Cost Range or One Time Development Cost**	**Annual Operating Cost Range**	**Comments**
Monitoring	-	300-400[1]	Addition to existing programs - Provincial and Federal.
Implementation: • Management	-	400-500[2]	Implementation Team (Provincial and Federal)
Implementation: • Public Review	-	400-500[2]	Restoration Council (Provincial and Federal funding along with other sectors).
Environmental Research/Investigations	-	300-500[3]	Provincial, Federal, University.
Technology Development and Demonstration	3,000-4,000[4]	-	Federal, Provincial and Industry Programs with Universities.
TOTALS	**3,000-4,000**	**1,400-1,900**	**Major components already funded to about 50% of the total.**

Table 9 - continued on next page

ADMINISTRATION MANAGEMENT MONITORING R & D			
Item	**Capital Cost Range or One Time Development Cost**	**Annual Operating Cost Range**	**Comments**

Notes:

(1) Estimate provided by Hamilton Harbour RAP Writing Team based on 1990 Workshop on Monitoring and Surveillance.

(2) Estimates provided by WCR/MOE for financial plan for FY 91/92.

(3) Estimate based on support level for RAP program - 1986 - 1991.

(4) Estimate based on WTC/Environment Canada submissions to the Great Lakes Cleanup Fund and Reports on the Great Lakes University Research Fund, 1990-1991.

SUMMARY OF RANGE OF COST $ MILLIONS (1990) - Figures Rounded			
Unit	**One-Time**	**Annual**	**10 Year Annualized**
Hamilton-Wentworth Region Jurisdiction	286-368	10-18	39-55
Halton Region Jurisdiction	25-55	4-7	6-12
Industry (MISA Program)	120-240	5-10	17-34
Contaminated Sediment/Oxygenation	60-154		6-16
Habitat and Watershed Watershed Renovation	8-18		1-2
Implementation	3-4	1-2	2-3
TOTALS	**503-838**	**21-37**	**71-121**

Many of the options that seem most viable to ‘retrofit’ the existing communities to meet the targets set in this Plan, seem best tackled through ‘end-of-pipe’ technology. These types of solutions, while least ‘costly’ in most respects, do involve use of more treatment chemicals and more energy. Fortunately we have found that there are efficient ways of using the chemicals. Electrical energy co-generation is also feasible by using the methane produced in STP digesters or through recovering oil from sludge. Yet some increase is to be expected in the consumption of both chemicals and energy. This has overall implications for energy use in the region although they are probably minor in comparison with gasoline use for motor vehicles, home heating and coal use by the steel industries. There are also consequences for sludge disposal and for the by-products of energy production at nearby generating stations.

With these qualifications, cost estimates are presented in Table 9 as a guide to the scale of financial commitment required to achieve conditions in Hamilton Harbour sufficient to protect the beneficial uses proposed by the GLWQA and the local communities.

VI.10.3 Financial Perspectives

In themselves, these costs may appear great. However, they are not more extensive than many other ventures in the region. For example, these costs are comparable to what has already been spent in the past 15 years to reach the improved conditions already achieved (estimated as $600 Million in 1990 dollars).

In terms of regional responsibilities (sewage treatment plants and sewer systems) the annualized costs represent, after the normal provincial subsidies, an additional cost to the municipalities of about one-half or less of what is currently spent on operating the water supply/sewer systems.

Costs are comparable, as well, to the major expressway/highway projects and to the industrial investment plans in the region during the next 5 to 10 years (Robinson and Schaefer, 1991; Table 5.2).

In the end, it comes down to making choices for the community as a whole and developing within the communities some equitable way to share the responsibility for realistic water pricing.

VI.10.4 Financing the Plan

At this stage in our planning we do not have a detailed commitment from the governments, agencies and industries to implement all the things that have been listed. Most agencies are waiting to hear the public response to this report. Notwithstanding this, the Regions of Hamilton-Wentworth and Halton, the steel industries and the provincial and federal governments have already moved forward to meet a number of the needs expressed in earlier reports of the Hamilton Harbour RAP. In fact, $25M to $50M has already been expended or committed by all of these Stakeholders to carry out remedial work or to make the necessary preparations to do the work.

These commitments have been made to address immediate requirements and are generally the most cost-effective measures. It is interesting that most of these initiatives have been voluntary efforts (as opposed to being responses to regulatory orders). These first steps, combined with the tremendous $600 Million program already completed and the obvious improvement in the Harbour are encouraging signs to those involved in assembling the Plan.

While it is relatively straight-forward to identify the lead agency responsible for carrying out each portion of the Plan, the financial responsibilities are more broadly shared. The following table (Table 10) is a general guide to where the financial responsibility could reside for various parts of the Plan.

We encourage the development of partnership agreements amongst the many sectors involved (Recommendation #49) because some of the problems relate to a time when we had no understanding of the consequences of pollution. Also, there are many shared jurisdictions. Finally, there are unusual constraints on discharges to a small body of water like the Harbour. Hence the restrictions on these discharges are more severe than on the communities or industries that discharge to the open Lake. And, in fact, the whole Lake benefits from the more restrictive constraints, because almost all of the reduced loadings to the Harbour will result in corresponding reductions in the discharge of the Harbour to the Lake.

It should be noted, as was done in an earlier section, that a portion of the costs proposed to be incurred by Hamilton-Wentworth Regional Municipality involve correction of aging infrastructure and currently inadequate STP capacity. About $50 to $100 Million of these costs could be ascribed to this necessary upgrade and it is a moot point whether these costs are a part of the RAP. There are, however, obvious overall savings to the Municipality in addressing the sewer system modifications in a systemic fashion.

A number of the measures identified in this Plan are part of ongoing programs of the Region or Province. The measure to deal with combined sewer overflows and upgrades of the sewage treatment plants, once approved by the Province and Municipality, are eligible under existing programs for provincial grants of up to 33⅓ percent. The Plan elements calling for virtual elimination of the discharge by industry to the Harbour and to the sewer systems of persistent toxic substances is the subject of Ontario's Municipal-Industrial Strategy for Abatement (MISA) program.

In addition it should also be noted that the Regional Municipality of Hamilton-Wentworth had already recognized the problems associated with combined sewer overflows (CSOs) and has already taken action to remediate 25 percent of the volume of that overflow, and to address CSOs in the more sensitive western areas of the Harbour. Thus 80 to 85 percent of the proposed expenditures listed in the Summary Table 9 are encompassed in existing programs.

The new elements concern:

1. Habitat Restoration - a relatively small cost element of the Plan (2%) that has ⅓rd funding already committed by the Great Lakes Action Plan (Environment Canada) and further commitments from other participants, and

2. Remediation of Contaminated Sediments on the Bottom of the Harbour - a potentially costly measure (12-17% of the total), the details of which have not been settled. In this case the federal government is funding demonstration of the techniques to treat the material *in situ* techniques to remove the material with minimal deleterious impact on the water body, and techniques to treat material that is removed.

Table 10: Distribution of Responsibilities for Funding

Action	Parties Responsible for Action (Based on Current Practice)				
	Municipal Government	Provincial Government	Federal Government	Private Sector (e.g Industry)	Agricultural Sector
Sewage Upgrade	X	X			
Urban Runoff	X	X			
Agricultural Runoff		X	X		X
Contaminated Sediment Removal	X	X	X	X	
Industrial Upgrade of Treatment				X	
Fish and Wildlife	X	X	X		
Federal Facilities			X		
Public Consultation		X	X		
Program Administration Research and Development		X	X	X	

Thus the initial steps have been made to address the remaining elements of the program.

VI.10.5 Assessing the Benefits of the Hamilton Harbour RAP
VI.10.5.1 Introduction

The formal use of benefit-cost analysis can be viewed as inappropriate in evaluating remedial action planning for a number of reasons including: the large number of intangible benefits; the inappropriateness of discounting future benefits to the advantage of the present; and the fact that the decision to restore impaired uses has already been made through the GLWQA. Nevertheless, implementation of the RAP in Hamilton Harbour will yield considerable benefits not only for the environment, but also for the economic and social fabric of the area. Quantification of these benefits, where possible, is important to put the overall costs of the RAP in some perspective, to help prioritize remedial options, and to enhance the awareness of society and decision-makers of the numerous benefits that can result from commitment to RAP implementation.

This section explores some of these social and economic benefits. **It is not intended to be an exhaustive list,** but rather to provide some indication of the types and potential degree of beneficial impacts. Also, the discussion of benefits is intentionally separated from specific cost estimates because of the aforementioned points, and also because most benefits can not be accrued to specific remedial options, but rather are a product of implementing the RAP in general. This approach is consistent with the principles of integration and comprehensiveness manifest under the GLWQA and the remedial action process.

The source of information for this section comes largely from previous study. In some instances, the quantification of certain benefits is imprecise yet represents the best available information. Similarly, **the estimate of monetary benefits is just that - an estimate.** The estimates provided herein do not represent the full and absolute "value" of benefits, but rather are the closest economic approximations given available techniques. The exact magnitude of benefits for increased recreational use, economic impact and revitalization, or personal satisfaction with a cleaner environment, etc., will be a function of numerous factors, the most influential of which is likely to be the extent of remediation. Ultimately, the "real" benefit or value of the RAP defies adequate quantification. Nevertheless, quantification facilitates in assessing the relative magnitude of possible positive impacts.

The description of benefits is organized into seven sections including: economic impacts; use values; non-use values; property values; waterfront development and tourism; economic revitalization and infrastructure.

VI.10.5.2 Economic Impacts - Income and Employment

The benefits discussed in this section refer to the broader economic impacts that will accrue to the area in the form of increased employment and income as a result of expenditures made on remedial activities, and in connection with the increased recreational activity which occurs as a result of improved environmental conditions. One earlier study exists that begins to assess this benefit. The study identified the economic impact to the Hamilton-Wentworth and Burlington areas as a result of direct expenditures on materials and labour used in the implementation of specific control measures (remedial options) and the expenditures ('spin-off') arising from increased recreational activity in the Harbour (Marshall Macklin and Monaghan, 1988).

The study estimated that approximately $118 Million in income and 1,300 person years of employment will be generated during the capital construction phase of control options. Thereafter, $3 Million in income and 30 person years of employment will result per year. Also estimated was the economic impact from increased recreational fishing and swimming in the Harbour. Recreational fishing would add an additional $110,000 of income and 4 person years of employment annually while swimming would generate $2 Million in income and 70 person years of employment per year. (The direct economic impact of the increased use of the Harbour for these activities is elaborated upon in the next section.)

Since the time of this previous study (which was very limited in scope) the capital (one-time) and annual costs for implementing the RAP have been refined, as have the potential economic impacts. For instance, implementing all capital cost items of the RAP would generate added income of $450 to $750 million, and 5,500 to 9,100 in direct and 11,000 to 18,300 in indirect person years of employment.[1] Additional expenditures on operation and maintenance thereafter, would yield further annual added income and jobs.

VI.10.5.3 Use Values

Another approach to measuring economic effects, unlike those impacts outlined above, is through use values. Typically use values are benefits which accrue to the participants engaging in recreational activity. (The benefits associated with increased individual satisfaction that one could engage in these activities, even if one decides not to participate (non-use values), are outlined in Section 3.) Use values are associated with increasing the welfare of people who actually use the Harbour area, for example, for sportfishing or swimming. Calculation of use values usually requires estimating the number of new recreation days and the economic value associated with the new activity. Also, an increase in use value may arise from enhancing the existing recreation days.

VI.10.5.3.1 Recreational Boating

Research in 1987 quantified the use of the Harbour for recreational boating at approximately 78,000 user days per year (Marshall Macklin and Monaghan Ltd., 1988). This estimate was based on an inventory of facilities and programs in the Harbour, during the summer season. The estimate includes the activities of sailing, power boating and rowing, but does not include canoeing, kayaking, or recreational boaters based outside the Harbour who enter and use the Harbour occasionally (i.e. transient boaters). Consequently, the figure of 78,000 user days is likely an underestimate of existing recreational boating activity in the Harbour. Another study estimates that the Harbour currently experiences 264,000 user days for sailing and motor boating alone (Sproule-Jones, 1986). Although the precise value of this activity is difficult to assess, this last study estimates that sailing and motorboating alone in the Harbour contributes roughly $9 Million annually ('86 dollars) into the economy and employs 800 persons.

Water quality improvements will have varying levels of impact on different types of boating activity. In general, the activities of canoeing, kayaking and boardsailing (since they have greater potential for water contact) are likely to experience the greatest increase in participation as water quality improves. Two estimates have been developed to identify the potential increase in boating activity. The first is based on an Ontario Recreation Survey that suggests that up to 11 percent of the Hamilton-Wentworth and Burlington area population could participate in recreational boating (Tokarz, 1979), although not all in the Harbour.

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[1] This more recent estimate uses the same multiplier (additional income for non-residential construction of 0.9) as used in the previous study (Marshall Macklin & Monaghan, 1988), and applied to the new cost estimates of $502-$833 million in one-time capital costs. The estimate of employment is based on the creation of 11 direct and 22 indirect person-years of employment per $1 million of capital expenditure. Actual multipliers will vary depending on the specific option (i.e. typically, capital investment in public utilities provides fewer direct jobs (10 per $1M) in comparison to investments in other areas) (McKay, 1983). Consequently, the above number is only a general and likely under estimate.

This translates into roughly 1.7 million user days - an enormous increase from current activity levels. A more realistic estimate comes from another survey that suggests that the number of users would double upon improved water quality conditions (Wynia et al., 1990). Under this scenario the number of user days would more than double.

A conservative estimate utilizing the best available information, indicates that water quality improvements attained through the RAP could yield at least a doubling of current recreational boating activity in the Harbour. The additional economic benefit associated with this increase in use has not been quantified, although one analysis suggests that if Harbour usage were brought into equivalence with Ontario-wide norms for recreational boating (including canoeing, rowing and kayaking), an additional $14 Million in income (in '86 dollars) and 1300 person years of employment could be generated (Sproule-Jones, 1986). However, the impact of improved water quality on increased recreational boating must go 'hand-in-hand' with enhanced access and facilities. Also, since this study, some additional facilities have been provided and have therefore already 'captured' some of this potential impact.

VI.10.5.3.2 Recreational Fishing

The best available source of information on the current extent of use of the Harbour for recreational fishing is based on a study undertaken in 1987 in which it was estimated that the Harbour incurs approximately 4,500 user days during the spring and summer season, most of this in the form of shore or pier fishing (Marshall Macklin and Monaghan, 1988). Growth in this activity could be great if not only the water quality and fish habitat were improved, but also if public perception and access were enhanced.

If the RAP succeeds in significantly improving on these conditions it is estimated that local anglers alone, could potentially spend an additional 5,000 to 6,000 user days fishing in the Harbour (Marshal Macklin and Monaghan, 1988; Apogee, 1990). These studies estimate that increased fishing will yield an additional $130,000 ('87 dollars) to $174,000 ('89 dollars) per season. These studies assume that: only a limited number of remedial options are implemented; that the impact is on two fish species only; and that only local residents fish. Consequently, this monetary estimate does not represent the total potential interest in fishing in the Hamilton Harbour area.

However, using the frequency of participation from other sites, it has been estimated that, at some point in the future, local anglers could potentially spend 81,000 user days fishing in the Harbour. Under this projection, recreational fishing in the Harbour could be valued at over $1.8 Million per year, in 1987 dollars. Once again this number does not include anglers potentially attracted from areas outside the region. Consequently, this estimate could be on the conservative side, although this is balanced by the fact that much of this increased opportunity is dependent on improved facilities, access, water quality and habitat.

IV.10.5.3.3 Environmental Interpretation and Outdoor Education

The most recent estimate of the extent of this activity totals 63,000 user days, the majority of this occurring in the Nature Sanctuary in Cootes Paradise (Marshall Macklin and Monaghan, 1988). This includes participants in interpretive programs, outdoor education, naturalist outings, appreciation of wildlife and waterfowl, etc. This estimate does not include casual, unstructured use of trails, and therefore, is a conservative estimate of total effort.

An increase in the opportunity and demand for use of these facilities will likely result from enhanced water quality and wildlife habitat, as well as an improvement in facility programming. While the level of ultimate future use in the area of the Royal Botanical Gardens (RBG) is partially constrained by their funding and staffing, and the area's carrying capacity, there is still growth potential in certain parts of Cootes Paradise and the remainder of the Harbour.

A survey in 1989 (Wynia et al., 1990) indicated that approximately 9 percent of the Hamilton-Wentworth and Burlington area population engaged in some form of birdwatching, however, not all necessarily in the Harbour area. If water quality conditions were improved, 16 percent of the respondents said they would then participate in birdwatching - an increase of slightly less than 100 percent. If this rate of growth is applied to the most detailed and available inventory of 63,000 user days, then the total environmental interpretation and education activity level would also almost double. While no data exists, it seems reasonable that the RAP could cause a doubling, or more, of current participation in environmental recreation and outdoor education activity in the Harbour area. No monetary value has been associated with this increase in use.

VI.10.5.3.4 Swimming

During the late 1800's and early 1900's, a number of locations including Bay View Park, LaSalle Park, the Bay Street Beach and Victoria Park were all, at different times, very popular swimming locations. Swimming has been prohibited in the Harbour since the 1930's because of water quality and health concerns.

Plans within the RAP could make the Harbour swimmable once again. Using physical activity patterns developed by the Ministry of Tourism and Recreation, it has been estimated that potential swimming activity in the Harbour could reach roughly 840,000 user days (Marshall Macklin and Monaghan, 1988). Another estimate indicates that up to 1.1 million swimming user days could be realized (Apogee, 1990). Much of this potential increase is, however, contingent on improving access to the Harbour to participate in the activity. Nevertheless, enhanced swimming activity could be one of the more significant and tangible benefits of implementing the Hamilton RAP.

The above studies estimated the associated use value (consumer surplus) for this renewed activity in the Harbour at between $5.5 Million (in '87 dollars) and $6.6 Million (in '89 dollars) per year. This estimate could be viewed as a conservative value, since it includes only local residents' participation and does not include neighbouring or out of province participants. Further, another survey has indicated that up to 47 percent of the local population would participate in swimming if water quality was improved in the Harbour. On the other hand, since some of the swimming activity could be diverted from other locations, the net increase could be less that estimated. On the whole though, the above estimated user days and associated monetary values are the best available estimates.

VI.10.5.3.5 Other Recreational Activities

Enhanced use of recreational activities such as ice-boating and skating are more closely linked with climatic conditions than with improvements in water quality and environmental conditions. However, participating in these kinds of recreational activities, most of which occur in Cootes Paradise, can be influenced to some degree by improved public access, which is a component of the Hamilton RAP. As such, while difficult to quantify, the successful implementation of the RAP could provide some benefit for skating and ice-boating in the Harbour vicinity.

VI.10.5.4 Non-use Values

Non-use, intrinsic or social values are those which individuals place on improving environmental quality, **but do not involve the use of the resource**. This value is associated with the satisfaction of knowing that the natural ecosystem is available for future generations or inherently safe, clean and productive even if one may never directly use it. Understandably, these types of benefits are generally difficult to quantify, but are equally as important and valid, and in many ways represent the thrust behind the RAP process in the Great Lakes.

These values have traditionally been estimated through the use of contingent value analysis (willingness to pay) and while the technique has several limitations, it does represent the best available monetary indication of intrinsic value. The fact remains that the RAP process in Hamilton will generate enormous benefit in this area, some of which has been estimated and is reported on below.

One study has estimated the intrinsic value, or willingness of individuals to pay, for obtaining swimmable and fishable waters in the Harbour. This analysis estimates the non-use value associated with improving water quality conditions to permit swimming, and improving fishing conditions, at $100 per household per year (Marshall Macklin and Monaghan Ltd.,1988). Based on a 1986 figure of 196,000 households in the Hamilton-Wentworth and Burlington area, the total intrinsic value accruing for implementing a limited number of remedial options is approximately $19.6 Million per year (in '87 dollars). Another analysis estimates the non-use benefits associated with achieving swimmable water at $65 per household per year (Apogee, 1990). This figure would result in a total annual non-use value for obtaining swimmable waters in the Harbour at $13.1 million. Although enhanced access and facilities are again a precondition to realizing much of this benefit, the best available studies indicate that obtaining swimmable waters in the Harbour, whether one engages in the activity or not, represents one of the more significant benefits of the remedial action plan.

VI.10.5.5 Property Values

The potential impact of the RAP (through improved environmental conditions, water quality, recreational opportunities, etc.) on land values has generally been viewed positively by those in the RAP process. However, to this point, there has been no formal attempt to quantify this potential impact in the Hamilton AOC.

Previous study in other locations in North America has resulted in a range of results. Studies at residential sites have indicated that effective pollution abatement on polluted water bodies can increase the value of single-family homes by 0 to 25 percent. Pollution abatement on rural land near a large water body can be positively impacted by 8 to 65 percent. This positive impact on property values was felt up to 4,000 feet (1.2 km) away. The large range of appreciation was attributable to a number of factors or conditions. These conditions included: the specific land use type; the extent of initial degradation/contamination and duration of pollution in the water body; the extent of subsequent clean-up; distance of property from shore; the type and size of the water body; visual and physical access; the perceived improvement; as well as a number of locational amenities (i.e. parkettes) or disamenities (i.e. industry, major transportation corridors).

A preliminary and descriptive assessment of the potential impact of the Hamilton RAP on land values can provide a number of observations. First, because of the nature of the approach utilized in RAPs (i.e. ecosystem approach, comprehensive and integrated principles), it will yield improvements not just to water quality (like previous studies), but to a range of other environmental conditions throughout and beyond the Harbour. Second, this approach suggests that the extent or degree of clean-up is potential very high. Third, because initial water quality conditions in the Harbour are often perceived as very low, the appreciation from substantial water quality improvements, is potentially very high. Fourth, previous research indicates that land immediately adjacent to the Harbour waters, is likely to realize the greatest appreciation in value. This is not to say that waterfront owners would be the sole beneficiary. As environmental conditions and water quality in the Harbour area continues to show significant improvement, the entire Hamilton-Wentworth and Burlington area will become increasingly desirable as a place to live and to do business. As a result, even land values in the periphery would expect to show some appreciation. Consequently, the general conditions outlined above suggests, at least from an initial review, that land values could potentially increase as a result of implementing the Hamilton Harbour RAP.

In the spring of 1992, a 'brainstorming' session was held with a small group of interested and knowledgable individuals from a number of relevant departments and groups in the real estate field.[2] The intent of the meeting was to establish the suitability of quantifying the impact of the RAP on land values, the appropriateness of extrapolating from other results to Hamilton Harbour, and to assess the validity of possible results. A number of perspectives and conclusions resulted from the meeting and are briefly provided below.

1. Recreational and residential land uses have the greatest possibility for any appreciation in value. However, some felt that the value of residential properties,

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[2] Participants in the April 24, 1992 session included:
Scott Galbraith, Manager of Business Development, Economic Development, Region of H-W;
Richard Buckle, Chief Appraiser, City of Hamilton;
Jim Koppang, Market Analyst, Canada Mortgage and Housing Corporation;
Rob Kronas, President, Metropolitan Hamilton Real Estate Board;
Keith Rodgers, Coordinator - Hamilton Harbour RAP;
Karl Schaefer, Inland Waters Directorate, Environment Canada.

particularly for homes close to the waterfront, already had a sizeable premium included in their value as a result of their close proximity to the waterfront. As such, the RAP was viewed as having only a marginal impact for further appreciation in the value of these homes.

2. A suitable data base (number of market transactions) for detailed analysis is only available for the residential sector, since homes typically turn-over more frequently than other land uses. However, it was indicated that the number of transactions of homes in the Harbour area was not sufficient to provide a representative and reliable sample. Assessment values (for taxation) were equally viewed in this situation as an inappropriate base on which to assess appreciation.

3. Appreciation in industrial land would likely not be realized until a change in usage occurred. Given the very slow turn-over of industrial land in the bay area to other uses, it was deemed inappropriate to definitively attribute any appreciation from the RAP.

4. There was some concern whether significant improvement in environmental conditions, under the RAP, would sufficiently enhance the perception and awareness to modify buying behaviour and hence impact land values.

5. The results of previous research were based on areas that had a relatively homogenous land usage and were specifically selected as sites to minimize the impact of 'other' influences. Consequently, in Hamilton Harbour, the diverse mix of land uses and the abundance of these 'other' potential influences suggested that there would be limited confidence in the results, either from extrapolating from other studies, or by undertaking primary research in Hamilton.

6. A main conclusion was that even if it was assumed that the RAP was viewed as a positive influence on land values, a number of conditions could nullify or reduce this potential appreciation, such as: the visual disamenity of existing industrial uses on the Harbour; the abundance of major transportation corridors around the Harbour which restricts enhanced access; and general, more wide-spread economic conditions.

7. In contrast to the existing literature, it was felt that the RAP, in conjunction with a range of other improvements, is more likely to have a broader impact for land values across the region instead of those properties in close proximity to the Harbour.

In sum, there was consensus that isolating the specific influence of the RAP on land values would be extremely difficult. Further, it was felt that there would be little confidence in developing even a broad range of potential appreciation values. However, participants generally felt that land values may indeed be positively impacted by the Hamilton Harbour RAP, most likely on a broader regional scale. In fact, the main impediment to quantifying the impact on land values was viewed as more of a function of a lack of an available analytical technique to confidently isolate the influence attributable to the RAP.

Consequently, although the exact impact on land values in the area is difficult to quantify, the potential impact, at least in concept, is another likely positive benefit of the Hamilton Harbour RAP.

VI.10.5.6 Waterfront Development and Tourism

The Niagara/Mid-West tourist region, in which the Bay area is located, directly employed 25,278 persons as a result of tourism expenditures in 1989 by attracting 31.6 million tourist visitor days (Ontario, 1990). The expenditures from visitors totalled approximately $2.1 billion, or an average outlay of $66.39 per visitor. While currently many of these people only visit Niagara, a recent study estimated increases from waterfront development, the Bay clean-up, Confederation Park, the Bruce Trail and natural area use at 740,000 user-days (Savelli, 1991). (This estimate includes some of the estimates reported earlier in this section.) This could produce a minimum revenue of $49 Million per year, not including additional spin-offs.

The successful implementation of specific plans for the waterfront areas in both Hamilton and Burlington is very much connected with improved water quality and environmental conditions under the RAP. In Hamilton, two main initiatives on the waterfront are underway including:

1. the remediation of the former Lax site, and ultimately the development of a multi-use Harbour access point, which currently involves a $9.1 Million investment in cleaning-up, capping, grading and seeding, burying utility infrastructure and shoreline protection, and

2. a $2.2 Million investment into the development of Pier 4 Park for recreational use (Firth-Eagland, 1992).

In Burlington, a $1 Million restoration of the pavilion at LaSalle Park is planned. Also, while Burlington's waterfront park plans (initially a $14 Million plan, for the Spencer Smith Park - beach strip area, pending finalized cost-sharing arrangements), are officially outside of the Harbour, successfully attracting and maintaining visitorship is linked with improvements in water quality and general environmental conditions associated with the RAP (Stevens, 1992). The benefits associated with plans for the Burlington beach waterfront park were estimated in 1987 at $3.8 Million annually for the Region of Halton (HRCA, 1987).

Also, the success of the RAP may have some impact on enhancing the opportunities for making the proposed $63 Million Great Lakes Science Centre by the canal a reality. This proposal is expected to generate 600,000 annual visitors - an amount greater than attendance figures at the Waterworks Themepark, Hamilton Airshow, Art Gallery of Ontario and Dundurn Castle combined (Halton, 1990).

The potential impact of the RAP on waterfront development and tourism in the area is perhaps best articulated by the Centre for the Great Lakes' recent report. "For many cities, the waterfront development represents a reclaiming of some or all of their waterfronts from the manufacturing and transportation users which for decades occupied it. Centre research found that the new development enhances property values and image of urban communities, and can provide the spark for renewal of a city's core. Keys to successful waterfront development include promoting public access and recreation,... linking waterfront renewal with economic development,... to make the waterfront a year-round amenity,... and restoring waterfront environments. The success of the region's waterfront development effort is inextricably linked to improvements in the water quality of the Great Lakes and St. Lawrence River, and poor environmental quality can be a barrier to development and use of the waterfront" (Centre 1991).

VI.10.5.7 Economic Revitalization

The Hamilton-Wentworth area's economic structure has already begun to shift to rely less on the manufacturing sector. Much of the continued sought-after diversification and economic stability is dependent on changing the image or perception of the area. In many ways, implementing the RAP can facilitate or provide the catalyst for this change.

The enhanced reputation of an area - once thought to be the worst polluted - that has tackled these problems and solved them should draw environmental industries to Hamilton and Burlington; enhance the existing 'local business' in this field and capitalize more fully on the federal research and development facilities in the area, and the industrial developments that have been initiated here in the fields of pollution control, product recycling, etc. Significant opportunities exist for establishing global markets in these technologies.

Improvements in the Harbour should encourage downtown development thereby reducing the sprawl of housing and shopping developments in the suburbs. Increased intensification in areas of existing development, as opposed to sprawl, has enormous potential for reducing: energy consumption and automobile emissions associated with increased car traffic; loss of farm land; loss of greenspace; urban runoff; as well as reducing the additional costs of expanding roads and services into more distant suburbs (Greenbelt Alliance; Schaefer and Muir, 1992). Consequently, the urban structure becomes more efficient and sustainable from both an economic and environmental perspective.

VI.10.5.8 Infrastructure

The adoption of a comprehensive water demand/conservation management program as advocated in the RAP, can have significant benefit for water-related infrastructure. Significant reductions in the use of water can result in sewage treatment plants working more efficiently (Patry and Takacs, 1990), and reduce energy requirements and the chemicals required to treat the water[3]. Also, the shift to the user pay concept and full-cost pricing will become more equitable for consumers (Fortin and Mitchell, 1990; Rawson, 1990). But one of water conservation's greatest potential benefits is extension of the life of sewage and water treatment plants, or making expansion completely unnecessary (Patry and Takacs, 1990).

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[3] In Collingwood for example, once the water conservation program is in 'full-swing', it is estimated that water and hydro savings combined will total about $100 per customer, as well as lower costs for pumping, filtering and treating the water (----, 1992).

TABLE II: Summary of potential benefits of implementing the Hamilton Harbour RAP[1].

