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THE GREAT LAKES WATER QUALITY AGREEMENT

An Evolving Instrument for Ecosystem Management

National Research Council of the United States
and
The Royal Society of Canada

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PREFACE

When the Canadian and U.S. governments signed the Great Lakes Water Quality Agreement in 1978, they agreed to review it after the International Joint Commission (IJC) issued its third biennial report. The IJC plans to release that report in 1986.

In April 1984, the U.S. National Research Council's Water Science and Technology Board held a conference in Buffalo, New York to identify scientific, technical, and institutional issues on which a review of the Agreement might focus. Experts from the United States and Canada knowledgeable in many aspects of the Agreement attended, and the proceedings have since been published (National Research Council, 1984). Subsequently, a work plan was developed for a binational review of the Agreement by a committee of experts under the joint auspices of the Royal Society of Canada (RSC) and the U.S. National Research Council (NRC). On the basis of the issues identified at the Buffalo conference, the Royal Society of Canada and the Research Council selected the following general areas for examination:

Basinwide and Land/Lake Relationships

Several developments have been recognized recently as having the potential to alter the Great Lakes water quality. These include

- Increased use of water from inflowing rivers for irrigation and other consumptive uses such as cooling, and other industrial uses;
- Local alteration of groundwater reservoirs and wetlands;
- Partial implementation of winter navigation in the lakes above (i.e. upstream of) Lake Ontario and associated effects of mobile ice on shoreline wetlands and spawning grounds; and
- Secondary impacts on inflowing water quality that arise from future development plans by cities, states, and provinces.

The issue for examination concerned whether the Great Lakes Water Quality Agreement should give increased emphasis to studies of basinwide and land/lake relationships throughout the Great Lakes basin ecosystem.

Phosphorus Control: Monitoring and Modeling to Assess Response, Benefits, and Future Abatement Strategies

Phosphorus control programs for the Great Lakes have been under way for nearly 15 years. The response monitoring indicates that certain objectives are being achieved, while other goals such as improvement in oxygen concentration of deep water (in certain lakes) are not being achieved at the rate expected. The following considerations have arisen:

- The lack of response in O_2 represents a lag in the system or the inability to bring phosphorus inputs down to premodern levels; and
- Effects of inconsistencies in monitoring and the limitation of descriptive models of lake responses in the face of known year-to-year sources of variation.

The issues for examination was whether monitoring, analysis of existing data, development of more sophisticated models for evaluating within-year and year-to-year variability, and assessment of phosphorus abatement objectives might be included in an extension of the Water Quality Agreement.

Toxic Chemicals: The Data Base, Modeling, Research on Dose/Response, Hazard and Tolerances, and the Research Infrastructure

The slow water renewal times in some of the Great Lakes, the extended time required for chemical equilibrium, contamination of the sediments, the food chain, and the water itself by persistent chemicals are of exceptional importance to the public and to the several governmental institutions of the Great Lakes basin. Questions that were examined are:

- The adequacy of the geographic coverage, continuity, and quality assurance of measurements of these chemicals;
- Whether predictive models are adequate (i.e., model structure, data problems, or both) to meet the requirements of the Agreement; and
- Whether adequate information is available on loadings of toxic chemicals, toxicity, and exposure data for the human population.

Accordingly, research on the sources, partitioning, bioaccumulation, and toxicity of these chemicals was reviewed. The issue examined is whether the current level and scope of research meets the obligations under the existing Agreement.

In addition to reviewing these issues, the committee examined each of these study topics on the basis of the following recurring issues:

1. Technical knowledge of the chemical, physical, and biological integrity of the waters of the Great Lakes basin (water quality) and the factors controlling it in an ecosystem context;
2. Capabilities necessary to detect, monitor, and evaluate changes in Great Lakes water levels and in water quality;

3. Assessments of present trends and future actions that would affect water quality throughout the basin; and
4. Institutional arrangements required to fulfill the respective water-quality responsibilities of state, local, provincial, and federal governments.

As the study proceeded, the committee recognized that the land/lake water portions of its task statement should be an integral part of both the nutrients and toxic contaminants sections. Accordingly, the report treats this portion of the task statement throughout the chapters. In addition, the committee found that the institutional arrangements, despite similar applicability to the nutrient and toxic substance goals of the Agreement, were so complex as to warrant treatment in a separate chapter.

The committee, in arranging its relatively brief but intensive study, held meetings in Washington, D.C., on December 3-4, 1984, in Ottawa, Ontario, on February 13-15, 1985; again in Washington, D.C., on April 15-17, 1985; and at Niagara-on-the-Lake, Ontario, on June 5-7, 1985.

Committee members interacted with IJC Commissioners and staff from Ottawa, Washington, and Windsor, and leaders of the Great Lakes Water Quality Board and Science Advisory Board; commissioners and staff of the Great Lakes Fishery Commission; officials of the Canadian Embassy in Washington and the U.S. Embassy in Ottawa; experts from the U.S. Environmental Protection Agency (EPA), Department of State, National Oceanic and Atmospheric Administration; experts from the Canadian Department of the Environment and Department of Fisheries and Oceans; officials of the New York State Department of Environmental Conservation and Ontario's Ministry of the Environment and the Ontario Waste Management Corporation; experts from the city of Toronto's Department of Public Health and from the binational citizens organization, Great Lakes United; and scientists from the International Association of Great Lakes Research.

The committee is grateful to the people from these organizations who made presentations (see pages iv and v). Many other persons from these and other organizations were also helpful in providing information for the committee. The staff of the IJC, Environment Canada, and U.S. EPA were especially helpful in this regard.

The committee wishes to extend its thanks to many people including participants at a workshop on coastal waters who represented federal, state, and provincial governments; universities; and environmental organizations. Thanks for cheerful assistance are due to Pierre Garneau and Nancy Steeves of the RSC; Sheila Tooze, Environmental Officer, Embassy of Canada; Donna Wise, Director, Center for the Great Lakes; Jean LaForge, IJC, Windsor Office; and David LaRoche and Rita Kerner, IJC, Washington, D.C., section.

Both the planning activities for the committee's review and the actual review were sponsored by the William H. Donner Foundation, Inc., and the Donner Canadian Foundation.

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SUMMARY OF FINDINGS AND RECOMMENDATIONS

BACKGROUND

The United States and Canada signed the present Great Lakes Water Quality Agreement in 1978, a major elaboration of the previous 1972 Agreement. The new Agreement shifted the emphasis from a primary concern with excess nutrient loadings toward control of toxic substances. A broadly drawn "ecosystem approach" to management and ameliorative steps was also introduced.

A major opportunity to review the Agreement comes in 1986 after the International Joint Commission (IJC) has issued its third biennial report. The objective of the study by the U.S. National Research Council (NRC) and the Royal Society of Canada (RSC) was to review the progress under the Agreement since 1978 from a scientific and scholarly perspective. The study was conducted by a committee of 15 individuals knowledgeable in such areas as ecology, limnology, toxicology, zoology, environmental engineering, aquatic ecosystems, pathology of fish, biology, freshwater ecology, water chemistry, geology, chemical engineering, political science, and international, environmental, and water resources law. Many of these experts were also familiar with research conducted in the Great Lakes and with the joint institutions governing implementation of the Agreement. The review was carried out under the auspices of the NRC and the RSC. Funds were provided by the William H. Donner Foundation, Inc., of the United States and by the Donner Canadian Foundation of Canada. A study to define the scope of the project was carried out from January through October of 1984, including a conference in Buffalo, New York, in April 1984. The review reported herein was conducted from November 1984 through November 1985.

To increase its base of knowledge about water quality problems in the Great Lakes basin and the activities of the agencies responsible for managing them, the committee met with some 20 government officials and others who are involved with the implementation of the Agreement, and it commissioned ten reviews of specific subjects (see Appendix C).

This report is concerned primarily with the progress made under the water quality goals of the Agreement and the current state of scientific and scholarly understanding of water quality issues and the institutions dealing with them. The committee expressly avoided a review that might be considered a comprehensive audit of governmental programs and expenditures related to achievement of the Agreement's

objectives. Earlier studies, such as the 1982 audit by the U.S. General Accounting Office and the IJC's First and Second Biennial Reports of 1982 and 1984, have already indicated that although progress has occurred it has been slow and difficult, partly for reasons of technical and institutional complexity.

THE GREAT LAKES BASIN AND THE 1978 AGREEMENT

The Great Lakes basin's waters include the five Great Lakes (Figure 1-1) and four major connecting channels, with most of the outflow eventually entering the Gulf of St. Lawrence. The relatively small land area of the basin has many urban areas and centers of industrial activity, most of which are expanding. Significant areas of the basin are devoted to agriculture and forestry in which industrialized practices predominate. There is also a hinterland that is sparsely settled but used for recreational purposes. The industrial, commercial, and residential life of some 37 million humans in the basin, and many more millions living outside of it, have the potential to produce intense impacts on the basin ecosystem.

One unique characteristic of the basin, apart from holding a great proportion of the world's surface freshwater (perhaps 20 percent) is the fact that two of the lakes, Michigan and Superior, have a water renewal time of 100 years or more (water renewal time is a relative indication of the time required to flush out contaminants). The two lower lakes, Erie and Ontario, can be flushed more quickly, but their inflowing water comes predominantly from the upper lakes, which, if contaminated, exert a profound influence on the lower lakes.

Both the 1972 and 1978 Great Lakes Water Quality Agreements are widely recognized as among the world's pioneering international instruments designed to foster intergovernmental cooperation to correct pollution in a large river basin. As such, the committee believes that the two governments should continue and strengthen the 1978 GLWQA. These Agreements were undertaken in the context of the 1909 Boundary Waters Treaty between the United States and Canada, also a pioneering initiative for the time. That Treaty is concerned largely with water levels and flows but also with transboundary pollution. Several binational assessments of transboundary pollution problems were undertaken by the IJC within the framework of the Treaty between 1916 and 1968. The 1972 and 1978 Agreements are a continuing (albeit atypical) reference under the treaty, recognizing that periodic attempts to correct damages from pollution had been unsuccessful. By 1972, management capabilities had been developed with respect to water levels and flows, but water-quality actions were mostly reactive to events after they had reached crises.

Over the past century, several different types of action by human activities within the basin have led to deleterious effects on the water and aquatic biota. The problems have gradually expanded from local, to lakewide, to a basinwide scale. Some of these actions have caused relatively benign influences and some have been quite harmful; some have had relatively short-term consequences and others have

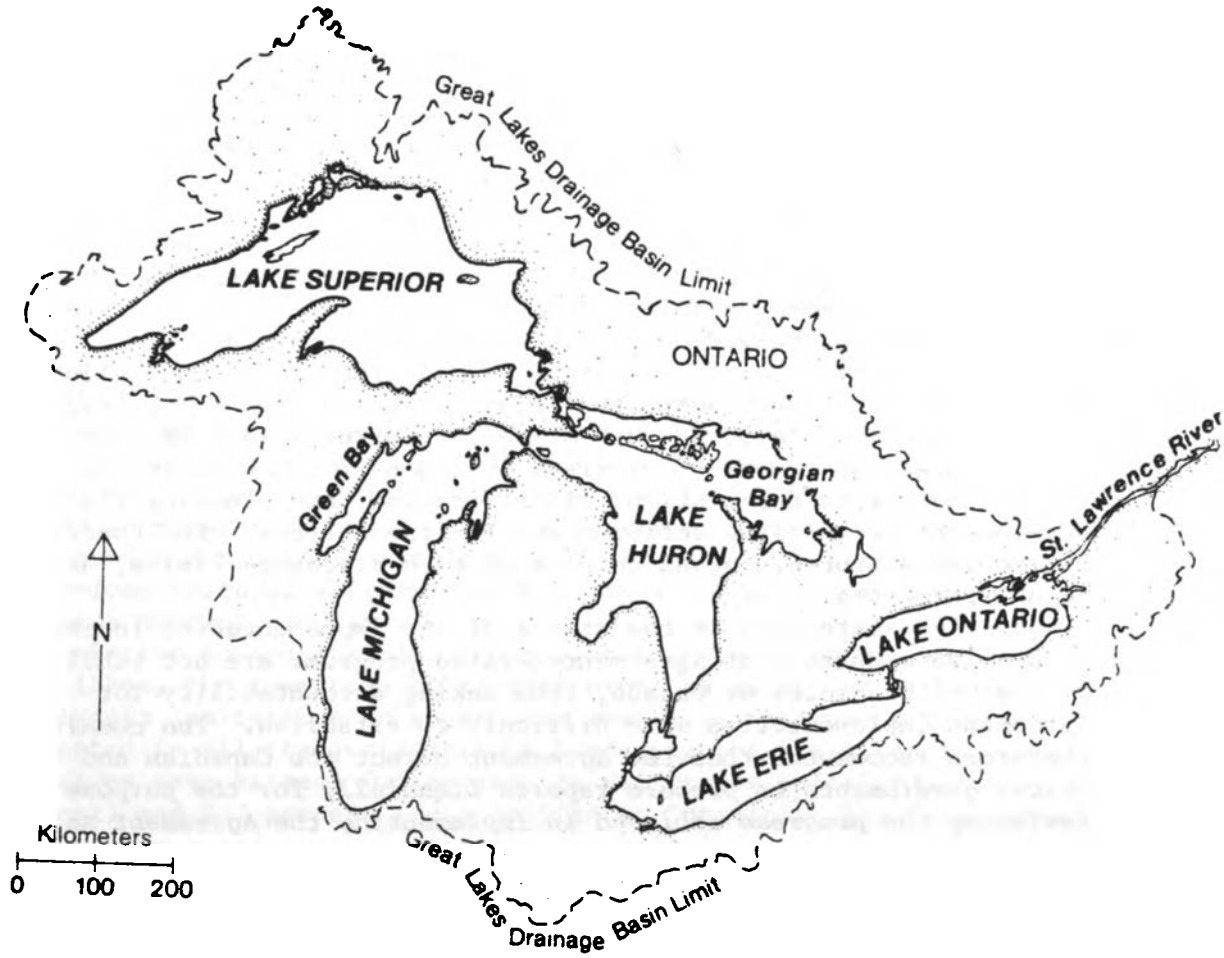


FIGURE 1-1 The Great Lakes.

affected the ecosystem for long periods of time. Some problems are readily apparent to laymen and some can be documented only by using advanced scientific methods.

The changes in the technical problems notwithstanding, the committee finds that major progress was achieved toward meeting the commitments of the 1972 Agreement and that progress with respect to the 1978 Agreement goals may become evident soon. The loadings of phosphates to the lakes have been reduced, and those waters that were severely enriched are showing signs of recovery. The concentrations of certain persistent chemicals are now lower than they were in the early 1970s.

The joint institutions created in the 1978 Agreement, the Water Quality Board (WQB) and the Science Advisory Board (SAB), have proven to be an effective means for advancing dialogue between the parties and among the various jurisdictions (states and provinces) on technical questions and on programs and expenditures.

The committee finds, however, that the goals of the 1978 Agreement have not been totally met. Some loadings of substances have shown decreases (e.g., phosphates, heavy-metal ions, some persistent pesticides, and some organic industrial chemicals from point sources), but others are unchanged or possibly are increasing (e.g., contamination by chemicals leaking from landfill sites and pollutants from various sources transported by air). Despite explicit language in the Agreement providing for corrective measures in what came to be called "areas of concern," progress in the past seven years has related mostly to description, classification, and planning the development of remedial action plans for these areas. Few concrete correction measures, beyond compliance with discharge limits, have been implemented.

Detailed statements on the status of the implementation in their respective countries of Agreement-related programs are not published by the United States or Canada, thus making accountability for Agreement implementation more difficult to establish. ***The committee therefore recommends that the Agreement direct the Canadian and United States governments to prepare reports biennially for the purpose of reviewing the progress achieved in implementing the Agreement and to hold bilateral meetings regularly at the ministerial level with respect to the Agreement.*** The reports by each government should be made public at least 90 days before the scheduled date of the next meeting and the meetings should involve, in addition to the two federal governments, all state and provincial governments in the Great Lakes basin.

ENRICHMENT

Scientific understanding of "eutrophication," or enrichment, in the Great Lakes has improved considerably since the 1972 Agreement, but controversies continue concerning the various responses being observed in the lakes and interrelationships among the various factors involved. The importance of phosphate ions in the enrichment process

has, however, been demonstrated in practice. Costly programs to reduce phosphate loadings have led to improvement in many aspects of water quality and resource productivity that are closely related to the water's fertility. However, both the implementation of phosphate reduction programs and the recovery of the lakes have been slow and are still incomplete.

The committee finds that insufficient attention has been directed to the complexity and dynamics of the enrichment processes, especially in coastal waters, and there is a need for more insightful management of nutrient loading. The usual static approach to sewage treatment may be transformed to a dynamic approach with new computer-based technology at costs less than those of additional conventional treatment facilities. After a slow start, nutrient loadings from diffuse sources in agricultural and urban areas are being combatted.

In addition, the committee finds that more intensive management of phosphorus sources will contribute to attaining the phosphorus control targets and that researchers should conduct an in-depth investigation of the progress and consequences of the eutrophication and phosphorus control program in the open and nearshore waters of the Lakes. If properly exploited, this large-scale experiment--of progressively greater loadings followed by progressively lesser loadings--will yield deeper insight into ecosystem dynamics as a basis for improving the cost-effectiveness of control programs. ***Therefore, the committee recommends that the Agreement should foster continued progress on control of phosphorus loadings with the aim of achieving, at a minimum, the targets specified in Annex 3 of the 1978 Agreement and the 1983 Supplement to Annex 3; and suggests that under Article VII of the Agreement a provision should be made to undertake a study of the decades-long cultural eutrophication process and of the more recent phosphorus control programs.***

In relation to industrial and nonpoint sources of phosphorus inputs to the lakes, the committee notes that with the exception of Ohio and Pennsylvania limitations on phosphorus levels in detergents have been implemented in all the jurisdictions bordering the Great Lakes. Legal limitations vary between 0.5 percent by weight (as specified in the Agreement) and 2.2 percent (as specified in Ontario). The Great Lakes Water Quality Board has calculated that additional reductions in phosphorus in detergents could reduce present phosphorus loadings in the Great Lakes basin by 6 percent. ***Although the prospective additional reductions would not be large, all are important, and the committee recommends that the Agreement further urge all parties to enact phosphorus limits in detergents.***

The committee also finds that the parties should place more importance on the control of nonpoint sources of contamination in order to control phosphorus, as documented by the Pollution from Land Use Activities Reference Group (PLUARG). This should involve a suite of actions, especially control of erosion by agriculture; rehabilitation and preservation of wetlands; and designation of riparian strips free from ploughing, grazing, and urbanization. Such activities would benefit fish habitat and general amenity and would help with the recovery of the lakes. ***Therefore, the committee***

recommends that the Agreement address targets related to control of nonpoint-source pollution in general and that these targets address factors such as erosion control, enhancement of wetland zones, use of riparian strips, and improvement of fish habitat.

It appears that increased investment in municipal sewage treatment plants is the main reason for the success story of the phosphorus control programs. Although initiatives to upgrade municipal waste treatment preceded 1972, construction programs were greatly expanded after that date. Maintenance and improvement of this sewage-treatment system is a problem in larger metropolitan areas, but maintaining sewage-treatment systems over time is a potential long-term problem. Sewage-treatment plants should take advantage of new computer-based capabilities to control effluent characteristics so that impacts on the highly variable nearshore zone are always at a minimum.

Therefore, given the continuing problems of upgrading some of the largest sewage-treatment facilities, the serious difficulties in correcting combined sewer overflow problems, and the narrow age range of the existing sewage-treatment infrastructure, the committee recommends that the Agreement continue to emphasize long-term commitment to the improvement, maintenance, and replacement of sewage-treatment systems. The committee also encourages the planning, design, and implementation of operationally flexible sewage-treatment systems linked to nearshore lake dynamics, in order that the effluent effect of sewage-treatment systems on the lake, and especially on nearshore waters, be minimized on a day-to-day basis.

Many problems cited in the 1969 IJC report on Lakes Erie and Ontario were in the nearshore area. The nearshore is a more complex environment than the open lake and, as a result, the committee recognizes that monitoring and forecasting of changes will present challenges. However, our understanding is not now so imperfect as to forestall certain immediate remedial actions.

The committee therefore recommends that, in view of the fact that the nearshore impinges most on the usefulness of the Lakes and because it is most likely to include the first areas to suffer change, more emphasis in the Agreement should be placed on remediation of nearshore problems caused by untreated sewage, nutrient overloading, and other degrading influences.

The committee finds that the planning and execution of monitoring and research programs should be more intimately coupled than has been the case in recent years; the monitoring programs should also be flexible and to that end should be subject to regular review.

Therefore, the committee recommends that the Agreement provide for the regular review of the progress, effectiveness, and cost-effectiveness of the monitoring programs and of their coupling with the research effort. That review, undertaken perhaps every 5 years jointly by the parties, state and provincial governments with the involvement of the IJC and external reviewers, should examine

- ***Whether the purpose and objectives of the Agreement (Articles II and III) are being served by the monitoring program;***

- ***Whether the program continues to be well matched to recognized and emerging problems; and***
- ***Whether the quality assurance and intercalibration have kept pace with advances in methodology.***

This review should also explore coordination of research projects as recommended by the IJC on research vessels and other platforms so as not to interfere with the primary purposes of those vessels and platforms. The review process should be coordinated with the Great Lakes Fishery Commission on a lake-by-lake basis.

TOXIC CONTAMINANTS

The parties made numerous commitments in the 1978 Agreement (see Appendixes A and B) concerning objectives and programs to control the amounts of "persistent toxic substances" and "hazardous polluting substances" entering the Great Lakes basin ecosystem. In retrospect, these goals were ambitious but probably appropriate for the time especially with respect to zero discharge. The "zero discharge" of persistent toxic substances for which no lower threshold of safety is apparent is consistent with Article IV in the 1909 Boundary Waters Treaty stating that the two countries should not pollute the boundary waters to the injury of the other.

Some progress has been made toward reduction of industrial discharges of toxic substances, although some problems remain. At the same time toxics originating from contaminated groundwater or from atmospheric deposition are more important sources to the Great Lakes than originally thought. Although tightly regulated, certain persistent compounds such as DDT, PCBs, and dioxins apparently continue to enter Great Lakes waters. Toxic substances in sediments continue to be a source for bioaccumulation through food chains into harvestable fish, especially in areas of concern in all the state and provincial jurisdictions. Leakage of contaminants from landfill sites into the Niagara River and into the St. Clair River are of great concern. ***Therefore, the committee strongly endorses the 1985 Great Lakes Science Advisory Board recommendation for mapping of groundwater conditions around and under the Great Lakes basin and for the necessity of data on geology and hydrology, soils, and depth to water tables.*** Toxic substances are carried into Great Lakes waters by vaporization from treatment plants, combustion of fossil fuels, and incineration of waste products from all parts of the basin and beyond it. Toxic substances are also transported to the lakes through the atmosphere from far outside the basin.

In this regard the committee finds that the toxic substances control programs that were relatively easy for governments to act on have progressed furthest (e.g., controls on use of pesticides and on emissions from certain industrial point sources). However, most of the progress on these sources had been made before the 1978 Agreement without reference to the Great Lakes. The more difficult programs, such as controls on diffuse sources, remediation of contamination from

landfill sites, development and implementation of measures to control in-place pollutants, and a more general comprehensive strategy to control atmospheric deposition of toxic substances, have been slow in advancing. For these difficult issues, researchers are still seeking to define and quantify the magnitude of the risks, and program managers and engineers are still considering various corrective measures. Funding for such research, which would result in the needed technological innovation, has been both limited and uncertain.

The committee concludes that the current programs for controlling persistent toxic substances in the Great Lakes Ecosystem are inadequate. Of concern are the lipophilic character of many of the chemicals (such as PCBs and dioxins), the hydrologic residence times of some of the contaminants in the lakes, the ability of the chemicals to biomagnify in the food chains, the evidence of effects on the ecosystem, and possible subtle effects on humans exposed to the chemicals. The lack of effective control measures seems likely to affect many generations to come. Thus, there is an urgency to achieve a reduction of toxic pollutants in the Great Lakes and thereby to reduce the risks to the human population using the resources of the basin.

The committee therefore recommends that measures be taken to increase the awareness of the public (including industry and politicians) as to the extent and implications of the toxic chemicals problems in the Great Lakes basin.

Despite a general goal of zero discharge from known point sources, the jurisdictions on both sides of the border seem not to consider the goal practicable and are accepting moderate levels of contaminant releases from industrial and other sources. The committee finds that significant sources of contamination have remained relatively uncontrolled in the Great Lakes for many years. While the Water Quality Board in 1984 began to develop plans for remedial action in the areas of concern, significant revisions of the relevant sections of the Agreement are still essential. ***The committee recommends that the Agreement encourage action on the major sources of contamination at the areas of concern, that effective solutions be implemented, and that rigorous evaluative case studies be undertaken and published.*** Overall, the committee finds that the sources of toxic substances in the Great Lakes basin are larger and more diverse than was anticipated in 1978, and that control programs need to be much more comprehensive than anticipated.

In view of the above, the committee strongly recommends that as part of a comprehensive toxic substances management strategy there should be components that deal fully with the diverse sources of contamination. This will require

- ***An inventory of all sources of toxic chemicals found at potentially significant levels in the Great Lakes ecosystem and, within the limits of data availability, those that are not responding to present control actions. This inventory would include extrabasin and intrabasin gaseous and particulate emissions, land-based inputs, resuspension from sediments, and inputs from contaminated groundwater.***

- ***Actions toward an effective long-term solution to leaking toxic waste dumps recognizing that although expensive in the short run, the result can be expected to be of benefit to the health of the Great Lakes ecosystem and human population.***
- ***Control actions against all identifiable sources of toxic chemicals to the Great Lakes basin. Studies on the cost-effectiveness of action programs should include the long-term benefits of such programs.***
- ***Siting and operation of modern toxic-waste treatment centers in all regions of the basin. An annex should be added to the Agreement to provide for strict management of toxic wastes, both those disposed of carelessly in the past and those in prospect for the future.***

Existing toxic-waste dumps as sources of contaminants to Great Lakes water are an especially difficult problem. Removal and treatment of these toxic wastes are difficult because they are mixed with earth, debris, and other solid wastes. The nature of the chemicals in these sites are often unknown, and the groundwater may be contaminated. Although action plans are being developed for the most serious sites, ***the committee recommends that the Agreement recognize this issue as an area of priority action.***

As regards the significance of toxic chemicals to human health, the committee finds substantial evidence from the results of studies done by both the U.S. and Canada that the human population living in the Great Lakes basin is exposed to, and accumulates, appreciably more toxic chemical burden than other human populations in similarly large regions of North America for which data are available. The difference appears to be largely due to the higher contaminant levels of food products derived from the Lakes and the basin.