	Increase in Annual Use Days	Use Value per Year	Non-Use Value per Year	Person-Years of Employment	Income Generated per Year
Recreation Boating	78,000 plus	Refer Note [1]	Refer Note [1]	1,300	\$17.8M[4] (\$14M in '86)
Recreation Fishing	5,000 to 81,000	\$.16M to \$2.2M (\$.13M - \$1.8M in '87)	Refer Note [1]	4	\$.14M (\$.11M in '87)
Swimming	840,000 to 1,100,000	\$6.7M to \$24.1 M[2] (\$5.5M in '87 to \$6.6M in '89)	\$14.9M to \$24.1M[2] (\$13.1M in '89 to \$19.6 in '87)	70	\$2.5M (\$2M in '87)
Economic Impact during capital construction				5,500 to 9,100 direct plus 11,000 to 18,300 indirect	\$450M to \$750M
Property Values	May result in positive impact on land values in area, although difficult to quantify.				
Waterfront Development and Tourism	Linked with the successful implementation of over \$26M[3] in planned waterfront activity in the AOC.				
Infrastructure	Water conservation can significantly reduce need for or delay expansion of infrastructure and associated costs.				

Notes: (1) This Table includes quantification done under previous study. Monetary estimates adjusted to 1992 dollars. Blank cells denote lack of study, not lack of value. Use and non-use estimates are not additive.
(2) Includes achieving better fishing conditions and aesthetics.
(3) The estimated benefits of recreational activities are dependent on increased access, facilities, etc.
(4) Additional facilities have been provided since this study. Therefore, some of this benefit may have been captured already.

A report of the Region of Hamilton-Wentworth's Finance Department (1989) recommended the move to full metering of properties, modification of rate structures, enhancement of public awareness and the implementation of a rebate or incentive program for the use of water efficient fixtures. The Region ultimately expects a reduction of 20 percent in water usage; the precise economic and administrative benefits of which are currently being investigated (Chechalk, 1992).

For some indication of the potential reduced costs, a preliminary study in 1990 of the Hamilton-Wentworth and Burlington area calculated that a 21 percent reduction in water use, would translate into a $750,000 per year savings in water treatment costs (Rivers and Kalinauskas, 1991). This could lead to an additional annual savings of $1.5 Million in the treatment of water at the STP, although it was recognized that some increase in operating and capital costs may be necessary in association with treating higher concentrated wastewater. The Region of Halton is also pursuing a more comprehensive water conservation program.

Detailed work on the economic impact of comprehensive water conservation programs for both municipalities and industry in the Hamilton Harbour area is not complete, however, experiences from other areas in Canada and throughout the United States suggest that water conservation will result in considerable benefits through cost savings for infrastructure.

VI.10.6 Cost Effectiveness Analysis

VI.10.6.1 Introduction

The essence of cost-effectiveness analysis is to measure the effect of a remedial action (e.g. kg reduced chemical discharge, increase in number of desirable fish species) and to compare these effects with the cost of achieving them by different means if alternatives are available. Thus two or more measures may be compared for the economy with which they achieve various objectives. Cost effectiveness analysis is only one of the several criteria used to make decisions about remedial option choices. It helps to prioritize options.

For the most part, the objectives of the RAP are quantified in environmental terms such as: a reduction in nutrient loading for the Harbour; achieving the desirable concentration of various substances in the water column or sediment or in fish and birds; realizing a certain amount of fish productivity; or altering the fish population structure (See Chapter IX). While the discussion of benefits (Section IV.10.5) addresses social or human activity measures, these are not used here. Only environmental aspects will be considered at this time.

If it were easy to quantify the relation between a particular remedial action and a desired effect on the Harbour, our task would be simple. In fact, there is uncertainty about some of these relations, especially as they concern the impact on biota. The effects on biota are often at a secondary or tertiary level, because there are other natural factors at work, and because there are major seasonal or year-to-year variations in the natural factors affecting biological parameters.

In addition, individual remedial actions can have a very specific, small geographical area of impact. For example, correction of a combined sewer overflow (CSO) problem generally eliminates faecal bacteria loading, nutrient loading, suspended solids loading and some hazardous chemical loadings as well as reducing unsightly floating material. One small CSO may, however, appear minor as regards the total loading to an area as large as Hamilton Harbour, but if it is located in a recreational area or near a potential swimming beach, it has a priority that is over-riding. Hence economic quantification in a cost-effectiveness analysis is balanced by values that are less easily quantified or have very site specific aspects.

There are also sets of actions that can achieve more than one goal. The impact matrices in Appendix L of this report or in the Marshal Macklin & Monaghan Ltd. report (1988) are useful as preliminary screening for the alternatives and the range of goals that they can affect. They reflect the fact that erosion control by itself conserves soil, reduces turbidity in the receiving waters and reduces the loading of nutrients and some trace contaminants. Or, alternatively, that various measures undertaken to modify treatment processes at an STP can affect in various ways, loadings of phosphorus or ammonia, loading of suspended solids loading of trace contaminants and the production of sludge waste. This necessitates ranking of the parameters being affected by each remedial option.

Evaluation of industrial projects as it is currently developing (B. Fleet and N.S. Fleet, 1992) incorporates new criteria. The standard financial analysis which considers capital costs, operating costs, cost savings and cost recoveries, is being supplemented with consideration of future legal liabilities, or corporate image and, as suggested by these authors, should include things such as future risk costs or loss to clients. This is as true for a regional municipal corporation that is dealing with pollution control and environmental impact, as it is for industry.

In addition to these factors we have given consideration to the need for flexibility in STP modifications with a view to future requirements (see discussion in Chapter IV). For instance, the choice of major additional treatment units for an STP, could make future options more costly to implement by virtue of space limitations, or interference with the hydraulic profile for the plant. Another example is the choice of the frequency of overflows for the design of CSO retention basins. The difference in cost between designing for 1 or 4 CSO events per year is about $50 Million in a $250 Million total cost using the one overflow per year criteria in Hamilton-Wentworth Region. Building for the lower standard (4 per year) and then finding out later that one must retrofit for the more stringent criteria would cost far more than the initial cost difference. Such considerations are required in RAP projects, and it cannot be said that new initiatives to incorporate such criteria are straightforward or easily quantified.

It should also be noted that sensitivity analyses done at an earlier stage of the RAP (Marshal Macklin & Monaghan Ltd., 1988) indicated that net benefits are very sensitive to the basis chosen for calculating non-use values (see Section IV.10.5). This also affects the judgements about the priority of various measures.

Cost-effectiveness analysis is a useful technique to help in prioritizing the remedial options. It does, however, have several constraints and must be viewed as one of several factors to be considered in choosing options.

VI.10.6.2 Sewer System and Sewage Treatment Plants

The analysis of the cost effectiveness of measures to improve hypolimnetic dissolved oxygen (Marshal Macklin & Monaghan Ltd., 1988) included the effect of individual measures and sets of control measures (Hamilton Sources, Burlington Sources, Industrial Sources and all sources) that reduced the discharge of ammonia or phosphorus. The model used to quantify the relation between loadings and dissolved oxygen is the same one used to estimate the loading requirements and end conditions given in the delisting criteria of this report (Chapter IX). It was concluded that the results for improvement of the most serious oxygen (minimum) levels in the hypolimnion in summer (DO_h) would be alleviated as follows:

Scenario 1	Control of Hamilton Sources	Improvement in DO_h = 1 mg/L	\$300 M$^{(1)*}$
Scenario 2	Control of Burlington Sources	Improvement in DO_h = less than 0.5 mg/L	\$50 M$^{(1)}$
Scenario 3	Control of Industrial Sources	Improvement in DO_h = less than 0.1 mg/L	\$13 M$^{(1)}$
Scenario 4	Control of All Sources	Improvement in DO_h = 3 mg/L	\$363 M$^{(1)}$

(1) Costs lumped.
* Most of the improvement in Scenario #1 is achieved with STP improvements of \$100 to \$150 M.

It is necessary to do a more detailed analysis within the options available to address the Hamilton and Burlington sources in order to find the cost-effective options. The measures proposed in 1988 (COA, 1988) for the industrial sources of ammonia have already been carried out because these measures also addressed phenols, cyanide and suspended solids which collectively provided reason enough to proceed.

The city sewer/sewage treatment systems are not comparable between Hamilton and Burlington. The plants were constructed in somewhat different ways. Combined sewer overflow is a major consideration in Hamilton, but not in Burlington. The major Hamilton plant has a substantial hydraulic 'bottleneck' in its primary capacity. In Burlington some modest modifications will be necessary to accommodate existing MOE guidelines when the plant is at full design capacity before they embark on measures to further reduce contaminant loadings.

The initial and final target loadings that have been set for these STPs is based on a measure of equity. The initial targets were set based on the understanding that they could be achieved at a low cost (optimized chemical coagulant injection for phosphorus reduction, and improved aeration or sludge age to reduce ammonia discharges). The final targets were based on having identical concentrations in the two major plant effluents and proportioning the load on the basis of the populations in the late 1980's. While this is somewhat equitable in terms of the current situation, it doesn't reflect the likely impact of disparate population growth in the two Regions, the cost per household affected by the expenditure (vs. the cost to the citizens who benefit), or any negotiation between the Regions of potential trade-offs that might be more cost-efficient. There may be room for collaboration in planning in the near future, given the restrictive nature of the capacity of the Harbour for nutrient loadings.

The individual measures to be taken within the 'city' source system where combined sewer overflows and improved sewage treatment are concerned will be addressed below.

The authors of the above-noted report comment on the other factors that affect dissolved oxygen. They note that control of agricultural sources of phosphorus has a small effect on the total loading as is also indicated in Figure 8 of this report. They have not, however, considered the impact of (for example) Spencer Creek on Cootes Paradise, as opposed to its effect on the much larger volume of water in the Harbour. More importantly, they estimate that efforts to improve dissolved oxygen by controlling sources of phosphorus and ammonia will have the added bonus of reducing by 50% the 'natural' control exerted by the oxygen demand of the Harbour sediments themselves. This statement is predicated on completion of all measures to control phosphorus and ammonia, and entails an uncertain waiting period of perhaps 10 to 20 years to realize the full recovery after all remedial work has been completed.

Details of the individual steps that might be taken in the sewage collection systems or sewage treatment plants have been developed for the Burlington Skyway STP (CH2M Hill, 1991), and the Hamilton-Wentworth Region Sewer System (J. Thiel and Associates, 1991). Other generic studies are also available to gauge the effectiveness of alternative modifications or additional treatment processes that can be applied to a particular plant (e.g. Nutt, 1991).

VI.10.6.2.1 Hamilton-Wentworth Region Sewer System

In the study noted above (J. Thiel and Associates, 1991) options for preventing combined sewer overflows (CSOs) in Hamilton-Wentworth Region were assessed. Five possibilities were presented, keeping in mind the goals for the RAP. These are found in Table 12. Other remedial options were considered including:

- adjustment of overflow regulations
- disconnection of roof down-spouts
- swirl concentrators with tanks at the CSOs
- public education, and
- Real Time Control.

These last five options were beneficial, in some particular locations, for reducing the frequency of overflows, for reducing the pollutant loading or for reducing basement flooding, but were found, individually, not to significantly reduce the total pollutant loading to the Harbour because of the large volumes of stormwater that have to be handled. Major measures will have to be undertaken in order to ensure meeting the Plan targets (as noted in the Table).

Table 12: CSO Storage Alternatives and Associated Costs

Option and Description	Number of Offline Facilities[1]	Length and Diameter of Inline Tunnel	4 CSO/Year Control Strategy				1 CSO/Year Control Strategy			
			Const'n Costs		Land Costs	Total Costs[2]	Const'n Costs		Land Costs	Total Costs[2]
			Tanks	Tunnel			Tanks	Tunnel		
1. Separate offline storage facilities at each outfall.	22	-	72.1	0	4.0	76.1	115.3	0	5.8	121.1
2. Offline storage facilities with some lumped facilities.	18	-	70.5	0	3.7	74.2	113.8	0	5.2	119.0
3. Offline storage facilities and inline storage from the Woodward Avenue WPCP to Gage Avenue.	12	Length = 4.5 km D = 7.0 m for 4 CSOs D = 9.0 m for 1 CSO	42.5	52.0	1.3	95.8	72.3	65.0	1.8	139.1
4. Offline storage facilities and inline storage from the Woodward Avenue WPCP to Wentworth Avenue.	10	Length = 6.2 km D = 7.0 m for 4 CSOs D = 8.5 M for 1 CSO	34.2	71.0	0.9	106.1	60.0	86.8	0.8	147.6
5. Offline storage facilities and inline storage from the Woodward Avenue WPCP to Highway 403.	9	Length = 11.2 km D = 6.0 m for 4 CSOs D = 7.0 m for 1 CSO	24.0	112.0	0.3	136.3	44.7	129.0	0.9	174.6

(1) Excluding the existing Greenhill CSO storage facility.

(2) Excludes WPCP expansion costs of $90 and $100 Million for the 4 and 1 CSO/year control strategies, respectively.

Note: All costs in Millions of Dollars.

Source: (Thiel and Associates, 1991 - reference Table 10.1)

Of the five major options considered (Table 12) options #3 or #4 were recommended as preferred. Note that under these preferred schemes, CSO retention tanks can proceed in the western part of the Harbour and Cootes Paradise (indicated as highest priority areas of impact for the RAP) before incurring the major costs associated with the inline trunk sewer storage. Two of the CSOs are being addressed (Queen and Hess St. CSOs) in a facility already under construction in 1992. The design criteria being used is one overflow per year for the period from May to October.

The report points out the critical need for major modifications to the Woodward Avenue sewage treatment plant to handle the additional volume of wastewater and to reduce the large amount of bypassing that already takes place at the plant. Studies are currently underway to audit the plant, but cost-effective measures have already been taken to reduce phosphorus loadings by 50% (chemical precipitation at multiple points in the plant), to reduce ammonia loadings by 50% (chemical additions plus changes to plant process procedures) and to reduce bypassing by more than 66% (by using step-feed control).

The next step, as described in the footnote to Table 12, is major modification of the primary capacity of the plant to accommodate both the additional stormwater from CSO diversions and additional wastewater that may arise from growth of the Region (unless water conservation measures can compensate for this growth). The cost effectiveness of these options is subject to uncertainty due to disagreements about how much contaminant is in the overflows. RAP estimates of loadings from CSOs are 5 to 6 times greater than those in the Pollution Control Plan Study. Efforts to resolve this discrepancy have not been successful. A new program of direct measurements may be necessary to settle the question. For loadings of nutrients and trace contaminants, this is a critical factor in judging the priority of these options. For bacterial contamination or for floating 'debris' from CSOs, the matter is more directly linked to each local impact zone and the priority of these geographic sites is much clearer.

Further study of the actual loadings from the larger CSOs is required before more quantitative cost-effectiveness estimates can be made. In the meantime, CSOs in critical areas and upgrade of the STP to improve treatment and to reduce bypassing are deemed most cost-effective - several measures of which have already been undertaken to meet initial RAP loading targets. The details of further measures to be taken at the STP will await the results of the audit currently in progress. The estimates for the preferred options are given in Table 13.

The work in Hamilton-Wentworth Region is proceeding in a logical manner consistent with RAP goals and priorities.

VI.10.6.2.2 Halton Region Wastewater System

The City of Burlington has a separated sewer system with one sewage treatment plant discharging to the Harbour - the Burlington Skyway WPCP. Only a small area of the city has storm drainage to the Harbour, and this can be handled separately. There is some infiltration to the sanitary sewer system during rainfall but it is not excessive. Along the

Table 13: Total Cost of Recommended CSO and WPCP Remedial Works

Level of Control	CSO Storage Option	CSO Storage Cost (Million)	WPCP Improvement Costs (Million)	Estimated Total Cost (Million)
4 CSOs/year	3. Offline storage facilities and inline storage from Woodward Avenue WPCP to Gage Avenue	95.8	90	186
4 CSOs/year	4. Offline storage facilities and inline storage from the Woodward Avenue WPCP to Gage Avenue	106.1	90	196
1 CSO/year	3. Offline storage facilities and inline storage from the Woodward Avenue WPCP to Gage Avenue	139.1	100	239
1 CSO/year	4. Offline storage facilities and inline storage from the Woodward Avenue WPCP to Wentworth Avenue	147.6	100	248

Source: Thiel and Associates, 1991 - reference Table 9.10

north shore there a need for a sewage lift stations. If the pumps fail and tanker trucks cannot empty the tank at the lift station quickly enough, there could be sewage discharged to Falcon Creek, for example. This is reported to be a very rare event.

Three reports are available, addressing the potential modifications to the Skyway WPCP to meet RAP goals. The sets of actions analyzed are:

1. Optimization of chemical treatment for phosphorus and total suspended solids (Murphy and Eastwood, 1991).
2. Biological nutrient removal (BNR) (CH2M Hill Engineering, 1992).
3. Operation Audit (CH2M Hill Engineering, 1991).

This last report details sixteen measures or studies required to modify the plant to reach loading targets.

It is the RAP Team's view that optimization of chemical treatment is the essential first step at this plant. The investigation of BNR retro-fit at this plant indicated that the plant is not well suited to the use of this process. Implementation of a physical-chemical precipitation system for phosphorus removal should be considered in the primary clarifiers in preference to BNR. A more detailed analysis of the feasibility and cost of retrofitting the plant to Phostrip should be performed.

The operational audit considered staged sets of projects to meet various degrees of treatment, as follows:

1. Measures to ensure that the plant meets current orders when operating at full capacity.

Table 14: Immediate Steps - An Overview of Recommended Upgrades with their Inter-relationship.

Problem/Bottleneck	Solution	Estimated Cost ($)
1. Uneven flow distribution to secondary clarifiers (at flowrates above 90,000 m^3/d, bypassing of the biological system occurs).	**Improve plant flow splitting** to secondary clarifiers and eliminate secondary bypass, following recommendations from Hydraulic Evaluation Report.	1,050,000
2. Filamentous sludge bulking affects secondary clarifier performance.	**Evaluate sludge chlorination techniques** to reduce number of filamentous organisms.	10,000
3. Accuracy of flow meters: effluent, return (RAS) and waste (WAS) sludge is unknown.	**Assess effluent flow meters' accuracy.** Calibrate RAS and WAS magmeters.	25,000
4. Occasional excursions in effluent phosphorus concentration.	**Optimize chemical addition** based on McMaster University studies.	No Estimate
5. Occasional excursion from recommended solids retention time (SRT).	Install computer assisted **SRT** control.	---
Source: CH2M Hill Engineering Ltd., 1991. (Report for Technical Steering Committee - Operational Audit of Burlington Skyway WPCP.)		

2. Measures to improve energy savings in the aeration system, with a reasonably short payback.

Table 15: Upgrades for Energy Savings in the Aeration System.

Upgrade	Reason	Estimated Cost ($)	Payback (years)
6. **Inspect existing blowers.**	Assess current operation status of blowers and define replacement needs.	10,000	----
7. **Retrofit aeration equipment to fine pore diffusers.**	Upgrade current aeration system to improve oxygen transfer efficiency.	1,600,000	4 to 6[1]
8. **Install automatic dissolved oxygen (DO) control system.**	Achieve energy savings by DO control while maintaining optimum DO concentration in aeration tanks.	400,000	1 for coarse bubble[1] 4 for fine pore[1]
(1) Under nitrification conditions.			
Source: CH2M Hill Engineering Ltd., 1991. (Report for Technical Steering Committee - Operational Audit of Burlington Skyway WPCP.)			

3. The secondary thickening/clarification capacity was recommended to be increased following completion of items 1 to 5.

Table 16: Secondary Thickening/Clarification Improvements

Problems/Bottleneck	Solution	Estimated Cost ($)
9. Secondary thickening/clarification capacity and hydraulic flow pattern within clarifiers need improvement.	**Test alternative baffles** and stress clarifiers to confirm future required clarification/thickening capacity.	120,000
10. If baffles improve flow pattern, then:	**Install baffles in all existing clarifiers.**	670,000
11. If existing clarification capacity (determined in stress tests) is not sufficient to meet future loadings at design flow rate, then:	**Construct additional secondary clarifiers** (the exact number of additional clarifiers will be determined based on results of clarifier stress tests).	9,200,000 (for 8 clarifiers)
Source: CH2M Hill Engineering Ltd., 1991. (Report for Technical Steering Committee - Operational Audit of Burlington Skyway WPCP.)		

The high cost of additional clarifiers has occasioned a caution that there may be less expensive alternatives to meeting the targets.

4. Finally, it was recommended that the following steps be implemented to achieve the initial RAP targets.

Table 17: Upgrades/Actions to Meet RAP Initial Goals.

Upgrade/Action	Reason	Estimated Cost ($)
12. **Pursue** requirement with MOE to use **Non-Nitrifying plant Secondary Clarifier design guideline criteria.**	Reduce by half the number of secondary clarifiers required by achieving pre-denitrification in anoxic basins.	8,000
13. **Pilot-scale testing** to determine design criteria for **anoxic pre-denitrification** (depending on results of Item 11)	Obtain design information for anoxic basins.	100,000
14. **Modify** existing **aeration tanks with anoxic pre-denitrification zones** (depending on results of Items 11 and 12).	Achieve denitrification, and potential biological selection of micro-organisms to reduce sludge bulking.	3,000,000
15. **Pilot test alternative type filters.**	Determine the maximum effluent polishing available and verify capital cost estimates.	120,000(1)
16. Build final effluent filtration system including low-fit pumping station.	Achieve RAP initial loading targets for phosphorus and total suspended solids.	13,850,000
(1) Excluding equipment acquisition.		
Source: CH2M Hill Engineering Ltd., 1991. (Report for Technical Steering Committee - Operational Audit of Burlington Skyway WPCP.)		

The impact of these sets of measures on loading of the three key parameters of phosphorus, ammonia and suspended solids is summarized in Table 18 (from CH2M Hill, 1991).

Table 18: Expected Loading Reductions with Capital and Study-Related Expenditures.

	Current Status(1)	After Implementation of Items 1 to 11(2)	Implementation of Items 1 to 15(2)	Initial RAP Target	Final RAP Target
TP Loading (kg/d)	82	47	30	30	12
TSS Loading (kg/d)	1,536	1,116	500	500	200
Nitrogen (TKN) Loading (kg/d)	374	115	115	470	115
Cumulative Expenditures ($1,000)	0	13,085	30,163	-	-

(1) At current flowrates: Qavg = 77,110 m^3/day based on results obtained during the first part of the audit.

(2) At plant average design flowrate: Qdes = 93,000 m^3/day.

Source: CH2M Hill Engineering Ltd., 1991. (Report for Technical Steering Committee - Operational Audit of Burlington Skyway WPCP.)

It should be noted that these sixteen measures are not deemed, by these authors, to meet the final phosphorus and suspended solids targets. The RAP Team feels that this is a conservative view and that these measures combined with optimized chemical treatment will go further to meeting the final RAP Targets than indicated in Table 18.

Nonetheless, there clearly are some serious constraints as the plant is pushed to its limits, especially when future population growth is considered.

It was noted earlier that a staged approach to implementation of the more expensive treatment measures was recommended to ensure that the Harbour responds as anticipated, to ensure that there is agreement on the final state chosen for the Harbour, and to monitor the actual loading reductions that can be reliably and consistently achieved with each set of remedial measures.

VI.10.6.2.3 Summary on Sewer Systems

The measures being implemented or considered in order to improve the quality of discharges from storm and sewer systems are in line with the RAP recommendations. A review of operating sewage treatment plants attempting to achieve effluent phosphorus concentrations well below 1 mg/L also confirms this strategy (Nutt, 1992). The actual steps taken in these difficult economic times will be examined carefully in the light of the more detailed studies that are due, in the light of experience with specific plants, and in the light of concerns about equity and ability to pay. Additional analyses of the options are required or are already in progress. Matters are moving in the right direction.

VI.10.6.3 Fish and Wildlife Rehabilitation

Cost-effectiveness analysis is helpful in considering carefully bounded questions. The study by Marshal Macklin & Monaghan Ltd. (1988) examined the littoral fishery habitat for Northern Pike and Largemouth Bass as one marker variable. While the cost estimates have been changed to reflect the latest information, their approach is adopted here. They have noted, for example, that there are other water quality parameters that affect fish, but which do not limit fish habitat. For this analysis faecal bacteria, trace metals and trace organics are set aside as being inconsequential for the fish habitat concerns alone (there are other connections with fish, but little related to solely fish habitat). This analysis was also limited to Northern Pike and Largemouth Bass as measures of a warmwater fishery that had a reasonable population balance. The measures examined include the habitat restoration projects as envisaged at that time (subsequently modified and currently - 1992 - in the design stages) and the improvements in water clarity that follow upon remediation of the sewer system (CSOs) and of sewage treatment to reduce phosphorus discharges.

The analysis shows that $13 Million of work on habitat restoration should provide a cumulative estimated yield (kg/year) of 300 to 1,000 for Northern Pike and 600 to 4,000 for Largemouth Bass. To provide cumulative yields between 200 to 1,400 kg/year for Pike and 800 to 4,000 kg/year for Bass by improving only water clarity (hence increased weed bed habitat for fish) would cost Hamilton-Wentworth and Halton Regions an estimated $300 Million if done by reducing nutrient and suspended solids loadings. Clearly the direct habitat improvements/restorations are most cost effective in enhancing the amount of fish habitat.

It is most important to note that the CSO and STP improvements are undertaken for other reasons than just fish habitat enhancement. As plans for habitat restoration become better defined, the more precise will become the cost-effectiveness analysis. It should also be noted that this same habitat reconstruction provides potential for public access, aesthetic improvements in some areas, bird habitat and protection of the shore from wave action (reducing erosion) and can provide some boat mooring protection.

VI.10.6.4 Contaminated Sediment

VI.10.6.4.1 Introduction

There are four geographically defined areas of the Harbour that are being considered for remediation. The Windermere Basin and Hamilton Park sites can be considered as having already been addressed (though the work on these two sites has not yet been quite completed) and these two sites are not considered further here.

The four subject sites consist of three areas of known or potentially extensive sites of contamination and/or toxicity, and the fourth is the general deep-water portion of the Harbour with 'moderate' toxicity and general contamination.

VI.10.6.4.2 The Most Seriously Contaminated Sites

The three areas of most serious concern are:

- Randle Reef,
- the Ottawa Street Ship and a contiguous 'plume' into the Harbour, and
- an ill-defined area in the shipping areas on the west side of Windermere Channel (not Windermere Basin).

The third of these is as yet poorly defined and cannot be addressed in detail, but it is thought to be a less serious matter than the first two at this time.

The first two have been sufficiently investigated to indicate their extent and degree of impact. The potential cost of remediating these two areas has been estimated very roughly (I. Orchard and C. Wardlaw, personal communication) to be between \$600 to \$1,500 per m^3. Various methods of removal and treatment of the sediments from these two areas are currently being investigated or demonstrated. No decision has yet been made on the feasibility or effectiveness of the various options.

Based on the impact of these two areas, however, priority has been placed on the Randle Reef site. A comparison of the two areas illustrates the reason for this priority:

1. Both areas contain about the same amount of material to be remediated (50,000 m^3 of sediment).

2. The Randle Reef site has a more serious level of toxicity.

3. There is no further major release of the materials that could recontaminate the Randle Reef site (whereas this is still a question at the Ottawa St. site).

4. There is an urgency to remove some of the material at the Randle Reef site for navigational requirements and this is not the case at the Ottawa St. site.

5. The Randle Reef site is potentially more subject to disturbance and subsequent spreading to other parts of the Harbour because of ship traffic, and wave action in much shallower waters.

6. The Ottawa slip site consists of material in a protected channel or in a deep portion of the open Harbour where ship activity is minimal and wave action is minimal (so that it would not be easily moved about the Harbour).

It should be noted that any measure to remediate contaminated sediment for the long term has to be preceded by major reductions in the potential for recontamination.

VI.10.6.4.3 The Central Deep Sedimentary Basin of the Harbour

There is a large portion of the Harbour where the toxicity of sediments is 'moderate' and several of the contaminants are present at levels that give rise to concerns that there may be an impact that is unacceptable. It must be admitted that there is no clear consensus on the degree of concern that there should be on this matter even though we have one of the most comprehensive data sets ever developed for any harbour.

The options that we have to deal with this situation, should there be a clear problem, are as follows:

(a) Removal

Depending on the amount of material involved, the cost would be in the order of $1 Billion ($1 Million/ha) and the impact on the benthic organisms during and after the removal would be drastic. Then there would be the question of where to put the material (about $10^7 m^3$) and how it might have to be treated before final disposal.

(b) Allow it to be 'naturally' capped by sedimentation

Recently deposited material is of better quality than material deeper down in the sediment column. If the quality of the sediment material being deposited was maintained or improved, the bottom sediments would improve. This would be gradual since only 3 mm/year is deposited and bioturbation keeps the top 10-15 cm mixed. The cost, of course, is zero for this option.

(c) Artificial capping

Such a measure involves the deposit of about 50 cm of sand evenly over the bottom of the Harbour in order to isolate the contaminated material beneath it. The cost is roughly $1 Million/ha.

(d) Oxygenation of the over-lying water

The toxicity of sediments has a seasonal cycle. It is most serious in summer when biological activity in the water and sediments is highest and the oxygen content of the hypolimnion is very low (0 to 1 mg/L at its minimum). The cause of the low oxygen is traced back to ammonia and phosphorus discharges - primarily now from sewage treatment plants. (Steel mill effluents **now** discharge very little in comparison to STPs, whereas they used to be comparable in the 1970s). Hence the idea is that if the toxicity is low in fall and winter when oxygen in the water column is high (due to uniform mixing of the Harbour from top to bottom) then remediation of the low dissolved oxygen in summer would maintain lower toxicity. The cost of remediating the sewage treatment plants is about $200 Million in total. This is expected to alleviate the problem of oxygen deficits (as well as other problems such as undesirable algae growths, and poor water clarity). If this improves 1,000 ha, this cost is about $200 Thousand/ha.

Artificial oxygenation has been demonstrated as feasible, but in the absence of source controls it would have to be done every year in perpetuity. Community advisors have recommended that source controls are preferable. The cost of artificial oxygenation is relatively low (capital cost of $1 to $4 Million and operating costs of $300 to $400 Thousand/year), but it is a 'bandaid' solution and does not get to the source of the problem. It could be done experimentally for two or more years after major source reductions have been made to see if it alleviated the sediment toxicity and allowed the benthic fauna to improve. The experiment would cost about $1 to $2 Million in addition to equipment installation.

No matter which method might be used to improve the oxygen content of the water column above the sediment, the full effects of the remediation would not likely be felt for several years.

(e) Direct chemical treatment of sediment (oxygenation)

Based on experience in Europe, tests are currently underway in the Harbour to assess the effectiveness of directly injecting oxidizing chemicals (like hydrogen peroxide, ferric chloride or calcium nitrate) into the sediments. These tests are not complete. However, if it is deemed successful, it will probably provide an almost immediate improvement in the sediments treated and will last perhaps for ten years. The cost may be of the order of $2,000 to $5,000/ha. The effectiveness will depend on the efficiency with which the material is injected (requires accurate navigation or extensive overlapping of treatment runs) and on the actual effect on the sediment and the benthic fauna assemblages.

VI.10.6.4.4 Summary and Conclusions Regarding Contaminated Sediment

There are certain specific small (50,000 m^2) areas of the Harbour that require immediate attention. The methods of removing and treating these more seriously contaminated areas have not yet been established. Test are currently underway. The larger body of the Harbour presents much greater uncertainty as regards proper assessment of its hazards to the aquatic ecosystem.

The cost estimates are subject to considerable uncertainty until such time as the technology demonstrations and treatability tests have been completed. As a consequence it is very difficult to carry out a cost effectiveness analysis because of the experimental nature of the alternatives and the early stage of the inquiry into ways and means to deal with the problems.

However, it can be concluded that:

1. it is most effective and priority should be given to proceed with the Randle Reef site,
2. intense investigation of the likely efficacy and economy of alternative ways to address the main body of the Harbour is required, and
3. at-source controls of the contaminants causing problems is essential and final limits on these established as soon as possible.

VI.10.6.5 Industrial Source Controls

The RAP program is relying on the Municipal-Industrial Strategy for Abatement (MISA) to define the requirements and cost-effectiveness for industry whose wastewater discharges reach the Harbour. Two components of the MISA program encompass the industrial discharges to Hamilton Harbour. These are:

(1) The Iron and Steel Sector (Dofasco and Stelco specifically for this area), and

(2) The Municipal Sector or Sewer Use Control (Commercial, Industrial and Residential discharges to municipal sewer systems in Hamilton-Wentworth and Halton Regional Municipalities).

The MISA program for the Iron and Steel Sector has completed and published the effluent monitoring data (September, 1991). Effluent regulations are currently under consideration and will probably be issued in 1993. The survey of Best Available Technology (BAT) has been drafted and the results are under discussion at the sector committee. Cost-effectiveness studies are underway.

The Hamilton-Wentworth Regional Municipality is one of five, and the largest of the candidate municipalities that have participated in a Demonstration Sewer Use Control Program. A draft report on this study was completed in November 1991 (Proctor and Redfern, 1991). In addition to providing extensive background data, there are recommendations on public participation, legal authority, industrial waste generators, sampling, an enforcement strategy, a permitting system, resources required to operate the system and the means for financing it.

Action has already been taken by the Regional Municipality of Hamilton-Wentworth to set up the laboratory and inspection unit required for this program. The report recommends that MOE develop a provincial strategy to ensure equitable conditions across Ontario with respect to cost recovery for sewer use control programs.

No cost-effectiveness studies have yet been carried out that would assist the RAP in selecting the priority actions. In the absence of this analysis the RAP Team endorses the current permitting and regulatory program that is in place for sewer use control and places special emphasis on source control (preferably source prevention) until this analysis and the Provincial Strategy are in place.

VI.10.6.6 Overall Summary and Conclusion of the Cost-Effectiveness Analysis

Cost effective analysis has been helpful in gauging the priority of certain measures to achieve the conditions desired in the Harbour. A full analysis, however, is not possible. In several instances the information is not yet available to carry out a proper analysis. In other instances there are no options - there is only one direction to go.

Hence, this separate analysis of cost-effectiveness - in so far as it has been possible - has confirmed the strategy behind the Recommendations of this report and the discussions in

Chapter IV. As has been pointed out at several points in this report, it will be essential to follow the implementation of the Plan and to pursue the development of key information which will assist decision-making with an adequate cost-effectiveness background.

VII PUBLIC CONSULTATION

VII.1 Description of Public Involvement Process

The Provincial and Federal governments are committed to public consultation as a means of involving citizens more directly in the decision-making process. It is being used effectively to involve the public in the development of Remedial Action Plans for Areas of Concern around the Great Lakes Basin. In addition to helping to refine the goals and timetables for water quality and ecosystem improvements, it provides a forum for discussion of cross-jurisdictional issues and develops heightened awareness of the problems and how society should respond to them.

Two public consultation processes are being employed in the Hamilton Harbour RAP. Public meetings for the general population of the watershed are open sessions designed to promote two way communication. The most recent information on the RAP is imparted to citizens and presentations and briefs from citizens and interested groups are invited.

The second process established a "Stakeholders Group" made up of representatives from agencies, organizations, institutions, governments (Municipal, Regional, Provincial and Federal), industries, environmental groups, recreational groups and private citizen groups who make use of, who wish to make use of, or in some manner have jurisdictional interests in the Harbour.

VII.2 Documentation of Participants

At the beginning of the process, approximately 60 citizens were interviewed individually of whom 49 agreed to form the Group. Fifty-nine percent of the original Group have remained members. At present, total membership, after almost four years, is 43 with 38 of the original groups or agencies represented. Five new groups or individual members have become part of the membership (Appendix H).

VII.3 Activities and Functions

The following section provides an overview of the public consultation programme from its inception in 1986 through to the present, as well as a synopsis of future plans.

The process to include the general public in the Hamilton Harbour RAP process was initiated in May 1986. Land Use Research Associates (LURA), a firm specializing in public consultation, mediation and educational programs related to environmental issues was hired to assist with the Hamilton Harbour public consultation programme.

Phase I of the process began with the following tasks (May - July 1986):

1. Identification of the concerns of major interest groups, agencies and industries relating to Harbour water quality and remedial measures necessary to implement a RAP.

2. Communication with all appropriate individuals in the Hamilton Harbour watershed to ensure the broadest possible opportunity for public involvement.

The first task of the newly organized Stakeholders Group was to develop an "Interim Report" based on discussions held during a two day workshop in July 1986 (see description below), and through subsequent meetings. The report, entitled, 'Interim Report of the Writing Team for the Hamilton Harbour Remedial Action Plan - Towards a Comprehensive Remedial Action Plan for Hamilton Harbour' summarized Stakeholders proposals for the RAP (Hamilton Harbour Stakeholders, 1986). The report was prepared by LURA and submitted to the Federal and Provincial Ministers of the Environment on behalf of the Stakeholders in September 1986. This report formed a basic point of reference for the RAP Team in preparing their draft interim RAP.

July 10-11, 1986 - Water Quality Workshop

A two day workshop was held to aid the Stakeholders in identifying water quality goals for the Harbour and to identify barriers to achieving these goals.

July 16, 1986 - Public Meeting

In December 1986, Phase II of the Public Consultation programme was initiated. This phase began by employing the two strategies utilized in Phase I: the public education/involvement programme, and the continuation of the Stakeholders process.

A public information and education programme was developed to inform and encourage participation by the watershed's public in the RAP process. The goals of the programme are outlined below:

1. To explain the concept of an Area of Concern,

2. To describe the Remedial Action Plan process,

3. To educate the public on the problems within Hamilton Harbour and its watershed,

4. To provide the public with a direct opportunity to participate in the RAP's development, and

5. To provide insight and gain input to the Stakeholders process, deliberations and recommendations.

A mailing list prepared in the first phase of the programme (May-August 1986) was updated and maintained throughout Phase II. At that time, the list consisted of approximately 2,200 names of organizations and individuals.

Advertisements, direct mail notices, newsletters, a seminar for Government officials, educational materials, publicity and a major public meeting were all used to achieve the above goals.

Below, in chronological order, is a description of the activities:

January 12, 1987 - Advertising

An advertisement was developed for insertion in the Hamilton Spectator newspaper. The objective was to create awareness about the Harbour's water quality and its status as an Area of Concern, advise the public that a clean-up plan was underway, and provide a description of the opportunities for participation. A direct response reply coupon was included to encourage participation and to provide the public with an opportunity to obtain further information.

Newsletter #1 - January 1987

The first "Dialogue on Hamilton Harbour" newsletter was mailed to approximately 2,000 Harbour area residents. A direct response reply coupon was included to encourage involvement and for people to obtain further information.

Newsletter #2 - March 1987

The second issue of the newsletter summarized the first two sections of the RAP: watershed characteristics and existing environmental conditions.

Seminar for Government/Agency Officials - February 24, 1987

The purpose of the seminar was to develop an understanding within agency and local government staff about the RAP process, content and development, and to encourage a constructive dialogue between the RAP Team and local officials.

Public Meeting - March 12, 1987

The first public meeting was organized in response to the public's request for a need to become involved in developing the RAP process. The Stakeholders reiterated this request. The RAP Team decided to focus the meeting on the "use" goals identified by the Stakeholders and technical remedial options to achieve these goals. A Draft Interim RAP Summary Report was prepared by the RAP Team and forwarded to over 300 individuals who had indicated a interest in becoming involved in the RAP programme.

The RAP Coordinator presented an outline of the summary report to an estimated audience of between 155 and 175. Briefs were presented by the audience followed by further presentations and a question and discussion period.

Results from the meeting contributed greatly to the RAP development, and provided a clear indication of the need to include area residents in the process.

Publicity

Media coverage of the RAP process through print, audio and visual aids was extensive throughout the Phase II program and included coverage of each Stakeholders meeting and the public meeting.

Education

An education programme was initiated to promote the Harbour as a resource tool for the elementary and high schools within the watershed. During January and February 1987, programme consultants for environmental studies, science and geography in Hamilton and Halton Separate and Public School Boards were contacted. School principals and educational organizations in the watershed received the newsletters.

It was recommended that an educational kit be developed in consultation with both Boards with the purpose of integrating RAPs into the existing school curriculum. At the present time, this has not been developed but may be considered as part of an education programme for the Stage II RAP.

The initial Stakeholders' program contributed greatly to the RAP process in terms of development and direction. Stakeholders indicated their commitment to be involved and act as a consulting body until the RAP was finalized and an implementation strategy developed.

During Phase II, (December 1986 - March 1987) four monthly meetings were held. Facilitation of all meetings was provided by LURA. The meetings reflected both the Stakeholders needs for information and discussion and the needs of the RAP Team for input and direction in beginning to develop the RAP document.

Meeting #1 - December 15, 1986

The Group reviewed their role and terms of reference. Members were asked to provide their constituents' response to the Interim Report and identify any outstanding issues that needed to be addressed.

In their response to the Interim Report, further information was requested by the Group on issues such as the dredging project in Windermere Basin, Shoreline Filling, the Perimeter Road (planned to be built along the southwest shoreline of the Harbour), Shipping and Navigation, and Recreation and Access. Issue papers were prepared and forwarded to the Stakeholders prior to their next meeting at which time these issues were discussed.

Meeting #2 - January 22, 1987

Stakeholders developed a better definition of the Ecosystem Approach to incorporate economic, environmental and social considerations and unanimously agreed that their goal for the re-establishment of an edible, naturally-reproducing, self-sustaining, warmwater fishery was a key indicator that the Harbour ecosystem had recovered from its degraded state. The afternoon session continued with discussions on the outstanding issues identified at the December 15th meeting.

Meeting #3 - February 26, 1987

Two sub-committees were appointed by the Group to address the issues surrounding the Windermere Basin Project, and the concept of "Recreation and Access". A summary of the draft Interim RAP was presented. In response, the Stakeholders raised two issues: the concept of an ecosystem approach should be overriding in the report, and the public may not accept the option of diverting STP discharges to Lake Ontario. Stakeholders were requested to prepare their comments on the draft report for the next meeting.

Meeting #4 - March 26, 1987

Small workgroup sessions reported in plenary with comments on the draft Interim RAP Summary Report and on the continuation of the public consultation and stakeholder processes.

In July 1987, Phase III of the Hamilton Harbour Public Consultation Program was initiated. This phase was essentially a continuation of the goals and objectives established in the first phase of the process.

Public Information and Education

The Public Information and Education program, a continuation of Phase II, provided the public with new information on the RAP and continued to promote and maintain public participation in RAP development. This was accomplished through two newsletters and a public meeting.

Newsletter #3 - August 1987

The newsletter emphasized the importance of public involvement in developing the RAP, outlined future stages of the RAP process, and highlighted actions taken to improve the water quality in the Harbour.

Newsletter #4 - January 1988

A progress report on the RAP process was provided. The newsletter focused on the results of research conducted in Hamilton Harbour in the summer of 1987. Once again, a direct response reply coupon was included to stimulate further interest and involvement in the RAP process and to determine if the readers were satisfied with the newsletter. Responses received were generally supportive of the newsletter and suggested additional topics.

Public Meeting - May 12, 1988

The second Interim RAP Report (Discussion Document) was made public by the RAP Writing Team two weeks prior to the meeting. Participants at the meeting were supplied with copies of the summary report, "Goals, Problems and Options for the Hamilton Harbour RAP" to facilitate discussion among the 200 people who attended the meeting.

An overview of the goals, problems and options for the RAP was presented followed by a question period. Stakeholders were presented with an outline of the Implementation Report and encouraged to provide comments.

The five Stakeholders meetings scheduled in Phase III focused on reviewing and commenting on:

- the Phase II Stakeholders Report,
- the socio-economic study,
- the "Goals, Problems and Options" report,
- how the Stakeholders Group would evolve in order to continue influencing the RAP process.

Meeting #1 - July 16, 1987

Stakeholders were updated on the progress of the RAP, the public consultation program and on current issues affecting the Harbour. Stakeholders were encouraged to comment on and revise the Draft Phase II Stakeholders Report. Following discussion, it was agreed that an implementation subcommittee would be formed. The Stakeholders expressed interest in being kept informed of issues evolving around the Harbour.

Meeting #2 - August 7, 1987

The RAP Coordinator and an OMOE representative outlined the proposed Socio-Economic Study to be undertaken by OMOE. Discussion followed which raised many concerns about the study.

Meeting #3 - October 28, 1987

Stakeholders were presented with a RAP progress report and results of the summer's research program by the RAP Team.

An overview of the Stage I Economic Assessment was presented and Stakeholders were provided with an opportunity to express their concerns and advice.

Stakeholders also discussed the progress made by the Implementation Subcommittee and the process to manage and implement the RAP.

Meeting #4 - April 27, 1988

Due to the five months which had elapsed since the last meeting, it was necessary for the Group to review their principles and goals relating to the RAP.

The "Goals, Problems and Options" report was released to the Stakeholders and general public. Following a presentation of the report, a discussion between the Writing Team and Stakeholders raised several concerns regarding the report. Stakeholders were requested to review the draft document with their organizations by August, 1988.

The Group was updated on the activities of the Implementation subcommittee and it was agreed that a copy of their report would be circulated with the Summary RAP Report for public review.

Meeting #5 - May 24, 1988

During this meeting, Stakeholders reviewed the report, "Assessment of Proposed Remedial Action Plans for Hamilton Harbour" and discussed its contents with the consultants involved with the study.

Newsletter #5 - July 1988

This issue was devoted to a summary of the "Goals, Problems and Options" report and extended an invitation to the general public to comment on the report.

To prepare for the Stakeholders workshops in June 1989, which would assess the remedial actions recommended for cleanup, various sub-committees met throughout the winter and spring. There were no regular Stakeholders meetings during this period.

January, 1989 - Planning Group

In consultation with RAP Team members, the committee established a structure for Stakeholders to review the remedial options at the workshops scheduled for June.

February, 1989 - Ecosystem Task Force

Met to develop a proposal for public awareness for COA Board of Review funding and to assess the extent to which the 22 remedial measures reflected the ecosystem approach.

Newsletter #6 - February 1989

The sixth issue provided an update on the RAP process and described the steps required to complete the RAP. A summary of 1988 summer research projects was also included.

February/March/May, 1989 - Technical Options Task Force

The committee met over a three month period to develop a format for describing each technical remedial option. To allow for the evaluation of the effectiveness of each of the options, a series of tables were produced.

February and March, 1989 - Implementation Committee

Options for implementation and management institutions were reviewed.

April 1989

The workbook for analysis of remedial options, prepared by the RAP Team and the Technical Options Task Force was completed, and reviewed by the Ecosystem Task Force.

STAKEHOLDERS MEETINGS

June 20 and 26, July 6 and 13, 1989

The two workshops in June were chaired by the Coordinator and facilitators were hired specifically for the task. Subsequent meetings held in July were organized and chaired by the Coordinator.

All Stakeholders were invited to the workshops to review decisions made to date and to develop a consensus on recommendations on preferred remedial options. Due to the nature of the discussion, it was necessary to hold two subsequent meetings in July to complete the agenda (see Appendix L for results).

September 27, 1989

The Stakeholders received progress reports on:

- the MISA programme (Municipal and Industrial),
- the Lake Ontario Toxic Chemicals Management Plan,
- the Stage I report and the Preferred Options Report.

October 13, 1989 - IJC Biennial Meeting

The RAP Coordinator and three Stakeholders gave presentations at a half-day workshop which focused on the successes of and obstacles in RAPs. The obstacles identified were the focus of workgroup sessions where participants developed recommendations for overcoming these obstacles.

November 29, 1989

Presentations were given on the status of wildlife around the Harbour, and on a proposed organizational chart for implementation. Discussion identified issues to be resolved.

A presentation on the Crombie Commission was followed by a discussion on the potential impacts of the Commission's work on the Hamilton Harbour RAP.

January 31, 1990

The Draft Preferred Options Report was released to Stakeholders and agencies.

The report, written by the RAP Team was an attempt to address the deliberations of the 1986 Stakeholders report and the proceedings of the 1989 workshops.

Discussion identified a need to address the following issues in greater detail:

- implementation structure
- education
- ranking of options
- loading reductions
- "authority" of RAP
- how to reflect the ecosystem approach
- monetary commitments

February 19, 1990

In response to concerns that the Stakeholders needed their own leadership to be identified, the Group elected a five-member Interim Executive Committee (IEC) to focus Stakeholders views on finalizing the Preferred Options Report and to enable the Group to look towards implementing the RAP.

The Ecosystem Committee presented the Group with proposed changes to the recommendations and proposed new recommendations in the area of education.

The Stakeholders requested a presentation from the Hamilton Harbour Commissioners on the proposed Marina Expansion Project in the Harbour.

March 28, 1990

The Group was offered an opportunity to participate at the Crombie Commission hearings and agreed that although there would be no formal representation from the Stakeholders Group, Gil Simmons in her presentation, would bring the Hamilton Harbour RAP to the attention of the Commissioners.

The Hamilton Harbour Commissioners (HHC) gave a presentation on the Marina Expansion Project and offered the Stakeholders an opportunity to comment on the Initial Environment Evaluation.

In response to a request from the Group, the HHC also provided an update on the Windermere Basin dredging project.

The IEC reported on their first committee meeting and presented their draft terms of reference which were accepted by the Stakeholders.

The next five Stakeholders meetings were chaired by alternate members of the IEC and facilitated by Adrian Tumber.

April 19, 1990

On behalf of the RAP Team, the Coordinator updated the Group on the progress of the RAP.

Before finalizing the POR (or Stage II RAP), the Stakeholders began a review of all the recommendations in the report. Their discussions focused on the intent of each recommendation rather than the actual wording.

May 7, 1990

Peter Rice presented an update on the Cootes Paradise dyking proposal.

The Stakeholders continued reviewing and commenting on the recommendations in the POR.

An opportunity to participate at Environment Canada's Green Plan consultations was presented to the Group.

June 4, 1990

Stakeholders reviewed the recommendations in Chapter 2 of the POR. Stakeholders were informed of the opportunity to participate at a proposed workshop on "Future Visions", and in a newly created RAP PAC Council.

June 18, 1990

Stakeholders reviewed and commented on recommendations for remedial action. The Group was invited to review and comment on MOE's MISA Issues Resolution Document.

June 21, 1990 - Cootes Paradise Canoe Trip

A Royal Botanical Gardens staff member led a two hour canoe trip for Stakeholders, providing them with the opportunity of experiencing first-hand, Cootes Paradise from the water.

July 4, 1990

The Implementation Task Force met to review the proposed implementation model accepted by the Stakeholders and its terms of reference.

July 9, 1990

Report of the Implementation Task Force - The committee presented proposed modifications to the implementation model which were accepted by Stakeholders.

New recommendations proposed by the RAP Team to address various concerns of the Group were reviewed by Stakeholders.

July 25, 1990

Stakeholders completed the review of new recommendations. Agreement was reached that a committee be formed to work with the RAP Team on three outstanding issues:

- how to reflect Stakeholders priorities in the RAP,
- how to finalize the recommendations for remedial actions,
- report structure of the final RAP report.

September 25-26, 1990

On behalf of the Stakeholders, the RAP Coordinator requested that Environment Canada's Inland Waters Directorate organize and run a two-day visioning workshop. The purpose of this exercise was to stimulate the Stakeholders into developing their vision of the Harbour for the year 2020, identify their priorities for making this vision a reality, and identifying obstacles to attaining their vision.

The first day included presentations from five Stakeholders on their initial visions of the Harbour, and concluded with a bus tour of the Harbour perimeter. On the second day, Stakeholders developed a common vision for the Harbour through a visioning exercise.

The Stakeholders who attended the workshop considered that they had been successful in formulating and expressing their vision for Hamilton Harbour. This exercise not only fulfilled the Stakeholders priority of looking at the future of the RAP through an ecosystem perspective, but also meets the Canada-Ontario RAP Steering Committee's suggestion that each Area of Concern have a visioning workshop as part of the process of integrating socio-economic factors into the RAP process.

Public Information and Education

Due to the length of time required for the Stakeholders to review and finalize the recommendations for remedial actions, the public information and education programme was not developed further until March 1990. At this stage in the process, the Stakeholders Communications Committee agreed to publish a document for the general public, summarizing the problem areas in and around the Harbour, and proposed remedial actions required for cleanup. This document will be one of many avenues by which the general public will be informed about the draft Stage II report. The intent of the public consultation programme is to inform the public of the problems in and around the Harbour, and to inform them about the recommendations suggested for cleanup. It is also designed to encourage the public to provide feedback on the plan and to stimulate public comment on the next stage of the RAP process (implementation).

VII.4 Final Public Consultation on the Plan

At the final stage of the Plan, a draft of the Plan was endorsed by Stakeholders, as well as a summary for the Plan, and this was presented to the public through media, six open houses including a wall display, displays in libraries around the Region, a call-in telephone for information and recorded comments, an invitation to complete a short questionnaire regarding individual views and concerns about the Plan. In addition presentations of the Plan were made to business, industry and environmental groups, to municipal committees (planning, engineering, environmental), to schools and to university groups with opportunities for discussion and debate. The details of this consultation are summarized in Appendix G.

The conclusion one can draw from this consultation is overall strong endorsement of the Plan. There is a preference to have the Plan address trace contaminant problems, other water quality problems and the loss of fish and wildlife habitat as a first priority while recognizing that the restoration of the aquatic system requires a multi-front approach on all issues, including planning and provision of access to the water for the general public.

Comments tended to emphasize concern that the Plan should be addressed urgently along with a willingness to pay what is necessary to achieve the objectives. There were also a number of comments expressing a desire for ongoing education and information about our progress with the Remedial Action Plan and bout the Harbour in general (see Appendix G).

In general, there is a ringing endorsement of the Plan by those who took the time to record their views. The Stakeholders executive has noted these comments and finds them to be supportive of the original recommendations.

VII.5 Final Review by the Stakeholders Group (October 1991 to June 1992)

The Stakeholders Group refined the wording of 2 goals and 8 recommendations, and endorsed the Plan as a whole as well as the inclusion of the public consultation report in the final report. They also revised the draft delisting criteria in consultation with the technical team.

VIII SURVEILLANCE, MONITORING, AND RESEARCH AND DEVELOPMENT

The existing long-term monitoring program for water quality in the Harbour, Cootes Paradise and the streams, and at industrial intakes and municipal and industrial outfalls has been invaluable in the assessment of the strategy for remediation. There are limitations to the existing network, however, and these data have been augmented by the collection of many more data during the intensive RAP studies of the past three years. There is now sufficient information to design a more effective and more comprehensive monitoring plan for the future.

This plan must include not only environmental information, but social, economic and land use data as well. The details are developed in Appendix I.

The key changes are overall expansion of the monitoring effort, a much heavier focus on the biota as indicators/integrators of the impact of all remedial measures, and a movement into socio-economic indicators.

It is also important that there be annual **analysis** and reporting of the monitoring data on an **integrated** basis. This analysis will usually require an in-depth investigation of why the trends are the way they are, and will depend upon the assistance of the research staff working on the Harbour. Computer, mass balance and other models of the ecosystem will be essential to understanding the trends observed. Such analysis could result in the identification of alternate remedial strategies, review of the effectiveness of existing measures, and identification of any new problems that might emerge.

Parallel with the more routine monitoring described above is the need for continuing research and development. Continuation of the intensive research effort typical of the past three years is necessary for two more years to finalize some remedial strategies. This should be followed by a continuing program of research and development that maintains touch with the "internal workings" of the aquatic ecosystem and the watershed. This activity would allow for rapid and knowledgeable assessment of any problems that arise, and would facilitate the regular review and interpretation of the monitoring data.

Funding arrangements will be required for the Stage 2 report to go forward with a commitment as designated in the Great Lakes Water Quality Agreement (action 6).

Essential to the complete Plan is access to information about the Harbour in both a reactive and proactive sense. Provision must be made to ensure that information is readily available.

IX DELISTING CRITERIA

IX.1 Criteria for Delisting

The beneficial uses selected for Hamilton Harbour call for achievement of a set of environmental conditions that are deemed necessary to ensure that these uses are not impaired. The following table makes those conditions explicit in both general and specific terms.

As well as can be established with our existing knowledge, these conditions or objectives are the measurable targets against which we can gauge our progress towards completion and maintenance of a restored Harbour. They are patterned on the International Joint Commission guidelines for the impaired uses listed in Annex 2 of the Great Lakes Water Quality Agreement (1978/87).

These criteria focus on conditions that can be corrected through local action. For example, a health advisory on fish in the Harbour that is no different than the health advisory for the whole Lake is not a reason to keep the area listed. Some of these 'whole Lake' problems will, however, require a coordinated effort on the part of all communities contributing to the problem, and in this context the final report on this Harbour will have to be consistent with lakewide management plans.

It is clearly understood the "common sense" will be needed in the application of these guidelines. It may not be possible to fully restore some areas. Natural factors (such as sedimentation) or social or economical factors (e.g. dredging of navigation channels) may preclude restoring the benthic community, for example (IJC Focus Magazine, Vol. 16 #1, March/April, 1991). At later stages in the implementation of the Plan information may arise that will undoubtedly give cause for revisions as well.

Implicit in all these criteria is that all water quality and sediment objectives are to be met.

The fisheries 'targets' represent our current estimate of what is achievable. This is a relatively new science and research behind these figures have yet to be published in the scientific literature. Questions regarding these targets and the current conditions, if they cannot be answered by reference to the Second Edition of the Stage 1 Report (COA, 1992), should be addressed to the Department of Fisheries and Oceans at the Canada Centre for Inland Waters.

For each of the beneficial uses identified in accordance with the 1987 Protocol for the Great Lakes Water Quality Agreement between Canada and the United States (Annex 2), the following criteria have been agreed upon for delisting Hamilton Harbour.

Table A: **Objectives to be achieved in order to permit delisting of Hamilton Harbour, in terms of: water quality; contaminants in fish and wildlife; sediment quality; loading targets for contaminants affecting the beneficial uses; the extent of habitat for fish and wildlife; and the population size and structure for fish and wildlife.**

	USE IMPAIRMENT	PROPOSED HAMILTON HARBOUR DELISTING OBJECTIVES
(i)	Restriction on fish and wildlife consumption.	That there be no restrictions on consumption of fish and wildlife from the Harbour attributable to local sources.
(ii)	Tainting of fish and wildlife flavour.	When survey results confirm no tainting of fish or wildlife flavour.
(iii)	Degraded fish and wildlife populations.	That the <u>fish community</u> has the following structure: 1. Shift from a fish community indicative of eutrophic environments, such as white perch, alewife, bullheads, and carp to a self sustaining community more representative of a mesotrophic environment, containing pike, bass, yellow perch, and sunfish. 2. Attain a littoral fish biomass of 200 - 250 kg/ha. 3. Increase the species richness from 4 species to 6-7 species per transect. 4. Increase the native species biomass from 37% to 80-90% of the total biomass. 5. Reduce the spatial variability in fish biomass within the Harbour. 6. Proposed nearshore fish community of Hamilton Harbour: **Category** / **Littoral Biomass (kg/ha)** Piscivores (pike, bass): 40 - 60 Specialists (Insectivores like pumpkinseeds and yellow perch): 70 - 100 Generalists (omnivores like carp and brown bullheads): 30 - 90 The percent of fisheries biomass allocated to the three trophic groups was based on the effects of improved water quality in the Bay of Quinte and Severn Sound. The littoral fish biomass of 200-250 kg/ha was based on electrofishing data collected from Hamilton Harbour, Bay of Quinte and Severn Sound in 1990.

Table A - continued next page

<table>
<tr><th colspan="2">USE IMPAIRMENT</th><th>PROPOSED HAMILTON HARBOUR DELISTING OBJECTIVES</th></tr>
<tr><td></td><td></td><td>5. <u>Colonial waterbirds:</u>

The overall objective is to have a self sustaining mixed community of colonial waterbirds generally with an increase of the rarer species and a reduction in the number of ring-billed gulls which currently nest in the Harbour. These figures are subject to revision once these general levels have been reached. Management of colonial waterbirds is experimental and achieving specific populations of particular species is highly speculative.

<table>
<tr><th>Colonial waterbirds:
<u>(Suggested Interim Targets)</u></th><th>Number
<u>of Pairs</u></th></tr>
<tr><td>Ring-billed gulls (<u>Larus delawarensis</u>)</td><td>5,000</td></tr>
<tr><td>Common terns (<u>Sterna hirundo</u>)</td><td>>600</td></tr>
<tr><td>Herring gulls (<u>Larus argentatus</u>)</td><td>350</td></tr>
<tr><td>Caspian terns (<u>Sterna caspi</u>)</td><td>>200</td></tr>
<tr><td>Double-crested cormorants
(<u>Phalacrocorax auritus</u>)</td><td>200</td></tr>
<tr><td>Black-crowned night herons
(<u>Nycticorax nycticorax</u>)</td><td>200</td></tr>
</table>

6. <u>Other wildlife</u> including waterfowl:

No target will be suggested for other species of birds or animals, but a target for habitat has been suggested which will enhance wildlife populations generally. In addition, management of some species may be necessary as a result of habitat enhancement.