Because of the presence of large numbers of hazardous chemicals in the Great Lakes ecosystem, the committee finds that there is a continuing need for development of methods to measure in-place effects of environmental contaminants, i.e., bioeffects monitors. The current level of bioeffects monitoring is inadequate for determining the impact of persistent toxic substances on the health of biotic systems of the Great Lakes basin. ***Therefore, the committee recommends that improved methods of the scientific study of biological effects of toxic contaminants be developed as an effective early warning system of risks based on subtle effects in indicator organisms such as lake trout. The committee also recommends that aquatic ecosystem objectives, accepted by the IJC, be incorporated into the Agreement and that Annex 1 be revised and published on a regular basis. Furthermore, consideration should be given to developing objectives for mixtures of organic toxic chemicals similar to those developed for mixtures of metals.***

The committee finds that there does not appear to be a coordinated effort by organizations in the United States and Canada to collect specimens encompassing the various components of the Great Lakes ecosystem and ***therefore recommends the incorporation of specimen banking into programs of monitoring and surveillance (Annex 11) as an effective means of augmenting both programs. Both countries should***

provide long-term commitments to specimen banking, as archiving must be continuous and relatively comprehensive.

Applied research on toxic chemical transport, fate, and effects, pertaining to large lake ecosystems, is limited. It is essential for establishing and reviewing reasonable loading targets for the management of toxic chemicals in the Great Lakes. ***Therefore, the committee recommends further development of large-lake transport/fate models for toxic contaminants, so as to understand better the options for controlling them and the consideration of using loading allocations, based on mass-balances, rather than effluent standards based on concentrations of toxic substances.***

Additionally, the committee recommends:

- ***Development of better exposure data for humans in the Great Lakes basin; in particular, the exposure from food consumption and the contaminant loadings of infants require systematic study, including the monitoring of contaminant concentrations in tissues of humans living in the Great Lakes basin compared with other regions.***
- ***Development and maintenance of large-scale epidemiological studies on human populations; such studies should consider the different types of diseases likely to be associated with exposures of the kind being experienced in the basin.***
- ***Where significant exposures are identified, the contaminants in question should become priorities for complete toxicity testing and hazard and risk assessment.***
- ***Where risk and hazard assessments are carried out, they should consider data on total exposures, the potential cumulative effects of such exposures, and the presence of highly exposed critical subpopulations such as breastfed infants.***

The characterization of risk to resources being taken now by the U.S. Environmental Protection Agency, associated with concurrent exposures to several carcinogens (on the basis of additivity) is an important precedent (Environmental Protection Agency, 1984). However, at present there is no existing U.S. law or program based on a policy that considers additive or synergistic effects and no such policy changes are in prospect.

The committee is concerned about the quality, continuity, and general access to data on the distribution and concentrations of toxic substances. ***Therefore, the committee recommends rapid implementation of the new Great Lakes Surveillance Plans and development of measures that will allow data generated by surveillance to be available for binational review.***

INSTITUTIONAL ARRANGEMENTS

The joint institutions involved in the Agreement are the IJC itself, with offices in Ottawa and Washington; the Great Lakes Regional Office in Windsor; and the Water Quality Board and the Science Advisory Board, each with a complicated structure of committees (see Figure 6-1

in Chapter 6). Various government institutions cooperate to implement the 1978 Agreement, including federal, provincial, and state agencies, each with a number of divisions involved. The cooperative arrangements under the 1972 and 1978 Agreements are complicated but no more so than the diversity of contributors to the pollution problems.

The committee finds that for some years after 1978 the joint institutions could only slowly come to grips with the terms of the 1978 Agreement. The Water Quality Board, representing the jurisdictions proceeded almost as a voluntary coordinating committee between government agencies, with little evidence until recently of a responsibility to the IJC for holding the parties to the terms of the Agreement. The Science Advisory Board moved deliberately with respect to the kind of activities begun under the 1972 Agreement, but seems to have had difficulty in dealing with new elements of the 1978 Agreement, especially the ecosystem approach. The inconsistencies in the 1978 Agreement, e.g., between commitments both to zero discharge of hazardous substances and to limited use zones, also appear to have restrained the functioning of the two major joint institutions.

The record of the IJC and the associated joint institutions is one of substantial success with respect to those responsibilities that most closely resemble those of a traditional reference, and for this they deserve much credit. However, these joint institutions have lagged in executing certain responsibilities; and in others, improvements could still be made.

The committee finds that some of the data provided to the Water Quality Board are of varying quality and accuracy and are given in a form that makes comparison across jurisdictions difficult or impossible. Therefore, the IJC should emphasize development of protocols for standardizing the collection of the data.

Because of a lack of central authority and central data system, neither the quality nor accuracy of the reported data can be assessed. This lack of a centralized data system makes it unlikely that all available data will be used, especially for whole lake or multilake studies. ***Therefore, the committee recommends that the Regional Office serve as a clearinghouse to provide information to researchers, governments, and other interested persons on where to locate comprehensive data on the Great Lakes.***

As a result of its review, the committee finds that the Water Quality Board's efforts to coordinate pollution-control programs adversely affects the ability of the IJC, with the assistance of its Boards, to offer independent advice to the parties. The Water Quality Board appears to spend a disproportionate amount of its effort on coordination. This activity diverts limited Board, IJC, and Regional Office resources from other responsibilities. Finally, this role is inconsistent with the Board's role of providing expert advice to the Commission on the implementation of the Agreement and involves the Commission too closely in managing the program that it is intended to evaluate.

The committee therefore recommends that the coordinating responsibilities for the control programs that implement the Agreement

be left to the parties, rather than to the Water Quality Board. This coordination should be handled through bilateral government-to-government meetings.

The committee recommends that:

- ***The Commission provide that members on the Water Quality Board include both individuals who are and are not representatives of government agencies and who reflect the diverse backgrounds relevant to Great Lakes issues, and that the parties to the Agreement cooperate with this Commission initiative;***
- ***The parties should establish that the Science Advisory Board be solely responsible to the Commission and that the Commission ensure the appointment of members who reflect the diverse backgrounds relevant to Great Lakes issues; and***
- ***Make the Regional Office wholly responsible to the Commission.***

Such an arrangement should reinforce the ability of the IJC to develop and offer independent recommendations to the parties.

Disputes over alleged violations of the 1978 Agreement's provisions are significant as they directly influence the continued effectiveness of the Agreement. Under the 1978 Agreement there is no provision for the final resolution of disputes. The procedure exists for formal submission of disputes under Article X of the 1909 Treaty and by design this procedure is cumbersome to ensure that both parties have consented to arbitration of their dispute. The committee believes that the Agreement should provide for both formal and informal means of dispute resolution. Therefore, as a result of the lack of effective dispute resolution mechanisms, ***the committee recommends that the 1978 Agreement provide for processes through which parties can resolve disputes arising over the implementation of the Agreement.***

The Commission and its joint institutions need guidance from the parties as to the priorities that should be pursued and the usefulness of the advice proffered. It is therefore essential that better processes of accountability than exist at present be institutionalized between the two parties and the IJC. ***Therefore, the committee recommends the Agreement call for a meeting between the parties and the Commission following publication of the biennial report from the Commission.*** This would provide a forum for the parties to respond to the contents of the report and to set priorities, within the limits of the Agreement for the ensuing period. The meeting should include officials from the U.S. Department of State and the Canadian Department of External Affairs.

The committee also finds that there is no mechanism for independent verification and peer review of the reports of the Water Quality Board (WQB) and the Science Advisory Board (SAB) to the Commission. As noted in the Commission's first Biennial Report, the Commission has questioned the completeness of the Board reports. ***The committee recommends that, as appropriate, the Commission arrange for an independent review of Board reports.***

The committee has found a trend toward more cooperation among government agencies through various intergovernmental arrangements in

the Great Lakes basin. ***To reinforce this trend the committee recommends that the Commission act to provide for a formal channel of communication between itself and other appropriate binational institutions having responsibilities relating to the water quality of the Great Lakes. This formal channel should however be made more explicit in the Agreement than the general coordination mandate stated in the present Agreement.*** Such formal channels could include a requirement for regular meetings between the IJC and other binational institutions or creation of a standing committee to assist in the coordination function.

The committee also finds that it is difficult for anyone to secure a thorough accounting of the programs and resources of the state and provincial governments devoted to implementing the Agreement. The Great Lakes National Program office attached to the U.S. Environmental Protection Agency, Region V, in Chicago, Illinois, is currently coordinating development of a single program plan that integrates requirements of all federal environmental programs with the initiatives needed for U.S. implementation of the Great Lakes Agreement, and the committee endorses this effort.

The committee recommends that the U.S. Environmental Protection Agency's Great Lakes National Program Office assemble and publish on a regular basis the portions of state and federal program plans for each of the eight Great Lakes states relating to the states activities under the Agreement. In addition, a similar accounting of provincial and Canadian federal program plans should be published regularly by Environment Canada and the Ontario Ministry of the Environment. The committee also recommends that all of the jurisdictions involved with programs and activities called for in the Agreement ensure the complete public disclosure of reports, documents and other records related to these programs and activities.

It appears to the committee that the public has little knowledge of the Agreements' purposes or effects. Therefore, the committee finds that while the public information programs of the IJC and its joint institutions have been useful, they should be improved and given greater financial resources. In addition, ***the committee recommends that the jurisdictions develop substantive reports related to their Agreement-related activities and that these reports be subject to complete public disclosure.***

ECOSYSTEM APPROACH AND SUSTAINABLE DEVELOPMENT

Advances in understanding ecosystem processes, including land-lake and air-water interrelationships in the basin, expanded rapidly in the mid-1970s but appears to have slowed in the 1980s. The 1978 Agreement has not served as a stimulus for further rapid progress with respect to the ecosystem approach. The years since the Agreement was signed may ultimately be seen as a maturation period, leading in future years to strong advances in ecosystem management for large systems, and the emphasis of recent IJC, WQB, and SAB reports of 1984 and 1985 show promise of such an advance.

Binational governance in the basin has been emerging gradually with respect to a number of major ecosystemic features: the hydrologic regime as reflected in lake levels, river flow diversions, and consumptive use; air quality locally as affected by industrial pollution; water quality as affected by phosphate enrichment and diverse chemical sources; and channels as affected by navigational modifications. These issues have been studied and managed in isolation from one another--ecologically, economically, and politically. Research is only now beginning to show how managers might encourage the necessary interactions in carrying out corrective programs.

The committee finds that improving and sustaining Great Lakes water quality is an objective that is intimately related to how the linkages within the basin ecosystem are viewed within and, to an important extent, outside of the Great Lakes basin. Advancing the technical understanding of the hydrology, hydrodynamics, chemistry, and ecology of the lakes serves only to identify continuing problems if institutions and actions are not also linked to the characteristics of the basin ecosystem. The use of the term "Great Lakes basin ecosystem" in the context of a comprehensive statement of purpose in the 1978 Agreement seems to mandate the use of a full understanding of the interconnections within the basin.

Influences on water quality such as climate change or introduction of preferred fish species are not addressed in the Agreement. The Agreement has not fostered forward-looking studies to examine these issues. For example, the rehabilitation of preferred fish species may help to counteract some of the symptoms of prolonged nutrient enrichment, but the fish increase the possibility of human exposure to hazardous contaminants in the lakes. Understanding of these ecosystemic interrelationships has developed slowly in comparison with the need, a situation for which the two parties to the Agreement may be held responsible.

The committee recommends that the overall objective of the Agreement should, therefore, continue to emphasize the systemic characteristics of the basin including the human activities taking place in it. Four kinds of information are needed: time series of monitored data, maps of key features of the ecosystem and of its use and abuse by humans, models of causal relationship integrating human uses and ecosystem responses, and case studies of management actions to demonstrate what has worked and what has not.

The committee also finds that the greatest long-term danger in the Great Lakes is from persistent toxic contamination. Present generations may reap short-lived benefits from exploiting this natural resource as a sink for waste chemicals, only to pass the costs of doing so to future generations. The present generation should more explicitly adopt programs that would remedy past abuses and avoid adverse impacts on future users of the Great Lakes. ***Therefore, the committee recommends that the interests of future generations be considered more explicitly in the Agreement. We should be guided in our actions by two principles of intergenerational equity: the first is conservation of quality, defined as leaving the Great Lakes basin***

ecosystem in no worse condition than it was received from previous generations; the second is to conserve the diversity of the natural resource base so as not to eliminate future options for use of the resource.

The committee finds that the past century presents a record of resource degradation expanding in area, extending in duration, and intruding more deeply into ecosystemic processes. The causes of the impairments are now more complex and have become less evident to the public as well as to scientists. Risks have been identified that seem to affect much larger populations. The sequence of environmental degradation, corrective measures, and then the creation of new environmental threats have not been brought under control by the Agreement.

Three types of future events are likely to occur in the Great Lakes:

- The certain ones that we can predict and understand, which allows the possibility for traditional control;
- The uncertain ones that we cannot predict but can understand, which require flexibility in order to adapt and design for the uncertain; and
- The surprising ones that we can neither predict nor understand which require an atmosphere for learning.

Therefore, the committee recommends that the Great Lakes basin ecosystem be managed not only reactively for unintended impairments but with foresight so as to anticipate and prevent any further diminishment of the resource.

In addition, the committee recommends that the parties to the Agreement carry out a focused binational study addressing questions as to what has happened as a consequence of a number of major interventions, as disclosed by subsequent surveys and monitoring. The aim would be to "mine" the existing data base so as to advance ecosystem understanding most effectively, an activity for which past support has been minimal in comparison with the costs of the interventions.

Looking to the future, the committee finds that there is now a set of issues that could trigger further interventions or actions:

- Consumptive water use within and outside of the basin that will raise demand for water removal and perhaps diversion;
- Transient and persistent toxic chemicals in land, water, and air;
- Existing capital infrastructures for past actions will age and become ineffective;
- Possible climate change; and
- Continuing abrupt changes in the fish and plankton communities as the consequences of fisherman and salmonid interactions.

Consistent with recommendations elsewhere in this review, the committee finds that research on the following topics is urgently needed and if appropriately supported by the parties could be

accomplished by interdisciplinary groups in and near the Great Lakes basin:

- Dynamic understanding of the basin ecosystem, especially with respect to the coastal waters;
- The connections between issues such as lake-level fluctuations, phosphate enrichment, toxic contamination, and fisheries management;
- Economic developments in the coastal zone that do not degrade the ecosystem;
- A comprehensive basinwide strategy for managing toxic wastes;
- A balanced interdisciplinary information system useful for considering the efficacy, cost-effectiveness, and equitability of programs, whether proposed or under way; and
- The likely effects of climate change on the Great Lakes basin and of how we might adapt to them.

In 1982, Charles Ross, a former Commissioner of the IJC, proposed a binational process and conference modeled on the 1972 Stockholm Conference on the Human Environment. The committee endorses his proposal for a conference on the Great Lakes. A conference like the Stockholm conference would focus attention on the importance of the Great Lakes as a resource and on the severity of the problems facing it. If the preparatory work is properly done, the conference could be a catalyst for insightful analysis of critical issues and a vehicle for building a new consensus supporting social and institutional reform. ***Therefore, the committee recommends that the parties to the Agreement hold a binational conference on the Great Lakes and that they establish a Preparatory Committee to develop a draft statement of principles and a draft action plan to be acted on formally at a conference to be held before the end of the present decade.*** The conference might use the kind of process developed for the 1972 Stockholm Conference on the Human Environment.

The committee finds that substantial further reforms are needed in the Great Lakes basin, far beyond the programs specified in the 1972 and 1978 Great Lakes Water Quality Agreements. Now is an appropriate time to face that challenge.

2

THE GREAT LAKES AS A SYSTEM AND ITS BINATIONAL ACCORDS

On partitioning of British North America, the Great Lakes came to be shared in a complex way by the United States and Canada. The early years of this sharing involved primarily exploitive use of the Great Lakes resources. Populations soon expanded, towns and cities grew, and economic activity increased. The Lakes became intensively utilized for transportation, fisheries and waste disposal for town and industry. Disputes over the use of the lakes were inevitable. To resolve several such disputes, at the turn of the twentieth century, such as over the economic use and the aesthetic value of Niagara Falls and the Niagara River and electric generation on the St. Marys River, the International Waterways Commission, forerunner of the present-day International Joint Commission (IJC), was formed in 1905.

The International Waterways Commission, however, recognized that its own purely advisory powers were too limited to deal with the broad range of problems arising along the common boundary. Thus, it recommended establishment of a body with the authority to make binding decisions on any use of the boundary waters affecting levels and flows on either side. The signing of the Boundary Waters Treaty in 1909 provided for such an authority--the IJC. The Treaty also dealt with the quality of the boundary waters.

"It is further agreed," states Article IV of the treaty "that the water herein defined as boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other." In combining the concerns of water quantity and quality within a single article of what is still today a landmark treaty, Canada and the United States took a far-sighted step in creating what has been called the "Regime of Boundary Waters" (Cohen, 1977). However, the problems afflicting the Great Lakes, and the consequences of increasing degradation by human activity, have not always been dealt with as successfully as this long binational institutional history might suggest.

PHYSICAL AND BIOLOGICAL CHARACTERISTICS

The Great Lakes and their associated catchment have been recognized as a unique water complex ever since the first explorations of North

America. The simple notions of interlocking "inland seas" gave them great distinction. Twenty percent of the world's surface freshwater resource is estimated to be in the Great Lakes. Features of their size, depth, and volume are summarized in Table 2-1.

Significant about the Lakes (Michigan and Superior, in particular) is their long water renewal time, which may make them extremely sensitive to pollutant inputs, if these chemicals remain dissolved in the water or if they are precipitated into sediments only to be mobilized again later through ecological processes. How long such chemicals may remain active in such lakes is not known. Thus, even small alterations in the hydrology of Lakes Superior or Michigan may take years to be expressed and are reversible only over a similar period.

Alterations in the biological resources of the Great Lakes, e.g., the fisheries, have proceeded progressively until recently and have been reversed only partially and with great difficulty. Beeton (1965), Regier (1979), and Sonzogni et al. (1983) have summarized these changes over the period since the mid-nineteenth century. In general, significant events in the history of the fishery have been:

1. Loss of the Atlantic salmon from Lake Ontario over a century ago because of loss of reproductive habitat in the inflowing streams and to the intensive fishing.
2. Spread or introduction of the sea lamprey into the lakes where they preyed on lake trout, whitefish, and some other species.

TABLE 2-1 Some Physical and Hydrologic Properties of the Great Lakes

Lake	Area (km^2)	Mean Depth (m)	Volume (km^3)	Mean Outflow ($m^3\ sec^{-1}$)	Turnover Time (yrs)
Superior	82,100	149	12,230	2,130	182
Michigan	57,800	85	4,920	1,470	106
Huron	59,700	59	3,537	5,320	21.1
Erie	25,700	19	483	5,730	2.67
Ontario	19,520	86	510	6,780	2.38

[a]Original source: Chart NOAA, HO 26-611 (11-71), Lake Survey Center, National Ocean Survey, NOAA; see Aubert and Richards, 1981.

[b]Turnover time is equal to the ratio of the lake volume to mean yearly outflow; it does not equal "residence time" of particular substances that may dissolve or form mixtures with the water of a lake.

3. Overfishing of the lake trout and whitefish in all the lakes and especially in the Upper Lakes during the 1950s in a race against the sea lamprey for remaining trout.

4. Enrichment and pollution of inshore areas important to fish through runoff and sewage discharges.

5. Introduction of lampricides in the 1950s to control the impact of the sea lamprey on long-lived species and subsequent implementation of a program of integrated management of the sea lamprey.

6. Controls on the use of DDT and other contaminants in the basin, partly to reduce contamination of the desirable fish, since the 1960s.

7. Expansion of controls of discharges of putrescible substances in the 1950s and nutrient discharges, particularly those from industrial and sewage wastes, in the 1970s.

8. Introduction of Pacific salmonids to the larger lakes to restore predation and control of the alewife since the 1960s.

9. Restoration of some self-reproducing lake trout stocks through re-introduction of eggs and fry on historic spawning shoals, since the late 1960s.

10. Natural recovery of various whitefish and chub stocks of the Upper Lakes and of walleye stocks in various shallow-water areas of the Lakes, since the late 1970s.

11. Health advisories on the consumption by humans of Great Lakes fish have been issued since the early 1960s. In the 1980s there is a trend toward more coordination and agreement on uniform standards to be used by the states in issuing health advisories.

Of greatest concern now is whether the contaminant level in fish is declining. As will be discussed later in Chapters 4 and 5, declines in some contaminants are evident owing presumably to reductions in loadings, flushing of the lakes, chemical breakdown, burial in sediments, and volatilization to the atmosphere, for example. However, new sources of toxic chemical inputs have recently been documented, such as contaminated groundwater, the scavenging of chemicals by rainfall, and dry atmospheric deposition. These inputs, usually of small quantities, may not be of great significance in the lakes with comparatively rapid cleansing times, but elsewhere they may present a new and difficult problem especially in the case of highly reactive pollutants. Where the contaminants are retained, the concentrations of toxic substances in the lake water will, over a century or more, approach equilibrium concentrations that are a function of loadings evaporation, runoff, and other rates. While not now recognized as a health threat in their own right, the prospect of increasing concentrations of certain persistent toxic substances in the water and sediments of these lakes arouses fears that contamination levels of some fish may continue to increase, rather than decrease, under present control strategies.

GREAT LAKES STUDIES, 1912 TO 1951

Widespread public and government concern about changes in the Lakes and study of the resulting problems date from the late nineteenth century. The investigation by the IJC that preceded the Great Lakes Water Quality Agreement of 1972 was, in fact, the IJC's third report dealing with the Lakes, all under the auspices of the 1909 Boundary Waters Treaty (Curtis and Carroll, 1983).

The most apparent pollution problem with the Lakes in the early 1900s was bacterial contamination of drinking water. Severe typhoid fever epidemics had been frequent during this period in cities dependent on the Lakes for their domestic water supplies. The causes of the problem were well understood.

The first study of the Great Lakes was requested by Canada and the United States in 1912 (Table 2-2), soon after the establishment of the Commission. The Commissioners had no technical expertise in such matters. Therefore, they called a conference to obtain advice concerning where and how the investigation ought to be carried out. A detailed plan was drawn up, and a small group of prominent medical doctors and sanitary engineers was appointed to supervise field work. The scope of the investigations was vast. In geographic terms, the studies stretched from Lake of the Woods in northwestern Ontario to the St. John River on the Maine - New Brunswick border, keeping the main focus on the Great Lakes and their connecting channels. The bilateral investigatory group reported that it was "the most extensive bacteriological examination of waters the world has ever known."

The Commissioners had further been asked by the governments of the two countries to recommend "remedial or preventive works." The conference of experts formulated a set of fundamental principles regarding sewage and water purification, which the IJC subsequently adopted. Perhaps the most basic of these was that, while recognizing situations where the ratio of water to volume of sewage was large enough to allow the discharge of crude sewage into boundary waters without danger (as then understood), "effective sanitary administration requires the adoption of the general policy that no untreated sewage from cities or towns shall be discharged into the boundary waters." During the course of the study, the Commission sponsored a series of scientific and engineering workshops on sewage disposal and held public hearings regarding both the extent and causes of pollution and remedial measures.

After receiving further technical documents in 1916, the Commissioners deliberated the findings and issued their final report to the two governments in 1918. This report found that the open waters of the Great Lakes were generally "in a state of almost absolute purity" but that the connecting channels, other rivers along the international boundary, and many nearshore areas were "unsightly, malodorous" and "polluted to an extent which renders the water in its unpurified state unfit for drinking purposes." Indeed, "so foul are they in many places," the Commission said, "that municipal ordinances have been passed prohibiting bathing in them." The causes were mainly

TABLE 2-2 Chronology of the Significant Reports, References and Actions Leading up to the 1978 Water Quality Agreement

Following the 1909 Boundary Waters Treaty, from 1912 until the present day, Canada and the United States have authorized investigations and struggled with the development of procedures to control the pollution of the boundary waters of the Great Lakes (excluding Lake Michigan). These efforts were highly intermittent, gaining in intensity with time. A synopsis of activities (as summarized by L. B. Dworsky) follows:

Date	Reports, References, Actions
1912	The two governments refer the matter of pollution of the Great Lakes to the IJC.
1918	IJC reports to governments that ". . . situation along the frontier is generally chaotic, everywhere perilous and in some cases disgraceful."
1920	Canada proposes a treaty to control pollution to the United States; agreement was not reached.
1946	A reference was again sent to the IJC similar to the 1912 reference pertaining to the St. Clair River, Lake St. Clair, and the Detroit River.
1946	Reference extended to include St. Marys River.
1948	Reference extended to include Niagara River.
1954	In report on 1946 Reference; IJC found injury being caused to health and property from municipal and industrial wastes and shipping sources; recommended that governments adopt specific water quality objectives and extend authority of IJC to maintain surveillance of water quality to insure achievement of quality objectives, Governments approved both recommendations and further authorized establishments of Advisory Boards on each of the connecting channels to report semiannually to the IJC.
1964	A new reference resulting from deteriorating conditions in Lake Erie and Ontario was given to IJC by the two governments.
1970	Final report submitted by IJC to the two governments relative to 1964 reference.
1969-1972	Numerous inter-jurisdictional activities preceding the completion of the Water Quality Agreement.