7. Fish and wildlife bioassays confirm no significant toxicity from water column or sediment contaminants.</td></tr>
<tr><td>(iv)</td><td>Fish tumours or other deformities.</td><td>When incidence rates of fish tumours or other deformities do not exceed rates at unimpacted control sites that are locally relevant and when survey data confirm the absence of neoplastic or preneoplastic liver tumours in bullheads or suckers.</td></tr>
</table>

Table A - continued next page

	USE IMPAIRMENT	PROPOSED HAMILTON HARBOUR DELISTING OBJECTIVES
(v)	Bird or animal deformities or reproductive problems.	When the incidence rates of deformities or reproductive problems in sentinel wildlife species do not exceed background levels in control populations.
(vi)	Degradation of benthos.	1. Biomass estimates for mesotrophic conditions to range from 25 to 50 g/m^2 wet weight of benthos. 2. Shift in oligochaete assemblages (benthic sludge worms) from Limnodrilus hoffmeisteri, Tubifex tubifex, indicators of eutrophic environments, to mesotrophic indicators such as Spirosperma ferox, Stylodrilus heringianus, and Llyodrilus templetoni. 3. An increase in the contribution of other species in Hamilton Harbour sediment indicative of mesotrophic conditions such as midges (Tanypus and Strictochironomus), fingernail clams (Pisidium), mayflies (Haxagenia) and the amphipod (Pontoporeia hoyi). 4. Reduction in oligochaete (sludge worm) density from an average 10,000 animals per m^2 found in 1984 to between 2,000 and 3,000 per m^2 in profundal sediments. 5. Appearance of crustaceans, such as freshwater shrimp, (Mysis relicta) in the deep water basin and the amphipod (Pontoporeia hoyi) in the surficial sediments throughout the hypolimnion. 6. Absence of acute and chronic toxic effects attributable to trace metals or organics in benthic macroinvertebrates throughout the Harbour and Cootes Paradise (Station 270 at the west end of the Harbour has been selected as an interim, local target). See also Dredging delisting criteria (vii).
(vii)	Restrictions on dredging activities.	When contaminants in sediments do not exceed biological and chemical standards, criteria, or guidelines such that there are restrictions on dredging or disposal activities.

Table A - continued next page

	USE IMPAIRMENT	PROPOSED HAMILTON HARBOUR DELISTING OBJECTIVES
(viii)	Eutrophication or undesirable algae.	That there are no persistent adverse water quality conditions for each of the components attributable to cultural eutrophication. The following net loading targets provide the specific objectives. Eutrophication goals and anticipated conditions in Hamilton Harbour, Cootes Paradise, and the Grindstone Creek area:

TABLE (a): Net Loading Targets (Kg/d)

	Phosphorous		Ammonia		Suspended Solids	
	Initial Goals	Final Goals	Initial Goals	Final Goals	Initial Goals	Final Goals
Hamilton STP	140	60	2270	530	3750	900
Burlington STP	30	12	470	115	500	200
CSOs	70	5	160	20	1400	200
Streams(*)	90	65			30000	20000
Industry (gen'l)			400	270		
Stelco					4000	1500
Dofasco					3500	1500

TABLE (b): Environmental Conditions

	Hamilton Harbour		Cootes Paradise	Grindstone Creek Area
	Initial Goals	Final Goals	Final Goals	Final Goals
P conc (ug/1)	34	17	60-70	60-70
Un-ionized NH_3 conc (mg/1)	<0.02	<0.02		
Chlorophyll a conc (ug/1)	15-20	5-10	20	20
Secchi Disc Trans (m)	2.0	3.0	1.0	1.0
Min. DO conc (ppm)	1-4	>4		
Aquatic Plant Area ha	105	170	240	50
Seston conc (mg/1)			10	10

* Stream loadings are extremely variable from year-to-year. The percentage of reduction is based on the estimated effect of best management practice.

Table A - continued next page

USE IMPAIRMENT		PROPOSED HAMILTON HARBOUR DELISTING OBJECTIVES
(ix)	Restrictions on drinking water consumption or taste and odour problems.	Maintenance of water quality conditions in the Harbour pertinent to standards for human health where a water supply would only require standard treatment procedures (settling, coagulation, disinfection).
(x)	Beach closings. (Water contact sports.)	1. That Hamilton Harbour effluent to Lake Ontario not give rise to conditions which would cause restrictions on open Lake water contact sports. 2. That water quality conditions in the west-end and in the north-half of the Harbour, be such as to permit opening of beaches and which would cause no significant restriction on water contact sports.
(xi)	Degradation of aesthetics.	When the waters are free of any substance which produces a persistent objectionable deposit, unnatural colour or turbidity, or unnatural odour (e.g. oil slick, surface scum).
(xii)	Added cost to agriculture or industry.	When there are no significant additional costs required to treat water prior to use for agricultural purposes (i.e. including, but not limited to livestock watering, irrigation and crop-spraying) and industrial purposes (i.e. intended for commercial or industrial applications and non-contact food processing). Cost associated with zebra mussels or other invasive organisms are excepted.
(xiii)	Degradation of phytoplankton and zooplankton populations.	When phytoplankton and zooplankton community structure does not significantly diverge from unimpacted control sites of comparable physical and chemical characteristics. Further in the absence of community structure data, this use will be considered restored when phytoplankton and zooplankton bioassays confirm no significant toxicity in ambient waters.
(xiv)	Loss of fish and wildlife habitat.	1. Increase quantity of emergent and submergent aquatic plants in Hamilton Harbour, Cootes Paradise, Grindstone Creek delta, and Grindstone Creek marshes to approximately 500 hectares in accordance with the Fish and Wildlife Habitat Restoration Project. 2. Provide an additional 10 km of littoral shore by creating 5 km of narrow islands. 3. Create an additional 344 ha of lagoon habitat for waterfowl. 4. Create 270 ha of colonial nesting habitat. 5. Water clarity targets for the summer season (June to September) as measured by Secchi Disc: Harbour 3.0 m Cootes Paradise & Grindstone Creek 1.0 m

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APPENDIX B: MEASUREMENTS & UNITS CONVERSION TABLES

Measurements and Units				
mg/L	= milligram per litre	=	part per million (ppm)
$\mu g/L$	= microgram per litre	=	part per billion (ppb)
$\mu g/g$	= microgram per gram	=	part per million (ppm)
m^3/d	= cubic metres per day		
cms	= cubic metres per second		
kg/d	= kilogram per day		

What do parts per million (ppm) and parts per billion (ppb) mean?

One part per million (ppm) - one inch in two miles
one minute in two years
one bad apple in 2,000 barrels

One part per billion (ppb) - one inch in 16,000 miles
one second in 32 years
one bad apple in two million barrels

As an example: Swimmers can detect chlorine in a pool at 1 ppm, sensitive noses can detect the odour of fuel at 1 ppb.

EQUIVALENT UNITS					
metre	=	m	1 m	=	3.28 feet
kilometre	=	km	1 km	=	0.621 miles
gram	=	g	1000 g	=	1 kg = 2.205 pounds
litre	=	L	1 L	=	0.22 gallons (Can)

CONVERSION TABLES

To Convert	Multiply By	To Obtain
acres	0.4047	hectares
acres	4047	square metres
feet	0.348	metres
grams	.002205	pounds
hectares	2.471	acres
kilograms	2.2046	pounds
kilometres	0.6214	miles
litres	0.2201	gallons
metres	3.281	feet
metres	1.094	yards
miles	1.609	kilometres
pounds	453.5	grams
square metres	0.000247	acres
temperature °C	(°C x 9/5) + 32	temperature °F
temperature °F	(°F - 32) x 5/9	temperature °C
yards	0.9144	metres

APPENDIX C: GLOSSARY

Algae	Simple one-celled or many-celled micro-organisms, usually free-floating, capable of carrying on photosynthesis in aquatic ecosystems.
Algal blooms	Excessive growths of algae and aquatic plants that form unsightly scums and layers of turbid water, impairing the water for recreational, domestic and aesthetic uses.
Algicide	A specific chemical highly toxic to algae. Algicides are often applied to water to control nuisance algal blooms.
Anoxia	The absence of oxygen necessary for sustaining most life. In aquatic ecosystems this refers to the absence of dissolved oxygen in water.
Anoxic	Without dissolved oxygen, or deprived of oxygen.
Areas of Concern	Geographic locations identified by the IJC where water, sediments, or fish quality are degraded and the IJC water quality objectives or jurisdictional criteria, standards, or guidelines are not met.
Benthic	Of or living on or in the bottom sediment of a water body.
Benthivore	An animal (e.g. white perch) which consumes benthic organisms or benthic matter.
Benthos	Bottom dwelling organisms - the benthos comprise: 1. sessile animals such as sponges, some worms and many attached algae; 2. creeping forms such as snails and flatworms; and 3. burrowing forms which include most clams, worms, mayflies and midges.
Benzo (a) pyrene	A PAH which is a suspected carcinogen found in such things as cigarette smoke. It is a by-product of combustion and is released to the aquatic environment during steel and aluminum-making process.
Berm	The bank of a canal opposite the towing-path.
Bioaccumulation	Uptake and retention of environmental substances by an organism from both its environment (i.e. directly from the water) and its food.
Bioassay	A determination of concentration (dose) of a given material (often suspected pollutant) necessary to affect living cells under stated conditions.
Biota	Species of all the plants and animals occurring within a certain area.
Bioturbation	The physical disturbance of sediments by burrowing and other activities of organisms.
Botulism	Poisoning due to eating decomposed food material containing *Bacillus botulinus*.
Carcinogen	Cancer-causing chemicals or substances.
Chlorophyll a	The photosynthetic green pigment present in most plants or algae.

Coliforms	Contaminating bacteria normally found in the gut of vertebrates and eliminated in the faeces (faecal coliforms). May cause gastric ailments in humans if they are swallowed.
Community	Group of population of plants and animals in a given ecological unit used in the broad sense to include groups of various sizes and degrees of integration.
Contaminant	A substance foreign to a natural system or present at unnatural concentrations in air, water, soil or food, causing use of those things to be limited. A naturally occurring substances may be found to exceed government guidelines or objectives, and thus be called a contaminant.
Contamination	The introduction of pathogenic or undesirable micro-organisms, toxins and other deleterious substances which render water, air, soils or biota unfit for use.
Conventional pollutants	A term which includes nutrients, substances which decompose using oxygen in the process, material which produce an oily sludge deposit, and bacteria. Conventional pollutants include phosphorus, nitrogen, chemical oxygen demand, biochemical oxygen demand, oil and grease, volatile solids, total and faecal coliform bacteria, and chlorides.
Conventional parameters	Parameters and pollutants that have been measured for many years, such as COD, phenols, cyanide, suspended sediments, nitrogen, phosphorus, sulphide, and organic carbon.
Criteria	Numerical limits of pollutants established to protect specific water uses.
Detention	When storm water is held in a facility prior to being treated in a sewage treatment plant.
Dioxin	A group of approximately 75 chemicals of the chlorinated dibenzodioxin family. 2,3,7,8-TCDD is considered the most toxic form.
Dissolved oxygen	The amount of oxygen dissolved in a given volume of water.
Dofasco	Steel industry situated on the south shore of Hamilton Harbour.
Dredgeate	The material removed from the river, lake or harbour bottom during dredging operations.
Ecosystem	The interacting complex of living organisms and their non-living environment; the biotic community and its abiotic environment.
Effluent	Contaminated waters discharged from facilities to either wastewater sewers or surface waters.
Environment	All biotic and abiotic factors that actually affect an individual organism at any point in its life cycle.
Epilimnion	Surface layer of water, above the thermocline (cf.), warmer and more oxygenated than the hypolimnion (cf.).
Erosion	The wearing away and transportation of soils, rocks and dissolved minerals from land surface shorelines or river bottoms by rainfall, running water, wave or current actions.

Euphotic Zone	The layer of a body of water down to the limits of effective light penetration for photosynthesis.
Eutrophication	Having abundant nutrients which leads to excessive productivity of plant and animal matter, frequently resulting in oxygen depletion in the lower layers of a body of water.
Exceedence	When the concentration of a pollutant exceeds the water quality guideline for that molecule.
Gallinaceous (birds)	Of or pertaining to the Gallinæ, a group of birds containing pheasants, partridges, grouse, turkeys, domestic fowls, and allied forms.
Great Lakes Water Quality Agreement	A joint agreement between Canada and the Unites States which commits the two countries to develop then implement plans to restore and maintain the many desirable uses of the waters in the Great Lakes Basin. Originally signed in 1972 and reviewed in 1978, the Agreement was amended in 1987.
Groundwater	All subsurface water in the land portion of a watershed.
Groyne	A structure of piles, concrete, etc., acting as a breakwater on a foreshore, and causing sand and shingle to be retained.
Halton Region	A political region which includes the city of Burlington and the north-east portion of the Hamilton Harbour watershed.
Hamilton-Wentworth Region	A political region which includes the City of Hamilton, the Town of Flamborough, Dundas, Ancaster, Stoney Creek and the west and south portions of the Hamilton Harbour watershed.
Hyperplasia	A tumour consisting of excessive tissue growth.
Hypolimnion	The deeper layer of a body of water, below the thermocline (cf.). Usually has less oxygen and is colder than the epilimnion (cf.).
In Situ	In place.
Invertebrate	A former subdivision of the animal kingdom, containing animals without a vertebral column.
Jackson Units	A measurement of turbidity determined by comparing the amount of light seen through a certain length of the sample against a series of standards.
Kjeldahl Nitrogen	Total nitrogen content of a sample, determined by digesting the sample with concentrated sulphuric acid, and distilling the resultant NH_4SO_4 to produce ammonia.
Leachate	Contaminated liquid that derives it content by dissolving or carrying particles from the soil, wastes or rock layers through which it moves.
Littoral zone	A shallow area along the shore of a body of water with light penetration to the bottom, usually with emergent subaquatic plants.
Loadings	Total mass of pollutant to a water body over a specified time (e.g. tonnes per year of phosphorus).
Macrophytes	A member of the macroscopic plant life (i.e. larger than algae) especially of a body of water (i.e. water weeds or marsh vegetation).

Mesotrophic	Moderately enriched.
Mirex	A pesticide which has been found in significant quantities in Lake Ontario. It accumulates in the food chain, causes reproductive problems and cancer.
Non-point source	Source of pollution in which pollutants are discharged over a widespread area or from a number of small inputs rather than from distinct identifiable sources.
Nutrient	A chemical that is an essential raw material for growth and development of organisms.
Oligochaetes	Sludge worm (such as tubificid) which is tolerant to organically rich waters.
Organochlorines	An organic compound which includes chemically bound chlorine. Many organochlorines are formed in industrial processes whenever chlorine or chlorine-based compounds are used. Thousands of chlorinated organic compounds exist, but only a small portion of those in industrial processes have been identified. Organochlorines include compounds such as PCBs (cf.) and pesticides.
Papilloma	A benign tumour, such as a polyp, on the skin.
Pelagic	Adjective, (in its reference to fisheries) pertaining to species of fish which inhabit the deeper regions of a lake (in depth of 10 m or more) where there is mud or ooze on the bottom and no vegetation.
Persistent toxic substances	Any toxic substance that does not break down to less than 50% of its original amount in a period of time less than eight weeks.
Pesticides	Any substance used to kill plants, insects, fungi or other organisms - includes germicides, insecticides, algicides and fungicides.
Phenolics	Any of a number of compounds with the basic structure of phenol but with substitutions made onto this structure. Phenolics are produced during the coking of coal, the distillation of wood, the operation of gas works and oil refineries, from human and animal wastes, and the microbiological decomposition of organic matter.
Phosphorus	Phosphorus occurs naturally in igneous and other types of rocks and may enter the aquatic environment through weathering of rock or precipitation. Some uses for phosphorus include soaps, detergents, fertilizer products, pesticides and insecticides. Domestic and livestock wastes, industrial effluents and agricultural drainage from fertilized land contribute phosphorus to waters. Phosphorus (total and soluble reactive) is an important nutrient utilized by plants and algae. Phosphorus is usually found in low concentrations in surface water because it is actively taken up by plants. High concentrations of phosphorus can promote nuisance levels of algal and plant growth.
Photosynthesis	A process occurring in the cells of green plants and some micro-organisms in which solar energy is transformed into stored chemical energy.

Phytoplankton	Minute, microscopic aquatic vegetative life; plant portion of the plankton; the plant community in marine and freshwater situations which floats free in the water and contains many species of algae and diatoms. They form the base of the natural food chain.
Piscivore	An animal (e.g. lake trout or salmon) which consumes fish.
Planktivore	An animal (e.g. alewife) that consumes plankton.
Pollution (water)	Anything causing or inducing objectionable conditions in the watercourses and adversely affecting the environment and use or uses to which the water thereof may be put.
Primary treatment	Mechanical removal of floating screenable, rackable or settleable solids from wastewater.
Priority pollutants	As defined by MISA, toxic chemicals that could pose a hazard to the receiving environment based on the chemical's persistence, potential to bioaccumulate, and acute and sub-lethal toxicity to organisms including humans. The list of about 150 pollutants includes heavy metals and pesticides.
Resuspension (of sediments)	The remixing of sediment particles and pollutants back into water by storms, currents, organisms and human activities such as dredging.
Retention	When stormwater is held in a facility prior to being released to the environment in a controlled manner.
Riprap	A foundation of loose stones, as in deep water, or on a soft bottom.
Scaup (lesser/greater)	A sea-duck of the genus Aythya esp. A. marila, found in the northern regions.
Secchi Disc	A standard size metal disc is painted in black and white quarters and suspended by a rope from its centre. The secchi disc is used to estimate water clarity by lowering the disc beneath a lake's surface and noting the depth at which it becomes invisible to the naked eye.
Secondary treatment	Primary treatment plus bacterial action to remove organic parts of the waste.
Sewer (sanitary)	A municipal sewer for the collection and transmission of domestic, commercial and industrial waste not including land drainage or stormwater runoff.
Sewer (storm)	A municipal sewer for the collection and transmission of stormwater runoff, land surface water and water from soil drainage not including any industrial wastes other than unpolluted cooling waters.
Silt	Fine sediment deposited by water.
Sludge	Solid removed from waste treatment facilities.
Solubility	Capability of being dissolved.
Stakeholders Group	A group comprising delegates from agencies, organizations, institutions, government departments, industries, and private citizen groups, all of which have an interest in Hamilton Harbour.

Stelco	Steel industry on the south shore of Hamilton Harbour.
Surficial sediments	The top layer of sediments.
Suspended sediments	Particulate matter suspended in water.
Suspended solids	Solids transported by water and held in suspension; the finer the solid the longer it is in suspension, the greater the distance it travels, and the greater the possibility of adsorbed pollutants.
Sustainable development	Development which meets the needs of the present generation without compromising the ability of future generations to meet their own needs.
Thermocline	Abrupt change of temperature in the water column of a water body; the interface between the epilimnion (cf.) and the hypolimnion (cf.).
Toxic substances	As defined in the Great Lakes Water Quality Agreement, any substance that adversely affects the health or well being of any living organism.
Toxicity	Quality, state or degree of the harmful effect resulting from alteration of an environmental factor.
Trace contaminants	Toxic and other deleterious substances found in trace concentrations in the environment.
Trace element	A chemical element found naturally or required by living organisms in extremely small quantities.
Trophic level	Functional classification of organisms in a community according to feeding relationships - the first trophic level includes green plants, the second level includes herbivores (plant eaters), etc.
Turbidity	A measure of the clarity of a water sample. Turbidity in water is caused by suspended matter, such as clay, silt, finely divided organic and inorganic matter, soluble coloured inorganic compounds, plankton and other microscopic organisms. The clarity of a natural body of water is a major determinant of the condition and productivity of that system.
Volatiles	Organic compounds that can readily evaporate, such as chloroform or trichloroethylene.
Water Quality Objectives	Under the Great Lakes Water Quality Agreement, goals set by the Governments of Canada and the United States for protection of the uses of the Great Lakes as in allowable concentrations of individual chemicals.
Water Quality Standards	A criterion or objective for a specific water use standard that is incorporated into enforceable regulations.
Xeriscaping	Landscaping with plants that can tolerate dry conditions.
Zooplankton	The animal portion of the community of small organisms that live suspended in the water column of a lake.

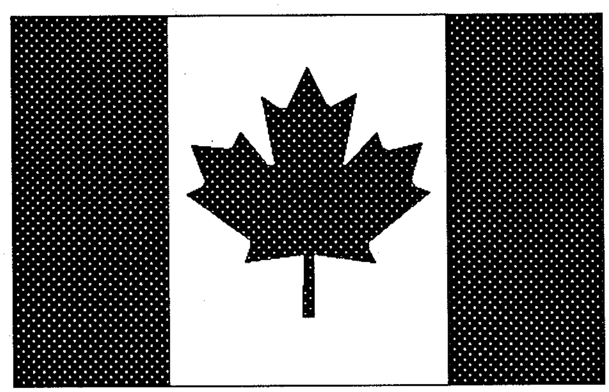
APPENDIX D: ACRONYMS

ANSI	Areas of natural scientific interest.
AOC	Area(s) of Concern.
BAIT	Bay Area Implementation Team.
BARC	Bay Area Restoration Council.
BAT	Best Available Technology.
BATEA	Best Available Technology Economically Achievable.
BNR	Biological Nutrient Removal.
BOD	Biological oxygen demand. The amount of oxygen necessary for the oxidation of water-borne oxidizable compounds by the micro-organisms present in the body of water.
CCIW	Canada Centre for Inland Waters.
CDF	Confined disposal facility for dredged material.
CMA	Census Metropolitan Area.
COA	Canada-Ontario Agreement respecting water quality in the Great Lakes.
CSO	Combined Sewer Overflow. A municipal sewer for the collection and transmission of surface and ground waters and sewage; combined storm and sanitary sewer systems.
CWS	Canadian Wildlife Service (Environment Canada).
DDT	Dichlorodiphenyltrichloroethane. A widely used, very persistent chlorinated pesticide. Most uses of DDT were phased out by 1969, but persists in sediments and biota.
DFO	Department of Fisheries and Oceans (Federal).
DO	Dissolved Oxygen.
DOE	Department of the Environment - alternately Environment Canada (Federal).
DOH	Department of Health (Ontario).
DPW	Department of Public Works.
EARP	Environmental Assessment and Review Process.
EC	Environment Canada.
GLLFAS	Great Lakes Laboratory for Fisheries and Aquatic Sciences.
GLWQA	Great Lakes Water Quality Agreement (signed 1972 revised 1978 & 1987).
GTA	Greater Toronto Area.

HHC	Hamilton Harbour Commissioners.
HRCA	Halton Region Conservation Authority.
IJC	International Joint Commission. A binational organization established in 1909 by the Boundary Waters Treaty. Through the IJC, Canada and the United States cooperatively resolve problems along their common border, including water and air pollution, lake levels power generation and other issues of mutual concern.
LURA	Land Use Research Associates - a firm specializing in public consultation, mediation and educational programs related to environmental issues.
MISA	The Municipal and Industrial Strategy for Abatement Program. The principal goals of this program is the virtual elimination of toxics discharged from point sources to surface waters in Ontario.
MOE	Ontario Ministry of the Environment.
MTO	Ministry for Transportation for Ontario.
NHW	National Health and Welfare (Federal).
NWRI	National Water Research Institute (Environment Canada).
OMAF	Ontario Ministry of Agriculture and Food.
OMMA	Ontario Ministry of Municipal Affairs.
OMNR	Ontario Ministry of Natural Resources.
OMOE	Ontario Ministry of the Environment.
OMTE	Ontario Ministry of Treasury and Economics.
PAH	Polynuclear aromatic hydrocarbons, some known to be carcinogens in mammals. Aromatic Hydrocarbons are composed of at least two fused benzene rings, many of which are potential or suspected carcinogens.
PCB	Polychlorinated Biphenyls. A class of persistent organic chemicals with a potential to bioaccumulate through the food chain, cause reproductive failure and is a suspected carcinogen. A family of chemically inert compounds, having the properties of low flammability and volatility and high electrical insulation quality. Past applications include use a hydraulic fluids, heat exchange, dielectric fluids, and plasticizers for plastics. They were banned in 1980, except for continued use in existing electrical equipment. As well as entering the Great Lakes from leaks and spills, PCB can be released by incineration and travel through the atmosphere.
pH	A measure of acidity of water on a scale from 0 to 14. 7 is neutral. Low numbers indicate acidic conditions, while high numbers indicate alkaline conditions.
PSQG	Provincial Sediment Quality Guidelines.
PWQO	Provincial Water Quality Objectives.

RAP	Remedial Action Plan. A plan is developed with citizen involvement to restore and protect water quality at each of the 43 Areas of Concern in the Great Lakes Basin. The RAP will identify impaired uses, sources of contaminants, desired use goals, target cleanup levels, specific remedial options, schedules for implementation, resource commitments by Michigan and Ontario, as well as, by the federal governments, municipalities and industries, and monitoring requirements to assess the effectiveness of the remedial options implemented.
RBG	Royal Botanical Gardens.
STP	Sewage treatment plant.
TC	Transport Canada.
WCR/MOE	West Central Region/ Ontario Ministry of the Environment.
WPCP	Water Pollution Control Plant - also referred to as Sewage Treatment Plant (STP).
WTC	Wastewater Technology Centre.

APPENDIX E: LETTER TO THE RIGHT HONOURABLE JOE CLARK, P.C., M.P. FROM MR. PHILIP SLYFIELD, SECRETARY TO THE CANADIAN SECTION OF THE INTERNATIONAL JOINT COMMISSION IN RESPECT OF A REVIEW OF THE STAGE I REPORT OF THE REMEDIAL ACTION PLAN FOR HAMILTON HARBOUR.



International Joint Commission
Commission mixte internationale

June 11, 1990

The Right Honourable Joe Clark, P.C.,M.P.,
Secretary of State for External Affairs,
Lester B. Pearson Building,
125 Sussex Drive,
Ottawa, Ontario.
K1A 0G2

Dear Mr. Clark:

The International Joint Commission has completed its review of Stage 1 of the Remedial Action Plan (RAP) for Hamilton Harbour, Ontario in accordance with Annex 2 of the Great Lakes Water Quality Agreement. The technical review of this plan was coordinated by the Great Lakes Water Quality Board and included input from the Great Lakes Science Advisory Board, the Great Lakes Fishery Commission, and individuals from several agencies in Canada and the United States.

The Commission endorses the conclusions of the enclosed Co-ordinated Review report of the Great Lakes Water Quality Board and commends the efforts of those who participated in the development of this RAP and its review. In addition to the technical review, the Commission offers the following comments on issues it believes are important to the further development of this Remedial Action Plan and, generally, to other RAPs that are being developed.

The Commission finds that this Remedial Action Plan generally meets the requirements of Stage 1, and represents an important step towards rectifying the serious pollution problems that have degraded beneficial uses in Hamilton Harbour. By identifying and assessing these impacts, the RAP provides a solid foundation for the development of remedial options and specific measures in Stage 2.

The Commission would draw attention, however, to additional elements inherent in applying a comprehensive ecosystem approach. In particular, it is desirable that the plan include an assessment and consideration of the implications of land use practices, both in terms of land use itself and the contributions of non-point pollution sources (including contaminated groundwater) to the harbour, to the extent that these may be

Ottawa • Washington • Windsor

pertinent to the refinement of remedial options. The influence of atmospheric sources, both local and long-range, may also be a relevant factor.

Clearly, this Plan has been subject to a substantial and effective public consultation effort. Such involvement of the community is both laudable and essential to the long-term sucesss of remedial and preventative programs in the Areas of Concern, including Hamilton Harbour. The active program of consultation by the community and the Hamilton Harbour Stakeholders' Group has been one of the models for public participation among the Areas of Concern. It would be helpful, however, if a more detailed description of the public involvement program and its role in reaching consensus on the goals of the RAP, and subsequently on remedial and other measures, were to be included in the plan.

Similarly, there is increasing recognition that economic and social information pertinent to RAPs and their implications should be taken into account. As causes or implications of remedial and preventative programs, factors such as demographic change (as pointed out by the enclosed review), industrial market forces, evolving land-use patterns and future development scenarios can help shape the challenges and opportunities facing RAP implementation. As the Commission has consistently pointed out in these reviews and the Fifth Biennial Report, Remedial Action Plans should systematically integrate information about environmental conditions with relevant socioeconomic factors and institutional frameworks, as part of the problem analysis. The Commission is aware that some of this work has, indeed, been carried out with respect to Hamilton Harbour, and would encourage its incorporation into the RAP documentation. The Commission would also encourage the continuation of efforts under the auspices of the Canada-Ontario Agreement Respecting Great Lakes Water Quality to develop appropriate methodologies and frameworks for this information.

The need to consider such additional data should not inhibit the implementation of obvious and needed measures to deal with identified major pollution sources. The Commission urges the responsible federal, provincial and local authorities, as well as the community in general, to implement these remedies as soon as possible, without waiting for the refinements of a fully comprehensive strategy.

The Commission commends the many individuals responsible for development of this RAP and hopes that these comments will help and encourage the Governments of Canada and Ontario to continue developing this Remedial Action Plan as the basis for a systematic and comprehensive ecosystem approach to restoring and protecting beneficial uses in Hamilton Harbour. The RAP process is iterative and progressive over time, and the Commission looks forward to reviewing this Remedial Action Plan again at Stage 2 of its development.

A similar letter is being sent to the Secretary of State of the United States by the United States Secretary of the Commission, and a copy has been sent directly to the Province of Ontario.

Yours sincerely,

Philip Slyfield
Secretary
Canadian Section

Enclosure

c.c. The Honourable David Peterson
Premier of Ontario

APPENDIX F: LETTERS OF ENDORSEMENT FROM STAKEHOLDERS AND THEIR CONSTITUENTS

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH
Transportation / Environmental Services Group

Environmental Services Department
71 Main Street West, Hamilton, Ont. L8N 3T4

Tel. (416)546-4170
Fax (416)526-6665

June 16, 1992

Mr. K. Hall
Executive Director
Bay Area Restoration Council
Life Sciences Bldg. - Room 329
McMaster University
Hamilton, Ontario
L8S 4K1

Dear Mr. Hall:

The Regional Municipality of Hamilton-Wentworth is pleased to respond to your letter dated March 23, 1992, with respect to the Remedial Action Plan for Hamilton-Wentworth.

Hamilton Harbour is the receiving body of water for our three Wastewater Treatment Plants and our numerous combined sewer overflows and storm sewer discharges.

It has been with this in mind that several significant projects have been undertaken during the past five (5) years, namely:

- Pollution Control Plans and associated works.
- MISA Sewer Use Demonstration Project.
- Improved effluent quality from the Woodward Avenue Wastewater Treatment Plant.
- Formation of an Environmental Services Department which includes a new Waste Management Division, responsible for both solid and liquid wastes.

As a result of our work and similar commitments from industry and other active bodies, there has been a significant water quality improvement in Hamilton Harbour.

The Woodward Avenue Wastewater Treatment Plant has reduced its pollution loads from between 50-85% during this period, with a series of C.S.O. storage facilities planned, which shall be used to store sewage during storm conditions prior to feeding back into the wastewater collection system for treatment.

Cont'd ....

Cont'd ....

We have recently completed our demonstration project on the MISA Sewer Use Study and shall continue to assist the M.O.E. in developing legislation to benefit the Hamilton Harbour Watershed.

We, therefore, in principle support the goals and objectives of the Stage 2A Report.

J Halliday

P J. (Jim) Halliday
Senior Director
Environmental Services

:cad

cc: R. J. Whynott, Regional Chairman
cc: M. Carson, Regional C.A.O.
cc: D. Wilson, Chairman, Environmental Services Committee
cc: L. D. Turvey, Commissioner of Transportation/Environmental Services

CORPORATION OF THE TOWN OF DUNDAS

OFFICE OF THE
TOWN CLERK

TOWN HALL, 60 MAIN STREET, P.O. BOX 8584, DUNDAS, ONTARIO L9H 5E7
TELEPHONE : (416) 628-6327 FAX : (416) 628-5077

April 29, 1992

Mrs. Anne Redish,
83 Terrace Drive,
Dundas, Ontario.
L9H 3X1

Re: Remedial Action Plan for Hamilton Harbour
Our File No. E00

Dear Mrs. Redish:

Please be advised that your request regarding the above mentioned matter was considered by the Physical Services Committee on April 15th at which time the attached recommendation was made.

The Town Council endorsed this Committee recommendation at its meeting on April 22, 1992.

Yours truly,

J. Roy
for (Ms.) Susan L. Steele, A.M.C.T.
Town Clerk

SLS:jr

Attachment

cc: Mr. R. McCabe, Manager of Engineering

HAMILTON NATURALISTS' CLUB

P.O. Box 5182
HAMILTON, ONTARIO L8S 4L3

P.O. Box 89052
Hamilton L8S 4R5

Bay Area Restoration Council
Life Sciences Building Room 329
McMaster University
Hamilton L8S 4K1

re: RAP Stage 2A report

Dear Sir:-

Your letter of Mar 23rd has just reached me on my return from vacation. I apologize for the delay.

On behalf o fthe Hamilton Naturalists' Club we endorse the report fully.

I believe that we have already indicated our intention for fianancial support of the report. As you know we raised $15000 for Cootes restoration and that is still ear marked for that project. We are engaging in a 1992 Walkathon in support of the Bay project and the Club's share of the proceeds will go to the Restoration program. As a Club we are committed to funding in kind and are negotiating on a portion of our Inventory Project, now nearly completed, be considered in this category. We are making plans for raising another $ 37,500.00 in cash over the term of the project.

You can be assured of the full and active support of our Club.

yours truly,

Doug. McCallum

Doug. McCallum,
President,
Hamilton Naturalists' Club

Hamilton Naturalists' Club is a non-profit organization dedicated to the study, appreciation, and conservation of our wild plants and animals.
All work is freely done by Directors, Officers and Members.

Hamilton Beach Preservation Committee
913 Beach Boulevard
Hamilton, Ontario L8H 6Z6

April 29, 1992.

The Bay Area Restoration Council
Life Sciences Building, Rm.329
McMaster University
Hamilton, Ontario L8S 4K1

attn: Ken Hall, executive director

Dear Ken,

On behalf of the Hamilton Beach Preservation Committee, I offer my whole hearted endorsement of the Draft Hamilton Harbour RAP report.

Due to our proximity to the Bay, our quality of life cannot help but improve as the water quality of the Harbour is likewise improved.

Our environmental sub-committee (chaired by Marion Pacey) has concentrated on air and particulate pollution from the industrial area; but, we have fought for and recieved approval for sanitary sewers on Hamilton Beach.

There are almost 400 septic systems on the Beach Strip that do not comply with current water quality standards. The introduction of sanitary sewers will reduce water table pollution from this one area.

We look forward to working with BARC in the futur.

yours truly,

Don Dowie

Don Dowie
secretary, Hamilton Beach
Preservation Committee

BURLINGTON SAILING & BOATING CLUB

Suite 110, 453 Brant St., Burlington, Ontario L7R 2G3

May 15, 1992

Mr. Kenneth Hall,
Executive Director,
Bay area Restoration Council.

Dear Ken,

I apologize for the delay in responding to your letter of March 23. This is to inform you that the Board of Directors of the Burlington Sailing and Boating Club has reviewed the Hamilton Harbour RAP Stage 2A Report, and has given it full endorsement.

We are currently actively involved with the LaSalle Park Marina Assocation and the Fish and Wildlife Restoration Committee in planning major improvements to the fish habitat as part of our breakwater and west dock re-construction.

I trust that this meets your needs.

Yours sincerely,

David J. Groves,
Rear Commodore of Sail

Conserver Society
of Hamilton and District Inc.

May 7, 1992.

Ken Hall, CEO.,
Bay Area Restoration Council,
McMaster University,
Hamilton, Ontario.

Dear Ken:

Trusting that this will be in time to serve some useful purpose and with apologies for my tardiness. My time is not my own these days and I am finding that I cannot do all I want to accomplish. Frieda is quite seriously disabled, a condition that we hope will be rectified sometime in late summer. The solution lies in surgery, which neither one of us look forward to, but it is the lessor of two extremely unpleasant choices.

You are probably aware that our Flamborough Chapter and the Hamilton chapter are each involved in work related to the restoration plan and program. The Hamilton Chapter ~~are~~ is spearheading a clean-up in the Red Hill Valley this Saturday May 9th.

The Society accepts the plan. We have no statement of changes or dissatisfactions. I do have some personal observations that i would like to pass on to the committee.

I believe that BARC has a co-ordinating role with the public and citizen groups such as the Conserver Society. Would you give consideration to calling a meeting of Environmental Groups of the Hamilton Wentworth region to discuss volunteer assignments of responsibility with a line of accountability to BARC. I think there would be a psychological plus if groups knew they were part of a larger operation, rather than the present state of isolation.

Should BARC wish to discuss this further and want my imput, I would be glad to respond to such an invitation. The Chapters of the C.S. Society are autominus units and would need to have separate invitations to such a meeting.

Sincerely,

Ed. Smee

Ed. Smee.

see addendum on reverse side.

A registered charitable organization. 155 James Street South, Suite 601, Hamilton, Ontario L8P 3A4

Addendum:

As you are aware, there are many jurisdictions involved in the various areas of interest. The restoration of the Red Hill Valley for instance involves a number of jurisdictions. Would it be worth exploring the possibility of Citizen groups working in conjunction with such jurisdictions. The Walk-A-Thon is an example of one type of action to which I am referring.

I realize that the plan has not been officially endorsed at this time. I am inclined to think that we can pioneer some work now however on the assumption that the plan will be endorsed. When such a time comes we could at least have on paper some ideas as to how the public can be mobilized to help, both financially and with people power.

Ed. S.

Ed. Smee.

DOFASCO

Dofasco Inc., P.O. Box 2460, Hamilton, Ontario, Canada L8N 3J5
Telephone (416) 544-3761 Telex 061-8682 Fax (416) 545-3236

May 21, 1992

FILE No. 5010-20-1
DATE June 2/92
JKR

Dr. K. Hall
Executive Director
Bay Area Restoration Council
Life Sciences Building, R. 329
Hamilton, Ontario
L8S 4K1

Dear Dr. Hall:

RE: HAMILTON HARBOUR RAP STAGE 2.A REPORT

Dofasco would like to express its support of the RAP process to date and the company's endorsement of the RAP Stage 2.A Report. This Report clearly enunciates the goals, objectives and options facing all RAP Stakeholders in the remediation of Hamilton Harbour and the restoration of its beneficial uses.

Substantial improvements have already been achieved over the last twenty years with respect to water quality, fish abundance, and water bird population diversity in Hamilton Harbour.

As the Report clearly states, contaminants in the water column have subsided significantly in the wake of control programs implemented by both Industry and Municipal Sewage Treatment Plants. With the exception of unionized ammonia and some metals on occasion, the open water quality criteria expressed in the Ministry of the Environment's Provincial Water Quality Objectives are consistently being met.

We understand that more than fifty-five species of fish now inhabit the Harbour. In fact the fish population appears to be thriving so well that our own Dofasco water intakes are teeming with fish. We also frequently receive comments from visitors to our plant regarding the widespread bird life seen on our green open spaces and water slips.

Further proof that progress is being made in the Harbour water quality is evidenced by improvements in the contaminant content of both fish and birds. Noticeable body burdens of contaminants are being found in only the large, older fish. The reproduction problems experienced by water birds in the 1970's, which were attributed to body burdens of trace organics, are almost non-existent as reproductive rates have returned to normal and deformities have not been observed.

One issue of large concern to Dofasco which remains is the contamination of bottom sediments. Dofasco is committed to assisting the BAIT technical subcommittee evaluating options to remediate contaminated Harbour sediments. We are interested in implementing an environmentally acceptable and cost-effective solution. (We are interested in the chemical oxidation process being investigated by Dr. T. Murphy and other technologies.)

Since 1963, Dofasco has spent over $230,000,000 on pollution control installations. These installations have been a major contributing factor to the above mentioned improvements to the Harbour. Examples of some of the water pollution control installations include the following:

- Larger Scale Pits for Settling Solids in the Hot Rolling Division (1965)
- Main Plant Cold Mill Oil removal Systems (1966)
- 135 Foot Diameter Clarifier for Settling Steelmaking Scrubber Solids (1967)
- Primary Settling and Secondary Biological Activated Sludge Treatment of Coke Plant Waste Waters (1967)
- Conversion of Once-through Cooling of Coke Oven Gas to Closed Circuit Cooling and Chemical Recovery for Ammonia, Hydrogen Cyanide and Hydrogen Sulphide from Coke Oven Gas (1967)
- Ammonia Still for Stripping Ammonia from Coke Plant Waste Water Prior to Activated Sludge Plant (1971)
- 45,000 gpm Capacity Hot Mill Deep Bed Filtration Plant (1971)
- No.1 Hydrochloric Acid Regeneration Plant (1971)
- Cold Mill Waste Water Treatment Plant for Breaking Cold Rolling Oil Emulsions and Treating all Contaminated Cold Finishing Solutions (1974)
- 160 Foot Diameter Clarifiers for Settling Blast Furnace and Melt Shop Waste Water (installed in 1975 and 1978)
- Zimpro Wet Oxidation Unit for Treatment of Coke Plant Waste Water (1982)
- No.2 Hot Mill Filtration Plant and Recycle System (1983)
- No.2 Hydrochloric Acid Regeneration Plant (1986)
- Continuous Caster Water Recycle Systems (1987)
- Blast Furnace Gas Washer Water Recycle System (1990)
- Cold Mill Complex Water Treatment Plant (1991)

Dofasco is also actively involved in the development of the MISA Effluent Limits Regulation. We are now scoping out the technology which will be necessary to meet the anticipated limits. The following briefly itemizes the major modifications we are now contemplating:

Cokemaking -	Biological Plant Upgrades and possibly evaporation technology
Ironmaking -	Tighter Recycle System; local slag pit recycle; improved metals removal
Steelmaking -	Tight Recycle System employing Carbon Dioxide Injection Technology
Hot Forming -	Tighter Recycle System with new thickener and dewatering systems

The progress which has been made in remediating Hamilton Harbour has been a collective effort, and contributions have been made by all of the Stakeholders. Dofasco is pleased to be a part of the RAP process and continues to be committed to the goals and objectives of the RAP as expressed in the Stage 2.A Report.

Yours truly,

T. McGuire

T.E. McGuire
Environmental Coordinator
Water Management

stelco steel

A. Adam
Vice President and Works Manager
Hilton Works

Hilton Works
Hamilton, Ontario
L8N 3T1
(416) 528-2511

May 21, 1992

Mr. Kenneth Hall
Executive Director
Bay Area Restoration Council
Life Sciences Building, R. 329
McMaster University
Hamilton, Ontario
L8S 4K1

Dear Mr. Hall:

It is a pleasure to respond to your letter of March 23, 1992 regarding the Remedial Action Plan for Hamilton Harbour.

Hamilton Harbour is vital to both Hilton Works and to our people in their capacity as residents of its watershed for many reasons. Its water provides a home for wildlife, fish, plants and a myriad of other species and, as well has a multiplicity of use for industry. It provides a major mode of transport for bulk materials, finished goods and for pleasure boats. In summary it is a source of commerce, of pleasure and of beauty.

Historically the growth of our communities and of business have had a significant negative impact on the Harbour. However, in the 1960's man started to reverse this trend. Industry has played a major role in the significant improvements which have been achieved since that time.

As part of this effort we used process changes, water recycle and water treatment installations to reduce our input by more than ninety percent. Installations have included sewer separation including a new sanitary sewer network, major water filtration plants and oil separation and removal facilities. Greenbelts have been established to enhance the aesthetics of the plant and especially the shoreline.

Since the start of the RAP process in 1986 major reductions in ammonia, solids and other substances have been brought about by the installation of new recycle facilities in our coke oven by-product operation and improvements in water filtration and oil removal equipment.

The total Works environmental program has cost more than $734 million (1991 Dollars). Of this approximately $346 million (1991 Dollars) are attributable to reducing inputs to Hamilton Harbour. About $13 million has been spent on these activities since the RAP process began.

As a result of our work plus similar work by municipalities and others, there has been a dramatic improvement in the water quality in Hamilton Harbour. Over 50 species of fish are present and the wildlife population has mushroomed.

The pie charts in Section VI of the report indicate that industry now plays a lesser role as a contributor to Harbour contamination. Page 96 of the report indicates that the level of metals and trace organics in the Harbour generally meet Ontario's stringent Provincial Water Quality Objectives.

We believe we have taken a responsible role in the improvement of the Harbour and we expect to continue to do so as our financial situation permits.

We will participate in projects under Ontario's MISA program aimed at further reducing our input to the Harbour water.

Therefore, in principle, we support the spirit, goals and objectives of the report.

Yours very truly,
STELCO INC.

AA*1

Royal Botanical Gardens
Les jardins botaniques royaux

March 30, 1992

Ms. Anne Redish
President
Bay Area Restoration Council
83 Terrace Drive
Dundas, Ontario
L9H 2Y5

RE: DRAFT REMEDIAL ACTION PLAN FOR HAMILTON HARBOUR

Dear Ms. Redish:

The Science and Education and Executive Committees of the Board of the Royal Botanical Gardens have reviewed the draft RAP and commend the Stakeholders for a very thorough report. Of the fifty recommendations, RBG is identified as an agency responsible for implementing six: specifically nos. 9, 10, 11, 24, 31 & 46. RBG is committed to the RAP and intends to play its full part in implementing these recommendations to the extent that it is financially able.

As you know, recommendations 9, 10, 11, and 46 are the embodiment of Project Paradise, that portion of the RAP's Fish and Wildlife Habitat Restoration Project that is to occur on RBG properties, namely the wetlands of Cootes Paradise and Grindstone Creek. RBG has initiated a support assessment study, pursuant to a fundraising programme for Project Paradise. Some funds are already at hand, and we expect to undertake a few of the elements of Project Paradise this year.

For fifty years, RBG has been the fortunate proprietor of Cootes Paradise and the lower reaches of Grindstone Creek Valley, 800 ha of valuable conservation lands within an urban setting. In the past 20 years, we have attempted to manage these lands to maximize biodiversity, usually at considerable odds and often alone. Yet we have been able to instill conservation ethic amongst the users of our natural areas and at the same time, have amassed much biological data for both our aquatic and upland sites. These data will provide an invaluable base against which we can measure the success of Project Paradise and the Remedial Action Plan.

P.O. Box 399 Hamilton Ontario Canada L8N 3H8
Tel (416) 527-1158 FAX (416) 577-0375

RBG is therefore very pleased now to be a major part of this regionally-based team devoted to implementing the RAP recommendations in pursuit of the community's goals for Hamilton Harbour.

Yours truly,

Grace Inglis
Chair,
Science and Education
Committee of the Board

c. c. Mr. Ken Hall, Executive director, BARC
Dr. Keith Rodgers, RAP Co-ordinator

RICHARD WALKER
R.R. #5, SIMCOE, ONTARIO
N3Y 4K4

(519) 426-1796

April 9/92

Mr. Kenneth Hall
Executive Director
Bay Area Restoration Council

Dear Sir:

As a Stakeholder representing agricultural interests we believe that the Stage 2A Report addresses the impact of agriculture to the Bay area in a fair and reasonable way.

Our only concerne in the future is that agriculture may be targeted unfairly instead of some other area, as the report is written at present there is no indication of this, therefore we urge you to get on with the job in a fair and equitable manner.

We are not necessarily qualified to make detailed comments on some areas concerning wildlife which we believe to be a major contributor at present and unless numbers are controlled may result in becoming a serious source of contaminants to the Harbour.

We are prepared to do our fair share to improve and maintain a better Harbour area and are prepared to endorse in principal the Stage 2A Report.

Sincerely
Richard Walker
Ontario Federation of Agriculture.

HALTON REGION CONSERVATION AUTHORITY
2596 Britannia Road, West
R. R. #2 Milton, Ontario
L9T 2X6
(416) 336-1158 Fax (416) 336-7014

April 2, 1992.

Mr. Kenneth Hall
Executive Director
Bay Area Restoration Council of
Hamilton-Wentworth and Halton Regions
Life Sciences Building, Room 329
McMaster University
Hamilton, Ontario
L8S 4K1

Dear Mr. Hall:

Re: Draft Stage 2 Report - Remedial Action Plan for Hamilton Harbour File No.: PPL-4

The Halton Region Conservation Authority has reviewed the "Draft Stage 2 Report Remedial Action Plan for Hamilton Harbour" and found it to accurately reflect the goals and recommendations of the Stakeholders Group. We wish to commend the writing team and stakeholders for the tremendous effort that has gone into the preparation of this important document. "The Remedial Action Plan for Hamilton Harbour" provides clear direction for accomplishing the goal of restoring this remarkable natural resource and ultimately delisting it as an "Area of Concern." To this end, the Halton Region Conservation Authority endorses the "Draft Stage 2 Report - Remedial Action Plan for Hamilton Harbour.

During 1992, the Halton Region Conservation Authority has entered into a partner agreement with Department of Fisheries and Oceans to conduct two projects which are based on the recommendations of the Remedial Action Plan and relate to fish and wildlife habitat restoration. The first project involves inventorying aquatic plant species on Conservation Authority landholdings and transplanting these species to the aquatic plant nursery at the Royal Botanical Gardens for use in future marsh restoration at Cootes Paradise and Grindstone Creek.

The second project involves the restoration of the pike spawning marsh in the Grindstone Creek by constructing a low berm to maintain water levels longer. Presently, the marsh dewaters early in the season leaving juvenile fish stranded. It is anticipated that this work will be completed by December, 1992. The Halton Region Conservation Authority is pleased to contribute in this manner to the Remedial Action Plan implementation.

Yours truly,

Brenda K. Axon
Manager, Resource Planning.

BKA:mrl

The Board of Education for the City of Hamilton

Le Conseil de l'éducation de la ville de Hamilton

100 Main Street West
Hamilton, Ontario
Telephone (416) 527-5092
Fax (416) 521-2536

100 ouest, rue Main
Hamilton (Ontario)
Téléphone (416) 527-5092
Fac-similé (416) 521-2536

1992 April 06

Mr. Ken Hall
Executive Director
Bay Area Restoration Council
Life Sciences Building
Room 329
McMaster University
Hamilton, Ontario
L8S 4K1

Dear Ken:

I strongly believe that all the hard work in preparing the Stage 2A Report will be rewarded with long-term benefits to all living things in this diverse ecosystem. The report contains specific data that could support independent study projects in OAC Biology and Chemistry. It also provides for linking educational program development to a unique habitat restoration project for Cootes Paradise.

As the representative of the Board of Education for the City of Hamilton in the stakeholders group, I strongly endorse the efforts of BARC and hope to be part of the educational program link to this exciting project.

Sincerely,

Jeff Nichol

Jeff Nichol
Consultant for Environmental/Outdoor Education
Board of Education for the City of Hamilton

/pp

Mailing Address
P.O. Box 2558
Hamilton, Ontario
L8N 3L1

Adresse postale
C.P. 2558
Hamilton (Ontario)
L8N 3L1

LEANDER BOAT CLUB
Phone 527-7377
CLUBHOUSE ON THE BAY AT BAY STREET
P.O. Box 83018, Jamesville Postal Outlet
Hamilton, Ontario L8L 8E8

April 16, 1992

Kenneth Hall
Executive Director
BAY AREA RESTORATION COUNCIL
Life Sciences Building, R329
McMaster University
Hamilton, Ontario
L8S 4K1

Dear Ken:

Leander Boat Club of Hamilton fully endorses the 2A RAP report. We see the vision and spirit of this plan as vital to the area and completely compatible with our relationship with the Bay. We would also like to applaud the hard work and effort of those responsible for its creation. This is indeed an ambitious undertaking. But the Bay is worth it as we've always believed.

Many changes have already taken place to Pier 4 Park and The Royal Hamilton Yacht Club that have directly impacted Leander. We were very pleased that we were consulted in the planning stages and were allowed input into these developments. We trust the same will be the case when the proposed island development takes place along the west harbour. (This is where we do 90% of our rowing). This has the potential to be a wonderful opportunity for us. You have our support and good luck with the next phase of the plan.

Yours sincerely,

M. LaForme

Mel LaForme

ML:egl

THE REGIONAL MUNICIPALITY OF HALTON
P.O. BOX 7000, 1151 BRONTE ROAD
OAKVILLE, ONTARIO, CANADA L6J 6E1

PLANNING AND DEVELOPMENT DEPARTMENT
TEL: 416/825-6161 FAX: 416/825-8822

Halton
A World Class Place To Be.

April 9, 1992

Mr. Kenneth Hall
Executive Director
Bay Area Restoration Council of
Hamilton-Wentworth and Halton Regions
Life Sciences Building, R.329
McMaster University,
Hamilton, Ontario
L8S 4K1

Dear Mr. Hall:

Re: Remedial Action Plan - Hamilton Harbour (File: WF07A)

My previous correspondence to you of March 6, 1992 indicated that I will be providing Halton Council's position on the Draft Remedial Action Plan by April 15, 1992.

Unfortunately, as a result of other priorities and my scheduled vacation, I will not be able to present a report to Council until May, the earliest. Because the draft plan has far-reaching implications for the Region, I do not think it is appropriate to provide you with a staff endorsement as requested in your letter of March 23, 1992.

I will be back on April 21, 1992 and will give you a call that week. Meanwhile, if you have any questions, please feel free to call Ho Wong, Director of Policy, Research and Planning Services.

Yours truly,

for Patricia Herring, M.C.I.P.
Senior Planner

/mp

605 James St. N.
Hamilton, Ontario, Canada
L8L 1K1

Hamilton 525-4330
Toronto 1-800-263-2131
Telex 061-8638

Fax Numbers
Administration 528-6282
Terminal 525-7258

The Hamilton Harbour Commissioners

VIA FACSIMILE & REGULAR MAIL

July 7, 1992

Bay Area Restoration Council
Life Sciences Building
Room 329
McMaster University
L8S 4K1

Attention: **Mr. Ken Hall**
Executive Director

Dear Sir,

SUBJECT: **Stage 2A Report**

Further to your request and our discussions, we are able to advise that The Hamilton Harbour Commissioners support most of the environmental, economic and social objectives set out in the above report for Hamilton Harbour.

We note that the majority of the recommendations in the report apply to agencies other than the Harbour Commissioners. We feel that it remains for these agencies to respond to those aspects with or without any endorsement by the Commissioners. With respect to those recommendations that apply to the Commissioners, we can advise that it is our intention to comply with these to the best of our ability and consistent with our statutory obligations.

To this end, the Commissioners have implemented a number of the Remedial Action Plan recommendations to date. These include:-

- Construction of some 200 metres (660 feet) of littoral habitat at the Commissioners' Harbour-West Marina Complex, with an additional 30 metres (100 feet) to be constructed over the next three years.

- At the same location, the Commissioners have recently constructed a small park for public use which is already seeing significant use for viewing and fishing. Upon completion in two years, a large public area of open space will be available providing some 400 metres (1,300 feet) of new publicly accessible shoreline and 7,000 square metres (1.7 acres) of public open space.

- The Commissioners have and will continue to review all projects within the context of the Federal Environmental Assessment Review Process and furthermore, the Commissioners have an Environmental Code of Practice which will continue to provide guidance in the development of the Port.

We look forward to reviewing the final report.

Yours very truly,

THE HAMILTON HARBOUR COMMISSIONERS

J. BROOKFIELD
PORT PLANNER

jwb/h/wp/ltr159

Hamilton Region Conservation Authority

RAP - Harbour

July 7, 1992

Mr. Kenneth Hall,
Executive Director,
Bay Area Restoration Council of
Hamilton-Wentworth and Halton Regions,
Life Sciences Building, R. 329,
McMaster University,
Hamilton, Ont.
L8S 4K1

Dear Mr. Hall:

Re: Draft Remedial Action Plan for Hamilton Harbour

I am pleased to advise that the Hamilton Region Conservation Authority is in general support of the 50 recommendations contained in the above draft document. More specifically, the Conservation Authority is prepared to play a role in the implementation of the following recommendations:

R3 - Assist in the development of a shoreline management strategy (already started)

- Subject to the availability of funding, may assist in the acquisition of shoreline property in order to improve public access and use

R5 To take the lead in co-ordinating efforts in reducing erosion from construction sites (already started)

R6 To take a lead role in the identification of soil erosion areas and, wherever feasible, encourage corrective action (already started)

R8 Assist in improving harbour water quality by seeking a reduction in the inflow of suspended solids

R9 Assist in the restoration of Cootes Paradise as a marsh habitat by sourcing suitable plant material (already started)

...........2

P.O. Box 7099, 838 Mineral Springs Road, Ancaster, Ontario L9G 3L3 (416) 525-2181 or 648-4427 Office Fax 648-4622 Shop Fax 525-2214

R31 The Conservation Authority already has dramatically reduced the use of pesticides on its holdings within the Hamilton Harbour watershed. This effort will continue

R34 To assist in disseminating information to the public regarding the Hamilton Harbour Restoration Project

R36 To assist in the preparation of guidelines for shoreline development, taking into account aesthetic and habitat functions of the shore zone

In addition to the above, the Authority would like to continue its membership on the BARK and/or BAIT committees to ensure that the recommendations contained in the report are implemented on a timely and efficient basis.

Yours sincerely,

B.W. Vanderbrug,
General Manager

BWV/sg

cc: Bruce Duncan

Canadian Environmental Law Association
L'Association canadienne du droit de l'environnement
517 College Street, Suite 401, Toronto, Ontario M6G 4A2
Telephone (416) 960-2284
Fax (416) 960-9392

January 1, 1980

The Bay Area Restoration Council
of Hamilton-Wentworth and Halton Region
Life Sciences Building, Room 329
McMaster University
Hamilton, Ontario
L8S 4K1

Dear BARC:

Re: Hamilton RAP Stage II Report

The Canadian Environmental Law Association (CELA) has participated in the Hamilton Remedial Action Plan (RAP) Stakeholder Group for five years. CELA has endeavoured during that time to see the RAP fullfill the goals of the Great Lakes Water Quality Agreement, particularly as it relates to the elimination of persistent toxic chemicals.

Everyone involved has laboured long and hard to have an ecosystem RAP and the work has been influential in broadening the scope of RAPs basin-wide. The RAP's work on the economics of clean-up has been significant as well. The RAP recommendations to increase water budgets by water conservation and full cost pricing, have been important.

However, we have difficulty in endorsing the Stage II Report as a complete plan because it is not an adequate action plan to achieve the goal of zero discharge of persistent toxics.

It is regrettable that the governments' regulatory reform has failed to keep pace with the RAP's needs, and their own Agreement commitments. This has meant that the RAP is merely remediating current exceedences of inadequate guidelines. By using the status quo as our clean-up standard, we cannot hope to eliminate the continuing disccharge of contaminants which are now impacting the fish and wildlife in the harbour. Most persistent toxics are not now adequately controlled. The Sixth IJC Biennial Report--released yesterday--calls upon the parties to establish time tables to sunset these toxics. We have not yet identified the many sources discharging to area sewers that will need to be controlled at source. We do not know if we can adequately remediate the huge contaminated sediment problem.

CELA is encouraged that the Stakeholders have firmly staked the public's claim to the Bay in their Plan by calling for an accessible waterfront with land use planning that is responsive to the RAP.

While we can see the value of creating new wildlife and fish habitats, we are concerned that the plans for new islands are premature. We may be inviting contaminant uptake and new health risks, by scheduling habitat recreation before achieving clean-up. It will be necessary to ensure that the creation of the islands is subject to an adequate environmental assessement to avoid the problems that have plagued the Windermere Basin "clean-up". We support the designation of those islands as a public trust to foster a public stewardship of them and to further the public's involvement in bringing back the Bay.

CELA is anxious to continue to work with BARC in the future to help see that governments and industry who are responsible for RAP implementation take action, and that the public's involvement in RAP implementation continues.

We would offer the help of our researcher capacity and resource library to BARC should they need information for their work. We have the best environmental collection in Ontario of technical, government, legal, and public interest documents.

The work CELA is doing on several regulatory reform initiatives will, we hope, result in better tools for public interest groups such as BARC to achieve clean-up. We are currently involved in a compaign to green the Planning Act through the Sewell Commission and in a committee that is drafting an Environmental Bill of Rights for Ontario. In our work as a member of the Great Lakes Action Plan Strategic Advisory Committee to the Federal Government, we will continue to press for adequate resources for RAP implementation, regulatory reforms and a strengthened Canada-Ontario Agreement (COA). In our work on the Board of Great Lakes United we will continue to work to strengthen the public influence in Great Lakes decision-making.

We look forward to continuing our work with BARC on the tough job of clean-up ahead.