TABLE 2-2 Continued

1972	On April 15, 1972, the Great Lakes Water Quality Agreement signed in Ottawa by President Nixon and Secretary of State William Rogers for the U.S. and by Prime Minister Trudeau and Secretary of State for External Affairs Mitchell Sharp for Canada.
1972	The Water Quality Agreement of 1972 attached two additional references as tasks to be undertaken by the IJC. The first was "To study pollution in the Great Lakes System from agricultural, forestry and other land use activities"; the second was to "Study pollution problems of Lake Huron and Lake Superior" - the upper lakes.
1978	Following the first five-year review, the Great Lakes Water Quality Agreement of 1978 was signed at Ottawa on November 22, 1978.
1979	The IJC in May 1979 provided governments with a report on "Water Quality of the Upper Great Lakes."
1980	The IJC in March 1980 provided governments with a report on "Pollution in the Great Lakes Basin From Land Use Activities."

domestic sewage and storm runoff, but vessel and industrial wastes were also involved.

The IJC recommended that all municipal and other sewage should be treated, detailed the appropriate "collecting and treatment works" to be constructed, and recommended that the discharge of industrial wastes be prohibited. The Commissioners also recommended that the IJC itself be given the authority to oversee implementation of these remedial measures and to regulate on pollution matters in the boundary waters as a whole. However, the governments did not see fit to confer the necessary powers on the IJC to implement their recommendations. Instead, the general response of the many jurisdictions on the Lakes was the relatively simpler and less costly treatment of their own municipal water supplies with chlorine rather than the more complex and costly treatment to remove organic materials and their decomposition products from the effluents. Typhoid outbreaks largely disappeared, although other pollution problems remained.

The IJC subsequently undertook a second extensive investigation on the Great Lakes between 1946 and 1948 as the result of a series of three references from the two governments. The scope of these references limited the Commission to studying and providing recommendations on the water-quality problems of the Lakes' connecting channels (i.e., the St. Mary's, Detroit, and Niagara Rivers), but the studies were broad in terms of pollutants. The Commission's 1951

report to the governments emphasized not only bacteriological problems, which it found now three or four times greater than in 1918, but also industrial contaminants, which were "now a major problem." Among the specific problems were phenols, oils, and cyanides, as well as high biological oxygen demand. On the basis of this investigation, and perhaps mindful of the fate of the recommendations of the 1918 report, the Commissioners urged international agreement on a set of water quality objectives and establishment of an international board to make further recommendations and to monitor the progress toward meeting these objectives. The approval of both countries of these recommendations, creating modest institutional arrangements for the connecting channels, marked the beginning of a continuous IJC presence on the Great Lakes.

BACKGROUND TO THE 1972 AGREEMENT

The Great Lakes Water Quality Agreement of 1972 grew out of studies done under the IJC from 1964 to 1972 (Gunnerson and Oakley, 1974, and Munton, 1980). The review by Munton (1980) notes that after waiting 7 years for approval by the Ontario government for further study, Canada and the United States formally agreed on a new reference on pollution problems in the Great Lakes.

The Commission, in October 1964, appointed two joint investigatory boards for Lake Erie and Lake Ontario-St. Lawrence River, consisting of technical people drawn from the federal, provincial, and state government agencies. The interim reports of these boards drew extensively from earlier scientific studies and emphasized the problem of nutrients, especially phosphorus, as the cause of eutrophication of the Lakes. The Commission forwarded a report to the two countries in the fall of 1965, with the recommendation that measures be taken to limit phosphorus inputs. Munton observed that "Ontario and the various American governments were not yet willing to consider such measures and the report was set aside" (Munton, 1980). The studies on the Great Lakes continued through 1966-1967.

In 1968 the two boards (for Lakes Erie and Lake Ontario-St. Lawrence River) drafted their final report, which was delivered to the IJC in the early fall of 1969. The report concluded that Lakes Erie and Ontario were indeed being polluted on both sides of the boundary. The report emphasized problems with phosphates and eutrophication and presented data showing, for the first time, the relative contribution of the U.S. and Canadian sources of pollution. The major recommendations were that phosphate control programs "were needed and should be implemented"; new water quality objectives should be established; programs should be adopted so as to achieve the quality objectives; and a new international board should be established to coordinate both the programs and the required monitoring (International Joint Commission, 1970).

Despite indications of differences between representatives of the two countries, the first ministerial-level meeting devoted to Great Lakes pollution problems took place in June 1970 (Gunnerson and

Oakley, 1974; Munton, 1980). The two sides agreed that transboundary pollution existed and that such pollution was contrary to the obligations each had under the Boundary Waters Treaty. A proposal for a joint working group to examine the present programs and the need for a possible agreement was accepted.

In June 1971, the Joint Working Group Report was approved by the two countries' ministerial representatives and the way was cleared for the beginning of formal negotiations of an agreement. A facilitating Canada-Ontario agreement was concluded during the following few months. Finally, after 6 years of studies and 2 years of intensive discussions and negotiations, the 1972 Great Lakes Water Quality Agreement was signed on April 15, 1972, by Prime Minister Trudeau and President Nixon in Ottawa, Canada.

The essence of the Agreement was a set of common water-quality objectives, compatible standards, commitments on implementing programs to achieve these objectives, and procedures for monitoring subsequent progress. Additional responsibilities were given to the IJC for collection and analysis of information on objectives and programs, for the verification of data, for a Water Quality Board to supersede the old Connecting Channels Board, and for a Research Advisory Board to coordinate future scientific work. Such problems as vessel wastes, pollution of the Upper Lakes, and pollution from land use (nonpoint sources) had proved too contentious or too complex; while identified in the Agreement, they were given to the IJC for future study. In September 1972, after consultation with the governments, the commissioners proposed Windsor, Ontario, as the location for the new Regional Office and submitted a staffing plan and budget. The Regional Office staff's responsibilities consisted of acting as a secretariat for the two boards and their various subcommittees under the supervision of the IJC.

Munton (1980) notes that "if institutional developments stemming from the 1972 Agreement, such as the IJC boards and Regional Office, were fairly soon in coming, program developments were considerably slower." The first two reports were careful in trying to evaluate progress versus failure. The IJC report of 1972 emphasized the Commission's need for water-quality data and for better and more comparable analyses of these data. The tone of later IJC reports, based on those of its boards, gradually became more critical. In the 1975 version, the commissioners underscored the board's conclusion that progress had been "generally slow" (Munton, 1980).

THE 1978 AGREEMENT

During the 6 years following signing of the 1972 Agreement many technical studies were conducted cooperatively by experts of the two countries (International Joint Commission, 1982a). Most can be subsumed under three headings: those relevant directly to the 1972 Agreement and conducted under the auspices of the Water Quality Board or the Research Advisory Board; those of the Upper Lakes Reference Group (1976-1977); and those relevant to the International Reference

Group on Great Lakes Pollution from Land Use Activities, PLUARG (1978). The Great Lakes Basin Commission and other groups actively produced relevant information during this period (see Chapter 3). Although there were numerous experts and interested laymen who would have welcomed the opportunity to participate in the writing of the 1978 Agreement, that task was undertaken and completed in comparative secrecy by a small number of officials of the two countries. The IJC was not involved.

The 1978 Great Lakes Water Quality Agreement was signed into effect in late November in Ottawa. The basic structure of the 1972 Agreement was maintained: Joint water quality objectives and standards were set, commitments to implement control programs were made, and the IJC mandate for monitoring progress was continued. There were several more specific changes, however, and these were in some cases quite significant. A revised set of water quality objectives was established, including substantially more stringent standards for radioactivity and contaminants. It was agreed that municipal and industrial pollution abatement and control programs would be put into effect no later than the end of 1982 and 1983, respectively. More stringent overall reductions in phosphorus loadings were set for each of the Great Lakes. The actual division of loadings between the two countries, a much more contentious matter, was left to be negotiated separately within 18 months. The new Agreement further called for the discharge of toxic chemicals to be largely eliminated and specified, by chemical name, approximately 350 "hazardous polluting substances" to be banned from the Lakes. A new surveillance program was also outlined. Finally, but by no means least important, a new term was introduced; the "Great Lakes basin ecosystem," defined as

> . . . the interacting components of air, land, water and living organisms, including man, within the drainage basin of the St. Lawrence River at or upstream from the Point at which this river becomes the international boundary between Canada and the United States.

Thus, in contrast to the 1972 version, which had called for control programs only for Lakes Erie and Ontario, and to the 1909 Boundary Waters Treaty, which defined "boundary waters" as those through which the boundary passed, the new Agreement covered all five Lakes and their tributaries. Consistent with this broader perspective, the purpose of the Agreement was defined as

> . . . to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem. In order to achieve this purpose, the Parties agree to make a maximum effort to develop programs, practices and technology necessary for a better understanding of the Great Lakes Basin Ecosystem and to eliminate or

reduce to the maximum extent practicable the discharge of pollutants into the Great Lakes System.

Since the turn of the century, scientific, policy, and institutional developments have reflected, to a certain degree, a progression toward defining and attempting to deal with the consequences of increasing human exploitation and degradation of the Great Lakes in a broader ecosystemic manner. From the rather narrow, largely bacteriological focus of the 1912-1916 IJC study, through the broader concerns of the Commission's 1951 report, to the exceptionally broad prospectus of the 1978 PLUARG Report, the 1978 Upper Lakes Report, and more recent Commission documents, binational scientific efforts at identifying pollutants and sources have come to a recognition of the multitude of causes. There has been an increasingly broad understanding of the complex effects of these pollutants on the Lakes' ecosystem, including impacts on people. From the restricted focus of the reference on the connecting channels, the geographic area of concern has been broadened to the air, land, and water of the Great Lakes region.

3

THE ECOSYSTEM APPROACH: AN INTEGRATIVE THEME OF THE GREAT LAKES WATER QUALITY AGREEMENT

The catchment that supplies the Great Lakes also supports extensive forestry and agriculture and the commerce of some 37 million people. Since continental glaciers left the basin less than 10,000 years ago, creating a long period of hydrostatic response, the climate of the region has continued to fluctuate. Thus, even the natural systems of the basin are driven by large-scale variations in physical and biological phenomena. The natural variability is, however, damped or magnified to various degrees by socioeconomic activities taking place within the basin and even outside its boundaries. Also, many studies have documented that industrial and agricultural activities, fisheries, water usage, and shoreline developments have altered water quality, biotic productivity, and biological diversity almost everywhere in the basin. Thus, human interventions are probably now the largest influence on the Great Lakes as a resource system, and the result affects most current and intended uses.

The Great Lakes is a closely interconnected system, in space between the land and the lakes, in socioeconomic subcomponents, and in time, as from one generation to the next. Discussion of the interconnections of the system have come to be known as an ecosystem approach apparently as a consequence of development in this field during the 1970's and adoption of a similar phrase in the 1978 Agreement (IJC, 1982b). This chapter explores the scientific background for the adoption of an "ecosystem approach" in the 1978 Agreement, provides definitions, and reviews their implications.

ROOTS OF THE ECOSYSTEM APPROACH

Although the 1978 Agreement was the first formal recognition of the need for an ecosystem approach to management and study of the Great Lakes, the idea had been developing for almost a century. By the mid-1970s, several schools of thought were converging with respect to interconnected phenomena at a significant spatial scale (Patten, 1972; H.R.I., 1976). The main features involved incorporation of quantitative expressions for abiotic processes such as in hydrology and meteorology, biological processes represented in ecology and soil formation, human processes as in demographic and economic studies, and

a synthesis of several of the above as in urban and regional planning and in renewable resource management.

THE EMERGENCE OF THE ECOSYSTEM APPROACH

The pioneering limnologist, E. A. Birge, was one of the first to advance an integrated view of lakes as systems. Sellery (1956) reports that Birge's imagination

> . . . was captured by a view of a lake, or of its plankton community, as a unit whole, a water-cosmos, a complex, interlocking network of physical, chemical, and living processes, yet subject to general laws which should not be beyond the wit of man to discover."

In the decades between Birge's principal studies and the drafting of the 1978 Agreement many other limnologists pursued the concept of interaction between environmental factors, living organisms, and human beings in a holistic, sustainable system, usually referred to as an ecosystem. Numerous individuals from the Great Lakes region have pioneered deterministic modeling within an ecosystem framework. The early limnological systems studies (NAS, 1969), followed by modeling studies on nutrient loadings sponsored by the Water Quality Board, was a novel change from traditional ecology and engineering practices. Compartment models have since been applied to many other water bodies, and from these beginnings more sophisticated modeling in physical limnology, toxic substance biomagnification and chemistry have developed.

From the late 1950s ecosystem studies in the Great Lakes developed in the context of comparative limnology and fisheries limnology, both fostered by the International Limnological Society. The studies by Vollenweider (1968) and Vallentyne (1974) utilized the traditions of comparative limnology; Vollenweider's work with respect to eutrophication was particularly important. Fisheries researchers undertook in 1968 a comparative study of the salmonid community in the Great Lakes and comparable lakes. They focused attention on the separate and joint effects on the salmonid community of eutrophication, overfishing, and introduction of exotic fish species (Loftus and Regier, 1972). Subsequently, a similar study was undertaken of the percid community (Colby and Wigmore, 1977). Attempts have been made since then to develop explanatory simulations of phenomena noted in those symposia (see, e.g., Kitchell et al., 1977).

Regional planning as a complement to ecosystem studies seem to have been fostered in the Great Lakes basin as an extension of river basin planning, an extension in the United States of river basin engineering and resource economics. In 1967 the Great Lakes Basin Commission (GLBC) initiated comprehensive documentation and publication of information on the Great Lakes basin as a human-nature ecosystem

(Great Lakes Basin Commission, 1976). The initiatives were followed by the Great Lakes Environmental Planning Study from 1978 to 1981 (Heidtke and Sonzogni, 1981). The overall motivation of the GLBC was to provide better information for comprehensive planning.

Additional steps toward making ecosystem analysis a predictive science took place during the International Biological Program, which operated for a decade beginning in the mid-1960s. Mathematical and simulation techniques were applied in an attempt to gain an understanding of the workings of ecosystems and to test hypotheses that were derived from prior comparative study. The main emphasis of the International Biological Program was on biological aspects of natural ecosystems in which humans had not been a dominant force, but some of what was learned in these studies with respect to the substance and techniques of ecosystem analysis has since been applied to the Great Lakes (Kitchell et al., 1977; Scavia and Robertson, 1979; Shuter et al., 1979).

During the International Hydrological Decade (1965-1975) a systemic approach to the physical structures and processes of water bodies was fostered. In the Great Lakes, this program led to an International Field Year of the Great Lakes with a fairly comprehensive, multidisciplinary study of Lake Ontario in 1972-1973 (Aubert and Richards, 1981).

Concurrently, the Organization for Economic Cooperation and Development (OECD) in Paris fostered pragmatic initiatives toward understanding systems of importance to humans, including human-environment issues cast in a systemic context. Some of the individuals associated with OECD at the time later worked on modeling global phenomena under the auspices of the Club of Rome. A detailed application of these approaches was implemented to assist planners in the Lake Erie basin (Mesarovic et al., 1970).

In the early 1970s, the International Institute of Applied System Analysis began applications of systems approaches to issues of international importance. One of the Institute's programs went beyond conventional modeling of natural resource systems and proposed techniques termed "Adaptive Environmental Assessment and Management" (Holling, 1978). The human-nature system, as presented by Holling and colleagues, was capable of outcomes that had to be viewed as "surprises," not only because of the ignorance of experts managing the systems, but also because reality was changing (evolving), and fundamentally new properties were appearing in some systems.

To extend the technical advances on the ecosystem approach to policy-related questions a series of Canada-U.S. University Seminars were conducted. Starting in 1971 the first (1971-1973) and second (1975-1977) focused on the use of a multipurpose resource management (river basin) system concept of to plan Great Lakes basin development (Dworsky and Francis, 1973; Dworsky et al., 1974; Dworsky, 1977), the second also initiated studies of the rehabilitation of degraded "areas of concern" (Francis et al., 1979), and the third (1982-1984) treated more comprehensive aspects of the ecosystem approach. A further major attempt to advance understanding of the ecosystem approach took place at a workshop at Hiram College in 1983 under the sponsorship of the

IJC, the Great Lakes Fishery Commission, Great Lakes Tomorrow, and the International Association for Great Lakes Research (Christie et al., 1985). What was sought was a compromise of the more pragmatic and the more reform-oriented interests.

THE 1978 GREAT LAKES WATER QUALITY AGREEMENT AND THE ECOSYSTEM APPROACH

The purpose of the 1978 Agreement as stated in Article II "is to restore and maintain the . . . integrity of the waters of the Great Lakes Basin Ecosystem"; this was a significant change from the 1972 Agreement. The rationale for the adoption of ecosystem goals in management of the Great Lakes basin was provided by the Research Advisory Board (the forerunner to the Science Advisory Board) in "The Ecosystem Approach" (Great Lakes Research Advisory Board, 1978). The report concluded that:

> The accent on water quality in the Boundary Waters Treaty of 1909 and the accent on water quality objectives in the Great Lakes Water Quality Agreement of 1972 have, in the absence of an ecosystem approach, unduly constrained the parties and the Commission from attaining the desired goal expressed in the Boundary Waters Treaty of 1909 . . . . Adoption of the ecosystem approach will relieve these constraints, facilitating the restoration and enhancement in perpetuity of the quality of boundary waters.

Although the 1978 Agreement embraced the concept of a Great Lakes basin ecosystem and the need for ecosystemic approaches to the management of the basin and the lakes, it did not specify how the concept and approach would be applied in an operational sense. There are, however, commitments in the Agreement that address particular sets of issues, including toxic chemicals, nutrients, and monitoring and surveillance, that are essentially ecosystemic in nature. For example, Article IV.3(b) of the Agreement specifies that the parties shall consult on

> The control of pollutant loading rates for each lake basin to protect the integrity of the ecosystem over the long term.

An important component for implementing an ecosystem approach is an appropriate comprehensive information system. To meet this need, the governments committed themselves inter alia, to the implementation of an ecosystem monitoring program, as specified in Article VI, Section (m), which calls for

> Implementation of a coordinated surveillance and monitoring program in the Great Lakes System . . . to assess compliance with pollution control requirements and achievement of the Objectives, to provide information for measuring local and whole lake response to control measures, and to identify emerging problems.

In its 1981 report (Water Quality Board, 1981), the Water Quality Board cautioned that the ecosystem concept is frequently "misused and misunderstood." The concept, they state, is

> . . . not a finite object, program, or activity. While it provides the philosophical framework and scientific rationale to grasp the notion that "everything in the basin is related to and affects, to some degree, everything else in the basin," actual jurisdictions are based upon the control or protection of specific uses of the water, the air, and the land. By reporting on the quality of the water, sediment, fish, and biota of the Great Lakes, the Board provides the status of the environmental quality of the lakes consistent with the ecosystem concept; and in doing so declares its belief that management of "Great Lakes environmental programs within an ecosystem concept is achievable and, indeed, progressing."

Other binational governance arrangements have also embraced the ecosystem concept in various statements. The Great Lakes Fishery Commission endorsed such a policy in 1981. In 1985, the Governors and Premiers of the Great Lakes States and Provinces signed the Great Lakes Charter, an agreement concerned mostly with issues of water quantity, i.e., levels, flows, consumptive use, and diversions. In its first principle, the Charter recognizes the Great Lakes as an ecosystem and sets in place a system for cooperation among the provinces and states for planning and management within an ecosystem framework, particularly issues such as diversions and consumptive uses of the Great Lakes waters (Great Lakes Governors Task Force on Water Diversion and Great Lakes Institutions, 1981). The Charter states:

> The water resources of the basin transcend political boundaries within the basin, and should be recognized and treated as a single hydrologic system. In managing Great Lakes basin waters, the natural resources and ecosystem of the basin should be considered a unified whole.

DEFINITIONS AND BOUNDARIES OF THE SYSTEM

We have shown that the term "ecosystem" connotes a system of interacting components, physical and biological, having some degree of internal linkage and an implied boundary, albeit inconstant and temporally indistinct. In relation to the purpose statement of the Great Lakes Water Quality Agreement, some individuals hold the view that the entire drainage basin, down the St. Lawrence River to a point upstream of its confluence with the Ottawa River, should be viewed as the ecosystem of primary concern, a system in which natural and human-modified components are interacting as parts of the basin ecosystem. Others argue that there is relatively little exchange between the major lakes and that each one functions as a separate ecosystem; they may also hold that human components are external influences on the system.

The differences between these views are, first, whether hierarchical linkages in space will or will not be emphasized, and second, whether culturally induced influences will or will not be viewed as integral parts of the system. The committee does not find these differences to be fundamentally contradictory, rather they are a matter of practical or theoretical convenience. However, it concludes that the language used in phrasing the purpose of the Agreement should be interpreted comprehensively.

Three primary characteristics of the ecosystem approach are evident from the background and definitions presented above (Lee et al., 1982):

- The ecosystem approach requires comprehensive consideration of the variables (water, chemicals, toxic substances, and the biota, for example) making up the basin ecosystem--variables that range widely in both temporal and spatial scales.
- When applied to a large regional system, the ecosystem approach requires consideration of three major interacting subsystems: physical, chemical, and biological phenomena; responsible institutions and their interactions; and the socioeconomic system that utilizes the resources and receives the benefits or bears the burden of the result of management actions.
- The ecosystem approach carries with it an expectation of management and criteria for taking management actions; the latter are implicitly beyond the scope of conventional scientific inquiry in that they incorporate societal values, relationships to increasingly scarce resources, and evolving life styles in the basin.

The sections that follow use the term "ecosystem approach" extensively, as does the literature cited. Our examination of the ecosystem approach, as it appears to have been implemented (or ignored) in managing nutrients and toxic substances, and in adopting institutions to pursue the goals of the Agreement, incorporates all three of the above considerations.

Use of the term "ecosystem approach" here encompasses two somewhat different concepts each of which can be seen in source materials as an "ecosystem approach." In one, it may be seen as an improvement over

comprehensive planning and applied systems analysis for purposes of cost-effective government, using mostly scientific and technical advances in an interdisciplinary context. Alternatively it may be seen as having deep connotations with respect to values and sustainability of development and may be invoked as support for a more radical reform of the resource use practices of western culture.

A broad spectrum of opinion seems to exist within the IJC family of institutions; there are those who view the ecosystem approach as involving at most a pragmatic improvement over business as usual and those who see in it hope for gradual change in resource development policies. The first six chapters of this review emphasize the pragmatic portion of this spectrum. While the seventh chapter takes up the more idealistic aspects of the ecosystem concept.

INTERDEPENDENCIES OF THE SUBSYSTEMS

Three substantive interacting subsystems were identified above: the biophysical, the institutional, and the socioeconomic. Past management of the lakes, and trends in management of terrestrial and aquatic resources in both countries, have followed a characteristic sequence: remedial management to protect or augment production from a local abuse is initially successful; however, social and economic dependencies grow (e.g., a larger more intensive fishery, more tourism); finally the management institutions tend to replace the original social goal with an operational goal (e.g., to hatch and stock fish, to augment visitor-days). In so doing the institutions may become subject to internal rigidities that make them insensitive to changes in the system being managed.

Improving and sustaining Great Lakes water quality is an objective that is intimately related to how the linkages within the basin ecosystem are viewed within and, to an important extent, outside the Great Lakes basin. Advancing the technical understanding of the hydrology, hydrodynamics, chemistry, and ecology of the Lakes serve only to identify continuing problems if institutions and actions are not also linked to the characteristics of the basin ecosystem. The future potential for economic development of the Great Lakes basin is related to the quality of the water; the habitat value of the shoreline and foreshore for wildlife, waterfowl, and fish; and the aesthetic and recreational amenities offered to human communities by the system as a whole. The use of the term "Great Lakes basin ecosystem" in the context of a comprehensive statement of purpose in the 1978 Agreement seems to mandate the use of a full understanding of the interconnections within the basin.

In the committee's opinion, the overall objective of the Great Lakes Water Quality Agreement should, therefore, continue to emphasize the systemic characteristics of the basin including the cultural (e.g., economic) activities taking place in it.

4

NUTRIENTS ISSUES

INTRODUCTION

A compelling consensus exists among limnologists that phosphate (PO_4 or simply P) is the usual limiting factor in lakes and that addition of P leads to proportionate increases in algal productivity and various secondary consequences (Likens, 1972; Schindler, 1977; National Academy of Sciences, 1969; Vollenweider, 1968). The consequences can involve deoxygenation and the loss of certain species of fish. There is no reason to believe that these broad principles do not apply to the Great Lakes. Indeed it has been established that excessive growths of Cladophora, a common alga on the shores of the lakes, with many undesirable attributes, are produced under experimental conditions by additional phosphate (Neil and Owen, 1964; International Association of Great Lakes Research, 1982).

The process of change in the quality of a water body caused by increased plant nutrient levels is called eutrophication or enrichment; when caused by human activities, the process of enrichment has been called cultural eutrophication. It is not appropriate to refer to cultural eutrophication as "premature aging."

The purpose of the Agreement is ". . . to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes basin ecosystem." To achieve this ambitious goal, the parties stated that one of their general objectives was that "These waters should be: . . . free from nutrients directly or indirectly entering the waters as a result of human activity in amounts that create growths of aquatic life that interfere with beneficial uses."

Phosphorus, although pre-eminent, is not the only limiting nutrient. Silica concentration influences diatom abundance and species composition, the nitrogen-to-phosphorus ratio affects the dominance of blue-green algae during summer algal blooms, and other nutrients, for example nitrogen, may become limiting in lakes in which the phosphorus concentration is already high (Welch, 1978). Nitrogen limitation is now widely believed to affect the degree of dominance by blue green algae, but not standing crop or production (Smith, 1983). However, the predominant role of phosphorus in regulating primary production of lakes, including the Great Lakes, and the availability of control options for major sources of phosphate inputs led to the primary emphasis on phosphorus control measures in the 1972 Agreement (Welch, 1978). Growing scientific consensus, results of modeling

studies, and advances in sewage treatment technology reinforced this emphasis on phosphorus control in the 1978 Agreement (Water Quality Board, 1985).

Therefore, nutrient issues addressed in this chapter deal almost exclusively with phosphorus. The committee details the objectives of the 1978 Agreement as they relate to phosphorus and the current condition of the lakes. It describes the control programs mandated by the Agreement and assesses their effectiveness. It finds that the parties have achieved substantial compliance with the commitments but that the Great Lakes ecosystems remain stressed under nutrient loadings and require continued attention.

CONTROL OBJECTIVES AND CURRENT CONDITION OF LAKES

Annex 3 of the 1978 Agreement states that the purpose of the phosphorus control programs is ". . . to minimize eutrophication problems and to prevent degradation with regard to phosphorus in the boundary waters of the Great Lakes System." The specific targets listed in Annex 3 are

(a) Restoration of year-round aerobic conditions in the bottom waters of the Central Basin of Lake Erie;
(b) Substantial reduction in the present levels of algal biomass to a level below that of a nuisance condition in Lake Erie;
(c) Reduction in present levels of algal biomass to below that of a nuisance condition in Lake Ontario including the International Section of the St. Lawrence River;
(d) Maintenance of the oligotrophic state and relative algal biomass of Lakes Superior and Huron;
(e) Substantial elimination of algal nuisance growths in Lake Michigan to restore it to an oligotrophic state; and
(f) The elimination of algal nuisance [growths] in bays and in other areas wherever they occur.

The Water Quality Board reported in 1985 that, on the whole, water quality problems caused by enrichment or eutrophication have decreased since 1972. Lake Superior continues to be oligotrophic (low in nutrient levels) although a few local nearshore areas have eutrophication problems. Lake Huron also remains oligotrophic, and the condition of Saginaw Bay is markedly improved. Lake Michigan remains oligotrophic, but some nearshore areas show signs of degradation, although there is no indication of worsening conditions. Lake Erie has remained fairly high in phosphorus content, possibly because of release of nutrients stored in sediments, but there are signs of a downward trend. Finally, Lake Ontario has shown a steady

decrease in phosphate; the mean total concentration in 1983 was the lowest reported in 14 years, and the composition of the plankton has changed to species indicative of oligotrophic systems.

Despite these successes, four of the Water Quality Board's recommendations in its 1985 report call for further reductions in the inputs of phosphate to the lakes. We support these recommendations and deal with them below.

RATIONALE FOR PHOSPHORUS CONTROL

Despite the encouraging reports of improvements in the Great Lakes arising from partial achievement of the phosphorus loading targets and implementation of the control programs set out in the Agreement, some problems remain. For example, although the estimated phosphorus loading into Lake Erie from all sources declined by 56 percent between 1968 and 1982, the annual mean concentrations of total phosphorus in the central basin's epilimnion over the same period declined from 21.3 to 12.0 mg m^{-3}; but those concentrations have been "highly variable and have not decreased in a fashion comparable to reductions in phosphorus loading" (Water Quality Board, 1985).

The other presumed index of nutrient enrichment in Lake Erie--development of anoxia in the hypolimnion of the central basin--has not yet shown an unmistakable downward trend distinguishable from the noise of year-to-year variability imposed by weather and water level changes. Figure 4-1 (Water Quality Board, 1985, based on data from F. Rosa, Canada Centre for Inland Waters, and from the Center for Lake Erie Area Research, Ohio State University) shows that, despite

> . . . some natural variability in oxygen depletion rates due to meteorological factors, highest oxygen depletion rates occurred during the 1960's and 1970's. It was then that Lake Erie was at the height of cultural eutrophication, exhibiting highest total phosphorus concentrations and algal biomass. In recent years (1980-1984), oxygen depletion rates appear to have decreased and are less variable. While the central basin still undergoes some degree of anoxia, this apparent decrease in the rate of oxygen depletion and less variability suggest that the phosphorus reduction program is having a positive effect on this region.

Other treatments of the same data set (for example, Charlton, 1980; Barica, 1982) lead to somewhat different interpretations; this remains an active area of research. Also other indicators of water quality such as water transparency, chlorophyll-a content, and possibly some beneficial changes in fish population are

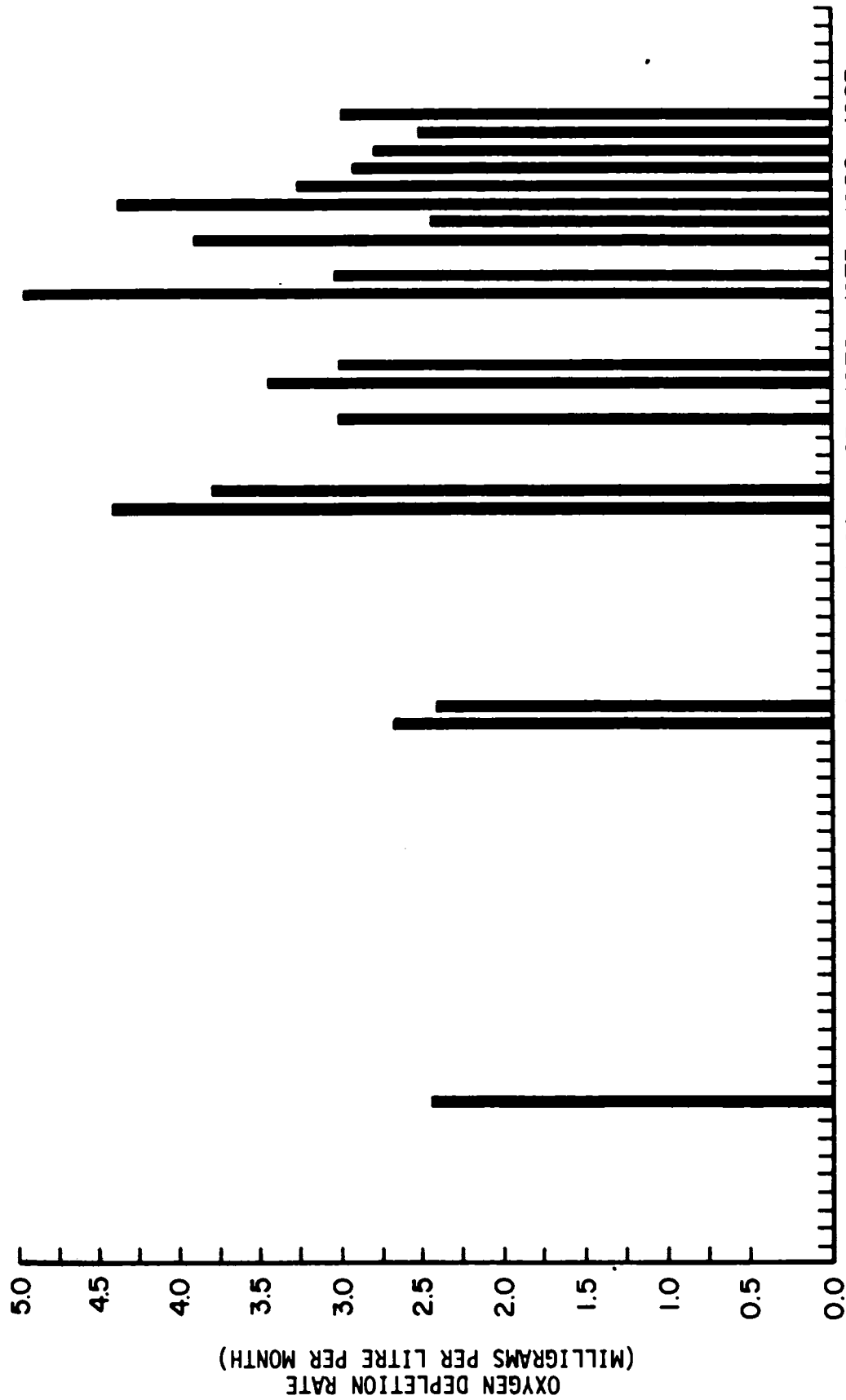


FIGURE 4-1 July hypolimnion oxygen depletion rates for the central basin of Lake Erie, 1929-1984.

SOURCE: Water Quality Board, 1985. (Based on data from F. Rosa, Canada Centre for Inland Waters, and from the Center for Lake Erie Area Research, Ohio State University.

> . . . suggestive of an overall improvement in well-being of the Lake Erie ecosystem. On the other hand, documented increases in the concentration of NO_3 + NO_2 should be interpreted as a potential cause for concern (Water Quality Board, 1985).

Another scientific debate in progress concerns the link between the production of algae and the control of phosphorus loads into Lake Michigan. Following the lines of generally accepted eutrophication theory, on which the phosphorus control programs were based, it had been predicted that increased loading would lead not only to an increase in biological productivity at several food chain levels but also to population changes toward dominance by less desirable blue-green algae. This may be seen as "ecosystemic control from the bottom up," from nutrients to algae to zooplankton to fish. However, there is evidence that another control mode may also have been operating "from the top down," in which reduction of predatory fish contributed to a proliferation of alewives, which led to reduction in large species within zooplankton populations with consequent changes in grazing pressures on algae; such changes in the grazing regimes with concomitant changes in phosphate cycling led to high densities of algae and the resultant turbidity. Different interpretations of algal increase in Lake Michigan, e.g., as espoused by C. L. Schelske, University of Michigan, and J. Shapiro, University of Minnesota, figured prominently in the Illinois versus Milwaukee case concerned with pollution of that Lake (Mortimer, 1981). That eutrophication had occurred was clear, specifically why it had occurred was debatable. The arguments and the outcome are perhaps less important than the fact that this and other debates on eutrophication theory continue and that it is now too early to specify the final effects and benefits of the phosphorus control measures in the Great Lakes. In the meantime the committee believes that

- More intensive management of phosphorus sources will be needed to attain the phosphorus control targets for point sources and control of phosphate concentrations in detergents and implementation of strategies for control of nonpoint sources (see similar recommendations in Water Quality Board, 1985); and, equally important,
- Researchers should conduct an in-depth investigation of the progress and the consequences of the eutrophication and phosphorus control program in the open and nearshore waters of the Lakes. If properly exploited, this large-scale "experiment"--of progressively greater loadings followed by progressively lesser loadings--will yield deeper insight into ecosystem dynamics as a basis for improving the cost-effectiveness of control programs. Therefore, the committee recommends continued progress on control of phosphorus loadings with the aim of achieving, at a minimum, the targets specified in Annex 3 of the 1978 Agreement and the 1983 Supplement to Annex 3 and that a study be undertaken of the decades-long cultural eutrophication process and of the phosphorus control programs.

PHOSPHORUS CONTROL PROGRAMS

Phosphorus enters the lakes from a variety of sources and in a variety of chemical forms. Municipal sewage-treatment plants have been consistently identified as major sources of ecologically active phosphorus. Other important sources include industrial pollutants, urban waste water, and rural runoff. The biological availability of phosphorus from nonpoint-source runoff is still a subject for research. The priorities for phosphorus control in the Agreement, therefore, first emphasized point-source reduction, to be followed by efforts to reduce nonpoint-source loading. A series of programs was itemized to achieve Annex 3 targets. These programs included:

(a) Construction and operation of municipal waste treatment facilities in all plants discharging more than one million gallons per day to achieve, where necessary to meet the loading allocations to be developed pursuant to paragraph 3 below (see page 25 of Agreement), or to meet local conditions, whichever are more stringent, effluent concentrations of 1.0 milligram per litre total phosphorus maximum for plants in the basins of Lakes Superior, Michigan, and Huron, and of 0.5 milligram per litre total phosphorus maximum for plants in the basins of Lakes Ontario and Erie.

(b) Regulation of phosphorus introduction from industrial discharges to the maximum practicable extent.

(c) Reduction to the maximum extent practicable of phosphorus introduced from diffuse sources into Lakes Superior, Michigan, and Huron; and reduction by 30 per cent of phosphorus introduced from diffuse sources into Lakes Ontario and Erie, where necessary to meet the loading allocations to be developed pursuant to paragraph 3 below, or to meet local conditions, whichever are more stringent.

(d) Reduction of phosphorus in household detergents to 0.5 per cent by weight where necessary to meet the loading allocations to be developed pursuant to paragraph 3 below, or to meet local conditions, whichever are more stringent.

(e) Maintenance of a viable research program to seek maximum efficiency and effectiveness in the control of phosphorus introductions into the Great Lakes.

In addition, by 1980, Canadian and U.S. governments, in cooperation with the provincial and state governments, were to confirm permissible

future phosphorus loads for each lake and establish load allocations and compliance schedules. When the parties finally completed this task in 1983, they did not, however, formally approve the future loading targets specified in Annex 3 of the 1978 Agreement. Instead they signed a supplement to Annex 3 (see Appendix A) which released target effluents for Lakes Erie and Ontario back to the 1972 Agreement level of 1.0 ppm.

MUNICIPAL SEWAGE SOURCES

Substantial progress has been made in implementing the municipal waste treatment facilities program. The United States and Canada have spent or committed more than $8.8 billion to construct and upgrade municipal wastewater treatment plants in the Great Lakes basin (Water Quality Board, 1985).

According to the WQB, by 1981, total loading objectives for phosphorus had been achieved approximately, in both Lakes Erie and Ontario (Figure 4-2). However, this claim of success should be treated with caution because Figure 4-2 (Water Quality Board, 1985) has no indication of the degree of reliability of the estimates, e.g., no confidence intervals. We also note that the WQB's round-robin study of laboratories that produced the data on phosphorus concentrations in municipal waste waters showed that a large number of the laboratories "have some difficulties in accurately carrying out phosphorus analyses" and that "their results may be biased, and, in a few cases, erratic" (Water Quality Board, 1985). The Reference Study that we have recommended would, as a matter of course, need to re-evaluate all such data and assign some level of confidence to them.

Though the 1978 Agreement originally called for effluent limits of 0.5 ppm phosphorus for all large sewage-treatment facilities in the Lake Erie and Lake Ontario basins, this was revised in 1983 to 1 ppm phosphorus.

By 1982, municipal sewage-treatment plants in both jurisdictions achieved an overall average effluent phosphorus concentration of 1.0 ppm in Lake Erie (Water Quality Board, 1985), but, of course, this does not imply full compliance. In Lake Ontario, progress has been slower, mainly because the average effluent concentration in U.S. sewage-treatment plants continued to exceed the 1.0 ppm level (Figure 4-3). Seven large sewage-treatment plants in Michigan, Ohio, and Ontario still exceed the 1.0 ppm phosphorus effluent limit (Water Quality Board, 1985). Although further progress may be expected from planned municipal projects, rising costs of separating combined sewer systems in large urban areas, as in Toronto, may substantially slow improvement rates. In many cases, approaches to improving sewage-treatment plants may have been biased toward costly capital improvement projects, sacrificing reliability and possibly less costly technical innovation in the process.

Increased investment in municipal sewage-treatment plants is the major success story of the phosphorus control programs of the 1972 and 1978 Agreements. Although initiatives to upgrade municipal

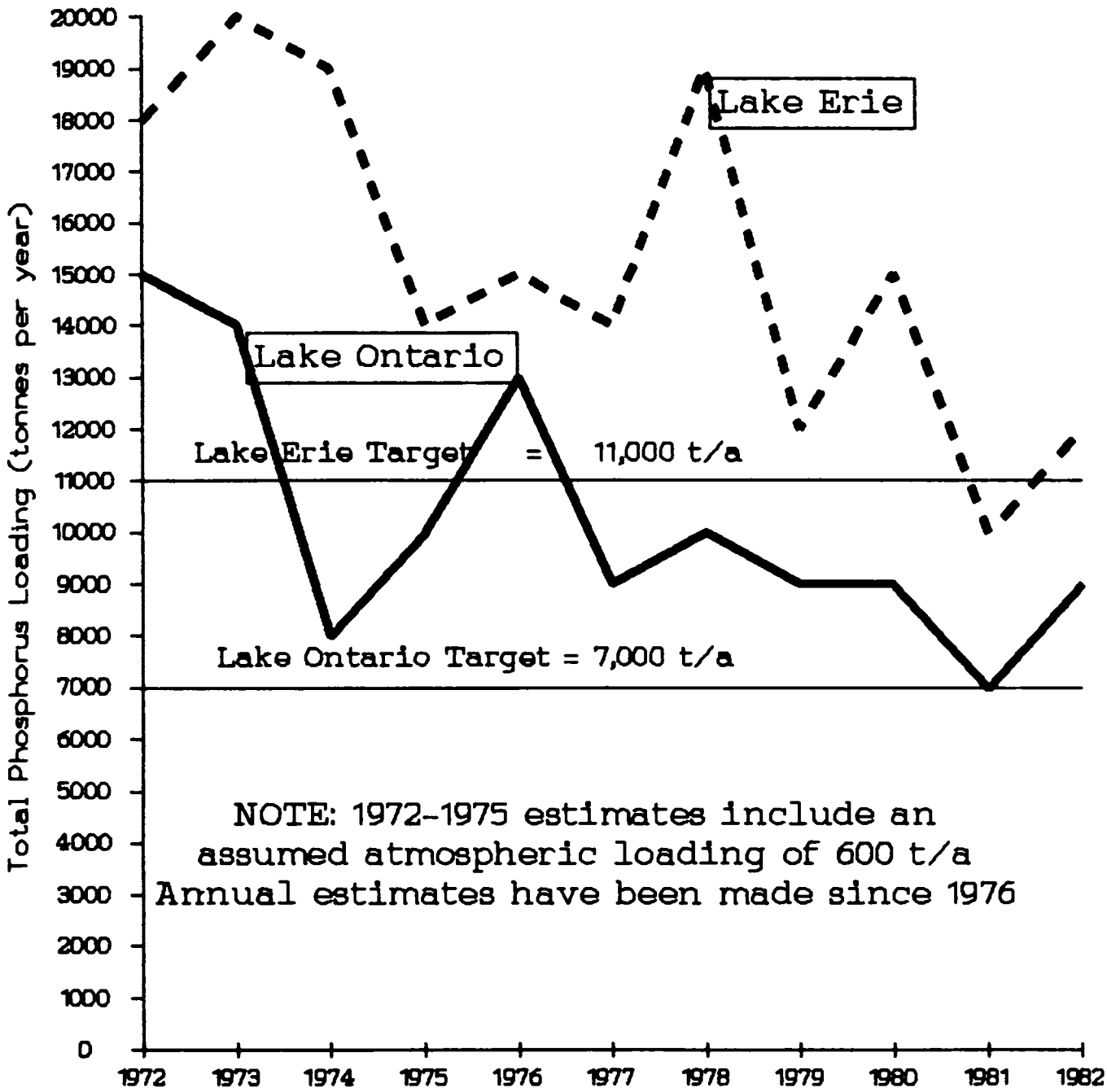


FIGURE 4-2 Estimated total phosphorus loadings to the lower Great Lakes.

SOURCE: Water Quality Board, 1985.

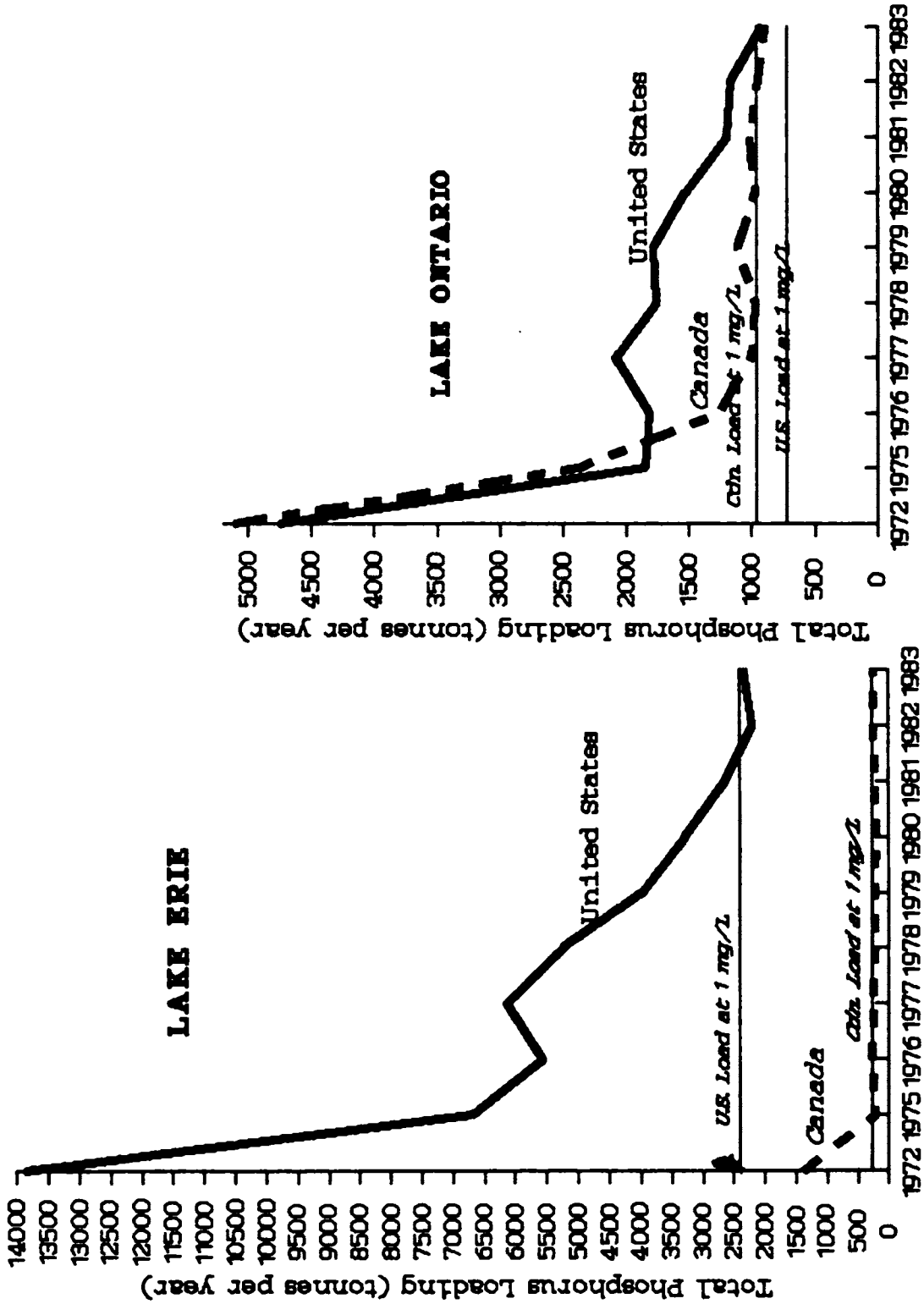


FIGURE 4-3 Municipal phosphorus loadings to the lower Great Lakes.

SOURCE: Water Quality Board, 1985.

waste-treatment preceded 1972, both Agreements have accelerated construction. Maintenance and improvement of this sewage-treatment system is currently a problem in some isolated sewage-treatment facilities in larger metropolitan areas, and the aging of the system is a potential long-term problem across the basin.

Given the continuing problems of upgrading some of the largest sewage-treatment facilities, the serious difficulties in correcting combined sewer overflow problems, and the narrow age range of the existing sewage-treatment facilities, this committee recommends that implementation of the Agreement continue to emphasize long-term commitment to the improvement, maintenance, and replacement of sewage-treatment systems.

Field and modeling studies (Hydroscience Inc., 1973; Thomann et al., 1974; Scavia, 1979) have shown that phosphorus loadings result in different daily limnological responses for different physical, chemical, and biological conditions. At the same time, sewage-treatment systems operate at variable efficiencies and produce variable amounts of effluent on a daily basis. Sewage-treatment systems should be designed to operate in a flexible fashion in order that their effluent will have minimum impact on the receiving water body on a real-time (short-interval) basis. Thus, during critical high flows in sewage-treatment systems, or during critical periods for algal growth, or critical mixing conditions, the sewage-treatment systems would operate to have a minimum impact on the lake with low probability of exceedance.

With modern automated water-quality data collection and computer-controlled operational capabilities of sewage-treatment systems, it is now timely to combine the concepts of limnological response models and sewage-treatment planning and design modes into an operational water-quality management tool (Beck, 1981). Such real-time flexible sewage-treatment operations, in fact, are being implemented in some metropolitan districts in the United States, where the importance of the receiving water and benefits of quality receiving water are recognized (Coffee et al., 1979, McPherson, 1980). Such design and planning concepts need to be assessed for the Great Lakes and implemented wherever possible. Furthermore, this ecosystem-oriented lake-response concept needs to be applied to future planning and design of treatment plants.

The committee finds that planning, design, and implementation of operationally flexible sewage-treatment systems linked to nearshore lake dynamics should be emphasized in order that the effluent effect of sewage-treatment systems on the lake, and especially on nearshore waters, be minimized on a day-by-day basis.

INDUSTRIAL AND NONPOINT SOURCES

In 1983, the Great Lakes Water Quality Board estimated that phosphorus inputs into the Great Lakes from industrial sources are less than 10 percent of the municipal load to the lakes. The Board concluded that "while industrial phosphorus inputs do not constitute a major

system-wide problem their contribution to specific areas of concern demands greater jurisdictional attention." Reporting also appears to be a problem for industrial sources (Water Quality Board, 1985), and the committee endorses the 1985 Water Quality Board recommendation to monitor and report those industrial sources that discharge 3.8 kg/day or more of phosphorus.

With the exception of Ohio and Pennsylvania, limitations on phosphorus levels in detergent have been implemented in all the jurisdictions bordering the Great Lakes. Legal limitations vary between 0.5 percent by weight (as specified in the Agreement) and 2.2 percent (as specified in Ontario). The Great Lakes Water Quality Board has calculated that additional reductions in phosphorus in detergents could reduce present phosphorus loading in the Great Lakes basin by 6 percent. Although the prospective additional reductions would not be large, all are important, and the committee recommends that the Agreement further urge all parties to enact phosphorus limits in detergents.

Progress in programs to control diffuse and nonpoint sources of phosphorus has been uneven. Nonpoint sources remain the major obstacle to achievement of phosphorus load targets specified in Annex 3 and affirmed by the parties in the 1983 Supplement to Annex 3. It seems clear that the main source of nonpoint loading of phosphorus is from agriculture, and the committee endorses the approaches for controlling agricultural runoff that are specified in the Supplement to Annex 3.