Yours sincerely,

CANADIAN ENVIRONMENTAL LAW ASSOCIATION

Sarah Miller

Sarah Miller
Co-ordinator

Cathy Spoel

Cathy Spoel
President of the Board of Directors

APPENDIX G: CONSULTANTS REPORT ON THE PUBLIC CONSULTATION FOR THE DRAFT REMEDIAL ACTION PLAN

Hamilton Harbour

SUMMARY AND ANALYSIS OF PUBLIC RESPONSES TO THE HAMILTON HARBOUR REMEDIAL ACTION PLAN

PREPARED BY JAG COMMUNICATIONS INC.

MARCH 31, 1992.

Port de Hamilton

COMMUNICATIONS INC.

190 Catharine Street South Suite 200 Hamilton, Ont. L8N 2K3

This draft report has been prepared under a contract between JAG Communications Inc., and Environment Canada, on behalf of the Hamilton Harbour Remedial Action Plan (RAP).

Presented here is an analysis of responses gleaned from the public during the course of the consultative campaign on the Hamilton Harbour RAP.

The gathering of responses was not designed to produce a statistically valid sample of opinion, but to provide the public with an opportunity for feedback to RAP stakeholders.

The analysis presented here, therefore, reflects the views of those who were in some way motivated to fill out a response form. Their responses, while indicative of the views of some segment of the community, cannot necessarily be considered "representative" of the community as a whole.

Corporate Communications . . . Public Relations . . . Public Affairs . . . Research, Copywriting & Design

(416) 527-4747 Facsimile (416) 527-4331

PUBLIC RESPONSE FORM SURVEY ANALYSIS

- Total of **1,024** response forms circulated during public consultation period.

- Total of **150** response forms completed and returned for analysis, for a response rate of **14.6%** - upper mid-range for a non-demand public domain survey.

Breakdown:

LOCATION	# CIRCULATED	# RETURNED	RESPONSE RATE
Dundas & Ancaster Library	188	38	20.2 %
Hamilton Public Library:			
Central Branch	222	54	24.3 %
Other Branches	164	21	12.8 %
Open Houses	75	18	24.0 %
Centre Mall	250	1	00.4 %
Info Burlington & Libraries	125	0	00.0 %
Canada Centre for Inland Waters	N/A	19	N/A
TOTAL	**1,024**	**150**	**14.6 %**

- There were **13** response forms incorrectly filled out, therefore **137** were counted for analysis. Revised response rate is **13.4 %.**

- Toxic Contamination is Problem Area of primary concern to **50.8 %** of respondents.

- Access and Aesthetics was ranked as Problem Area of least priority by **45.2 %** of respondents.

- Water Quality was Problem Area of primary concern to **29.9 %** of respondents - ranking second as an area of primary concern.

- Fish & Wildlife Habitat was ranked as a top priority Problem Area by **10.9 %** of respondents, but as a third area of concern by **35.5 %** of respondents. A large group is concerned about this issue, but considers it of secondary, rather than primary importance, in relation to such problem areas as Toxic Contamination and Water Quality.

- The same distribution pattern for ranking Problem Areas of concern is common to both those who are members of an environmental group with an interest in the Hamilton Harbour RAP and those who are not members. (See graphs.)

- Bacterial Contamination was ranked by only **2** respondents **(1.5 %)** as a Problem Area of primary concern. The majority, **31.4 %**, ranked this issue as their fifth area of concern among the six problem areas presented.

- A majority of respondents, **73 %**, indicated the Remedial Action Plan meets their needs. (See Figure 3.) Most respondents also provided additional comments. The majority indicated support for actions which will improve Hamilton Harbour, and a desire to see remedial actions implemented in the foreseeable future. Many respondents also asked for ongoing information and education about Hamilton Harbour and RAP.

Conclusions:

Toxic Contamination appears to be the problem area of major concern among respondents, with 50.3 % indicating it is the problem area of highest priority. Supplementary comments volunteered by respondents on response forms support the numerical data.

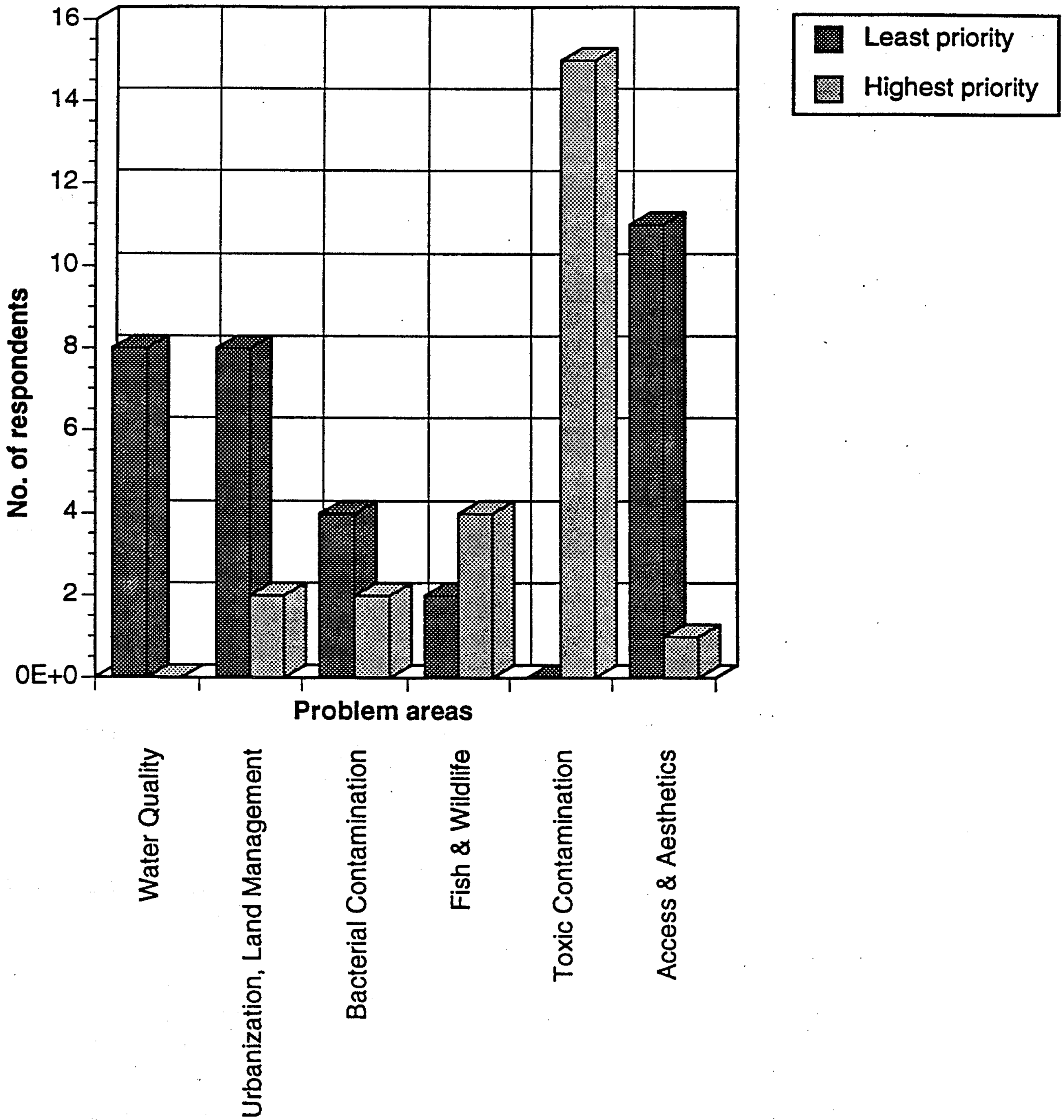
Water Quality is the second problem area with a significant weighting. Though only 22.6 % of respondents rank Water Quality as a problem area of prime importance, cumulatively 73.7 % of respondents rank Water Quality as either first, second or third in priority.

Therefore, even though there is no one significant group of respondents ranking Water Quality as a priority problem area, it should be noted that cumulatively a majority of respondents indicate Water Quality is, comparatively, a priority area of concern.

In comparison, a cumulative total of 66.4 % of respondents indicate Fish and Wildlife Habitat is their first, second or third priority, while 85.4 % rank Toxic Contamination this way. Conversely, 16.7 % of respondents rank Access & Access as either first, second or third priority.

Figure 2

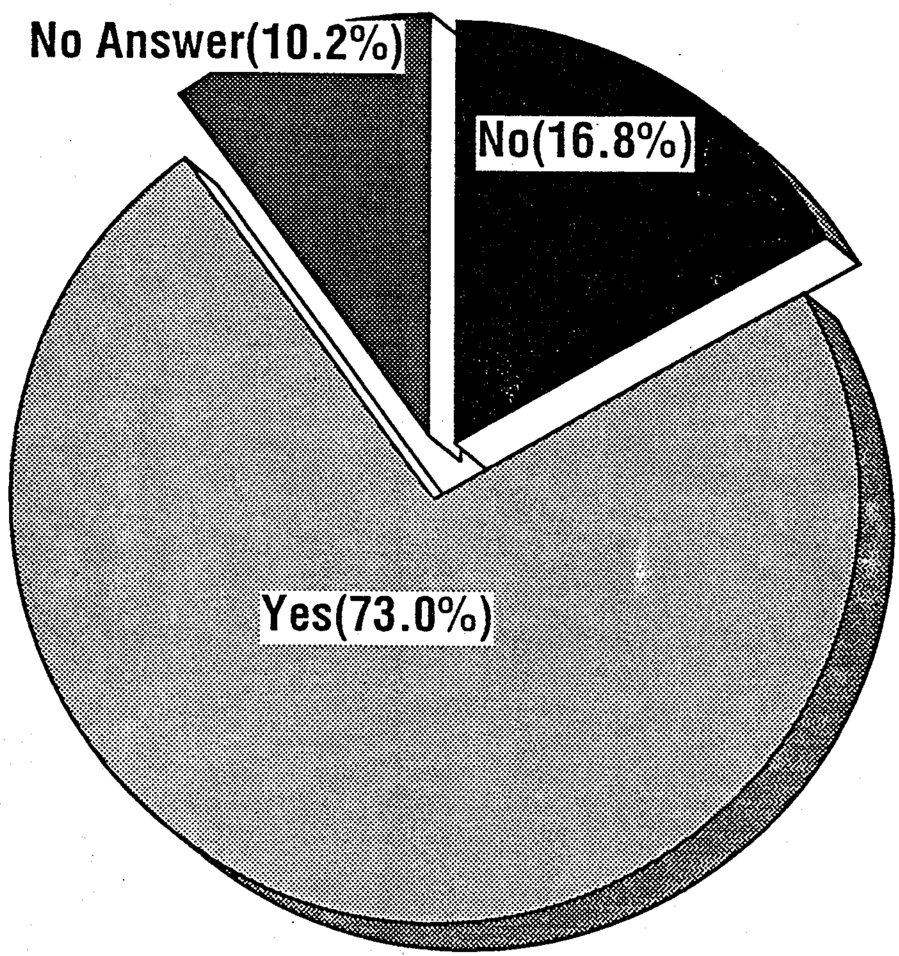
Problem areas identified as highest and least priority – members of environmental groups* with interest in RAP



* This group represents 21.1 percent of all respondents

Figure 3

Does this Remedial Action Plan respond adequately to your needs or concerns about Hamilton Harbour?



Conclusions, cont'd:

The pattern which emerges from the data available also indicates that a significant number of respondents (43 %) rank remedial action in the Fish and Wildlife Habitat problem area as either second or third in importance.

Bacterial contamination is ranked either fourth, fifth or sixth in importance by a cumulative total of 63.5 % of respondents. A similar pattern exists for the Urbanization and Land Management problem area.

It appears, therefore, that there is concern among respondents about all of these issues, even though no single group of respondents ranks just one of these areas as a top priority.

A significant number of respondents, (45.2%), rank Access and Aesthetics as the problem area of least priority.

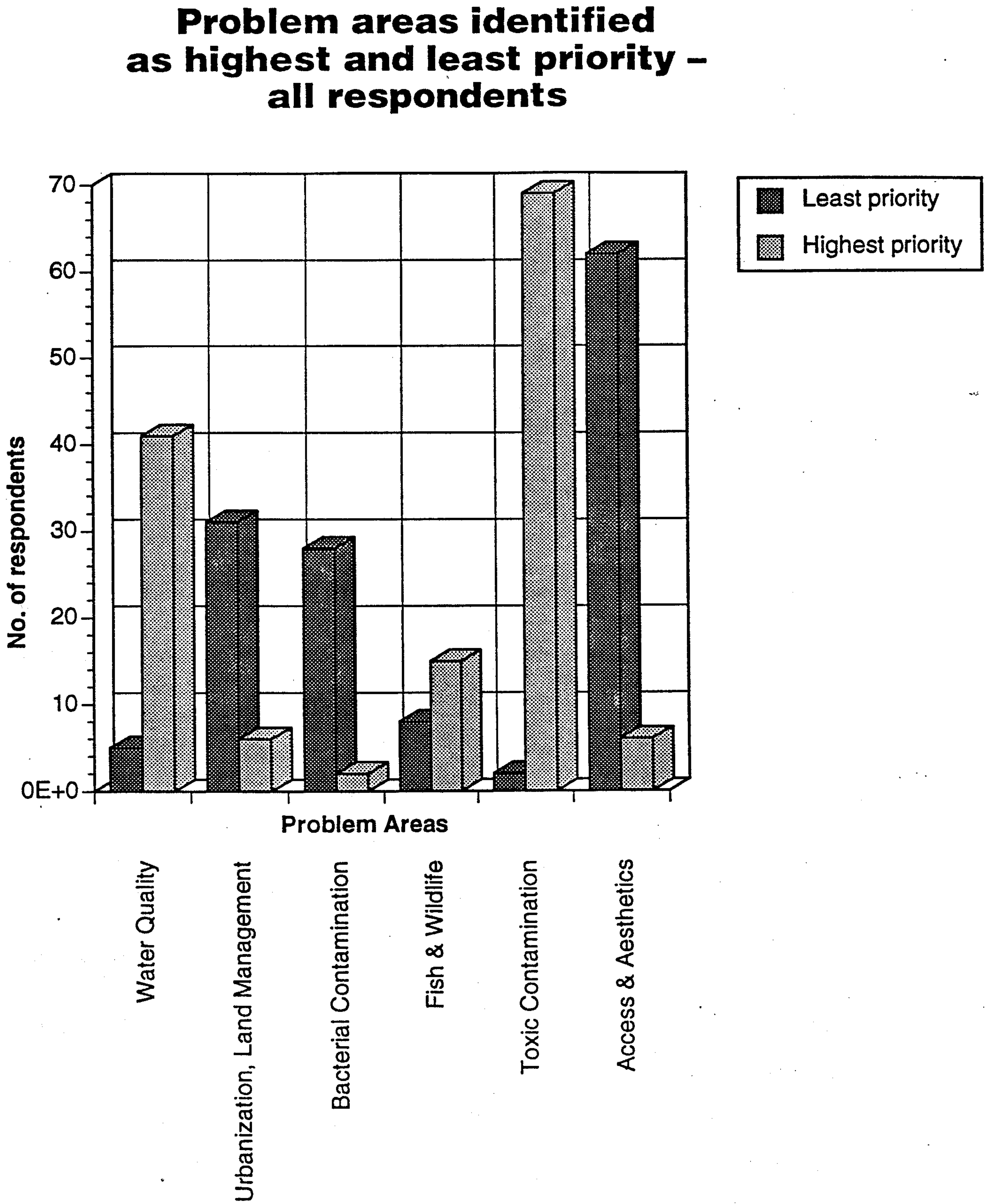
Of the respondents, 73% indicate support for the RAP proposals (Figure 3), as they are presented now. On the positive side, there appears to be a willingness among the respondents to bear the implementation costs of the remedial actions.

Among the 16.8 % of respondents who indicate the RAP recommendations do not presently meet their needs, there is no outright rejection for the proposals. Rather, the supplementary comments tend to be of the "I like it, but.." genre, prompting the negative response.

Over all, the supplementary comments offered by respondents indicate support for the Remedial Action Plan - and a willingness to pay the price of implementation. The other common element is an awareness of time: action is called for now, and many express the fear that the RAP recommendations will not be acted upon.

Supplementary comments also express a desire for ongoing education and information about RAP and Hamilton Harbour, which suggests there is a need to establish an accessible vehicle for continued communication between RAP and the general public.

Figure 1


Problem areas identified
as highest and least priority –
all respondents
70
60
50
40
30
20
10
0E+0
No. of respondents
Least priority
Highest priority
Problem Areas
Water Quality
Urbanization, Land Management
Bacterial Contamination
Fish & Wildlife
Toxic Contamination
Access & Aesthetics

Sampling of Respondents' Comments:

From those who indicated the RAP responds adequately to their needs or concerns:

"It's a good start. Please hurry."
Dundas

"I am glad to see a plan, and I really hope it goes a lot further. If I can help, give me a call."
Gary Michor, Alberton

"STOP TALKING. Just get on with it!"
Anonymous

"...The part I am not clear on is when and how do the recommendations get implemented. Governments only react to organized public pressure, which seems to be lacking in this situation. The environmental issues have been studied to death and all the data are in. It is time for some action..."
Lynden

"I think that the things (problem areas and recommendations) listed would do much for improvement, however there is no indication of how this will be accomplished and not much on timelines. I would like to know more about this aspect of the plan...I would like to be involved in any way possible...Please contact me..."
Hamilton

"I am concerned that polluters will not be forced to either clean up or stop their pollution if economic concerns of their businesses are cited. Will this be more toothless legislation?"
Dundas

"It is very ambitious; I hope you have a critical path. Managing pollution, and use and improving the water go hand-in-hand."
Hamilton

"There should be a ban on the practice of spraying every lawn in the city for weeds. The city is negligent in keeping streets clean; all this dirt, leaves, etc., washes down in the sewers. Far too much salt is dumped on city streets. I agree with most (recommendations), but there should be fines for polluting."
Anonymous

"Further increase public awareness of what RAP is, and what it can do for Hamilton."
Hamilton

"Use the money set aside for Red Hill Creek Expressway, and put it towards cleaning up Hamilton Harbour...In order to succeed you will need to do massive public education sessions to guarantee support..."
Anonymous

"is a Harbour Plan map available to the public, or teachers? Any education material available for schools?"
Hamilton

Environmental concerns are taking a back seat to the economic situation (bleak). Will there be adequate public response and support for a real 'clean up' and not just small isolated efforts some people refer to as window dressing?"
Hamilton

"Given that funding could be difficult to obtain, especially the municipal level, I hope that the stakeholders will consider a public fundraising appeal at some point -- perhaps through the Bay Area Restoration Council...I believe this plan is strong enough to generate a positive response in terms of public donations. I would definitely contribute."
Hamilton

From those who indicated the RAP does not respond adequately to their needs or concerns:

"Too much 'long term'. Let's start somewhere, soon -- please. How about Cootes Paradise? I would like to participate more in the process...Indeed, I would not be participating in this public response process had I not read about it in the newspaper. More public environmental education is needed!"
Hamilton

"Technically it does (meet my needs or concerns) -- but the time frame is **too long!**"
Anonymous

"...The further discharge of toxins...is well controlled by current law and should be strongly enforced. Let's prioritize our activities to give the most results for the least tax dollars. Less scare tactics and dubious science would go a long way to restoring voter confidence."
R.S. Innes, Hamilton

"WHEN -- NOT HOW MUCH. I'll pay -- let's get it done! Let's get a timetable for some physical action on the cleanup."
Hamilton

"I would like to do it, but I think I don't have the background (technical) to support my ideas. I think the priorities (are) ... all interconnected...starting with the source of toxics (industrial) is essential."
Hamilton

Concluding Statements:

The information contained in this report will be considered by the Hamilton Harbour RAP stakeholders and where deemed appropriate, included in the preparation of the final document.

Questions and issues that have been raised by respondents will be addressed, and those who requested the opportunity to be appraised of future RAP activities will receive such information via future mailings.

The Hamilton Harbour RAP stakeholders appreciate the effort and interest demonstrated by those who responded to the recommendations.

Thank you.

APPENDIX H: NAMES AND AFFILIATIONS OF THE INDIVIDUALS OF THE STAKEHOLDERS GROUP FOR THE HAMILTON HARBOUR REMEDIAL ACTION PLAN AND THE TECHNICAL TEAM.

Hamilton Harbour RAP Stakeholders Group

STAKEHOLDER*	AFFILIATION
Adamczyk, Adam	Steel Workers Area Office
Aikman, John	Council of Ontario Outdoor Educators
Anderson, June	West Burlington Citizens Group
Axon, Brenda (alt) Edmonson, Bob	Halton Region Conservation Authority
Brookfield, Jeff	Hamilton Harbour Commissioners
Cooke, Joe	Burlington Chamber of Commerce
Dowie, Don	Hamilton Beach Preservation Committee
Drewitt, Kathy	Hamilton and District Chamber of Commerce
Eisler, Hugh	Stelco Inc.
Fraser, Don	United Steel Workers of America, Local 1005
Gartner, John	Citizen at Large
Greenfield, Murray (alt) McGuire, Tom	Dofasco Inc.
Groves, David	Burlington Sailing and Boating Club
Hall, Ken	Executive Director, Bay Area Restoration Council (BARC)
Halliday, Jim	Director of Plant Operations, Regional Municipality of Hamilton-Wentworth
Hayes-Potter, Pat	NETforce
Herring, Pat	Regional Municipality of Halton
Joncas, Harry (alt) Leeson, Dennis	Golden Horseshoe Outdoors Club Inc.
Laforme, Mel (alt) Morreale, Mark	Leander Boat Club
Lang, Brian	Ontario Ministry of Agriculture and Food
Llewellyn, Simon (alt) Tseng, Tom	Environmental Protection - Ontario Region, Environment Canada
Luton, Bill (alt) Aitken, Bill	Hamilton Naturalists' Club
McFadden, Jack	Ministry of Natural Resources

*** Current membership as of March 1992**

STAKEHOLDER*	AFFILIATION
McLeod, Jeff	Burlington Golf and Country Club
Miller, Sarah	Canadian Environmental Law Association
Minns, Ken	Fisheries and Oceans Canada
Mitchell, Bill	Macassa Boat Club
Mulkewich, Walter (alt) Deloyde, Leo	Mayor, City of Burlington
Nichols, Jeff	City of Hamilton, Board of Education
Pollution Probe	
Redish, Anne	Representative, Town of Dundas
Rice, Peter (alt) Simser, Len	Royal Botanical Gardens
Simmons, Gil	Central Area Plan Implementation Committee, City of Hamilton
Smee, Ed	Conservers Society of Hamilton
Sproule-Jones, Mark	Professor of Urban Studies, McMaster University
Thompson, R.	Hamilton Yacht Club
Vallentyne, Jack	Citizen at Large
Vanderbrug, Ben	Hamilton Region Conservation Authority
Walker, Richard	Ontario Federation of Agriculture
Webb, Madelyn	Environment Canada, Great Lakes Tomorrow
Wong, Hardy (alt) Stewart, Ray	Director, West Central Region, OME

Murphy, K.L. (alt) Brown, Hugh	'Ex Officio' member for Hamilton-Wentworth Regional Chairman's Committee on Environmental Affairs

*** Current membership as of March 1992**

HAMILTON HARBOUR REMEDIAL ACTION PLAN TEAM	
Boyd, Duncan	Ontario Ministry of the Environment
Cairns, Vic	Canada Department of Fisheries and Oceans
Lang, Howard	Ontario Ministry of Agriculture and Food
Murphy, Tom	Environment Canada
Painter, Scott	Environment Canada
Rodgers, Keith (Coordinator)	Environment Canada
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APPENDIX I: A SURVEILLANCE AND MONITORING PROGRAM FOR THE HAMILTON HARBOUR REMEDIAL ACTION PLAN

A SURVEILLANCE AND MONITORING PROGRAM FOR THE HAMILTON HARBOUR REMEDIAL ACTION PLAN

I Introduction

This appendix describes the recommended monitoring plan requirements for the Hamilton Harbour Remedial Action Plan including a "routine" program (i.e. repeated, systematic observations), followed by a summary of "non-routine" research studies and modelling efforts which need to be undertaken.

This plan was based on discussions with technical personnel at the various agencies involved in environmental programs in Hamilton Harbour, and discussions at a follow-up workshop. A series of summary Project Descriptions has been included, and these are referred to throughout the discussion.

For the purposes of the following discussion it will be helpful to define three types of monitoring: ***compliance*** monitoring, ***effects*** monitoring, and ***surveillance*** monitoring. Arbitrary distinctions can be made between these types of monitoring in terms of their objectives, recognizing that we do so solely for convenience, not because they are exclusive in any absolute sense.

I.1 Compliance Monitoring

Compliance monitoring usually refers to the assessment of point source discharges to see that the conditions of a Certificate of Approval or Control Order are being met for effluent chemical concentrations and loadings. Traditionally, compliance monitoring has been associated with industrial and municipal discharges as representing the greatest, and most readily regulated, sources of contaminants. Improved estimates of other, non-point sources of contaminants have shown the need to control such sources as urban and agricultural run-off; a need that will become of increased relative significance as point sources approach the goal of "zero discharge".

Although there are certain aspects of compliance associated with some biological assessments (e.g. effluent toxicity testing) or receiving water investigations (e.g. mixing zone definition, beach monitoring for public health), it may also be convenient to consider these as effects monitoring.

I.2 Effects Monitoring

Effects monitoring attempts to establish the cause-effect link between point source discharges and environmental effects in the receiving water. In many cases this will be closely tied to water quality modelling but it may also include a whole range of receiving water assessments involving water, sediment, or biological tissue chemistry, *in situ* bioassays, and laboratory bioassays.

I.3 Surveillance Monitoring

Surveillance monitoring encompasses those activities which seek to assess the integrated impacts of multiple sources and their corresponding impacts resulting from a series of combined cause-effect links (as determined through effects monitoring). This category goes beyond toxicity and chemical analysis of water, sediment and tissue, and includes observations on such things as habitat and wildlife populations. The chief element of this type of monitoring is that the factor being observed is generally not directly linked to any single, specific source of pollution.

All types of monitoring can be used to develop an understanding of the aquatic system sufficient to allow us to define problems, predict the effectiveness of proposed solutions, and track the effectiveness of the selected solutions. All monitoring can be linked to problem assessment and abatement at some level although the degree of certainty associated with cause-effect hypotheses may vary widely. In general, compliance oriented monitoring will have the highest degree of cause-effect certainty and surveillance monitoring will have the lowest. Surveillance monitoring, though, most closely observes those environmental indicators (or goals) for which protection is being sought in the first place. A properly planned program must contain a balance of all three types of monitoring.

II Routine Monitoring in Hamilton Harbour

Table I-1 summarizes the various components of the recommended monitoring plan for Hamilton Harbour which includes a balance of compliance, effects, and surveillance monitoring. A brief discussion of these monitoring activities appears below; detailed project descriptions will be available from the project leaders at the various agencies involved.

II.1 Compliance Monitoring

Compliance monitoring will tend to exhibit the most direct and rapid responses to abatement activity. As a result, the most straightforward way to gauge the effectiveness of measures introduced to reduce concentrations of contaminants in municipal or industrial effluent will be to sample the final effluent directly from these sources. For this reason it makes sense to focus the highest frequency of routine sampling at this level.

In the case of Hamilton Harbour, compliance monitoring will be predominantly driven by the Ontario Ministry of the Environment (OMOE) Municipal Industrial Strategy for Abatement (MISA) program which is currently generating effluent limits regulations for the iron and steel industries based on the "best available technology economically achievable" (BATEA). Monitoring aspects of this program have been, and will continue to be, largely implemented by the industries themselves (particularly STELCO and DOFASCO) in conjunction with MOE, the agency responsible for administering the MISA program. Now that sampling results from the MISA Monitoring Regulation for the iron and steel sector are available, it

TABLE I-1: Summary of potential benefits of implementing the Hamilton Harbour RAP[1].

	Increase in Annual Use Days	Use Value per Year	Non-Use Value per Year	Person-Years of Employment	Income Generated per Year
Recreation Boating	78,000 plus	Refer Note [1]	Refer Note [1]	1,300	\$17.8M[4] (\$14M in '86)
Recreation Fishing	5,000 to 81,000	\$.16M to \$2.2M (\$.13M - \$1.8M in '87)	Refer Note [1]	4	\$.14M (\$.11M in '87)
Swimming	840,000 to 1,100,000	\$6.7M to \$24.1 M[2] (\$5.5M in '87 to \$6.6M in '89)	\$14.9M to \$24.1M[2] (\$13.1M in '89 to \$19.6 in '87)	70	\$2.5M (\$2M in '87)
Economic Impact during capital construction				5,500 to 9,100 direct plus 11,000 to 18,300 indirect	\$450M to \$750M
Property Values	May result in positive impact on land values in area, although difficult to quantify.				
Waterfront Development and Tourism	Linked with the successful implementation of over \$26M[3] in planned waterfront activity in the AOC.				
Infrastructure	Water conservation can significantly reduce need for or delay expansion of infrastructure and associated costs.				

Notes:
(1) This Table includes quantification done under previous study. Monetary estimates adjusted to 1992 dollars. Blank cells denote lack of study, not lack of value. Use and non-use estimates are not additive.
(2) Includes achieving better fishing conditions and aesthetics.
(3) The estimated benefits of recreational activities are dependent on increased access, facilities, etc.
(4) Additional facilities have been provided since this study. Therefore, some of this benefit may have been captured already.

will be possible to develop a more specific compliance monitoring plan. However, effluent monitoring for suspended solids, trace metals, and PAHs should be included, as should some form of effluent toxicity testing.

The sewage treatment plants (STPs) will also be regulated through MISA although the current emphasis is on the development and implementation of sewer use regulations, rather than limits regulations for the treated effluent. As a minimum, though, regular effluent monitoring for suspended solids, phosphorus, nitrogen, and BOD should be undertaken.

Although current estimates of contaminant loadings associated with non-point sources need to be improved, there is no doubt that a significant proportion of nutrients, trace metals, and trace organics are associated with sources other than municipal and industrial discharges. For this reason, a new compliance monitoring program is recommended for evaluating urban run-off control (corresponding regulatory limits will need to be developed). This program would logically include a storm and combined sewer overflow program with involvement by MOE and municipalities. It would also include elements best undertaken by the municipalities such as visits to construction sites to evaluate contaminant loadings associated with run-off.