The parties' slow progress on nonpoint-source phosphorus loading is, in part, due to the large number of institutions involved in making and enforcing regulations. In a larger sense the delay in implementing basinwide phosphorus limits in detergent, the delay in adopting phosphorus loading targets in Annex 3, and the lack of programs to address nonpoint-source control of phosphorus loading suggest a loss of "will" to do more than attempt control of point sources of phosphorus pollution with rather old-fashioned methods.

Because of its importance in control of phosphorus (and probably also of toxic substances), as documented by the Pollution from Land Use Activities Reference Group, the Agreement should place more importance on the control of nonpoint sources of contamination. This should involve a suite of actions, especially control of erosion by agriculture, rehabilitation and preservation of wetlands, and designation of riparian strips free from ploughing, grazing, and urbanization. Such activities would benefit fish habitat and general amenity and would help with the recovery of the lakes. Therefore, the committee recommends a clear focus on targets related to control of nonpoint-source pollution in general and that these targets address specific factors such as erosion control, enhancement of wetland zones, use of riparian strips, and improvement of fish habitat.

PROBLEMS IN THE NEARSHORE AREA

The problems cited in the 1969 International Joint Commission (IJC) report on Lakes Erie and Ontario, and many of those dealt with in later reports, were primarily in the nearshore area. It is, of course, there that the public generally becomes aware of changes. These include excessive growths of Cladophora, floating refuse, beaches closed because of bacterial contamination, and decline of fishing. Offshore problems such as oxygen depletion (as in the deep waters in Lake Erie) and blooms of planktonic algae are less generally apparent.

The eutrophication theory, which was central to limnological thought at the time that the Agreement was drawn up, was a suitable framework on which to base it, but concepts change with increased insight, and this theory has not proven to be as universal a predictor of Great Lakes effects as may have been hoped 20 years ago.

Despite the importance of nearshore areas to the general amenities of the Lakes, until recently the chief concerns under the Agreement were largely with whole-lake phenomena and mostly with the open waters (e.g., phytoplankton, oxygen depletion in the hypolimnion, and other aspects of eutrophication). The "areas of concern," all in nearshore waters or in connecting channels, have not been taken seriously until recently. We note that the Water Quality Board has undertaken to coordinate the development of Remedial Action Plans to be completed for all the 42 "areas of concern" by the end of 1986 (Water Quality Board, 1985). We also note the Science Advisory Board's recommendation that the parties "embark on developing management strategies for the improvement of two areas of concern" (Science Advisory Board, 1985).

The committee therefore recommends that, in view of the fact that the nearshore impinges most on the usefulness of the lakes and because it is most likely to include the first areas to suffer change, more emphasis should be placed on remediation of nearshore problems caused by nutrient overloading, toxic contamination, and other influences.

In making this recommendation, the committee is aware that the nearshore is a more complex environment than the open lake and that, as a result, monitoring and forecasting of changes will present challenges. However, our understanding is not now so imperfect as to prevent immediate remedial action.

MONITORING AND SURVEILLANCE

It is known that the Cladophora growths in Lake Erie increased during the early years of the century (Shear and Konasewich, 1975) and have declined in recent years. Coliform contamination of beaches also rose and has now declined, and other unmeasured changes have reduced offensive debris and have affected certain fish populations. Indeed, the lake frontage of several urban centers has improved notably in appearance. Credit for the improvements noted is certainly due to improved point-source pollution control, and thus all, or any, of

these changes could have been the basis for formal surveillance. In view of this, and the fact that monitoring of parameters in the open water did not indicate large change, it seems that the system of monitoring needs improvement and expansion. The Aquatic Ecosystem Objectives Committee of the Science Advisory Board has proposed more relevant parameters to observe, with particular emphasis on nearshore areas and bearing in mind the desirability of obtaining data that are comparable between lakes.

The planning and execution of monitoring and research programs should be more intimately coupled than has been the case in recent years; the monitoring programs should also be flexible and to that end should be subject to regular review. Therefore, the committee recommends that the Agreement provide for the regular review of the progress, effectiveness, and cost-effectiveness of the monitoring programs and of their coupling with the research effort. That review, undertaken perhaps every 5 years jointly by the parties, state and provincial governments with external reviewers, should examine

- Whether the purpose and objectives of the Agreement (Articles 2 and 3) are being served by the monitoring program;
- Whether the program continues to be well matched to recognized and emerging problems; and
- Whether the quality assurance and intercalibration have kept pace with advances in methodology.

Because of substantial expenditures of money and effort for data collection, such a review has the potential to determine whether the parameters selected for measurement, the methods of data collection, and methods of data storage and retrieval are supportive of research development as required in paragraph I.C (iii) in Annex 11. This support is necessary to encourage iterative improvement in the understanding of ecosystem processes and the consequent focus of surveillance and monitoring programs. This review should also explore coordination of IJC-approved research projects on research vessels and other platforms without interfering with the primary research objectives. The review process should be coordinated with the Great Lakes Fishery Commission on a lake-by-lake basis.

The general role of monitoring in the broader content of balanced information services for ecosystem management is considered in Chapter 7.

5

TOXIC CONTAMINANTS ISSUES

INTRODUCTION

Control of toxic contaminants was a primary objective of the 1978 Agreement because of the hazards that these contaminants pose to the Great Lakes ecosystem including human populations. However, the large number of chemicals involved, the difficulty in detecting them at the low concentrations at which they are nevertheless hazardous, and the diverse ways by which they reach Great Lakes waters have made achieving this objective difficult.

1978 Agreement Goals and Objectives

For toxic substances, the 1978 Agreement has three main objectives: controlling the entry of toxic substances into the Lakes; the restoration of the ecosystem and its protection from these substances; and the development of programs and technologies necessary to eliminate or reduce the discharge of pollutants into the Lakes.

Water-quality objectives relating to toxic substances and hazardous polluting substances are presented in various ways and in several different places in the Agreement. The commitments of the parties are in terms of "elimination of discharges" or "zero discharge" for the persistent toxic substances, on the one hand, and programs to "control risks of release" for the hazardous polluting substances, on the other.

Annex 1 to the Agreement lists many persistent toxic substances, organic pesticides, and metals, along with concentrations of these substances that should not be exceeded in water or in fish to protect human consumers of fish, aquatic life, fish-consuming birds, and public water supplies. Nonpersistent toxic substances are addressed similarly with separate consideration of organic and inorganic substances.

The "hazardous polluting substances" are listed in Annex 10 of the Agreement. Important commitments are made toward maintaining and continually revising a list of substances known to be hazardous or potentially hazardous.

"Persistent toxic substances" as a class are defined and program objectives are stipulated in Annex 12 of the Agreement, with the intent that these programs will virtually eliminate the input of persistent toxic substances to the lakes (zero discharge). Annex 12

also requires that the jurisdictions identify raw materials, processes, and waste sources involving persistent toxic substances; achieve close coordination between air, water, and solid waste programs; and implement joint programs for disposal of hazardous materials. Monitoring and an early warning system were to be established. Research by both governments was to be undertaken to determine the pathways and effects of persistent toxic substances.

Within the framework of these general principles and goals, the articles of the Agreement and its various Annexes lay out a wide variety of commitments by the parties. An assessment of progress toward the goals of the 1978 Agreement must be made primarily in relation to these commitments (Appendix B).

SOURCES OF TOXIC CHEMICALS IN THE LAKES

Through advances in analytical methods and improvements in detection instruments, the extent of Great Lakes contamination by persistent organic chemicals has become more fully documented over the past decade. With each succeeding report from 1972 to 1985, the Water Quality Board has listed the detection of more chemicals (from a dozen to over 1000), in concentrations as low as parts per trillion.

Direct Industrial and Municipal Discharges

The Great Lakes basin contains some 50 percent of Canadian and 20 percent of U.S. industrial activities. In the United States, remedial programs and discharge limitations for both municipal and industrial discharges are based on a combination of national technology-based standards and water quality standards and are implemented primarily via the National Pollutant Discharge Elimination System. In Canada, effluent controls are put in place either through negotiated efforts or through control orders that define compliance objectives and dates; new or modified industrial waste-treatment facilities are issued Certificates of Approval that delineate permissible discharge levels. However, for the most part, both U.S. and Canadian industrial discharge permits currently focus mainly on conventional pollutants such as biological oxygen demand (BOD) and suspended solids and toxic metals; less attention is given to other toxic constituents.

Key industrial sectors present in the basin include pulp and paper, iron and steel (including coking), tetraethyl lead production, and general petrochemical production. All these sectors have been scrutinized and control actions taken. However, in 1983, 43 percent of Canadian and 18 percent of U.S. sites were not meeting the regulations on effluent discharges. In some cases little or no waste treatment was used, allowing gross pollution to occur (Water Quality Board, 1985; Canadian Great Lakes Toxic Chemicals Committee, 1984). It appears that certain industries continue to be slow in upgrading and implementing treatment processes to bring them into compliance. On the other hand, there are new industrial installations such as that

of the Steel Company of Canada at Nanticoke that are based on closed-loop systems and use pretested, nontoxic chemicals, thereby minimizing the need for industrial waste treatment.

Municipal treatment plant effluents have recently been identified in Ontario as a major source of "priority pollutants" such as polychlorinated biphenyls (PCBs), trihalomethanes (from effluent chlorination), and metals (from illegal industrial connections) (Canadian Great Lakes Toxic Chemicals Committee, 1984). In addition, old, combined, sewer overflows and sanitary sewer overflows caused by illegal storm water connectors contribute toxic chemical loadings from urban runoff and sewer scouring during storms and snowmelt. In Toronto, Ontario, for example, combined sewer overflows contributed to the closing of all Toronto beaches for most of the summer in 1984 and also in 1985 at the time of writing this report. Progress is slowly being realized through disconnection of combined sewers, which prevents overflows of sewage and toxic chemicals.

Most industrial and municipal treatment of water produces sludge, the bulk of which is disposed of on land. Disposal of sludge, which has concentrated toxic chemicals from effluents, in many ways converts an urban point-source water-pollution problem into a rural nonpoint-source problem. A small amount of these contaminants may be picked up by crops if the sludge is used for agriculture (Environmental Protection Service, 1976). Alternative sludge-management technologies exist but are not widely used because of cost. Chemicals such as PCBs, chlorinated dioxins, and chlorobenzenes, when applied to land, ultimately find their way into the atmosphere or leach into surface water, some of them eventually into the Great Lakes.

Despite a general goal of zero discharge from known point sources, the committee finds that the jurisdictions on both sides of the border seem not to consider the goal practicable and are accepting undetermined levels of contaminant releases from industrial and urban sources.

Inputs from Runoff and Waterways

The Pollution from Land Use Activities Reference Group (International Reference Group on Great Lakes Pollution from Land Use Activities, 1978; International Joint Commission, 1980a), a major study carried out under the 1972 Agreement, found that land use activities are contributing or have contributed several groups of toxic or hazardous substances to Great Lakes waters. PLUARG estimated that as much as 11 million metric tons of sediment from inland reach the lakes each year, transporting phosphorus, metals, and other pollutants to the lakes. Another estimate of annual loadings to the Great Lakes from their terrestrial catchment of selected toxic chemicals caused by urban runoff gave combined loadings of 420 tons for zinc, lead, copper, nickel, and chromium; 8 tons for cobalt, mercury, arsenic, selenium, and cadmium; 0.077 ton of PCBs, 0.069 ton of chlorinated benzenes; and

0.034 ton of organochlorine pesticides (Canadian Great Lakes Toxic Chemicals Committee, 1984).

In a 1975 survey of 11 catchments in Ontario draining into the lakes, Frank et al. (1982) found that an average of 39 percent of the land surface was treated with a total of 81 pesticides at a mean rate of 8.27 kg/ha. In the same study, instream waters were analyzed between May 1976 and April 1977 for 60 pesticides and PCBs. Among the pesticides in current use, atrazine, endosulfan, and simazine persisted long enough to appear in water throughout the year. The overall unit-area loading or loss to streams of pesticides was 2.18 g/ha/yr of which 2.02 g was atrazine. Of these loadings 60 percent was attributed to storm runoff, 18 percent to base flow from internal drainage, and 22 percent to carelessness or spills adjacent to streams. PCBs, DDT, dieldrin, endosulfan, and heptachlor epoxide were found to exceed objectives for lake and stream waters entering the Great Lakes.

In-place Pollutants

Sediment-associated contaminants that have the potential to contaminate or act as a pollutant source to overlying water are referred to in recent Water Quality Board Reports as "in-place pollutants." Many of the harbors, river mouths, and parts of the nearshore waters in the Great Lakes have sediments contaminated with in-place pollutants. Even upstream stretches of some Great Lakes tributaries have contaminated sediments. Perhaps the most widely known example of an in-place pollutant problem is the PCB load held in the sediments of Waukegan Harbor. These sediments are thought to be one of the largest sources of PCBs to Lake Michigan.

Recently, the Water Quality Board's Dredging Subcommittee (Water Quality Board, 1983) considered the problem of alleviating the problem of in-place pollutants. A number of criteria were suggested to evaluate possible remedial action, once the type and extent of the problem was defined and the source to the water body controlled. The Subcommittee suggested that natural processes may tend to bury contaminated sediments with uncontaminated ones so that biota are no longer exposed to them. In some situations, actions might be taken to aid natural processes that would tend to bury sediments or move them to an unconfined area where they could be dispersed.

The less volatile contaminants may be deposited and buried in sediments in the deeper areas of the Great Lakes. The long-term ecological significance of accumulations of sediment-bound pollutants in these areas is not yet understood, and more information is needed. The committee finds a substantial basis for concern about the potential for more extensive pollution during efforts to remove in-place pollutants and supports the Water Quality Board's recent (1985) recommendation for demonstration studies with new techniques to manage in-place pollutants.

Groundwater

Subsurface pathways involving toxic chemical transport through soils, sediments, and/or fractured rock provide important routes for chemicals to enter Great Lakes waters. The sources of chemicals entering groundwaters include shallow waste-disposal sites such as landfills, dumpsites, and lagoons; deep and shallow well injection of liquid waste; and leachate of persistent pesticides or other chemical residues from agriculture and of radionuclides from nuclear refineries (Canadian Great Lakes Toxic Chemicals Committee, 1984).

Recent surveys estimate that there are in excess of 1000 shallow disposal sites licensed in Ontario in the Great Lakes basin (Water Quality Board, 1985). The state of Michigan is believed to have as many as 50,000 sites that have known groundwater contamination problems caused mostly by accidental spills and leaks, with 20 percent associated with industrial lagoons and 15 percent attributable to landfills (Canadian Great Lakes Toxic Chemicals Committee, 1984).

The highest density of sites of groundwater contamination in close proximity to the lakes occurs along the Niagara Frontier in the counties of Erie and Niagara in New York. General overall groundwater contamination with metals and synthetic organic chemicals occurs here (Report of the Niagara River Toxics Committee, 1984). Disposal sites such as those belonging to Occidental (Hooker) Chemicals along the Niagara River (Hyde Park, S area, 102nd St.) are widely believed to be responsible for significant contamination of the Niagara River and Lake Ontario (Elder, 1981; Hang and Salvo, 1981; Schwarzenbach et al., 1983). Compounds known to be interred in these dumps include PCBs, dioxin, chlorinated benzenes, and chlorinated phenols.

The U.S. Resource Conservation and Recovery Act requires monitoring of landfills for only 30 years after closure; unfortunately, 30 years is not a realistic time frame. As clearly occurs in the Niagara area, for decades, chemicals migrate out of the dumps, in this case contributing to the pollution of Lake Ontario and the Niagara River. The practice of dumping of wastes by the chemical companies was expedient at the time. However, the cost and control of toxic dump sites will be a burden imposed on future generations. Although expensive in the short run, an effective long-term solution to leaking dump sites will be beneficial to the area's image and economy and to the long-term health of the Great Lakes basin ecosystem.

Deep-well disposal of wastes is also a concern. Disposal of liquid industrial wastes by injection occurred in the Detroit River rock formation in the St. Clair River area (185-275 m depth). Disposal was at a rate of 750,000 liters/day between 1958 and 1976 (Canadian Great Lakes Toxic Chemicals Committee, 1984). Since 1976 only the disposal of brine solutions has been allowed. Documented outbreaks of industrial waste seepage at the surface on both sides of the St. Clair River, particularly from shallow-water wells, indicate that the disposed liquids were not confined to the receiving depths. The presence of waste at shallow depths and also in the receiving depths, if continually pressurized, constitutes a potentially significant source of contamination by chemicals in the St. Clair River area, a

recognized area of concern. The committee strongly supports the concerns about groundwater contamination expressed by the Science Advisory Board in its 1985 report.

Atmospheric Deposition

Atmospheric deposition is a major source of toxic chemicals for lakes, such as Superior, that are remote from the high concentration of population and industrial activity. Mass-balance studies by Eisenreich et al. (1981) indicate that atmospheric deposition contributes over 80 percent of the total PCB input to Lake Superior. Allen and Halley (1980) did a similar analysis for inorganic inputs for the International Joint Commission (IJC). Inputs to each of the lakes from atmospheric deposition is roughly proportional to its surface area. For this reason, Lake Superior receives the largest total atmospheric input. Further, since loads of pollutants reaching Lake Superior from other sources are relatively small, the atmospheric input make up a large proportion of the total load to that lake (Tables 5-1 and 5-2).

Fugacity equations, which allow the prediction of environmental movements of contaminants, using known physical-chemical properties, indicate that the atmosphere and the sediments of the Great Lakes ecosystem are the two major sinks for most of the persistent toxic chemicals entering the water (MacKay and Patterson, 1984). These findings lead to the realization that persistent contaminants can cycle for long periods between the atmospheric, terrestrial, and aquatic components of the ecosystem until they are transported out of the region, are immobilized in soil or sediment, or destroyed by existing or emerging technology.

Disposal of contaminated sewage sludge on lands and open lagoon treatment of toxic waste (particularly by aeration) may be major sources of substances entering the atmosphere, in addition to extrabasin and intrabasin gaseous and particulate emissions from incinerators, stacks.

Eisenreich et al. (1980) and others note that of the atmospheric loadings to Lake Superior of (6-9) x 10^3 kg/year of PCBs, nearly two thirds is made up of vapor and particulate deposition, and only one third is in rain and snow. Of these proportions, no estimate is available as to how much of the gross deposition originated through volatilization from the lake surface, thus potentially decreasing by a considerable amount the net loading to the lake from external sources.

The fluxes of PCB out of the lakes are similarly uncertain. Eisenreich et al. (1980) calculated an outflow of 0.3 x 10^3 kg/year from Lake Superior and then estimated the yearly sedimentation rate to be 8.7 10^3 kg/ha of PCB. However, biological processes contribute to resuspension, and volatilization from the surface is known to occur. Efforts to measure net sedimentation indicate a sink of only 4.9 $\pm$ 5.4 x 10^3 kg/year, considerably less than the gross loadings noted above. Determining whether the balance of net inputs and net outputs is such as to bring about rapid reduction in PCB

TABLE 5-1 Relative Contributions of Sources of PCBs to Lake Superior

Source	kg/yr	Percent of Total
Atmosphere	6600-8300	82-86
Tributary	1300	13-16
Municipal Discharges	66	1
Industrial Discharges	2	1
Total	8000-9000	

SOURCE: Eisenreich et al., 1981.

TABLE 5-2 Estimated Annual Atmospheric Inputs of Several Organic Contaminants to the Great Lakes (metric ton/yr)

	Lake				
Compound	Superior	Michigan	Huron	Erie	Ontario
Total PCB	9.8	6.9	7.2	3.1	2.3
Dieldrin	0.5	0.4	0.6	0.2	0.1
Total PAH	163	114	118	51	38
Total DDT	0.6	0.4	0.4	0.2	0.1
p,p^1-Methoxychlor	8.3	5.9	6.1	2.6	1.9

SOURCE: Eisenreich et al., 1981.

concentrations following limitations on its use is, therefore, almost impossible with the present data. Eisenreich et al. suggest that the residence time for PCBs in Lake Superior is about 5 years and that the total burden of PCB in the system (including sediment load) may be doubling every 11 years.

Similar computations could be made for each of the other lake systems in which tributary inputs of toxic contaminants are larger because the inflowing streams are larger. Figure 5-1 presents results from the 1985 Water Quality Board report indicating that, for a species at the top of the food chain (herring gulls), the concentrations of PCB and dieldrin have remained constant or declined only slightly since 1979, the end of a progressive decline that began in the early 1970s. Interestingly, Lake Superior has a higher concentration of dieldrin and only a slightly lower concentrations of PCB than the other three lakes, indicating considerable transport of these toxic substances, apparently by air as well as water, throughout the Great Lakes basin.

The committee believes that additional research should focus on measuring the net loadings and net sinks for toxic substances of atmospheric origin over each of the Great Lakes and on controlling or immobilizing atmospheric inputs of toxic substances to the headwater lakes of the basin, lakes characterized by the longest flushing times and representing feedwaters to the lower lakes.

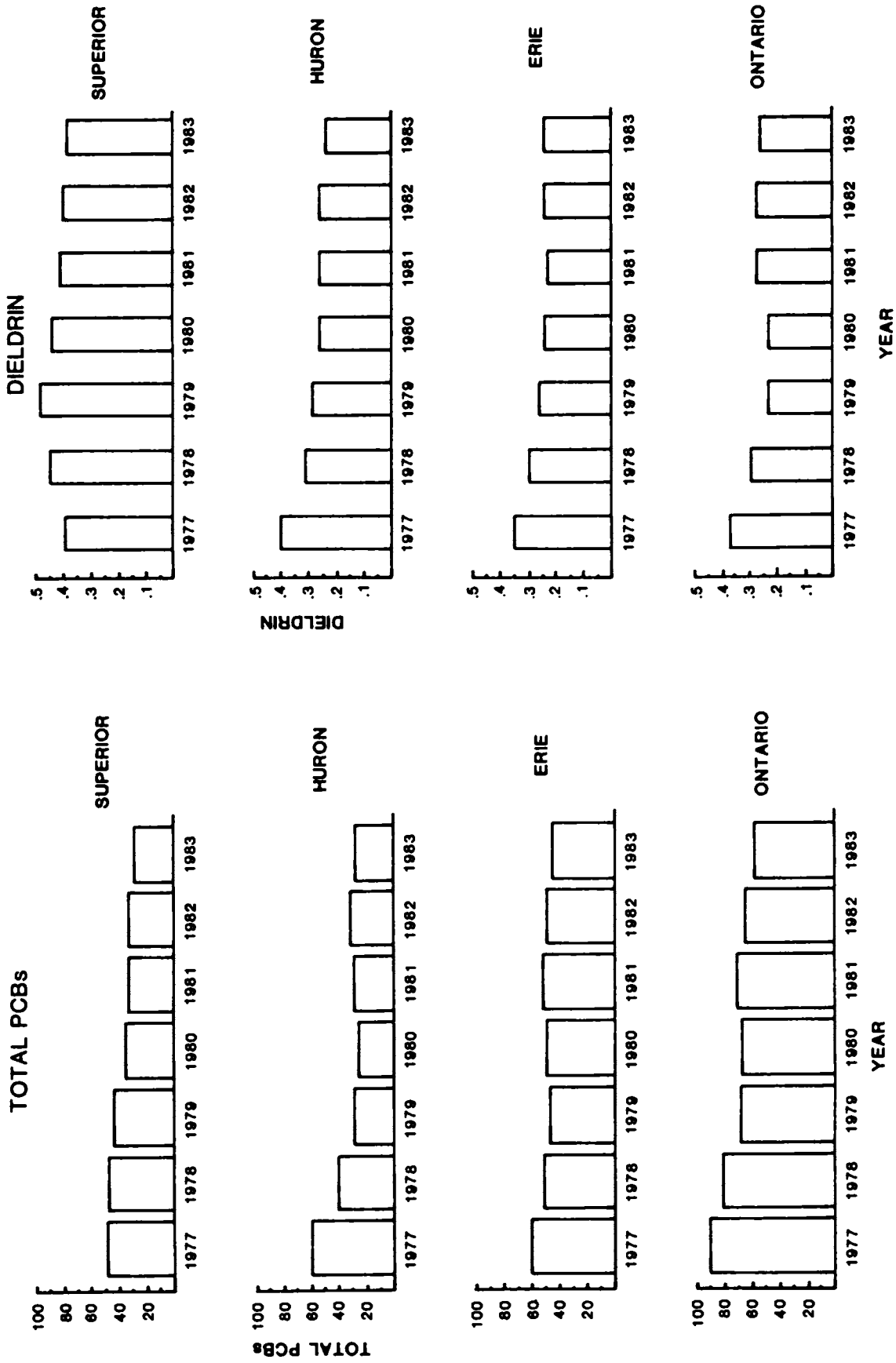


FIGURE 5-1 Total PCB and Dieldrin in herring gull eggs from two populations on each of the four border lakes (mg/kg net weight).

The reports of the IJC and of the Water Quality Board and Science Advisory Board since 1978 show that the sources of toxic substances in the Great Lakes basin are larger and more diverse than was anticipated in 1978 and that management or control programs will need to be much more comprehensive than was probably anticipated.

In view of the above, the committee strongly recommends that as part of a comprehensive toxic substances management strategy there should be components that deal more completely with the diverse sources of contamination. This will require

- An inventory of all sources of toxic chemicals being found at potentially significant levels in the Great Lakes ecosystem and, within the limits of data availability, of those that are not responding to present control actions. Data would include extrabasin and intrabasin gaseous and particulate emissions, diffuse land-based inputs, resuspension from sediments, and inputs from contaminated groundwater.
- Work toward an effective long-term solution to leaking toxic waste dumps, recognizing that although expensive in the short run, the result can be expected to be of benefit to the health of the Great Lakes ecosystem and its human population.
- Control action against all identifiable sources of toxic chemicals to the Great Lakes basin. Studies on the cost-effectiveness of action programs should include the long-term economic benefits of such programs.