II.2 Effects Monitoring

Effects monitoring will track the consequences of improvements in effluent quality (both for nutrients, and trace metals and organics) on receiving water quality, sediment quality, biological tissue chemistry, and sediment toxicity. This will be less directly attributable to specific abatement measures at specific locations than compliance monitoring and it will be necessary to tailor the frequency and distribution of sampling to the spatial and temporal variability of specific contaminants in various types of samples. For example, receiving water sampling related to eutrophication will require a relatively high frequency sampling protocol focusing on water, while effective monitoring for receiving water improvements related to reductions of trace metals and organics loadings will need to emphasize a lower frequency component examining sediment, biological tissue, and toxicity (rather than water quality). Effects monitoring will not be warranted at the same frequency as compliance monitoring.

II.3 Tributary Water Quality Sampling

The stream/watershed monitoring programs currently performed by MOE and the Conservation Authorities should be modified so that they are flow proportional to yield a more accurate estimate of concentrations and loadings. It is also recommended that the monitoring be conducted further upstream in the watershed so that problem areas may be better identified. The sampling frequency should be increased from monthly to weekly in order to improve estimates of phosphorus and suspended solids loadings.

Although suspended sediment sampling at tributaries (as well as at municipal discharges and industrial discharges) will be undertaken primarily for the detection of trace metals and organics, analysis for eutrophication-related parameters (nitrogen, phosphorus, BOD_5) should also be included. This suspended sediment sampling should be repeated every five years as a means of improving estimates of aqueous and particulate loadings to the Harbour.

II.4 In-Harbour Water Quality Sampling

The Ontario Ministry of the Environment (MOE) regular water quality testing by West Central Region will form the core of in-harbour effects monitoring. This program currently incorporates water quality sampling at three stations (5 depths) every six weeks for nutrients, metals, and several physical parameters. It is recommended that this program be enhanced by:

(i) sampling closer to outfalls (subject to the definitions of the "mixing zones" between outfalls and harbour waters);

(ii) adding pesticides and chlorinated organics, and PAHs to the suite of chemical tests currently being requested on an occasional basis;

(iii) increasing the number of sites in the southeast portion of the Harbour and in Cootes Paradise for early spring ammonia sampling; and

(iv) increasing the frequency of phosphorus, water clarity, and algae (biomass and chlorophyll) sampling from once every six weeks to once every two weeks at the three regular stations in the central portion of the Harbour.

The MOE Water Resources Branch will also implement a less frequent program at 12 sites in the Harbour, with sampling at two depths. Samples will be analyzed for over 100 parameters including nutrients, metals, organochlorines, chlorobenzenes, and PAHs. Sampling was first carried out in 1987, and should be repeated at five year intervals.

Several other smaller scale programs will complement these basic programs: the Watershed Network Monitoring program implemented by MOE should continue at two or three sites each month during the open water season; the Water Quality Branch of the federal Department of the Environment occasionally undertakes water quality analyses; the ongoing suspended sediment assessment program at the National Water Research Institute also investigates levels of trace metals, organics and toxicity at three sites (two depths), integrated over 3-4 weeks. Although these three programs will not be relied upon to supply long-term, regular data, over the short-term they will provide a strong baseline data set upon which future monitoring protocols may be designed.

II.5 In-Harbour Sediment Quality Sampling

Sediment quality monitoring should be implemented by MOE as a continuation of the historical sediment quality assessment program. A minimum of two sampling sites in depositional zones should be sampled throughout the survey season every three years (in conjunction with sediment bioassays) as a means of tracking the integrated effects of source control and other sediment-related remedial actions. In addition, sediment chemistry data and benthic tissue data (along with enumeration data as part of surveillance monitoring) should be obtained from a 30 station grid every five years. A periodic reassessment of trace metals and organics loadings involving sampling of suspended sediment and whole water (or effluent) should also be undertaken as a continuation of the existing MOE centrifuge sampling program. Other sediment chemistry analyses (conducted by NWRI) on an occasional basis will complement this program.

Bioassessment of sediment quality should include benthic invertebrate toxicity tests (e.g., chironomid and mayfly tests) and is expected to continue as part of the work already begun by the Department of Fisheries and Oceans, National Water Research Institute and the Ontario Ministry of the Environment. The recommended protocol for regular sampling includes two mid-Harbour sites, six times per year (i.e. two sampling occasions during spring, summer, and fall), repeated every three years.

II.6 Tissue Sampling

Analysis of biological tissue for certain trace metals and persistent, bioaccumulative organic compounds will need to include benthic macroinvertebrates, juvenile fish (restricted range, bottom feeding), and top predator fish. Benthic tissue collection and analysis will be undertaken as part of the periodic large-grid sediment surveys described above. The existing MOE spottail shiner sampling program, which collects juvenile fish from a minimum of three locations in the Harbour at approximately two year intervals, will be continued. Top predator fish collection and analysis is currently undertaken by the Ontario Ministry of Natural Resources (MNR) and MOE in support of the sport fish consumption advisory program. This program collects new samples at approximately five year intervals and will be continued. Additional sampling has also been undertaken by the federal Department of Fisheries and Oceans (DFO), and any future surveys will serve to augment the MOE/MNR data base.

II.7 Surveillance Monitoring

Surveillance monitoring will examine the overall picture on a less frequent basis than effects monitoring. Here, the focus will be on examining whether the abatement driven improvements in water and sediment quality are being translated into improved habitat, the presence of healthy populations of benthic invertebrates, plankton, fish, birds, and other wildlife, and the restoration of other "beneficial uses".

A periodic assessment of trends in the relative abundance and diversity of desirable species of benthic macroinvertebrates, zooplankton and phytoplankton, and fish will form the core of surveillance monitoring for the aquatic compartment of the ecosystem. Similar observations for birds and other terrestrial wildlife will cover the combined land-water system.

II.8 Benthos

Benthic macroinvertebrates form an important component of the ecosystem and can provide important information regarding the long-term ecosystem response to range abatement measures. Although the most direct initial response is anticipated to be related to improvements in mid-summer concentrations of dissolved oxygen at the bottom of the Harbour, the gradual improvement in sediment quality associated with reduced loadings of trace metals and organics is also expected to result in improved benthic populations. This will be particularly true in those areas currently designated as "hot spots" where contaminant-related toxicity has been demonstrated.

Assessment of benthic community structure should be undertaken in combination with the sediment surveys described above. Two sites should be sampled, six times (twice for each of the open water seasons) from March to November every three years. Also, longer-term monitoring of the benthic community should be completed once every five years at the 30 station sediment grid. Present information on the normal variability of the community will yield a baseline database upon which to compare the long-term results. The principal responsibility for this activity will lie with MOE, but cooperation with NWRI and DFO is anticipated.

II.9 Fisheries

The presence in the Harbour of a well balanced population of contaminant and disease free fish is an important indicator of the ultimate effectiveness of many remedial actions (as the result of improved water and sediment quality, water clarity, habitat quality, etc.). It is also one of the principal beneficial use goals outlined by the RAP team and Stakeholders. Monitoring programs for fisheries health, community structure, and habitat are, therefore, of central importance.

The evaluation of remedial measures for fisheries health will be implemented by the Department of Fisheries and Oceans (DFO), based on the modification of an existing program. A survey of 200 fish from two species (white sucker and brown bullhead) should be conducted to determine the frequency and causes of tumours and papillomas (these surveys must be matched with comparable programs elsewhere in Lake Ontario and the other Great Lakes in order to draw reasonable comparisons). This intensive sampling should be done once every five years in mid-April and July at two sites in the Harbour. Results from initial collections should be used to enhance the future design of the program.

An integral part of any aquatic ecosystem health assessment must include an assessment of fisheries community structure. In the case of Hamilton Harbour, this is especially important, since the promotion of a self-sustaining warmwater fishery is one of the Hamilton Harbour RAP's major goals. Species richness and biomass will be estimated by nearshore electrofishing (i.e. the littoral zone) in 100-metre transects along the north and west shores of the Bay, as well as Cootes Paradise. The sampling will be done seasonally (i.e. in May, August, and November). Sampling for this program should be undertaken in the same years as the sampling program to determine fish health (as outlined above). This program will also be implemented by DFO as an enhancement of an existing program.

An additional component of this program should include an inventory of marsh habitat and submergent vegetation. This would incorporate such factors as the abundance of submergent aquatic plants and the extent of cover. As with the fish community survey, initial sampling should be intensive, with results of these initial data defining the temporal scale of future surveys in more detail. Both NWRI and DFO have related, ongoing projects which will complement this investigation (i.e. NWRI: water clarity, fisheries habitat, DFO: wetlands and littoral habitats for fisheries recruitment).

II.10 Wildlife Management

Since the effects of contaminants in the aquatic environment on human health are extremely difficult to quantify, tissue levels of contaminants in terrestrial birds and other wildlife are important as surrogates in the evaluation of risks to human health. An existing program addresses tissue levels of contaminants in birds, mink, and turtle eggs. This could be enhanced to look more intensively at mink and other resident mammals.

The present programs being carried out by the Canadian Wildlife Service (CWS) of DOE, and MNR, should continue at the two sites where collections are presently being made. The frequency of monitoring should be increased to once every year (rather than once every two or three years), the number of contaminants being tested for should also be increased. The Canadian Wildlife Service will take the lead role in implementing this program.

Several programs (Canadian Wildlife Service, Royal Botanical Gardens, and Hamilton Naturalists' Club) currently survey wildlife populations. Taken together, they comprise a wildlife community structure database which can be utilised to monitor the effects of remedial actions on wildlife populations which use the Harbour. In order to enhance the use of this information it is recommended that CWS take a lead role in this program and that intensive surveys be conducted every two years at three sites around the Harbour (including Cootes Paradise). The program should focus on control of the ring-billed gull population, and fostering of species which have shown population reductions in recent years (i.e. increases in the abundance and habitat of rare or endangered species in the area such as the Prothonary Warbler). The best recommendation is for an integration of a wildlife habitat survey implemented concurrently with the current surveys of wildlife populations.

III Research and Development

In addition to the monitoring activities described above, there are a number of areas which require additional research and development before they can be incorporated into a routine sampling program. These efforts will generally involve cooperation between various government agencies, universities, and consultants. Given their research mandate, it is probable that NWRI will play a lead role in this effort. Research and development activities can be grouped under the headings: model development, sediment, plankton toxicity, atmospheric loadings, and enhanced treatment at industrial and municipal sources.

III.1 Model Development

Current phosphorus and ammonia loading targets for the Harbour were developed with a dissolved oxygen (DO) model calibrated using data from the late 1970s up until the mid 1980s. This model also required certain assumptions (e.g. the Harbour is a "well mixed reactor") which have either not been verified or which are known to be false. There is a high priority need to update the previous model to take advantage of recent nutrient loading and receiving water data, and to accommodate hydrodynamic variability across the Harbour. It is recommended that the RAP Team and Stakeholders develop an improved DO model which incorporates recent data (reflecting reductions in nutrient loadings), and allows for variations in the Harbour hydrodynamics. This exercise should be led by staff from NWRI and MOE.

In addition to improved DO modelling, there is a need to develop an enhanced suspended sediment mass balance model for the Harbour. Many trace metals and organics will tend to be closely associated with suspended sediment particles and in order to forecast the response of Harbour sediment quality to future reductions in sediment-related contaminant loadings, it will be necessary to develop an enhanced suspended sediment budget which accounts for the proportion of particulate loadings to the Harbour which are retained within the Harbour, and the proportion which are delivered to Lake Ontario (this will also be of benefit to the Lakewide Management Plan for Lake Ontario). This mass balance may also need to be enhanced to account for spatial variation in the quality and quantity of suspended sediment loadings, and sediment transport factors (such as wave action and ship traffic).

Suspended sediment data collected by MOE (centrifuging at major point sources) and NWRI (sediment traps at three locations throughout the Harbour) are available for 1988 and 1990 and should be pooled as part of the model development process by these agencies.

III.2 Sediment

Research into other aspects of the contaminated sediment problem is also required. One important question which needs to be resolved concerns the toxicity of future sediment following deposition of current suspended sediment loads. Although existing information suggests that future sediment quality will improve if current sediment load patterns are maintained, these sources may still result in future sediment which fails to meet the draft Provincial Sediment Quality Guidelines. The need for additional point source control by municipal or industrial dischargers will be best supported by a demonstration of the potential biological effects of the suspended solids in their final effluent. Undertaking a bioassay on sediment created by concentrating suspended sediment from an effluent stream cannot be considered a routine assessment procedure (i.e. it is currently a purely experimental approach), but if it can be shown that sediment from a source elicits an acceptable toxic response, then point source control in addition to that associated with **water** quality will not be required. Considering the experimental nature of this procedure it is recommended that a limited initial assessment be undertaken to develop and evaluate methods for the collection of suspended sediment and the subsequent use of the material in a sediment bioassay. This work should be undertaken cooperatively by MOE and NWRI.

Another requirement with respect to contaminated sediment is the development and application of biological "clean-up" criteria for highly contaminated sediment (e.g. the coal tar contaminated zone west of the Stelco property), and "target" criteria for marginally contaminated areas. Much of the Harbour is unlikely to meet the "Lowest Effect Levels" stipulated in the draft Provincial Sediment Quality Guidelines in the foreseeable future, however, sediment bioassays have shown that it is possible to exceed these criteria without observable toxic effects on benthic invertebrates. A well-supported, generally accepted biological standard which can be applied in conjunction with bulk sediment chemistry is needed to assist the RAP in setting realistic, measurable targets for sediment-related remedial actions. Ongoing research and guideline development at NWRI and MOE should be coordinated, using the RAP as a case study.

Apart from the coal tar contaminated zone (which is contaminated to the point where the preferred option must involve removal and treatment) there are large areas where it is probable that point source control, by itself, will not bring about sufficient improvement in sediment quality within an acceptable time frame. Although the extent of such areas has not yet been determined (see the previous discussion on modelling requirements), there is a need to develop remedial actions that fall between the extremes of "point source control" and "removal and disposal". Pilot scale experimentation with *in situ* treatment methodologies should proceed in anticipation of the need for their future application. Bench scale work has been in progress at NWRI, and this should be expanded in cooperation with the Wastewater Technology Centre (WTC) and MOE. These same agencies should also support the development of treatment and disposal methods for coal tar and metal contaminated sediment.

III.3 Plankton Toxicity

There are a number of research or monitoring programs which have addressed the effects of contaminants on benthic invertebrates, but few have addressed similar effects on planktonic organisms. It has been suggested that using planktonic organisms as biomonitors (as has been done with benthic organisms to detect long-term effects on the aquatic ecosystem) would yield beneficial results for the detection of short-term effects such as spills or effluent testing. Some recent work with phytoplankton assays (chronic and acute exposures) has been investigated, but this toxicity work should be pursued by the appropriate research staff at MOE, NWRI, and DFO, along with the further development of species abundance and diversity targets as indicators of overall ecosystem health.

III.4 Atmospheric Loadings

Atmospheric loadings data, both from local sources and on a synoptic scale, are extremely limited. While their relative significance for eutrophication and contaminated sediment issues is probably not great, they may well be of considerable significance as far as issues such as fish consumption advisories for PCBs. The lack of information concerning atmospheric loadings relative to other non-point sources increases the uncertainty associated with the predicted benefits of various remedial options and should be rectified with the assistance of the appropriate groups within MOE and Environment Canada. Modification of existing local air quality monitoring programs could provide additional information on local sources, while the inclusion of a regional monitoring station in the Hamilton area as part of a synoptic program would yield useful large-scale information.

III.5 Enhanced Effluent Treatment

Further reductions in nutrient and suspended solids (and associated contaminants) loadings from municipal and industrial point sources constitute the primary remedial actions needed to bring about further water and sediment quality improvements in the Harbour. Hence, the development of improved effluent treatment technologies for sewage treatment plants, and iron and steel industry operations remains as a high priority. The goal is to achieve affordable improvements in treatment efficiency so that loading targets can be met and maintained.

APPENDIX J:

BY-LAW
BAY AREA RESTORATION COUNCIL
of
HAMILTON-WENTWORTH AND HALTON REGIONS
Inc

adopted by the board of directors
July 29, 1991

HUGH EISLER
KENNETH HALL
ANNE REDISH
GILLIAN SIMMONS
MARK SPROULE-JONES

BY-LAW NUMBER 1

BE IT ENACTED as a by-law of the Corporation as follows:

ARTICLE ONE
Interpretation

1.01 Definitions. - In this by-law and all other by-laws and special resolutions of the Corporation, unless the context otherwise requires:

"Act" means the Corporations Act of Ontario, and any Act that may be substituted therefor, as from time to time amended;

"board" means the board of directors of the Corporation;

"by-laws" means this by-law and all other by-laws of the Corporation from time to time in force and effect;

"Corporation" means the corporation incorporated as a corporation without share capital under the Act by Letters Patent dated the thirteenth day of June, 1991 and named The Bay Area Restoration Council of the Hamilton-Wentworth and Halton Regions Inc;

"Letters Patent" means the Letters Patent incorporating the Corporation, as from time to time amended and supplemented by supplementary Letters Patent;

"members" includes both ordinary members and associate members unless stated to the contrary;

"meeting of members" includes an annual meeting of members and a special meeting of members;

words importing the singular number include the plural and vice versa; words importing the masculine gender include the feminine and neuter genders; and words importing persons include individuals, corporations, partnerships, trusts and unincorporated organizations.

ARTICLE TWO
Purpose of the Corporation

2.01 Purpose. - The Objects of the Corporation are set out in the Articles of Incorporation. More specifically, the main purpose of the Corporation is the promoting, monitoring and assessing of the implementation of plans for the environmental protection and restoration of Hamilton Harbour as outlined in the Hamilton Harbour Remedial Action Plan.

ARTICLE THREE
Business of the Corporation

3.01 Head Office. - Until changed in accordance with the Act, the head office of the Corporation shall be in the City of Hamilton, in the Regional Municipality of Hamilton-Wentworth.

3.02 Corporate seal. - Until changed in accordance with the Act, the corporate seal of the Corporation shall be in the form impressed hereon.

3.03 Financial year. - Until otherwise ordered by the board, the financial year of the Corporation shall end on the thirty-first day of March in each year.

3.04 Execution of instruments. - Deeds, transfers, assignments, contracts, obligations, certificates and other instruments may be signed on behalf of the Corporation by any two of the President, the Secretary and one other director authorized by the board to sign on behalf of the Corporation. In addition, the board may from time to time direct the manner in which and the person or persons by whom any particular instrument or class of instruments may or shall be signed. Any person authorized to sign an instrument on behalf of the Corporation may affix the corporate seal thereto.

3.05 Banking arrangements. - The banking business of the Corporation shall be transacted with such banks, trust companies or other firms or corporations as may from time to time be designated by or under the authority of the board. Such banking business or any part thereof shall be transacted under such agreements, instructions and delegations of powers as the board may from time to time prescribe or authorize.

3.06 Voting rights in other companies. - The proper signing officers of the Corporation may execute and deliver instruments of proxy and arrange for the issuance of voting certificates or other evidence of the right to exercise the voting rights attaching to any shares or other securities held by the Corporation. Such instruments, certificates or other evidence shall be in favour of such person or persons as may be determined by the officers signing them or arranging therefor. In addition, the board may from time to time direct the manner in which or the person or persons by whom any particular voting rights or class of voting rights may or shall be exercised.

ARTICLE FOUR
Directors

4.01 Number of directors and quorum. - The affairs of the Corporation shall be managed by its board of directors. Until changed in accordance with the Act, the number of directors shall be five of whom three shall constitute a quorum for the transaction of business. Notwithstanding vacancies the remaining directors may act if constituting a quorum.

4.02 Qualification. - No person shall be qualified as a director unless he shall be eighteen or more years of age and shall at the time of his election and throughout his term of office be a member of the Corporation.

4.03 Election and term. - The directors of the Corporation shall be elected and shall retire in rotation and that at the first meeting of the members for the election of directors, **3** directors shall be elected to hold office until the second annual meeting of members after that date, and **2** to hold office until the next annual meeting after that date, and subsequently at each annual meeting directors shall be elected to fill the positions of those directors whose term of office has expired and each director so elected shall hold office until the second annual meeting after his election. A director shall be ineligible for re-election after he has served three consecutive terms.

4.04 Removal of directors. - The members may, by resolution passed by at least two-thirds of the votes cast thereon at a general meeting of members called for the purpose, remove any director before the expiration of his term of office and may, by majority vote at that meeting, elect any person in his stead for the remainder of his term.

4.05 Vacation of office. - The office of a director shall be vacated upon the occurrence of any of the following events: (a) if a receiving order is made against him or if he makes an assignment under the Bankruptcy Act; (b) if an order is made declaring him to be a mentally incompetent person or incapable of managing his affairs; (c) if he ceases to be qualified as provided in section 4.02; (d) if he shall be removed from office by resolution of the members as provided in section 4.04; or (e) if by notice in writing to the Corporation he resigns his office and such resignation, if not effective immediately, becomes effective in accordance with its terms.

4.06 Vacancies. - Vacancies on the board may be filled for the remainder of the term of office either by the members at a general meeting of members called for that purpose or by the board if the remaining directors constitute a quorum. If the number of directors is increased, a vacancy or vacancies on the board to the number of the authorized increase shall thereby be deemed to have occurred which may be filled in the manner above provided.

4.07 Calling of meetings. - Meetings of the board shall be held from time to time at the call of the board or the President or any two directors. Notice of the time and place of every meeting so called shall be given to each director not less than 48 hours (excluding Saturdays, Sundays and bank holidays) before the time when the meeting is to be held, save that no notice of a meeting shall be necessary if all the directors are present or if those absent waive notice of or otherwise signify their consent to such meeting being held.

4.08 First meeting of new board. - Provided a quorum of directors be present, each newly elected board may without notice hold its first meeting immediately following the meeting of members at which such board is elected.

4.09 Regular meetings. - The board may appoint a day or days in any month or months for regular meetings at a place and hour to be named. A copy of any resolution of the board fixing the place and time of regular meetings of the board shall be sent to each director forthwith after being passed, but no other notice shall be required for any such regular meeting.

4.10 Place of meeting. - Meetings of the board shall be held at the head office of the Corporation or elsewhere in Ontario or, if the board so determines or any absent directors consent, at some place outside Ontario.

4.11 Chairman. - The President or, in his absence, a Vice-President who is a director shall be Chairman of any meeting of directors. If no such officer be present, the directors present shall choose one of their number to be Chairman.

4.12 Votes to govern. - At all meetings of the board every question shall be decided by a majority of the votes cast on the question.

4.13 Interest of directors in contracts. - Each and every director shall be disqualified by his office from contracting with the Corporation.

4.14 Declaration of interest. - It shall be the duty of every director of the Corporation who is in any way, whether directly or indirectly, interested in a contract or arrangement or proposed contract or proposed arrangement with the Corporation to declare such interest to the extent, in the manner and at the time required by the Act, and to refrain from voting on such contract or arrangement.

4.15 Remuneration. - The directors shall serve as such without remuneration but shall be entitled to be paid their travelling and other expenses properly incurred by them in attending meetings of the board or of the members.

4.16 Executive committee. - Whenever the board consists of more than six directors, the board may elect from its number an executive committee consisting of not less than three, which committee shall have power to fix its quorum at not less than a majority of its members and may exercise all the powers of the board, subject to any regulations imposed from time to time by the board.

4.17 Other committees. - The board of directors may by resolution create one or more other committees which may but need not include members of the board. Until otherwise provided, the President shall be a member ex officio of all committees. Other committees created by the board of directors shall be given written terms of reference by the board.

ARTICLE FIVE
Officers

5.01 Election of President. - From time to time the board shall elect from among its members a President.

5.02 Appointment of other officers. - From time to time the board shall appoint a Secretary and may appoint one or more Vice-Presidents, a Treasurer and such other officers as the board may determine. The officers so appointed may but need not be directors and one person may hold more than one office, save that the President may not hold the office of Secretary.

5.03 Terms of office and remuneration. - The terms of employment and remuneration of officers appointed by the board shall be settled by it from time to time. The board may remove at its pleasure any officer of the Corporation, without prejudice to such officer's rights under any employment contract. Otherwise each officer elected or appointed by the board shall hold office until his successor is elected or appointed, except that the term of office of the President shall expire if and when he shall cease to be a director.

5.04 President. - The President shall have the general management and direction, subject to the authority of the board, of the business and affairs of the Corporation.

5.05 Vice-President. - During the absence or disability of the President, his duties shall be performed and his powers exercised by the Vice-President or, if there are more than one, by the Vice-Presidents in order of seniority.

5.06 Secretary. - The Secretary shall attend and be the Secretary of all meetings of members and directors and shall enter or cause to be entered in books kept for that purpose minutes of all proceedings thereat. The Secretary shall give or cause to be given, as and when instructed, all notices to members and directors. The Secretary shall be the custodian of the stamp or mechanical device generally used for affixing the corporate seal of the Corporation and of all books, papers, records, documents and other instruments belonging to the Corporation except when some other officer or agent has been appointed for that purpose.

5.07 Treasurer. - The Treasurer shall keep full and accurate books of account in which shall be recorded all receipts and disbursements of the Corporation and, under the direction of the board, shall control the deposit of money, the safekeeping of securities and the disbursement of the funds of the Corporation. The Treasurer shall render to the board whenever required an account of all his transactions as Treasurer and of the financial position of the Corporation.

5.08 Other officers. - The duties of all other officers of the Corporation shall be such as the terms of their engagement call for or as the board or the President may prescribe. Any of the powers and duties of an officer to whom an assistant has been appointed may be exercised and performed by such assistant, unless the board or the President otherwise directs.

5.09 Variation of duties. - From time to time the board may vary, add to or limit the powers and duties of any officer.

5.10 Agents and attorneys. - The board shall have power from time to time to appoint agents or attorneys for the Corporation in or out of Canada with such powers of management or otherwise (including the power to sub-delegate) as may be thought fit.

5.11 Fidelity bonds. - The board may require such officers, employees and agents of the Corporation as the board deems advisable to furnish bonds for the faithful discharge of their duties, in such form and with such surety as the board may from time to time prescribe.

ARTICLE SIX
Protection of Directors and Officers

6.01 Limitation of liability. - No director or officer of the Corporation shall be liable for the acts, receipts, neglects or defaults of any other director or officer or employee or agent appointed by the board to represent the Corporation, or for joining in any receipt or other act for conformity, or for any loss, damage or expense happening to the Corporation through the insufficiency or deficiency of title to any property acquired by order of the board for or on behalf of the Corporation, or for the insufficiency or deficiency of any security in or upon which any of the moneys of the Corporation shall be invested, or for any loss or damage arising from the bankruptcy, insolvency or tortious act of any person with whom any of the moneys, securities or effects of the Corporation shall be deposited, or for any loss occasioned by any error of judgment or oversight on his part, or for any other loss, damage or misfortune whatever which shall happen in the execution of the duties of his office or in relation thereto unless the same are occasioned by his own wilful neglect or default.

6.02 Indemnity. - Every director and officer of the Corporation and his heirs, executors and administrators and estate and effects, respectively, shall from time to time and at all times be indemnified and saved harmless out of the funds of the Corporation from and against:

(a) all costs, charges and expenses whatsoever that such director or officer sustains or incurs in or about any action, suit or proceeding that is brought, commenced or prosecuted against him for or in respect of any act, deed, matter or thing whatsoever made, done or permitted by him in or about the execution of the duties of his office; and

(b) all other costs, charges and expenses that he sustains or incurs in or about or in relation to the affairs of the Corporation except such costs, charges or expenses as are occasioned by his own wilful neglect or default.

6.03 Validity of actions. - No act or proceeding of any director or board of directors shall be deemed invalid or ineffective by reason of the subsequent ascertainment of any irregularity in regard to such act or proceeding or the qualification of such director or board of directors.

6.04 Directors' reliance. - Directors may rely upon the accuracy of any statement or report prepared by the Corporation's auditors and shall not be responsible or held liable for any loss or damage resulting from acting upon such statement or report.

ARTICLE SEVEN
Members

7.01 Members. - There shall be two classes of members in the Corporation, namely ordinary, voting, members and associate, nonvoting, members. When admitting persons who have an interest in, and support, the environmental protection and restoration of Hamilton Harbour as provided in paragraph 2.01 to ordinary membership in the Corporation, the board of directors shall endeavour to maintain a balance so that the ordinary membership shall represent the social, economic and environmental constituencies in the area and shall include (without being limited to) political, educational, business, industrial, environmental and citizen groups.

(1) Each ordinary member shall be entitled to one vote at all meetings of the Corporation. Each ordinary member shall pay annual membership dues as set by resolution of the directors of the Corporation from time to time as provided in paragraph 7.05.

(2) The associate members shall not be entitled to vote at meetings of members of the Corporation. Each associate member shall pay annual membership dues as set by resolution of the directors of the Corporation from time to time as provided in paragraph 7.05.

The ordinary members shall consist of the applicants for incorporation of the Corporation, and of such other persons as are admitted as ordinary members by resolution of the board of directors as provided for above. Each ordinary member shall promptly be informed by the Secretary of his admission as a member. The associate members may include the members of the Bay Area Implementation Team and such other persons as are admitted as associate members by resolution of the board of directors. Each associate member shall promptly be informed by the Secretary of his admission as an associate member.

7.02 Term of membership. - The interest of the members in the Corporation is not transferable and lapses and ceases to exist upon his death or when he ceases to be a member by resignation or otherwise in accordance with the by-laws of the Corporation.

7.03 Resignation. - Members may resign by resignation in writing which shall be effective upon any date or time on or after the execution of the instrument of resignation. In the case of resignation, a member shall remain liable for payment of any assessment or other sum levied or which became payable by him to the Corporation prior to acceptance of his resignation.

7.04 Removal. - Upon thirty days' notice in writing to a member of the Corporation, the board may pass a resolution authorizing the removal of such member from the register of members of the Corporation and thereupon such person shall cease to be a member of the Corporation. Any such member may re-apply for membership in the Corporation.

7.05 Dues. - The dues or fees payable by ordinary members and associate members shall from time to time be fixed by the board of directors, which vote shall become effective only when confirmed by a vote of the ordinary members at an annual or general meeting.

The Secretary shall notify the members of the dues or fees at any time payable by them and if they are not paid within 30 days of the date of such notice the members in default shall thereupon automatically cease to be members of the Corporation but any such members may on payment of all unpaid dues or fees be reinstated by the board of directors.

ARTICLE EIGHT
Meetings of Members

8.01 Annual meetings. - The annual meeting of the members shall be held at such time and on such day in each year as the board or the President may from time to time determine, provided that an annual meeting shall be held at least every fifteen months, for the purpose of receiving the reports and statements required by the Act to be placed before the annual meeting, electing directors, appointing auditors and fixing or authorizing the board to fix their remuneration, and for the transaction of such other business as may properly be brought before the meeting.

8.02 Special meetings. - The board or the President shall have power to call a special meeting of members at any time.

8.03 Place of meetings. - Meetings of members shall be held at the head office of the Corporation or elsewhere in the municipality in which the head office is situate or, pursuant to section 8.05 or if the board shall so determine, at some other place in Ontario.

8.04 Notice of meetings. - Notice of the time and place of each meeting of members shall be given in the manner hereinafter provided not less than twenty-one (21) days before the day on which the meeting is to be held to each member of record at the close of business on the day on which the notice is given who is entered in the books of the Corporation. Notice of a special meeting of members shall state the general nature of the business to be transacted thereat. The auditors of the Corporation are entitled to receive all notices and other communications relating to any meetings of members that any member is entitled to receive.

8.05 Meetings without notice. - A meeting of members may be held at any time and place without notice if all the members entitled to vote thereat are present in person or represented by proxy, or if those not present or represented by proxy waive notice or otherwise consent to such meeting being held, and at such meeting any business may be transacted which the Corporation at a meeting of members may transact.

8.06 Chairman, Secretary and scrutineers. - The President or, in his absence, a Vice-President who is a director of the Corporation shall be Chairman of any meeting of members. If no such officer is present within fifteen minutes from the time fixed for holding the meeting, the persons present and entitled to vote shall choose one of their number to be Chairman. If the Secretary of the Corporation is absent, the Chairman shall appoint some person, who need not be a member, to act as Secretary of the meeting. If desired, one or more scrutineers, who need not be members, may be appointed by a resolution of the members or by the Chairman with the consent of the meeting.

8.07 Persons entitled to be present. - The only persons entitled to attend a meeting of members shall be the ordinary members who are those entitled to vote thereat, the auditors of the Corporation and others including the associate members, who although not entitled to vote, are entitled or required under any provision of the Act or the Letters Patent or by-laws to be present at the meeting. Any other person may be admitted only on the invitation of the Chairman of the meeting or with the consent of the meeting.

8.08 Quorum. - A quorum for the transaction of business at any meeting of members shall be the greater of five persons, or twenty-five percent of the ordinary members, present in person and each entitled to vote thereat.

8.09 Right to vote. - At any meeting of members every person shall be entitled to vote who is at the time of the meeting entered in the books of the Corporation as an ordinary member.

8.10 Alternates. - At any meeting of members an alternate duly and sufficiently appointed by an ordinary member who is an incorporated or unincorporated organization shall be entitled to exercise, subject to any restrictions expressed in the instrument appointing him, the same voting rights that the member appointing him would be entitled to exercise if present at the meeting. An alternate need not be a member. An instrument appointing an alternate shall be in writing and, if the appointer is a corporation, shall be under its corporate seal, subject to the Act. An instrument appointing an alternate shall be acted on only if, prior to the time of voting, it is deposited with the Secretary of the Corporation or of the meeting or as may be directed in the notice calling the meeting.

8.11 Votes to govern. - At any meeting every question shall, unless otherwise required by the Letters Patent or by-laws of the Corporation or by law, be determined by the majority of the votes duly cast on the question.

8.12 Amending the By-laws. - The by-law(s) of the Corporation may be amended, suspended or repealed in whole or in part by two-thirds of the votes cast at an annual meeting or at a special meeting of the members duly called to consider the bylaw(s). The proposed amendment(s) shall have been submitted to the members at the previous annual meeting or in writing to every ordinary member at least twenty-one days before the meeting at which the amendment(s) is (are) to be voted upon.

8.13 Show of hands. - Any question at a meeting of members shall be decided by a show of hands unless, after a show of hands, a poll thereon is required or demanded as hereinafter provided. Upon a show of hands every person who is present and entitled to vote shall have one vote. Whenever a vote by show of hands shall have been taken upon a question, unless a poll thereon is so required or demanded, a declaration by the Chairman of the meeting that the vote upon the question has been carried or carried by a particular majority or not carried and an entry to that effect in the minutes of the meeting shall be prima facie evidence of the fact without proof of the number or proportion of the votes recorded in favour of or against any resolution or other proceeding in respect of the said question, and the result of the vote so taken shall be the decision of the members upon the said question.

8.14 Polls. - After a show of hands has been taken on any question, the Chairman may require or any person entitled to vote on the question may demand a poll thereon. A poll so required or demanded shall be taken in such manner as the Chairman shall direct. A demand for a poll may be withdrawn at any time prior to the taking of the poll. Upon a poll each member present in person or represented by alternate and entitled to vote shall have one vote and the result of the poll shall be the decision of the members upon the said question.

8.15 Casting vote. - In case of an equality of votes at any meeting of members either upon a show of hands or upon a poll, the Chairman of the meeting, who shall not ordinarily vote, shall be entitled to a casting vote.

8.16 Adjournment. - The Chairman at a meeting of members may, with the consent of the meeting and subject to such conditions as the meeting may decide, adjourn the meeting from time to time and from place to place.

8.17 Procedure at meetings. - Meetings shall be conducted according to the procedure rules known as Robert's Rules of Order.

ARTICLE NINE
Notices

9.01 Method of giving notices. - Any notice (which term in this Article 8 includes any communication or document) to be given (which term in this Article 8 includes sent, delivered or served) pursuant to the Act, the Letters Patent, the by-laws or otherwise to a member, director, officer or auditor shall be sufficiently given if delivered personally to the person to whom it is to be given or if delivered to his last address as recorded in the books of the Corporation or if mailed by prepaid ordinary mail addressed to him at his said address or if sent to him at his said address by any means of wire or wireless or any other form of transmitted or recorded communication. The Secretary may change the address on the Corporation's books of any member, director, officer or auditor in accordance with any information believed by him to be reliable. A notice so delivered shall be deemed to have been given when it is delivered personally or at the address aforesaid; a notice so mailed shall be deemed to have been given when deposited in a post office or public letter box; and a notice sent by any means of wire or wireless or any other form of transmitted or recorded communication shall be deemed to have been given when delivered to the appropriate communication company or agency or its representative for dispatch.

9.02 Computation of time. - In computing the date when notice must be given under any provision requiring a specified number of days' notice of any meeting or other event, the date of giving the notice shall be excluded and the date of the meeting or other event shall be included.

9.03 Omissions and errors. - The accidental omission to give any notice to any member, director, officer or auditor or the non-receipt of any notice by any member, director, officer or auditor or any error in any notice not affecting the substance thereof shall not invalidate any action taken at any meeting held pursuant to such notice or otherwise founded thereon.

9.04 Waiver of notice. - Any member (or his duly appointed alternate), director, officer or auditor may waive any notice required to be given to him under any provision of the Act, the Letters Patent, the by-laws or otherwise and such waiver, whether given before or after the meeting or other event of which notice is required to be given, shall cure any default in giving such notice.

ARTICLE TEN
Auditors

10.01 Appointment of an Auditor. - The members shall at each annual meeting appoint an auditor to audit the accounts of the Corporation, to hold office until the next annual meeting, provided that the directors may fill any casual vacancy in the office of the auditor. The remuneration of the auditor shall be fixed by the board of directors.

ARTICLE ELEVEN
Effective Date

11.01 Effective date. - This by-law shall come into force when confirmed by the members in accordance with the Act.

PASSED by the directors and sealed with the corporate seal the twenty-ninth day of July, 1991.

Anne Redish **Kenneth M. Hall**

President **Secretary**

CONFIRMED by the members the 29 day of July, 1991.

Kenneth M. Hall

Secretary

APPENDIX K: LAND USE PLANNING INITIATIVES IN RESPECT OF THE REMEDIAL ACTION PLAN FOR HAMILTON HARBOUR

I Land Use Planning Initiatives in Respect of the Remedial Action Plan for Hamilton Harbour and its Watershed

I.1 Recommendations for Official Plans:

1. Incorporate a general policy statement in support of the Remedial Action Plan (RAP) and the Lake Ontario Toxics Management Plan.

2. Incorporate into the appropriate sections the goals and recommendations of the RAP in respect of:

   a) stormwater policy and the treatment of stormwater,
   b) development policy,
   c) erosion control,
   d) wetland protection,
   e) ANSI (Area of Natural and Scientific Interest) protection,
   f) aquatic habitat protection and restoration,
   g) goals for public access to the Harbour waters,
   h) water course protection (e.g. setbacks) and, in the
   i) agricultural section - land practice and good farm practices to protect groundwater and surface water quality.

APPENDIX L: STAKEHOLDERS WORKSHOP TO REVIEW TECHNICAL OPTIONS

I Review of Technical Remedial Actions

Measures that may be used to reduce the discharge of waste materials to the Harbour generally include those which address materials right where they are first used or produced, or at some place downstream in the line between the source and the discharge point into the Harbour. The measures addressed in this section, other than source reduction, are largely technical measures. That is, they involve treatment of wastewater or mitigation of the condition in the Harbour itself. Source reduction measures are addressed elsewhere.

The measures reviewed in this section include:

<u>Remedial Measure</u>	<u>Title</u>
1.	Improved Chemical Treatment at Sewage Treatment Plants
2.	Nitrification at Woodward Avenue and Skyway STPs
3.	Ammonia Loadings from Steel Industries
4.	Installation of Sand Filters at the Skyway and Woodward Avenue STPs
5.	Diversion of STP Discharges to Lake Ontario (Halton and Hamilton-Wentworth)
6.	Remediation of Combined Sewer Overflows - Hamilton-Wentworth Region
7.	Rerouting of Dundas and Waterdown Sewers to the Woodward Avenue Plant (Hamilton)
8.	Phosphorus Control for Rural Runoff
9.	Erosion Control: Rural - Agricultural
10.	Erosion Loadings from Construction Activity
11.	Oxygenation of Hypolimnion in Summer
12.	Control of Bacterial Contamination from North Shore Streams or Resuspended Sediments
13.	MISA - Iron and Steel Sector (Dofasco and Stelco)
14.	MISA - Municipal STP Sector - Industries and businesses discharging to the municipal sewers
15.	Remedial Action for the More Seriously Contaminated Sediments in the Harbour
16.	General Sediment Contamination (less seriously contaminated sediments)
17.	Spill Controls
18.	Control and Creation of Colonial Bird Nesting Sites
19.	Cootes Paradise Marsh Development (Dyking)
20.	Restore Emergent Vegetation (Harbour)
21.	Additional Littoral Habitat (Harbour and Cootes Paradise)
22.	Restructuring the Fish Community - Plantings

Each measure was rated by the Technical Team as to its impact on the water use goals specified by the Stakeholders. Table L-1 illustrates the significance of each measure for the total set of water uses to be enhanced or re-instated (sub-totals and grand totals along the base of the table). From the column at the right, one can gauge the uses or goals that are most sensitive to a larger set of remedial measures.

Thirty-one Stakeholders then took part in an assessment procedure devised by the Technical Options Sub-Committee of the Stakeholders.

A background document was prepared describing each measure and its impact. The content of information sheets included:

i. Introduction
   (a) Presentation of the issue that the remedial measure addressed. (ammonia control, habitat for fish, etc.).
   (b) Overview of the issue (area affected, relation to other measures).
   (c) Problems affected if the issue is not addressed.
   (d) Source of the problem.

ii. Description of the Remedial Measure

iii. Results expected
   (a) General.
   (b) Impaired uses affected.
   (c) Side effects.

iv. Implementation
   (a) Costs.
   (b) Agency responsibility.
   (c) Manage Plan Step.
   (d) Potential time-frame or sequencing required.

II Results

From Figure 39 it can be seen that Stakeholders do not collectively rank any of their goals as particularly low. Six of them are ranked somewhat higher than the others, however. These include use of the Harbour as a wastewater receiver, reinforcing their wish **not** to use Lake Ontario as the prime receptacle for wastewater discharges - albeit under conditions requiring all necessary effluent controls (1986 Interim Report of the Stakeholders). Others ranking somewhat higher are the fisheries, wildlife, educational, access and aesthetic goals.

Recreational boating, navigation concerns, industrial uses and swimming uses ranked slightly lower. With such an even ranking of water use goals (or 'beneficial uses', to use the terminology of the Great Lakes Water Quality Agreement), the rated effectiveness of each

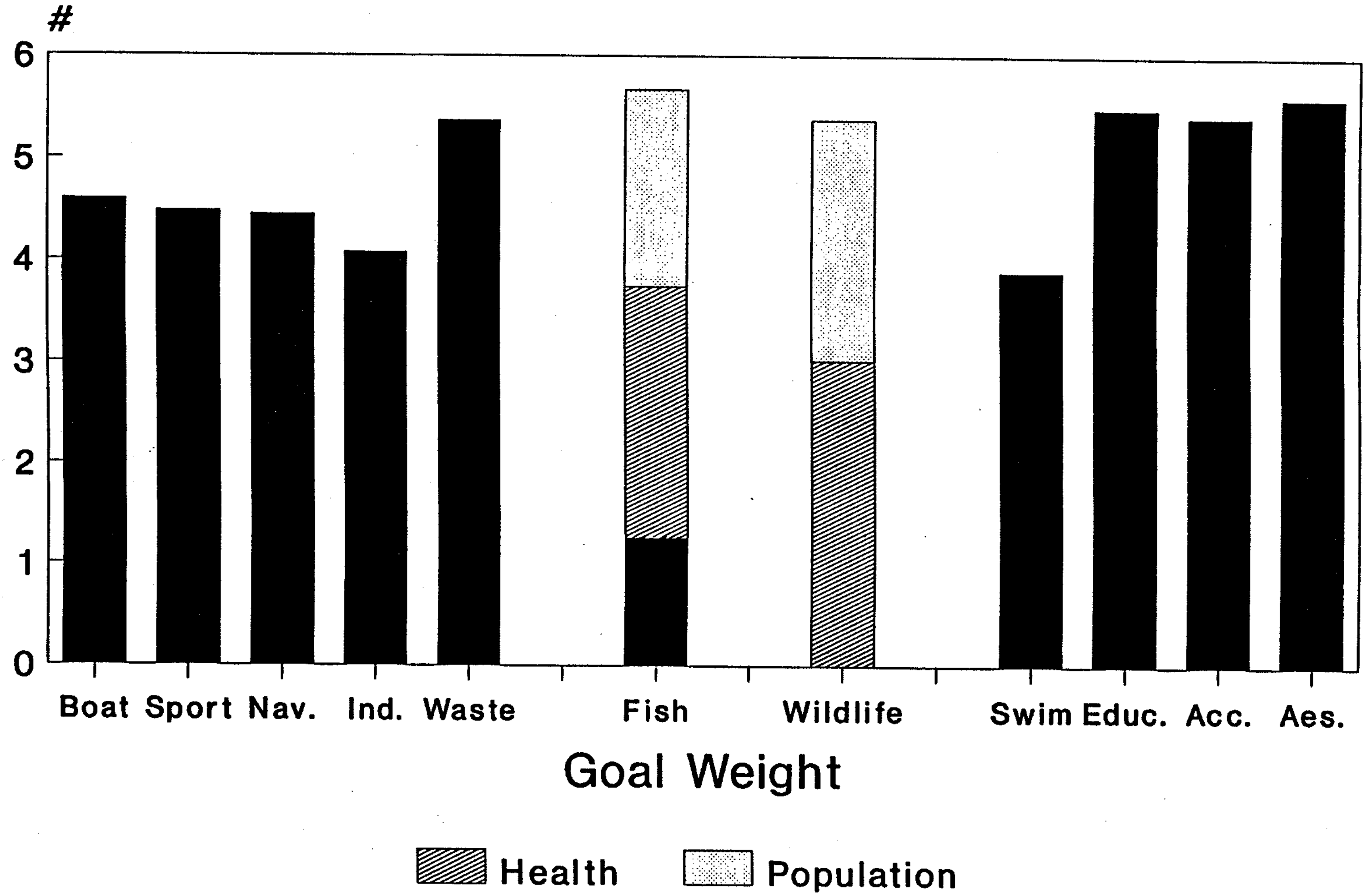
Table L-1: Stakeholders Workshop Summary

GOALS AND USES AFFECTED	STP-Chem	STP-Nitri	Ind.-NH_3	STP-Filters	STP Diversion	CSO-H-W	Reroute STP	Rural Phos.	Rural Erosion	Urban Erosion	Oxygen	Bacti (Burl.)	MISA Indust.	MISA Munic.	Sed. Hot Spots	Sed. Gen'l Cont.	Spills	Col. Bird Habitat	Cootes Dykes	Fish Habitat (Weeds)	Fish Habitat (shores)	Fish Control	MEASURE OF SENSITIVITY TO REMEDIAL ACTION
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
Recreational Boating	1			2	1	2		1	1	1							1		1				11
Water Sports	1			2	1	3		1	1	1		3					1			1			15
Shipping/Navigation/Dredging			1			2				1			x	x	2	1		-1					6*
Industrial Use	1			1		1											1						4
Wastewater Receiving Body	2	2	2	3	2	2	2	1	1	1	1	1	x	x			1						21*
Fisheries: • Fish Consumption				1		1					1		x	x	1	2							6*
• Fish Tumours		2		1		1					1		x	x	3	3	1						12*
• Fish Population	2	3	1	3	1	2	1	1	4	2	3					2	1		-1	4	2	4	35
Wildlife: • Population	1			2	-1	1	1	1	2	1							1	2	5	4		4	24
• Health				1	1	1							x	x		1	1						5*
Swimming	1			2	1	4		1	2	2		4										2	19
SUB TOTAL	9	7	4	18	6	20	4	6	11	9	6	8	-	-	6	9	8	1	5	9	2	10	
Education																			5				5
Access																			3		2		5
Aesthetics	2		1	3	1	4	±2	2	4	3		1					2	3	3	3	2	2	35
GRAND TOTAL	11	7	5	21	7	24	4	8	15	12	6	9	-	-	6	9	10	4	16	12	6	12	

NOTE:
- X means that these areas are anticipated to be affected if MISA is taken into consideration but values were not estimated.
- -1 means a likely negative impact on the specified use.
- 5 means the measure has a major impact on the use (20% or more).
- Values from 2 to 4 are gradations between 1 and 5 which is often difficult to quantify.
- * means that when MISA is taken into consideration, value will increase.

Source: Stakeholder Workshops - Summary Document 1989

Figure 40: Average Goal Weight



Source: Stakeholder Workshops - Summary Document, 1989.

remedial measure is given by Table L-2. Hence, the priorities derived were dependent on the range of uses that might be affected.Samples of the ranking distributions of options are given in Figure 40. The overall rankings of all remedial measures assessed were as follows:

Remedial Measure	Title	Rank
06	Combined Sewer Overflows	1
04	Sand Filters at STPs	2
09	Erosion Control - Rural	3
19	Cootes Paradise Marsh Restoration	4
10	Erosion of Construction Sites	5
01	Improved Chemical Treatment at STPs	6
17	Spills Control	8
20	Harbour Vegetation Enforcement	10
12	North Shore Bacterial Control	10
08	Rural Runoff-Nutrient Controls	10
22	Fish Community Restructuring - Carp Control	10
05	Diversion of STPs to Lake Ontario (last resort)	12
07	Dundas STP Measures for Overload (overflow to Hamilton system)	13
21	Littoral Habitat Improvements	14
03	Industrial Ammonia Loadings Reduced	14
02	Ammonia Removal at STPs	16
16	General Sediment Contamination over Harbour	16
15	Hot Spots in Sediment - Contamination	17
18	Colonial Bird Habitat - Alterations	18
11	Oxygenation of Bottom Water	19

Notes:

1. Measures with a low rank were often those with the least "interconnectedness", that is, they did not affect as many other activities as the more highly-ranked options, but this does not mean that a lower-ranked measure would not be implemented in order to meet water quality goals.

2. Measure 5, STP effluent diversion to Lake Ontario, was given a low ecosystem approach score and three individuals rejected this measure and refused to rate it. This measure was discussed by the Stakeholders and Recommendation #3 reflected the majority view that diversion should only be considered as a last resort.

3. Where there was a 'tie' in ranking, the Ecosystem Committee rankings were used to break the tie.

4. Measure 19, Cootes Paradise Dyked Marsh, has undergone major revisions as noted in Section IV.10.

Table L-2: Final Assessment

REMEDIAL MEASURE	Rating Based on Principals[1]	Effectiveness Rank[2]	Technically Feasible Time Frame[3]	Cost Ranking[4]	Proponent	Rating Key[5]	Recommendations (Short Form)
1. STP-Chemical	B-	6	short	low	Regions	A	Link with #2 and #4 (1st Step)
2. STP-Nitrification	B+	16	medium	medium	Regions	A	Link with #1 and #4 (2nd Step)
3. Ammonia (NH_3) - Steel Industry	A-	15	short	medium	Stelco/Dofasco	A	Most of this already completed
4. STP-Filters	B	2	medium	high	Regions	G	Delay pending #1 and #2 (3rd Step)
5. STP-Diversion	C	12	medium	high	Regions		Rejected completely
6. CSO-HW Region	B+	1	short/medium	high	H-W Region	A	Accelerate implementation: Stormwater management
7. Dundas Reroute	C	13	short	medium	H-W Region	G	Subject to demonstration of all possible alternatives measures
8. Phosphorus-Rural	A	10	short	low	OMAF	A.G.	Proceed - essential
9. Erosion-Rural	A	4	medium	low	OMAF	A.G.	Proceed - essential
10. Urban Runoff	A	5	medium	low	Regions	A-	Needs better specs and developer planning
11. Oxygenation	C	20	short	medium		E	Asses as 5 year option - don't forego source control
12. Bacterial-Burlington	B	9	short	low/medium	Halton Region MOE	G	Endorsed
13. MISA-Steel	A-	-	medium	high	Industry/MOE		Establish toxic loading targets ASAP for protection of environment
14. MISA-STPs	A/C	-	medium	medium/high	Region/MOE		Proceed ASAP
15. Sediment-High Concentration	C	18	short	high			Proceed ensuring safe disposal
16. Sediment-General	-	17	medium	high		G	Assess developing technology
17. Spills	A	7	short	low	Industry/MOE	A	Accepted subject to noted comments
18. Bird Habitat	B	19	medium	medium	MNR	G	Study required ASAP; HHC dev. require EA (see also Windermere)
19. Cootes Dyke	B	3	short	medium/low	RBG	A	Legal issues; resolve fish/waterbird uses (Workshop in 1990)
20. Fish Habitat	B	9	short	medium	MNR/DFO	E	Consider alternatives to islands; consider boater access
21. Littoral Fish Habitat	B	14	short/medium	medium	MNR/DFO	B	Proceed
22. Fish Populations	B	11	medium/long	medium	DFO/MNR		Begin carp exclusion; tackle #2 before introduction of fish

(1) Ecosystem Committee Advice:

A meets criteria
B acceptable with modification
C unacceptable

(2) Stakeholder Rank: (Composite at Workshop)

There is little differentiation amongst options 7 to 13 inclusive

(3) Time Frame:

Short: 1-3 years
Medium: 3-10 years
Long: 10+ years

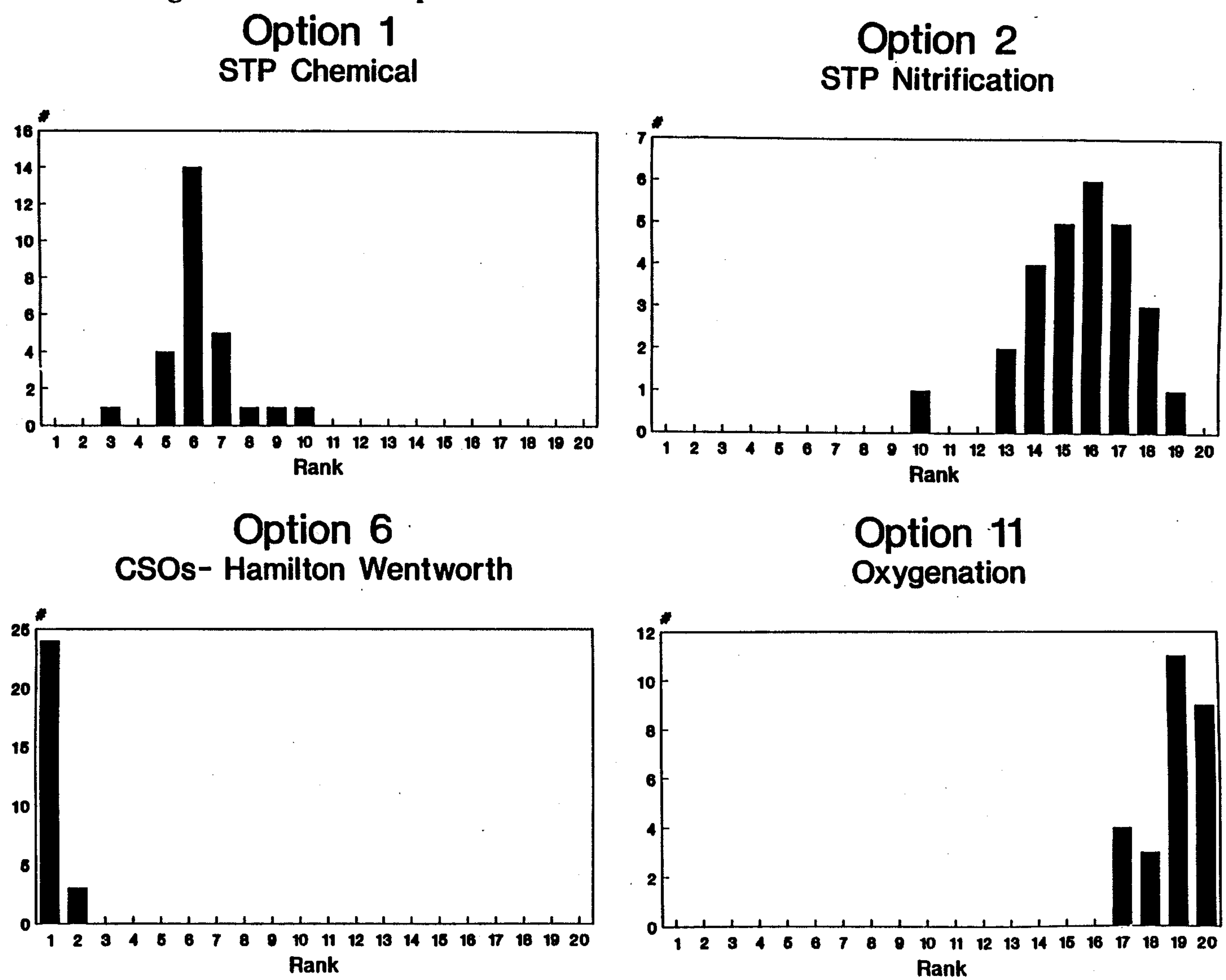
(4) Estimated approximately:

Low: less than $2M
Med.: less than $2-$10M
High: greater than $10-15M

(5) Rating Key for Remedial Measures:

A Currently being implemented or scheduled for implementation
B Immediate implementation.
C Implementation as soon as possible.
D Delayed implementation.
E Implementation dependent on known factors.
F Implementation dependent on unknown factors.
G Needs further study.
H Other. (Requires explanation.)

Figure 41: Ranking Distributions of Options



Source: Stakeholder Workshops - Summary Document, 1989.

5. MISA program elements (numbers 13 and 14) were not ranked by Stakeholders because it was felt that too little information was available to address these measures at this stage. However, adoption by the Stakeholders of the Principle of Zero Discharge consistent with virtual elimination (see Section III.3.2) is one measure of the significance that is placed on the issue of persistent toxic chemicals.

These data need interpretation in light of the discussion by Stakeholders of each of these measures. It is noted above that measure 19 dealing with wildlife habitat restoration using dyked cells received some concern as regards conflicts between fisheries and wildlife goals. These conflicts were resolved through a new strategy reflected in the final recommendations.

In addition, some measures only addressed one goal (i.e. oxygenation of Harbour water), but this one factor can be crucial in a way not well reflected in this analysis. In this instance the impact of dissolved oxygen on exclusion of fish from the coldest water of the Harbour in summer; on the toxicity of bottom sediments to benthic fauna; and on the release of contaminants from the sediments of the water column have to be considered in concert. Some measures are linked, such as the several measures dealing with sewage treatment plants. In this case it is necessary to address these measures in a way which reflects the logical sequence of measures that could be implemented at the plants, and the cost efficiency of each measure.

A brief summary of the workshop deliberations on these measures are presented in Table L-1.

From these data, including the detailed comments made by Stakeholders in the workshop, the following rankings emerged:

1. Correction of combined sewer overflows with first priority to discharges in Cootes Paradise and the western half of the Harbour.

2. Improved efficiency in the design of the sewage treatment plant operations including:

   a) process audits
   b) improved chemical treatment
   c) improved aeration and hydraulics and any necessary clarifier or recycle line capacity modifications
   d) computer aided automated operational control systems installed

3. Installation of filters as an additional step in sewage treatment at the Burlington and Hamilton-Wentworth Sewage Treatment Plants (after #2, if required).

4. Erosion control in the rural and urban areas, with emphasis on processes affecting channel erosion below the escarpment, on erosion from construction

sites (housing developments, highways, railroad and industrial) and potential nutrient discharges from farming operations.

5. Greater control on spills that can impact on the Harbour directly (such as a cargo spill or a direct industrial spill) or indirectly, such as spills into the sewer system that disrupts the operation of a sewage treatment plant.

6. Measures to address habitat restoration for fish and wildlife and to address needs for changes in the species composition of the fish population.

7. Control of bacterial contamination sources affecting the north shore of the Harbour.

8. Further controls on industrial discharges (details as yet incomplete but emphasizing in-plant recycling and source reductions).

9. Addressing the problems associated with bottom sediments contaminated by a variety of toxics from past and current discharges to the Harbour.

10. Mitigation of low hypolimnetic oxygen conditions (summer only) until causes of the dissolved oxygen depletion have been remediated.

These priorities should not be viewed entirely as a linear set of independent actions. Judgements about the sequence of serial or parallel measures need to consider such things as:

a) Remediation of combined sewer overflows requiring an increase in the sewage treatment plant capacity,

b) Sand filters should not necessarily be considered ahead of STP audits if the loading targets for the Harbour can be met by more cost effective methods,

c) The technology exists to proceed promptly with a number of STP measures, but must be viewed as part of a complete system,

d) The potential for population and industrial development of different kinds, under various degrees of control, to affect future wastewater volumes and quality, and

e) While much 'end-of-pipe' technology exists, there has been little in-depth development of more dispersed or source control methodologies.