SIGNIFICANCE OF THE TOXIC CHEMICALS BEING DETECTED

Significance for Human Health

Humans living in and using the Great Lakes basin are inadvertently exposed to a large number of chemicals through a variety of exposure pathways: drinking water drawn from the lakes, water contact through recreation use, air inhalation, and consumption of food originating in the basin. Infants may be exposed in utero via placental transfer and after birth through ingestion of breast milk. The reports available indicate that the total exposures from these pathways for populations around each of the Great Lakes have not been well documented.

About 1000 chemicals have been identified in the resources that the human population uses. These represent a wide range of chemical forms and possible risks. Lipophilic chemicals are relatively insoluble in water and extremely soluble in fat, they have high octanol:water partition coefficients; they tend to move from the aquatic medium into the fat tissues of biota. Lipophilic compounds that are also slowly metabolized such as DDE, PCBs, and dioxin are bioaccumulated through the food chain, often resulting in increases in concentration of several orders of magnitude between trophic levels. Humans are among the ultimate consumers; they may accumulate relatively high body burdens of the persistent contaminants, as is evident from the presence of PCBs, dioxin, and chlorinated dibenzofurans in adipose

tissue of people from the Great Lakes basin (Mes et al., 1982; Ryan and Williams, 1983; Williams et al., 1983).

The presence of contaminants in drinking water is a constant public health concern. Both in vivo and in vitro studies have demonstrated carcinogenic effects in fish and mammals of complex organic chemical mixtures isolated as concentrates from raw and finished drinking water supplies (Pelon et al., 1980). In addition, there are data that suggest that contaminated water may be linked to elevated cancer mortality rates in southern Louisiana (Harris, 1974 and Page et al., 1976). Recent studies clearly indicate that for chemicals that act as initiators of carcinogenesis there is no safe threshold.

However, the consumption of Great Lakes fish and of foods grown in the basin appear to be the largest route of exposure to chemical contaminants for the general population. The monitoring of contaminants in fish and the establishment of fish consumption guidelines based on average residue levels are conducted in both the United States and Canada. Individual fish regularly exceed these levels (Frank et al., 1978a, 1978b), and the guidelines are often ignored by the public. Commercial fishermen and their families, sports fishermen and their families, and native groups heavily dependent on fish as part of their diet are three subpopulations that may have high exposures to persistent contaminants caused by their large intake of fish.

Other foods in addition to fish also appear to result in significant human exposures. Contaminants deposited on soil and directly on plants themselves are taken up by crops, which are then ingested by livestock and humans. Although the presence of environmental contaminants in foods other than fish is not well documented, the U.S. Food and Drug Administration has detected PCBs in dairy products, eggs, potatoes, oysters, crabmeat, candy, meat, poultry, and cereals (Pim, 1981). PCB levels in Canadian beef are much higher in Ontario and Quebec (i.e., the Great Lakes basin and its outlet, the St. Lawrence River) than in the Atlantic or western provinces (Saschenbrecker, 1976). The ubiquitous presence of PCB residues in foods is exemplified by their presence in whole milk from southern Ontario at an average concentration of 0.889 ppb in 1983 (Frank et al., 1985a); an intake of 1 liter/day would result in an annual intake of 327 ug. This is substantially greater than the estimates of annual PCB intakes calculated for Great Lakes residents from drinking water (2.9 ug) and respiring ambient air (7.9 ug) (Sonzogni and Swain, 1980a, 1980b; Swain, 1980).

As evidence increases that environmental contaminant residue levels are no longer decreasing, and with new residues being discovered (e.g., dioxin), the lack of data on contaminant levels in food and hence on total human exposures constitutes a serious information gap.

Infant humans are also a high-risk population as they represent an even higher trophic level than adults and are exposed to contaminants at sensitive stages of development. A 1975 Canada-wide survey of mother's milk by Mes and Davies (1979) indicated that the highest average PCB levels were found in Ontario and were 17 ppb for whole

milk. Table 5-3 indicates the presence of contaminants in breast milk for Ontario women in 1978.

A study in Sheboygan, Wisconsin (Smith, 1984) found that the average level of PCBs in breast milk of fish-eating women was 1.26 ppm on a milk fat basis, while that of nonfish-eating women was 1.07 ppm. Assuming an average fat content of 3.7 percent (Smith, 1984), these values convert to 45 ppb and 38.5 ppb, respectively, for whole milk. The Canadian Department of National Health and Welfare's maximum acceptable residue for breast milk is 50 ppb (Morrison, 1978).

At 10 ppb in whole mothers' milk, for an average intake of 600 ml/day (Wickizer et al., 1981), an infant would be ingesting 6 ug/day of PCBs and would have an annual intake of 2190 ug. Similarly the level of 45 ppb found in the Sheboygan study results in a daily intake of 27 ug and an annual intake of 9855 ug. For an infant weighing 4 kg these intakes represent 1.5 to 6.75 ug/kg/day. This is higher than the intake levels determined for most Great Lakes fish eaters (Humphrey, 1976) and exceeds the maximum daily PCB dose rate of 1 ug/kg/day set for adults by the U.S. Food and Drug Administration.

Brain development for infants may be affected by exposure to contaminants. The highest PCB concentrations in a stillborn, full-term human infant were found in the liver and the brain (KiKuchi et al., 1969). Studies employing psychological testing and measurements of newborn infants by Jacobson et al. (1984) and Fein et al. (1984) have shown smaller birth size, lower gestational age, and neonatal behavioral deficits to be associated with maternal consumption of contaminated fish. The authors point out that, although they have implicated PCBs as the possible offending agents, other contaminants may be involved. The study of the women from Sheboygan, Wisconsin, indicated that maternal serum PCB levels were positively associated with infectious illnesses in the newborn infants (Smith, 1984). In the same study no negative effects were observed from breast feeding at the PCB concentrations present (averages of 38.5 to 45 ppb on a whole-milk basis). These studies have implications for human health resulting directly from environmental pollution of the Great Lakes. Further studies on infants are required

TABLE 5-3 Levels of Organochlorines in Mothers' Milk for Women from Ontario - 1978

Contaminant	Content in Whole Milk (ppb)
DDT[a]	27.3
dieldrin	0.54
heptachlorepoxide	0.34
hexachlorobenzene	0.51
PCB	21.0

[a]DDT = sum total of *p*,*p*'-DDE; *p*,*p*'-TDE, and *p*,*p*'-DDT.

SOURCE: Frank et al. (1985b).

to determine the effects of exposure to contaminants during these developmental stages. The implication of high infant exposure levels to total body burdens acquired over a lifetime remain unknown. Considering the latency period for cancers to appear (20 to 30 years), high exposures of infants to contaminants may result in significant future health effects.

In order to understand the long-term implications of environmental contaminants on human health, it is necessary to carry out long-term epidemiological studies on humans. These can take the form of cohort studies, case-referent studies, or cross-sectional studies. Cohort studies, used most commonly for occupational exposures, are those that compare the disease outcomes for a group of exposed persons with those for a group of unexposed persons. Case-referent studies are those in which a disease or group of diseases is defined and persons with the diagnosed disease(s) are examined for a common exposure that may have caused or contributed to their condition. With a cross-sectional study, a representative sample of people is examined to determine for each individual whether they have the exposure and the disease under study.

Epidemiological studies based on environmental exposures often prove difficult because they usually involve chronic exposures to low contaminant concentrations and to complex mixtures of compounds. Nonetheless, there have been successful studies of exposures to environmental contaminants, the most notable of which are those on children in the United States exposed to environmental lead (Needleman, 1983). The case referent approach has considerable unused potential for environmental health studies. Maps of cancer, birth defects, and other medical events could be coordinated by computer with environmental monitoring, and appropriate reference groups could be constructed demographically (Silbergeld, 1984). Also, cohort studies are both possible and desirable with the highly exposed groups identified in the previous section, i.e., people with a high intake of Great Lakes' fish and individuals exposed to contaminants in utero and in breast milk as infants. The continuous maintenance of cancer registries is an important aspect of these studies.

Epidemiological studies tend to focus on cancer outcomes, although the contaminants in question are often known also to cause immunological, neurobehavioral, and reproductive effects at low concentrations (Silbergeld, 1983). Epidemiologists should study all the different types of disease outcomes likely to be caused by the exposures to toxic chemicals.

In light of this information, the committee finds substantial evidence that the human population living in the Great Lakes basin is exposed to, and accumulates, appreciably more toxic chemical burden than people in other similarly large regions of North America for which data are available. The difference appears to be largely due to the higher contaminant levels in food products derived from the Lakes and their basin.

Significance to Ecosystem Health

While much emphasis in the Water Quality Board and Science Advisory Board reports has been given to studies of toxic substances in water, sediments, and biota, work on the effects of these substances on the ecology and productivity of the Great Lakes ecosystem has been limited.

Harm to biota from contaminants in the Great Lakes was documented nearly 20 years ago in the breeding failures in herring gulls (Keith, 1966; Ludwig and Tomoff, 1966) and in black-crowned night herons (Edwards, 1970). Hickey and Anderson (1968) concluded that the herring gull was suffering from DDE-induced egg-shell thinning in Lake Michigan. In the early 1970s, congenital abnormalities (crossed bills, malformed eyes, and extra limbs, for example) were present in chicks of some species of fish-eating birds in Lake Ontario (Gilbertson et al., 1976; Gilbertson and Fox, 1977).

Herring gulls on Lakes Ontario and Erie have shown improvement in reproductive success over the years 1974 to 1978, paralleling the decrease in major organochlorines in herring gull eggs over the same period. This decline continued until 1980, from which time there has been no significant decrease or increase (Figures 5-2(a), 5-2(b) and 5-2(c)). At present, the levels of contaminants in the lower Great Lakes are not known to be producing any gross effects on reproductive success of the herring gull (Mineau et al., 1984), but the number of species and life stages being observed systematically is limited. Recently, the Canadian government has suspended its program for measuring the reproductive success of the herring gull, a program that had provided valuable information about the effects of toxic chemicals on the ecosystem.

Polynuclear aromatic hydrocarbons also have been implicated in harm to biota. Links have been found between the presence of these compounds in bottom sediments and the development of neoplastic disease (cancerous tissue growth) in several different kinds of bottom dwelling/feeding fish species from both marine water and freshwater, including the waters of the Great Lakes where the cancers in some cases are epidemic in proportion (Black, 1983, 1984a; Baumann et al., 1982). These field observations are reinforced by laboratory data that indicate that fish, including some of the very species which exhibit the cancers in the polluted environments, develop histologically similar tumors when exposed to those pollutants in the laboratory (Hendricks, 1982; Black, 1984b; Black et al., 1985). Because polynuclear aromatic hydrocarbons are not recognized as liver carcinogens on the basis of their activity in mammals, it has been difficult to accept the idea that these agents may be the cause of the liver cancers in the wild fish populations. Recent biochemical studies have provided insight as to why these compounds can readily cause neoplastic and preneoplastic liver lesions in fish. In brief, it appears that fish produce greater amounts of the carcinogenic metabolites of these compounds, at least as based on studies of the metabolism of 3,4-benzo(a)pyrene (Nishimoto and Varanasi, 1985). Recent work has confirmed that polyaromatic hydrocarbons including 3,4-benzo(a)pyrene do cause cancer in fish.

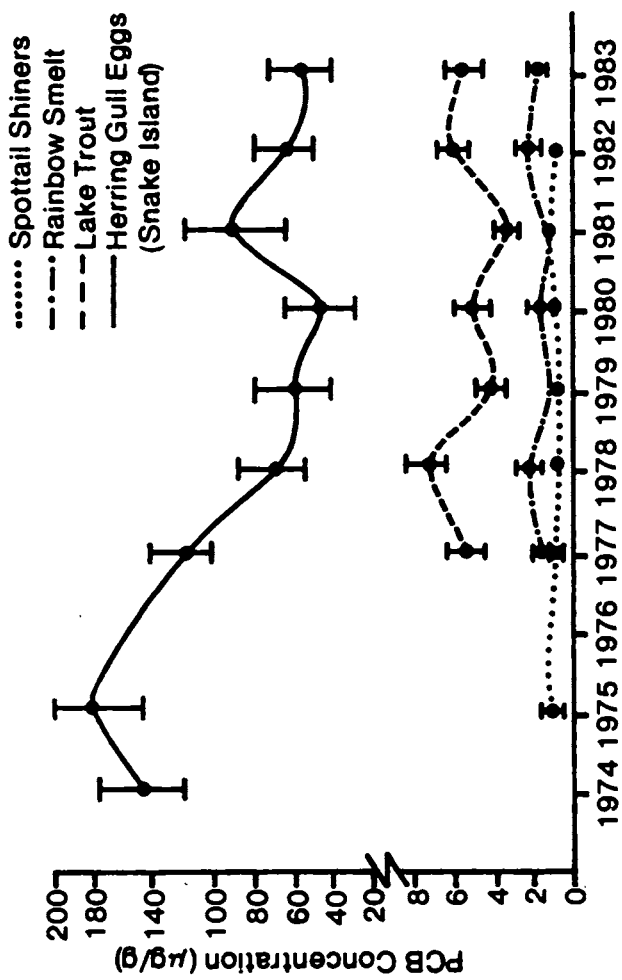
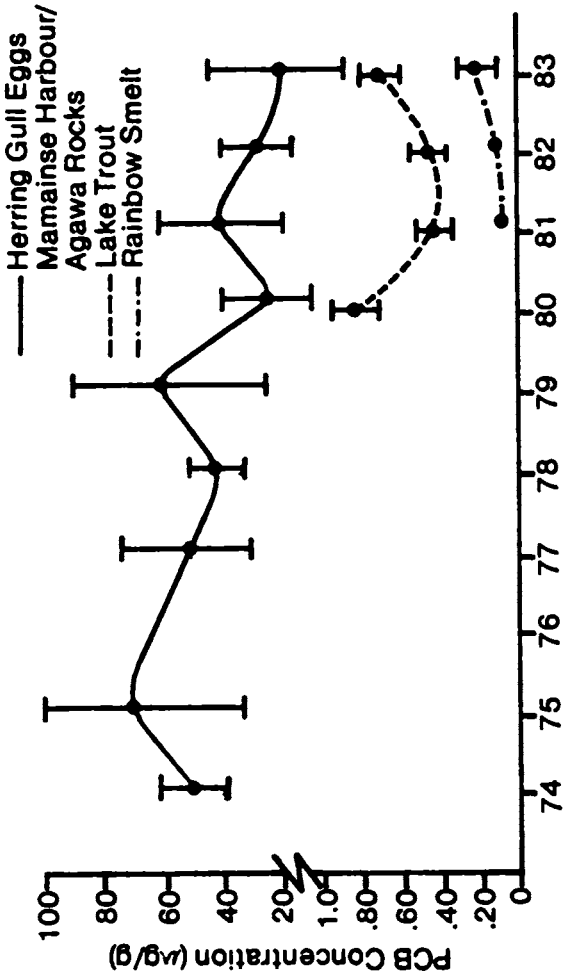
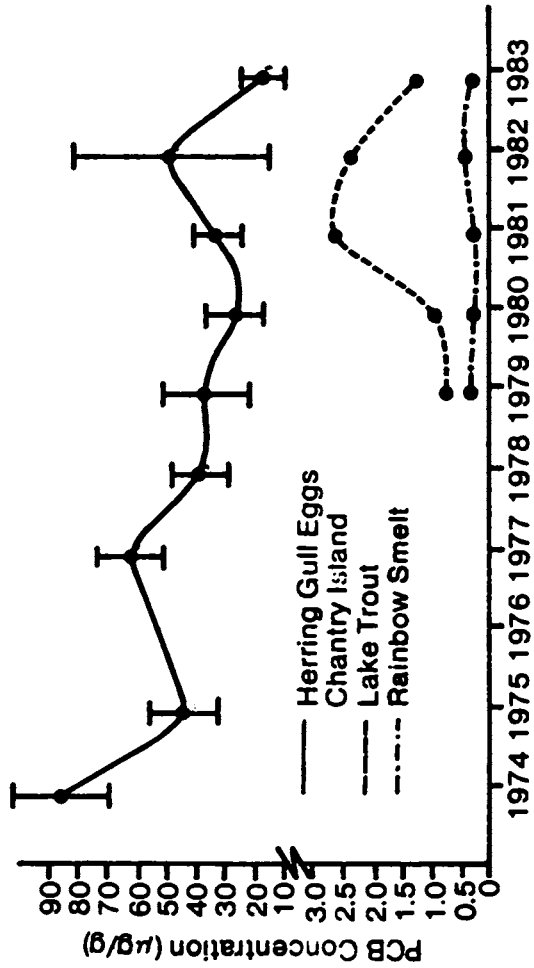


FIGURE 5-2(a), (b), and (c) PCB concentrations in Lake Ontario biota.

SOURCES: Struger, J., et al., 1983; Whittle, D. M., unpublished data; Whittle, D. M. and J. Fitzsimmons, 1981; Suns, K., Ontario Ministry of the Environment, 1983.



(b)



(c)

Available studies still do not allow for the prediction of the impacts from chronic exposure of organisms or biotic communities to low concentrations of chemicals. For this reason and because of the presence of large numbers of chemicals in the Great Lakes ecosystem, the committee finds there is a continuing need for support and development of methods to measure effects of environmental contaminants, i.e., the Canadian herring gull monitoring program and other bioeffects monitors. To date, these methods include studies on fish tumors, mixed function oxidase induction, and congenital anomalies in exposed organisms. In addition to providing valuable information about ecosystem health, these and other bioeffects monitoring initiatives would contribute to the "early warning system" described in Annex 12 of the Agreement. The current level of bioeffects monitoring is inadequate for determining the impact of persistent toxic substances on the health of biotic systems of the Great Lakes basin.

Therefore, the committee recommends improved methods of scientific study of all biological effects of contaminants in order to understand more fully the consequences for the biota and resource productivity of Great Lakes contamination. One important aim is to develop an effective early warning system based on subtle effects on indicator organisms.

PROGRESS IN REMEDIATION

The 1978 Agreement establishes a remarkably innovative set of mechanisms for two nations to use to deal with concerns about toxic chemicals issues of international waters, particularly in view of the limited understanding of the whole problem at that time. Although the levels of several toxic residues (e.g., DDT, PCBs, mercury) in fish and herring gulls had been declining because of actions by both nations earlier in the 1970s, Figures 5-1 and 5-2(a), 5-2(b), and 5-2(c) show that this downward trend has not continued (Water Quality Board, 1985; Whittle et al., 1985). The Water Quality Board (WQB) reports show notable progress in the area of reduced industrial and municipal discharges, but problems associated with these sources remain and other inputs (e.g., from groundwater and from atmospheric deposition) are much larger for certain lakes than had been anticipated in the Agreement.

The Agreement also calls for many studies on the behavior of chemicals in the environment. Because of the results of these studies we now know that effecting control is much more complex than previously thought and that new approaches are required. The WQB (1985) has recognized this and is attempting to design such new approaches and recognizes the need for more new thinking.

Actions on Specific Toxic Substances

The 1983 WQB report summarizes regulatory actions taken in both countries to control products containing toxaphene, dioxins, PCBs, and lead (Water Quality Board, 1983). The cancellation of most uses of the pesticide toxaphene in the United States should decrease the amounts of this substance entering the Great Lakes from the atmosphere. The U.S. Environmental Protection Agency (EPA) has also issued revised regulations on the use of PCBs in electrical transformers, electromagnets, and capacitors and for the content of lead in gasoline. In response to concerns about environmental contamination by chlorinated dioxins, the U.S. EPA has proposed an intensive investigation into effects of such contamination, implementation of cleanup measures, evaluation of disposal alternatives, and evaluation of measures to prevent future contamination, but there are still no plans evident to the committee for any emissions inventory of dioxin sources in and around the Great Lakes basin.

The WQB (1983) also reports that during that year the Ontario Ministry of the Environment established provisional ambient air guidelines for dioxins and furans, developed a draft guideline for the disposal of waste containing PCBs, and established tentative criteria for chlorophenols and chlorobenzenes.

Hazardous Wastes

The WQB (1983) has several times reported on hazardous-waste management programs in the United States. These include the cradle-to-grave regulation of hazardous wastes under the Resource Conservation and Recovery Act and the toxic disposal provisions in the Toxic Substances Control Act. The Comprehensive Environmental Response, Compensation, and Liability Act (Superfund) is now being implemented in the United States, and the hazardous-waste sites and spills management program is now operational.

In Canada, the WQB notes, the objective of Ontario's program of hazardous waste management is to prevent poor industrial-waste treatment or disposal practices that may lead to contamination of water supplies or adverse impact on aquatic ecosystems or high-cost remedial measures. The province also is developing its program for management of hazardous wastes, i.e., those waste materials with characteristics such as ignitability, corrosivity, reactivity, pathogenicity, and toxicity.

Although the toxic and hazardous substance control programs in both nations are important, and may ultimately be protective of the Great Lakes basin, the committee finds that none of them were designed specifically with the alleviation of Great Lakes contamination problems in mind. Neither the present inputs of toxic substances from groundwater nor from on-land volatilization and atmospheric washout will be reduced significantly in the near term.

The committee recommends that the parties should agree to site and operate modern toxic waste-treatment centers in all regions of the

basin and that the Agreement should provide for strict management of toxic wastes, both those disposed of carelessly in the past and those in prospect for the future.

Aquatic Ecosystem Objectives

Objectives for 28 contaminants are listed in the 1978 Agreement. As of 1983, seven more objectives have been proposed and two of the previous objectives have been reviewed (International Joint Commission, 1980b, 1981a, 1983b). These have been accepted by the IJC; however, there has been no response by the parties to these, and they remain only proposed objectives. In order for the Agreement to remain current, it is necessary for new objectives to be responded to by the parties within a reasonable length of time, e.g., one year, and for a revised Annex 1 to be published regularly, e.g., biennially.

The rationale for the development of objectives is outlined in each annual report of the Aquatic Ecosystem Objectives Committee (AEOC), and since 1983 objective development also incorporates peer review. The current objectives should be subjected to continual review by the AEOC and new objectives developed as adequate data become available.

In 1981 the AEOC (International Joint Commission, 1981a) reported a mechanism for estimating the potential toxicity of mixtures of metals in Great Lakes waters, i.e., the sum of the ratios of each metal concentration and its respective objective concentration was recommended not to exceed 1.0. This target was developed primarily on the basis of fish toxicology, and although the scientific basis is limited, its application to surveillance data analysis would provide an indication of areas requiring further investigation. To date, there has been little similar research on organic toxic chemicals. The characterization of risk to resources associated with concurrent exposures to several carcinogens being taken now by the U.S. EPA (on the basis of additivity) is an important precedent (Environmental Protection Agency, 1984).

The committee recommends that aquatic ecosystem objectives accepted by the IJC be incorporated into the Agreement and that a revised Annex 1 should be published on a regular basis. Furthermore, consideration should be given to developing objectives for mixtures of organic toxic chemicals similar to those developed for mixtures of metals.

Areas of Concern

Surveillance programs for toxic substances in the Great Lakes have shown that the most serious levels of resource contamination and the most serious inputs occur at 42 locations, mostly harbors or industrial sites. At one time, the term "limited use zone" was thought to permit more lenient water-quality objectives for these areas. The Agreements' intent for this term is unclear, and the concept has been found to be legally untenable in the United States. Over the years, these areas have come to be identified in WQB reports

as "Areas of Concern." They tend to be locations with multiple sources of pollution (industrial discharges, groundwater contamination, and in-place pollution), and progress toward their remediation has been slow.

The 1985 report of the WQB lists 42 areas of concern in the Great Lakes basin, of which 38 contain contaminants. Comparisons between problem areas considered in the WQB reports from 1975 through 1985 indicate that during this period there have been improvements as a result of better sewage treatment, reductions of phosphorus, reduction of erosion, and disposal of some contaminated dredgeate in contained areas, but little if any progress toward reduction of persistent toxic substances in most of these areas. The Board in 1985 adopted a new system for categorizing and planning actions for areas of concern that may lead to progress over the next decade.

The highest concentrations of toxic chemicals tend to occur at sites toward the southern edge of the Great Lakes. Not coincidentally these locales also have the most severely degraded water quality. The so-called areas of concern, although perceived as largely localized problems, also affect more extensive regional areas.

Paradoxically, the areas of concern are also often in or close to heavily populated regions and are, therefore, most accessible. Because they involve nearshore areas, they would, except for their degraded water quality, be of value for both their recreational and aesthetic potential. Even the subtle gains in Lake Erie's water quality (from nutrient control programs) have dramatically improved a wide range of lake usages from swimming and fishing to the stimulation of commercial developments around the harbors.

Areas of concern may be characterized by the fact that one or two major sources are usually the cause of the problem, for example, in-place pollutants or a major sewage treatment plant. To deal with an area of concern, programs must focus on the major sources and follow through with an analysis for the most cost-effective methods to control that source.

The committee finds that the present proposals for planning remediation of the areas of concern are an improvement over the proposals contained in the 1978 Agreement. However, progress in the control of contaminants at these locations has been minimal (with a very few exceptions), and in this sense the Agreement has failed within the time frame of the past 7 years. Part of the failure to make substantial progress in elimination of the areas of concern may lie in the wording of the 1978 Agreement. For example, Article IV, Specific Objectives, item (1)(f) states:

> Limited use zones in the vicinity of present and future municipal, industrial and tributary point source discharges shall be designated by the responsible regulatory agencies within which some of the Specific Objectives may not apply.

The subsection goes on to note that "establishment of these zones shall not be considered a substitute for adequate treatment or control

of discharges at their source" and "the size shall be minimized to the greatest possible degree, being no larger than that attainable by all reasonable and practicable effluent treatment measures." Significant revisions of the relevant sections of the Agreement are essential. The committee recommends that the Agreement encourage action on the major sources of contamination at the areas of concern, that effective solutions be implemented, and that rigorous evaluative case studies be undertaken and published.

DATA, MODELING, AND RISK ASSESSMENT

Monitoring, Surveillance, and the Problem of Incomplete Data

The 1978 Agreement provides that the various jurisdictions (eight states, two provinces, and the two federal governments) will undertake programs of monitoring (in the sense of regular measurement of quantities of known significance) and surveillance (in the sense of studies designed to identify and define new, potentially significant chemicals or other properties).

Several concerns about monitoring and surveillance have been expressed by a variety of persons including participants at the 1984 U.S. National Research Council (NRC) Buffalo Conference on the Agreement (National Research Council, 1984). Aubert, at the Conference, discussed operational limitations to these programs imposed by budgetary constraints that result in less than effective monitoring efforts. He noted that EPA cuts are continuing, e.g., open lake monitoring for Lake Superior was suspended in 1983 and Michigan is scrapping its tributary monitoring. Similarly funding for some Canadian surveillance programs has been reduced, for example, the Herring Gull monitoring. Inconsistent sampling makes data noncomparable and involves waste of expended funds. Fears were also expressed that a proposed Great Lakes International Surveillance Plan may generate a great deal of data without giving sufficient attention to analysis and review (although it had yet to be funded) and that an increasing percentage of research funds is used for monitoring, thereby diminishing research capacity. Others stated that baseline data are sketchy and that research funds may not be used to acquire these data. Progress seems to be measured by the number of regulations being implemented rather than by scientific information indicating improvement or degradation in the quality of the water or the ecosystem.

Other information presented during discussions at the 1984 NRC Buffalo Conference led the commentators to reach several findings, two of which are

1. Quality of information. A large data base on the Great Lakes exists for some subject areas, but much of it has not been assessed critically. Other subject areas, such as trace organic metabolites, are poorly understood. There have been many interagency and binational references on analytical procedures (e.g., for trace

organics). Many of the early research initiatives focused on Lake Erie and on Lake Ontario, and the work on chemical structure-activity correlations, metal toxicity, and atmospheric inputs were unique and carried out carefully, but others were not done so well. As with the need for continuity of data and related information, there is a need to have recognized mechanisms for assessing the highest technical quality of this information in both countries.

2. Data repository and data assessment. The repository for basic data on pollutant concentrations generally has been with the individual U.S. and Canadian agencies concerned with the Great Lakes, but consideration should be given to pulling the several elements together. Continuity is the major concern here, but others include whether the role of the Windsor office or of certain contractors should be enlarged and whether an assessment of the data is to be made.

The committee finds that the concerns about quality, continuity, and general access to data on the distribution and concentrations of toxic substances derived from the 12 jurisdictions are justified. The committee recommends not only rapid implementation of new programs under the Great Lakes International Surveillance Plans but measures that will allow the data to be available for broad binational review at the earliest possible date.

Transport and Fate Modeling for Toxic Chemicals

Transport and fate modeling provides a means for estimating input pathways, interpreting and predicting trends as well as determining the fates of toxic chemicals. Modeling cannot stand alone but is dependent on other factors such as monitoring data and physical-chemical properties data for model development and validation. The current state of the art in modeling appears to be limited to single-chemical fate estimation.

The committee finds that applied research on toxic chemical transport, fate, and effects, pertaining to large lake ecosystems, is very limited. It is essential for establishing and reviewing reasonable loading targets for the management of toxic chemicals in the Great Lakes. The committee recommends the further development of large-lake transport and fate models for toxic contaminants, so as to better understand the options for controlling them, and that consideration be given to the use of loading allocations, based on mass balances rather than on effluent standards based on concentrations of toxic substances in effluents.

Role of Tissue and Sediment Banks

Included in the early warning system called for in Annex 12 of the Agreement is the maintenance of a biological tissue bank and sediment bank.

A properly maintained archive of environmental samples allows for accurate retrospective monitoring of formerly unconsidered or recently identified toxic compounds. It will also provide answers as to when a compound entered the environment, where it came from, and whether levels have been increasing or decreasing. The usefulness of tissue banks is apparent from the retrospective analyses and trend monitoring of mirex and dioxin made possible with archived Great Lakes herring gull eggs.

The Tissue and Sediment Bank Task Force of the Science Advisory Board found that 48 organizations have banked 14 different classes of samples from the Great Lakes using a variety of storage procedures. Of the 48 organizations, 15 have ongoing sampling programs, and of these only 5 are archiving material in a manner suitable for future chemical analysis. Some human tissues are also collected by different agencies, although this is apparently being done mostly on an ad hoc basis. This Task Force is currently compiling a list of organizations with banked human material.

The need for environmental sediment specimen banking has been recognized internationally. Both the United States and Germany have established national pilot programs to do experimental work on sampling, processing, analytical, and storage methodologies. The Canadian Wildlife Service has been conducting similar research on tissues of birds from the Great Lakes for several years. This type of research is necessary for the development of specimen banking as different materials require different handling procedures to prevent the loss of chemical residues. In conjunction with this, each specimen bank should have an integrated quality assurance program to monitor for any ongoing degradation.

The committee finds that, at present, there does not appear to be a coordinated effort by organizations in the United States and Canada to collect specimens encompassing the various components of the Great Lakes ecosystem. The committee recommends the incorproation of specimen banking into programs of monitoring and surveillance (Annex 11) as an effective means of augmenting both programs. Both the United States and Canada should provide long-term commitments to specimen banking, as archiving must be continuous and relatively comprehensive.

Toxicity Testing and Risk Assessment

One perplexing question left open by the 1978 Agreement is how toxicity testing and exposure data collection for hazard and risk assessments in the Great Lakes basin will be provided. There are serious questions as to whether the risk assessments and risk management obligations suggested under Annex 12 can be carried out with the limited data available.

The WQB's Toxic Substances Committee's report (International Joint Commission, 1980c) states that more than 30,000 compounds of industrial or commercial significance are produced in the Great Lakes basin and that 200 to 3000 new compounds are being added each year.

There are currently 1065 hazardous or potentially hazardous substances identified in the water of the Great Lakes basin (International Joint Commission, 1983a).

Testing of toxic substances is usually conducted to determine two different but somewhat overlapping classes of effects from chronic low exposures: effects on biotic systems (ecotoxicology) and effects on humans (epidemiology). The effects on biological systems include alteration of germination and birth, maturation, reproduction, and death. All of these ultimately determine the biomass of various species in the system. Other effects, such as induction of mixed function oxidase, behavioral changes, and immunological changes, are considered to be secondary effects that may directly influence ecologically important parameters. Damage to the structure and function of a biotic system, especially at the level of communities, should be considered as a potential undesirable effect of contaminants. Such persistent or potentially irreversible effects are important considerations in ecotoxicology.

The Organization for Economic Cooperation and Development (OECD) (1984b) developed a comprehensive set of guidelines for the ecological testing of new chemicals before they reach the marketplace. The United States and Canada have both agreed to follow these procedures for testing new chemicals. There are no such guidelines or agreements for testing chemicals now present in the Great Lakes basin, although the OECD guidelines, with some modification, would be appropriate. Without testing of this type, the significance of the effects of the existing contaminants on the ecosystem will remain unknown.

Toxicity Testing for Evaluating Human Health Risks

Toxicity testing of environmental contaminants is carried out by agencies in both the United States and Canada. In Canada, the federal government allocates funds to the Department of National Health and Welfare specifically for the toxicity testing of chemicals found in the Great Lakes basin. In the United States, environmental contaminants from the Great Lakes receive no special status over other environmental contaminants in determining priorities for testing. Toxicity data for evaluating human health risks should include information on acute toxicity, carcinogenicity, reproductive effects, mutagenicity, neurobehavioral effects, immunological effects, and any other chronic adverse effects. Environmental contaminants have also been implicated in nonspecific deterioration of health and well-being, e.g., decrease in intelligence. Few tests are currently available for measuring this latter type of effect.

The Health Effects Committee (International Joint Commission, 1981b) lists 195 chemicals for which there are insufficient chronic toxicity data to conduct health hazard assessments. This list continues to grow as the number of chemicals identified each year is considerably greater than the number that can be adequately tested. There have been several research projects investigating the toxicological properties of many priority Great Lakes chemicals.

These have helped to develop a data base for future hazard assessment; however, the number of compounds tested remains a fraction of the chemicals present. Genotoxicity screening has been carried out on a relatively large number of Great Lakes chemicals, allowing the identifying of certain chemicals for further investigation (Douglas, G. R., Department of National Health and Welfare, Canada, personal communication). Unfortunately, there has been little development in experimental toxicology of short-term tests for measuring other types of effects, e.g., reproductive, neurobehavioral, or immunological. The study of quantitative structure-activity relationships shows considerable promise for identifying chemicals of concern; however, this area is still at a developmental stage and is not yet adequately advanced for the evaluation of the toxicity of chemicals.

Most testing is being done on a single-chemical basis, although exposures are to many chemicals simultaneously. There is little information available as to the potential effects from exposures to such mixtures. On the basis of conventional toxicity protocols, there seems to be no reason to question why testing should not be done in any well qualified laboratory in the United States or Canada. Contaminants in the Great Lakes have no unique characteristics in terms of toxicity. However, where Great Lakes' contaminants may differ from those other environments is in the multiplicity of pathways and magnitude of resultant human exposure. Because toxicity testing is expensive and there is only limited availability of funds, it is important that where human exposures are identified those chemicals become priorities for testing and subsequent hazard and risk assessments.

The committee recommends

- Development of better exposure data for humans in the Great Lakes basin; in particular, the exposure from food consumption and the contaminant loadings of infants require systematic study, including the monitoring of human tissues concentrations in the Great Lakes basin compared with other regions.
- Development and maintenance of large-scale epidemiological studies on human populations, such studies to consider the different types of diseases likely to be associated with exposures of the kind being experienced in the basin.
- Where significant exposures are identified, the contaminants in question should become priorities for complete toxicity testing and hazard and risk assessment.
- Where risk and hazard assessments are carried out, data on total exposures should be considered, including the potential cumulative effects of such exposures and the presence of highly exposed critical subpopulations such as breastfed infants.

Limitations of Risk Assessments

The development of adequate hazard and risk assessments for a chemical requires toxicity data as described previously, as well as

consideration of both the total exposures of human populations and the existence of critical subpopulations. The present state of knowledge of the toxicity and exposure of humans and other organisms to chemicals is not adequate to develop hazard and risk assessments for the majority of chemicals found in the Great Lakes basin. The obtaining of these data and the development of these assessments are very long resource-intensive processes and will probably not be carried out for all chemicals of concern in the near future.

There are several other limitations to risk-assessment methods available at present, other than those pertaining to inadequate toxicity and exposure data. In the past, as with toxicity testing, risk assessments have usually been applied on a single-chemical basis, whereas exposures are to many chemicals simultaneously. However, the new proposed EPA guidelines for risk assessment of carcinogens states that the characterization of risk due to concurrent exposure to carcinogens is to be calculated on the basis of additivity (Environmental Protection Agency, 1984). Although this does not take into account any synergistic relationships, it is currently the best method available for dealing with multiple exposures.

A further problem with the risk-assessment methodology now available relates to its being carried out primarily for the toxicity endpoints of cancer and heritable mutation. For many other adverse effects, the incidence is continuous rather than probabilistic, i.e., at a given dose all exposed individuals will exhibit a given effect within a normal distribution. For example, a low dose of chemical with a reproductive effect (e.g., effects on oogensis, fertility, or conception) may result in a slight impairment of fertility in all exposed individuals. With the endpoint of cancer, however, only some of the exposed individuals will contract the disease. The science of these other areas of toxicology, i.e., relating to reproductive, neurobehavioral, or immunological effects, for example, is currently not adequately developed to allow meaningful hazard assessments. The permissible level of a chemical with these types of effects is now usually determined on the basis of a "no adverse effects" threshold with a safety factor (often 1/100 of threshold value) applied.

Despite the limitations of risk and hazard assessments, they are currently the best available approach for determining whether drinking water or Great Lakes fish may be considered safe for human consumption. However, they should not be used for determining permissible effluent discharges for stack emissions on an individual basis since total loadings and the resulting total exposure must be taken into consideration.

TOXIC CHEMICALS MANAGEMENT STRATEGIES

Much progress toward achieving the overall goal of the 1972 Agreement is apparent in the reports of the IJC Advisory Boards. However, many observers and the Commission itself [Addendum to the International Joint Commission (1982b) First Biennial Report] have been critical of the limited progress toward achieving an ecosystem approach to the

management of toxic chemicals throughout the Great Lakes basin, as specified in the 1978 Agreement. In its report (Water Quality Board, 1985), the WQB attempted to deal with this problem by adopting a two-track approach to protect the Great Lakes ecosystem from toxic chemicals. The primary track is designed to take action against eleven "critical pollutants," while the comprehensive track involves the systematic analysis and organization of the information available on the remaining chemicals (approximately 500) of potential concern in the Great Lakes ecosystem. This review committee endorses this approach but believes further measures are required to achieve the rehabilitation and restoration of the ecosystem.

For management purposes, toxic chemicals may be classified into three broad categories: new chemicals that are being produced now or in the future, old chemicals that are already present in the environment, and those chemicals that are not manufactured per se but are degradation or by-products. New chemicals are subject to fairly stringent regulation under the Toxic Substances Control Act in the United States and the Environmental Contaminants Act in Canada. Old chemicals and their degradation and by-products are much more difficult to manage, yet they make up a substantial part of the toxic chemicals problem.

Superimposed on these categories is the classification of a chemical as either persistent or nonpersistent. Persistent contaminants are of particular concern to the Great Lakes ecosystem because of their accumulation in the system, their long residency time, their low concentration thresholds (if any threshold other than 0 exists) for biological effects, and the possible long time delays between the entry of a contaminant into the system and the manifestation of those effects. Persistent pollutants must be managed on a transboundary basis because it is not possible to prevent their movement between jurisdictions.

Alternative Approaches and Principles for Management of Toxic Chemicals

Dealing effectively with chemical contamination problems within the Great Lakes basin necessitates considering the whole life cycle of hazardous chemicals, including production, usage, and disposal, as well as inputs from long-range transport. The use and dispersal of chemicals in the Great Lakes basin is widespread. Pesticides in agriculture account for an average release of 10 kilograms of chemicals per hectare in the environment; household consumption of pesticides, solvents, and chemicals is well over 20 kilograms per hectare. The latter and chemicals from many other diffuse sources find their way into the sewer systems, directly or as a result of runoff. An ecosystem approach requires a substantial effort to address the prevention side as well as the remediation side of the toxic chemicals problem.

Innovation has been an important feature of successful response to environmental problems, involving changes in products, process, and

control technology that are not only more efficient with respect to resources and energy but also more environmentally efficient and, hence, often more economic. Looking at the future (see Chapter 7) and, in particular, the shift from first- to second-generation problems, for which anticipation and prevention are the overriding concerns, innovation and technical change will be even more critical (Organization for Economic Cooperation and Development, 1984c).

Because of the long retention times of persistent toxic chemicals in the lakes, controls should be based on a load allocation plan using a mass balance concept rather than effluent concentrations. Such a plan has been suggested for the Niagara River in the Niagara River Toxics Committee Report, October 1984 (Report of the Niagara River Toxics Committee, 1984). This type of plan would progressively decrease ceilings on loading levels with an ultimate goal of zero discharge as described in Annex 12. Target loads for toxic substances would be developed similar to the target loadings for phosphorus in the supplement to Annex 3. Development of the models supporting this type of allocation are found in papers by Rodgers and Swain (1984) and Hallett (1985).

Toxic Waste Management

Waste disposal as a component of the hazardous chemical budget of the Great Lakes basin ecosystem presents society with an immense challenge. It is estimated that 11 million tons of hazardous wastes are generated each year in Region V of the U.S. EPA, while 1.5 million tons must be disposed of in the Province of Ontario. At this time, industry uses 55,000 different chemicals and produces 700 new substances each year. In North America, there are approximately 100 billion pounds of toxic wastes (350 pounds per capita) generated each year (Ristoratore, 1985), most of which goes untreated into landfills. The protection offered by state-of-the-art "secure" landfills is considered good during the life of the facility and medium in the very long term. As all containment systems are, over an extended time period, subject to failure, longer-term groundwater contamination is rated a danger with low to medium potential.

Modern toxic waste treatment technology is highly reliable, as compared with dumping the waste in landfills. High-temperature incinerators can destroy more than 99.99 percent of organic toxic materials; solidification processes neutralize inorganic waste and cast it into stone; special technologies such as incineration in high-temperature plasma and the scrubbing of effluents in molten salt beds can be used to destroy safely more refractory organic materials. Yet, releasing 0.01 percent of large quantities of toxic chemicals, the nature of which is unknown, contributes to atmospheric pollution and attracts the attention of the public, though the overall benefits of a reduction of 99.99 percent would obviously be great.

The committee finds that removal of existing toxic waste dumps as sources of contaminants to Great Lakes water poses a difficult problem. Treatment is complicated because the waste is often mixed

with earth, debris, and other solid wastes; the nature of the chemicals breakdown is unknown, and the underground water table is often contaminated. Action plans are being developed for the most serious sites, however, and the committee recommends that the Agreement should build on and extend these initiatives.

The prevention side of the toxic chemicals problem requires the banning of particularly hazardous chemicals, replacement of persistent toxic chemicals by less persistent, less-toxic alternatives, and the encouragement of the public and industries to recycle waste materials to the greatest extent possible. Education of the general public about the extent of the problem and the encouragement of a conservation ethic for society are important aspects of a comprehensive program for the management of toxic chemicals. Because hazardous chemicals may endanger human health and be injurious to resources basic for the economy, industry and consumers must, in cooperation with government institutions, work toward the establishment of an efficient hazardous chemical control strategy. The following principles are presented as guidelines for this control strategy:

(a) The replacement of the hazardous chemicals used in agriculture, forestry, and households by less-harmful alternatives. Study and education should focus on the most cost-effective benefit using the minimal amount of a chemical, e.g., integrated pest management for agriculture, forestry, and fisheries.

(b) The reduction of hazardous emissions should become a priority objective of the plant modernization process, with a longer-term goal of zero discharge. This includes the development of closed-loop systems and the use of nonhazardous nonpersistent alternatives.

(c) The establishment of effective hazardous-waste treatment facilities is necessary to ensure that risks to human health are eliminated to the greatest extent possible. Treatment facilities and programs should become precious assets of economic development and valuable contributors to solving problems of national interest.

(d) There is a need for cooperation between regulatory agencies and resource departments in fostering innovation in waste-treatment technology by streamlining environmental requirements and offering financial incentives.

(e) Basin municipalities and their citizens should make commitments to purify potable water with even traces of organic contaminants. This includes research into alternative treatments for drinking water, e.g., filtration through granular activated carbon.

(f) The determination of mass balances of the chemicals in circulation within the Great Lakes basin ecosystem is an essential feature of a chemical control strategy that interrelates all the above.

The committee finds that development of a comprehensive toxic chemical control strategy presents an unprecedented challenge to the two governments. The effective elimination of chemical hazards requires basin-wide and probably national strategies that deal with chemicals at each point in their life cycle. Governments will require

full cooperation of industry and the public to establish a comprehensive and compatible hazardous-chemicals management program.

The evidence of continuing high levels of toxic contaminants in the Great Lakes, and the complexity of controlling the diverse sources of these substances, leads the committee to conclude that the current programs for controlling persistent toxic substances in the Great Lakes ecosystem have proved to be inadequate. Because of the diverse sources of substances (air, land, groundwater, and industrial sources), the lipophilic character of many of the chemicals such as PCBs and dioxins, the hydrologic residence times of the lakes, the ability of the chemicals to biomagnify in the food chains, the evidence of effects on the ecosystem and subtle effects on humans exposed to the chemicals, the lack of effective control holds the risk of serious effects for generations to come. Thus, there is an urgency for approaches having the potential to achieve reduction of toxic pollutants in the Great Lakes and in the human population of the basin at the earliest possible date. Current research is exploring further the intricacies of potential effects, and our experience indicates that the consequences may be found to be even more severe than currently recognized. At the same time, there is evidence that the pollution of the Great Lakes is having some negative effect on economic development (see later sections).

Thus, the committee recommends that vigorous measures be taken to increase the understanding by the public of the long-term risks and the extent and implications of the various sources of toxic chemicals problems in the Great Lakes basin and to encourage a protection and conservation ethic for the population of the region from both the United States and Canada.

6

INSTITUTIONAL ARRANGEMENTS UNDER THE AGREEMENT

INTRODUCTION

The Great Lakes Water Quality Agreement of 1978 is part of a broad, complex, and changing set of institutional arrangements existing within and between the United States and Canada.

These arrangements and organizations may be cast into three distinct settings:

(a) The joint institutions established by the 1972 and 1978 Agreements that facilitate their (the Agreements) implementation;
(b) Other binational governmental and nongovernmental institutions concerned with Great Lakes resources; and
(c) The federal, state, provincial, and local governments within Canada and the United States governing environmental quality and resource allocations in the Great Lakes basin.

These institutions are important because it is through them that policies and programs relating to Great Lakes water quality are implemented. In spite of their importance, there is a "historical absence of a systematic analysis of the Great Lakes institutional system and its components" (Donahue, 1984). For some issues and concerns, this absence has hampered the committee's review of institutions.

The 1978 Agreement outlines a broad spectrum of organizational forms and program functions designed to achieve certain water quality objectives. In effect the Agreement may be interpreted as specifying a particular management system with interconnections between the various forms and functions for the purpose of achieving the objectives. Formalists emphasize the importance of the organizational and legal forms while functionalists affirm the preeminence of pragmatic functions within the system. In examining the current institutions under the 1978 Agreement the committee recognized that it was dealing with an evolving system which should not be criticized merely because the system's features, as manifested in 1985, differ in some ways from what may be inferred from the language of 1978.

In general, the recommendations set forth in this chapter arise from two basic concerns of the committee. One is the need for a clearer delineation of the responsibilities of the various institutions involved in managing Great Lakes water quality. Such

clarification should lead to a better functioning of the various institutions as well as greater accountability for their actions.

The second concern is based on the committee's desire to see Great Lakes water quality managed more from an ecosystem approach. This means, for example, that Great Lakes water-quality-related programs and policies, and the institutions that implement them, should be guided by the two basic ecosystem goals set forth in the 1978 Agreement to "restore and maintain the integrity of the waters of the Great Lakes basin ecosystem" (also see Chapter 3).

JOINT INSTITUTIONS UNDER THE AGREEMENT

We begin with a brief description of the history and organization of the joint institutions created by the 1972 and 1978 Agreements. These existing institutions are then examined, with respect to both their present responsibilities and an additional responsibilities relating to dispute resolution. The chapter ends with a discussion of other binational arrangements in the Great Lakes and suggests the need for a strengthening of the present institutional connections.

History and Organization

Examining the history and organization of the joint institutions is useful in developing an understanding of how they operate today. The International Joint Commission (IJC) dates to the 1909 Boundary Waters Treaty between the United States and Canada. Articles VIII-IX set forth the Commission's jurisdiction regarding questions and disputes that are brought before them. Article VIII gives the IJC jurisdiction over "all cases involving the use or obstruction or diversion of the waters with respect to which . . . the approval of the Commission is required." This "application procedure" was frequently invoked during the first several decades of the Treaty but is now infrequently used.

The relevant Article for both the 1972 and 1978 Agreements is Article IX of the 1909 Treaty, which provides that "any other questions or matters of difference arising between them involving the rights, obligations or interests of either in relation to the other or to the inhabitants of the other, along the common frontier . . . shall be referred . . . to the International Joint Commission for examination and report," whenever either the United States or Canada shall request it. While "references" were infrequent in the early years of the Treaty, they have in the last three decades surpassed the number of applications received by the Commission (International Joint Commission, 1982b). The Agreement represents in part a "reference" by the two parties to the IJC [Article VII, 1 (introduction), 1978 Agreement]. This "reference," however, is markedly different from most of those that the Commission receives because the Commission is charged with more than conducting an investigation and making recommendations.

The 1972 Agreement established a binational institutional framework to assist the two federal governments, the "parties," in implementing the Agreement. This framework was carried over in the 1978 Agreement. Article VII (1) of the Agreement, gives the IJC responsibilities of collating, collecting, analyzing, and distributing data; providing advice and recommendations; giving assistance in the coordination of joint activities relating to the implementation of the Agreement; investigating issues relevant to the Great Lakes basin ecosystem; and providing a public information service. These responsibilities are generally consistent with traditional references, except for the responsibility to coordinate joint activities.

Article VIII of the 1978 Agreement sets forth the institutions, which are in turn to assist the IJC in fulfilling these responsibilities (Figure 6-1). They consist of:

1. A Great Lakes Water Quality Board, "the principal adviser to the Commission" [Article VIII (a)].
2. A Great Lakes Science Advisory Board, "to provide advice on research to the Commission and to the Water Quality Board."
3. A Great Lakes Regional Office, "to provide administrative support and technical assistance to the two Boards, and to provide a public information service for the programs, including public hearings, undertaken by the International Joint Commission and by the boards."

The organizational charts of the Water Quality Board and the Science Advisory Board and their respective committees are given in Figures 6-2 and 6-3. The precise functions of both the Boards and the Regional Office are detailed in the Terms of References appended to the 1978 Agreement (see Appendix A).

The role of the Commission and its boards differs considerably under a traditional reference under Article IX of the 1909 Treaty and under the reference for the 1978 Agreement. Usually, a reference concerns a discrete issue, sometimes a rather broad one, which the Commission can address in a specific period of time and dispense with. Under the traditional reference, the Commission creates a board of experts. The board meets as necessary and issues a report. The IJC then holds hearings on this report and issues a report with its findings and recommendations to the two federal governments.

The role of the IJC under the Great Lakes Water Quality Agreement differs in a subtle way but in crucial respects from its role under most references from the two governments. First, the functions performed are explicitly ongoing as long as the Agreement is in effect; the mandate is that of a "standing" rather than "ad hoc" body [committee]. Second, the Commission is explicitly given the responsibility of evaluating those government programs (for research and pollution control) for which commitments were made in the Agreement. The most common form of reference to the IJC authorizes it to investigate a specific set of problems and make recommendations with respect to "remedial" measures, but these investigations are either explicitly limited in time (as in the case of the IJC 1970s

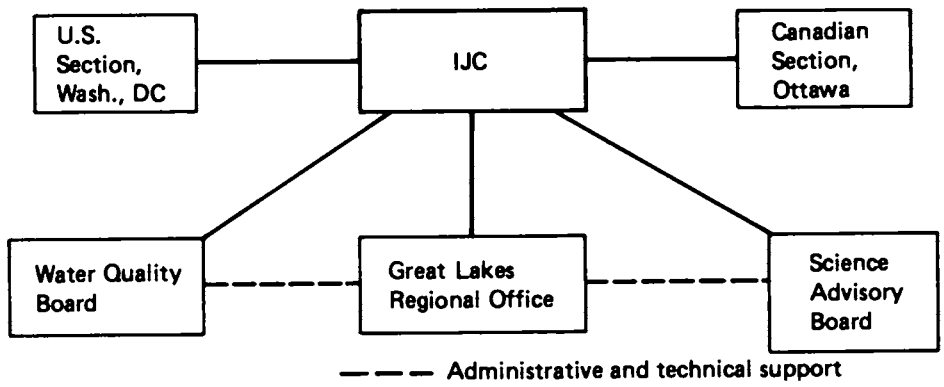


FIGURE 6-1 International Joint Commission and its advisory bodies including offices in Canada and the United States.

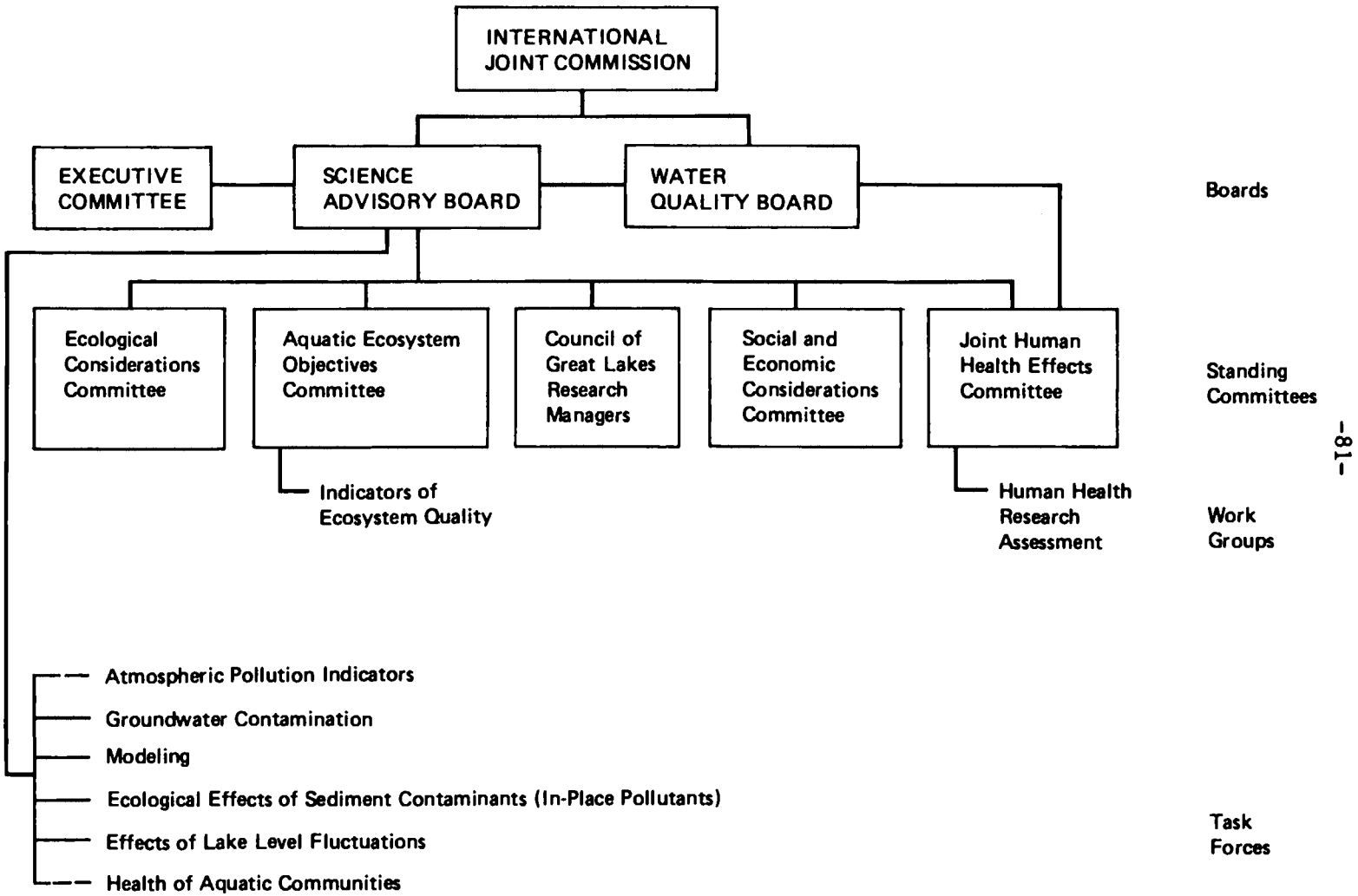


FIGURE 6-2 Organizational chart of the Science Advisory Board.

Note: The Council of Great Lakes Research Managers reports to the Chairman of the Science Advisory Board and to the Commission.

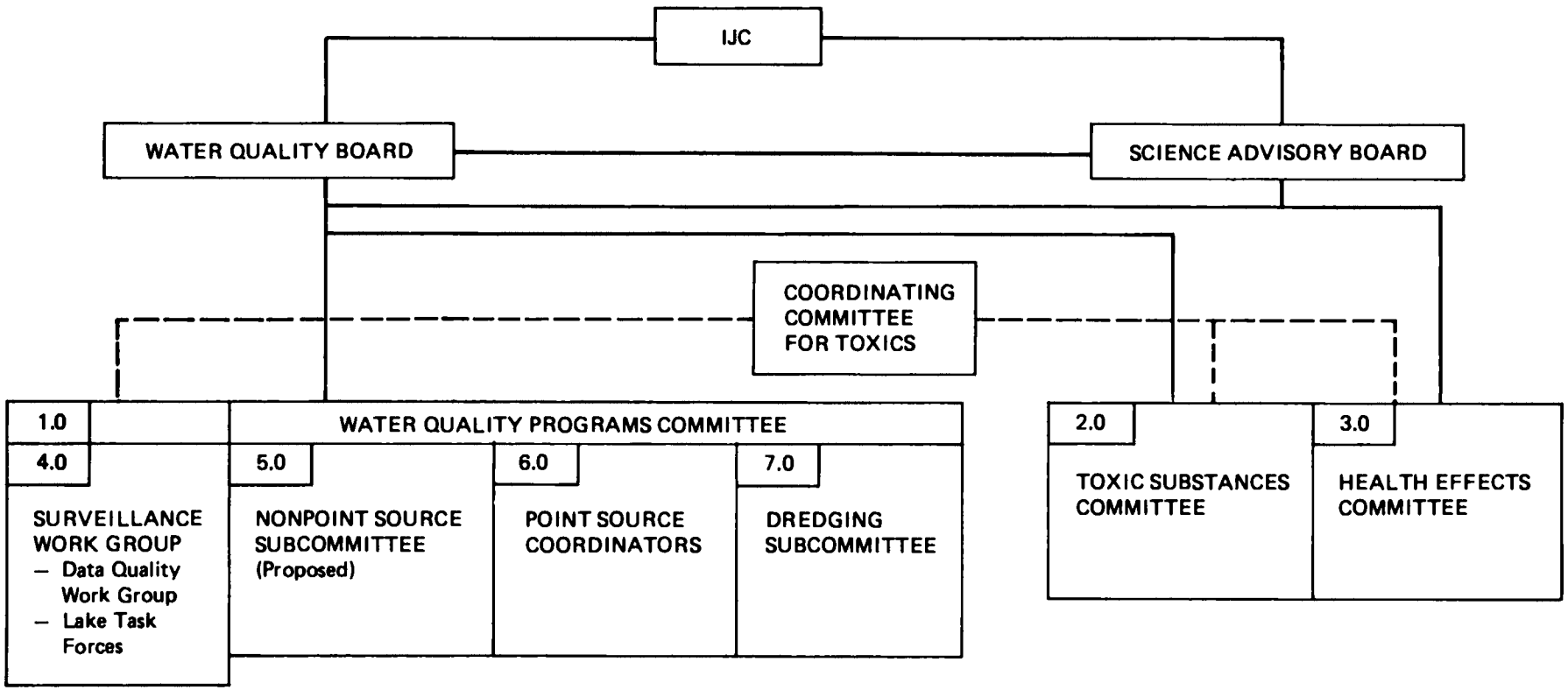


FIGURE 6-3 Organizational chart of the Water Quality Board.

Note: The Coordinating Committee for Toxics also coordinates the Aquatic Ecosystem Objectives Committee (see Figure 6-2).

reference on the Garrison Diversion project) or finite (as in the case of the IJC six year (1964-1970) study of the lower Great Lakes). They also do not involve an explicit program evaluation responsibility.

The selection of personnel for the Water Quality Board and Science Advisory Board also highlights the difference with a customary reference. Traditionally, the IJC appoints members to boards who serve in their professional capacity. These individuals are often technical experts or middle-level managers and serve in a technical advisory rather than a policy-making capacity. Under the 1978 Agreement, however, the IJC, in appointing the members of the Water Quality Board, accepts nominations from the states and provinces and their respective national governments. These appointees are agency officials who typically are appointed by virtue of their position and policy-making responsibilities. In the work of the Water Quality Board, they are generally policy-oriented and are expected to represent their "home" agency.

Existing Joint Institutions

Present Responsibilities

Overall, the record of the IJC and the associated joint institutions, as the record for the implementation of the Agreement, is one of substantial success at least with respect to their responsibilities that most closely resemble those of a traditional reference. For this they deserve much credit. However, the joint institutions have lagged in executing certain responsibilities, and in others improvements could still be made.

Data Collection, Analysis and Distribution Under Article VII 1 (a) and (b) of the 1978 Agreement, the IJC is directed to (a) collate, analyze and disseminate data and information supplied by the parties and provincial and state governments relating to water quality and pollution loading to the boundary waters and (b) collect, analyze, and disseminate data and information concerning the objectives and programs established under the Agreement. The Commission does not collect data in its own right, but relies on that provided by others. In addition, Article VII provides that the IJC "shall have authority to verify independently the data and other information submitted by the parties and by the state and provincial governments through such tests or other means as appear appropriate to it, consistent with the Boundary Water Treaty and with applicable legislation."

Data collection and dissemination involve the design and implementation of sampling and analysis procedures and the distribution of results. To obtain useful results the following functional details need to be considered in designing the data system: relevance to program objectives, a sampling model for the measurement system, definition of parameters, determination of methods of sampling, analysis of samples and verification of results,

definition of sampling sites and frequency of sampling relative to the model, and methods of data compilation and dissemination of information. The Commission has not undertaken to collect data in its own right.

The Water Quality Board has assumed primary responsibility for the functions related to data collection under the Agreement. Most of its programs have emphasized nutrient loading objectives (especially those relating to phosphorus), topics related to pollution from land-use activities (PLUARG), and toxic chemicals. The Science Advisory Board (or the Research Advisory Board prior to 1978) has directly or indirectly recommended or endorsed specific data-gathering projects such as International Field Year of the Great Lakes, project "HYPO," atmospheric contaminants in the Upper Lakes reference, and lake-wide review of agency surveillance. The Regional Office has played the role of review coordinator and has published findings related to specific objectives.

Individual governmental agencies, however, actually obtain the data and have exercised primary responsibility for their synthesis and summary; there has been little synthesis of information sets submitted by different agencies. Usually the Water Quality Board collates the agencies' summaries of results that cover nearshore studies conducted by states, the U.S. Environmental Protection Agency (EPA), and the Ontario Ministry of the Environment. Offshore data gathering has been the responsibility mostly of EPA, the U.S. National Oceanic and Atmospheric Administration and Environment Canada.

More often than not, state, federal, and provincial agencies appear to carry out their programs with little effective interagency coordination, even in cases where coordination was explicitly intended, as in the studies of the Niagara River Toxics Committee, where a group was established outside the IJC framework. Historically, the Water Quality Board has been able to specify a minimum number of parameters required to meet the defined objectives. The frequency, siting, intralaboratory and interlaboratory control, and reporting are not coordinated by this Board. It is cumbersome, if not impossible, to refine reported lake-wide averages to specific times and locations. Often one or more agencies may delay in reporting results. The media has even asserted that certain sensitive information has been withheld from the IJC by some agencies (The Globe and Mail, April 4 and April 10, 1985). An agency may argue that it has fulfilled its formal obligations, but what these are is not clear.

Continuing difficulties in measuring of toxic substances has led to some interagency cooperation, especially with regard to sampling, analytical control, and assurance. Although the regional office has carried out various round-robin studies, the effort seems to have intensified recently through Environment Canada and EPA protocols. It is not known how well these efforts are coordinated; some have been carried out on a laboratory-to-laboratory basis.

Since some of the data provided to the Water Quality Board are of varying quality and accuracy and are given in a form that makes comparison across jurisdictions difficult or impossible, the committee

recommends that the IJC should continue to develop protocols for standardizing the collection of the data.

The Water Quality Board, and to a lesser extent the Science Advisory Board, using the Regional Office, has annually or biannually reported data pertinent to objectives and programs in the Agreement. But because of a lack of central authority and central data system, neither the quality nor accuracy of the reported data can be assessed. In addition, this lack of a centralized data system makes it unlikely that all available data will be fully utilized, especially for whole lake or multilake studies. While it is not feasible for any one body to become a depository, the committee recommends that the Regional Office serve as a clearinghouse to provide information to researchers, governments, and other interested persons on where to locate comprehensive data on the Great Lakes.

The Water Quality Board, through its surveillance work group, has become increasingly aware of the criticisms of its monitoring and data-dissemination program. Through its design of the Great Lakes International Surveillance Program and modifications thereof, it hopes to improve data gathering and dissemination of information (International Joint Commission, 1984). Even with this implementation, however, data gathering and dissemination will still mainly be the domain of the federal, state, and provincial governments.

The IJC, however, could further improve Great Lakes data-management activities through judicious use of its authority, identified above, to verify independently data submitted to it by the parties and state and provincial governments. It might re-analyze information supplied by any of the governments. For example, the Commission could, independently of the jurisdiction, check the accuracy of data supplied to it on the total discharge of waste treatment plants in any or all jurisdictions.

An additional problem relating to data collection and analysis arises in the information provided by the Water Quality Board to the IJC. As noted above, the Board is dependent on the parties, states, and provinces to collect and transmit the data to the Board. In addition, the Board is composed of senior officials who represent these governments. While these representatives may be willing to share sensitive information among themselves, they may be less willing to share it with the Commission or to release it publicly. There is a two-step reporting process: (1) the Boards report to the IJC, and (2) the IJC then reports to the parties. At present the Commission does not exercise independent verification and peer review of the reports that the Water Quality Board issues to the Commission. Since, as noted in the Commission's first Biennial Report, the Commission on occasion has questioned the completeness of its "institutions" reports, the Commission should exercise its authority to arrange for an independent review of any Board report, as appropriate. The committee therefore recommends, that to the extent that Article VII (5) is interpreted not to apply to information submitted to the IJC by a board, the Agreement authorize that the Commission undertake as necessary to verify independently information submitted to it by any board. In so recommending, the Committee wishes to emphasize that it

is responding to the concerns of the Commission and does not believe that any Board has sought to mislead the Commission.

Advice and Recommendations by the Joint Institutions The 1978 Agreement sets forth the following responsibilities of the IJC that define this role:

1. Tendering advice and recommendations on "problems of, and matters related to, the quality of the boundary waters of the Great Lakes system." These matters include not only objectives, programs, and measures called for in the Agreement but also, in general, relevant legislation, standards, and other regulations [Articles VII (1) (d) and (e)];
2. Preparing a "full report" to these governments no less frequently than biennially "concerning progress towards the achievement of the General and Specific Objectives." This report is to include (a) as appropriate, matters related to programs set forth in the Agreement Annexes, (b) "an assessment of the effectiveness of the programs and other measures undertaken pursuant to this Agreement," and (c) advice and recommendations [Article VII (3)].
3. Tendering advice and recommendations and providing assistance in the Great Lakes basin ecosystem [Article VII (1) (f)].

To implement these responsibilities, the IJC relies on the joint institutions established in the 1978 Agreement: the Water Quality Board, the Science Advisory Board, and the Regional Office.

As an initial impression, the IJC has been successful in providing policy advice relating to Great Lakes water quality to the two parties and to state and provincial governments. The two Biennial Reports prepared under the Agreement by the IJC contain numerous specific program assessments and recommendations, as do the many reports issued by the IJC and its boards. For example, in 1982 the Science Advisory Board conducted a review of Great Lakes research activities to determine where gaps existed. The Board found that there was minimal research that examined the role of groundwater in contaminating the Great Lakes and subsequently created a Groundwater Contamination Task Force to review this question. As a result, recommendations were made in the Board's 1983 Annual Report regarding research needs on groundwater contamination (Science Advisory Board, 1983). This recommendation was transmitted to the parties in the IJC's 1984 Biennial report (International Joint Commission, 1984).

On further examination, the committee has concluded that this assessment of the IJC being successful in providing policy advice must be tempered. Although the IJC and its boards produce a considerable number of recommendations, information submitted to the committee indicates that only a fraction of them are formally recognized and responded to by the parties. This happens even though the parties through the Agreement originally solicited the advice. Furthermore, the committee is not aware of IJC advice and recommendations often

resulting in significant changes in the existing policies of the parties or state and provincial governments

Though many factors may contribute to this situation, the committee finds that the current institutional framework inhibits the ability of the IJC to provide adequate advice and recommendations to the parties and state and provincial governments. This institutional framework affects the information that the IJC is receiving from its boards and the activities of the IJC in preparing and conveying these recommendations.

The institutional framework established for the Great Lakes by the Agreement in theory calls for an objective, impartial set of institutions. For the Commission to function in this way, it is essential that it receive high-quality, objective, and impartial advice from its Boards. The 1978 Terms of Reference for the Water Quality Board direct it to assist the IJC "at the direction of the Commission," in developing this advice, including (a) identifying deficiencies in the scope and funding" of programs to achieve the Agreement's purpose and evaluating the "adequacy and compatibility of results"; and (b) examining the "appropriateness of such programs in the light of present and future socioeconomic imperatives."

In the past, however, the IJC itself has stated its concern over the quality of information that it is receiving from the Water Quality Board. In its discussion of "Institutional Roles and Opportunities" in the First Biennial Report to the parties, the IJC observed that the Water Quality Board, its "principal advisory board," is "composed of individuals not necessarily acting independently of their home organizations" (International Joint Commission, 1982b). Such a lack of impartiality is of great concern. Reportedly the parties both responded that members of the Boards were instructed not to serve as representatives from their agencies.

The type of information provided to the IJC is also of concern. In the First Biennial Report to the parties, the IJC noted that the information provided to it in the past (pre-1982) focused primarily on engineering and scientific concerns and was not in a form to assist the IJC's assessment of "larger social concerns and aspirations" (International Joint Commission, 1982b). This concern is repeated in the Second Biennial Report when the IJC stated that "the Commission is not satisfied that the information it now receives enables it to assess adequately programs and progress as required under the Agreement" (International Joint Commission, 1984). For example, much of the information provided to the Commission on progress toward water quality objectives is in the form of discharge permits or control orders and the related monitoring and surveillance. In the words of the Commission, these do not "establish a firm link between the implementation of the programs . . . and the achievement of specific objectives" (International Joint Commission, 1984).

In addition, though the Science Advisory Board has a broad mandate, its influence has lagged. As "science advisor" to the IJC and the Water Quality Board, the Science Advisory Board is charged with assisting the IJC in providing advice relating to research. Its 1978 Terms of Reference makes it responsible for developing recommendations

on all matters related to Great Lakes water-quality research and directs it to report to the IJC and the Water Quality Board on "all matters of a scientific or research nature relating to the operation and effectiveness of this Agreement." In addition, the Board is to "advise jurisdictions of relevant research needs." But much of its time is consumed with the preparation of the annual report to the Commission and the disbursement of the extramural funds, which are slightly less than $100,000 annually. While these funds do play an important role in stimulating new ideas or determining answers to a few key scientific questions, it is not always clear that the intended products are, in fact, useful to the Board's mission and that the results are effectively channeled into the ongoing work of the Board.

Some view the whole institutional structure of the Commission, the Water Quality Board, and the Science Advisory Board as suffering from the weight of too many committees, subcommittees, ad hoc panels, etc. That some members of the Science Advisory Board and the Water Quality Board had little previous association with Great Lakes issues is seen as contributing to problems. At an operational level this may make coordination between the various entities exceedingly difficult and time consuming, and, thus, it may not occur. Information exchange and the development of policy recommendations suffers as a result. In addition, coordination between the various subgroups within the two Boards (Table 6-2 identifies these Boards) and between these groups and the relevant boards of the Commission is difficult. This situation has been blamed for a perception that the IJC and its Boards constitute a ponderous organization.

Some of the difficulties noted above also may be due differences in value orientations among participants associated with differences as to the nature of the ecosystem approach (see Chapter 3). Simply stated, some individuals are pragmatists who seek to improve the functioning of existing infrastructure of the region, including elements of exploitive development, and these people may be uncomfortable with reformers (see Pepper, 1984) who seek to implement aspects of "sustainable development" within a short time-frame. If reduction of conflict within the IJC family is important, then some management of these differences may be desirable.

The joint institutions can undertake many steps to improve consensus development and the preparation and transmission of recommendations and supporting information to the IJC. Steps include consolidating committees, refining committee charges as appropriate, and appointing individuals to boards and committees with the outlook and range of expertise necessary to improve agreement on the broad variety of water quality problems facing the Great Lakes basin ecosystem. Other steps require changes in the Agreement. To this end, the committee recommends that

- The Commission provide that members on the Water Quality Board include both individuals who are and are not representatives of government agencies and who reflect the diverse backgrounds relevant to Great Lakes issues, and that the parties to the Agreement cooperate with this Commission initiative.

- The parties should establish that the Science Advisory Board be solely responsible to the Commission and that the Commission ensure the appointment of members who reflect the diverse backgrounds relevant to Great Lakes issues.

The expanded membership of the Water Quality Board will ensure that the individual federal, provincial, and state governments continue to be directly represented on this Board and that their concerns will be incorporated into the Board's deliberations while lessening their dominance. This arrangement should help the Board to offer on a consistent basis an independent evaluation of the specific measures and programs called for in the Agreement.

If the Commission is to be responsible for the active oversight of the Agreement, then it would be useful to have a strong Science Advisory Board to which it could ask questions and from which it would regularly receive advice. Making this Board solely accountable to the Commission should strengthen it. Such an arrangement would not preclude this Board from also assisting the Water Quality Board on research-related issues.

With respect to the activities of the IJC in preparing and conveying recommendations, its ability to execute these functions is hampered by its limited resources and the present responsibilities of the Regional Office. Under its Terms of Reference, the Regional Office is directed to provide "administrative support" and "technical assistance" to the Water Quality Board and the Science Advisory Board and their suborganizations. The Terms of Reference do not extend this support and assistance to the IJC. The Director of this Office is appointed by the Commission, in consultation with the parties and the United States and Canadian co-chairs of the two Boards. However, the Director is under the "general supervision" of the Water Quality Board and is "responsible to the co-chairman of each Board" for activities executed by the Office and its staff on behalf of a Board. The Office's annual budget is submitted jointly to the IJC by the two Boards. The result of this arrangement is that in practice there appears to be tension between the IJC and its Boards about to whom the Regional Office should be responsible, for what, and to what degree.

The 1978 Agreement called for a review of the staffing of the Regional Office within six months. This review took place and set forth several discrete recommendations relating to the role of the Director, staffing responsibilities, and communication with the Commission (Joint Canada/United States Study Group, 1979). Since the tension remains, the parties should now consider restructuring the relationship of the Regional Office to the joint institutions. The committee recommends that the parties make the Regional Office wholly responsible to the Commission. Such an arrangement should allow the regional office to continue to assist the Boards while reinforcing the ability of the IJC to develop and offer independent recommendations to the affected governments.

At the same time, the Commission and its joint institutions need guidance from the parties as to the priorities that should be pursued and the usefulness of the advice proffered. Thus, it becomes

essential that better processes of accountability than exist at present be institutionalized between the two parties and the IJC. The most effective and efficient way to accomplish this would be for the Agreement to call for a meeting between the parties and the Commission following publication of the biennial report from the Commission. This would provide a forum for the parties to respond to the contents of the report and to set priorities, within the limits of the Agreement for the ensuing period. For a brief period after the 1972 Agreement, the parties held an annual "stocktaking" meeting following issuance of the Annual Report; however, this practice lapsed. Since there now exists no regular channel of communication and accountability between the two parties and the IJC, the committee recommends that the Agreement provide for a high-level biennial meeting between the IJC and senior representatives of the two countries, which should follow publication of the biennial report.

Assistance in the Coordination of Joint Activities Article VII 1 (e) of the 1978 Agreement gives the IJC responsibility for providing "assistance in the coordination of the joint activities envisaged by this Agreement." The Water Quality Board, under its Terms of Reference, has the particular responsibility on behalf of the IJC to "undertake liaison and coordination between the institutions established under this Agreement and other institutions and jurisdictions which may address concerns relevant to the Great Lakes basin ecosystem so as to ensure a comprehensive and coordinated approach to planning and to the resolution of problems, both current and anticipated." The Science Advisory Board Terms of Reference gives a more limited role of advising the jurisdictions of relevant research needs, soliciting their involvement and promoting coordination.

In general, it is difficult to determine precisely how much of the desired coordination function is being accomplished currently by the joint institutions. Clearly, the recent annual reports of the Water Quality Board and Science Advisory Board show great evidence of communication and coordination between the parties and state and provincial governments, through the auspices of the Regional Office and the two Boards and their committees.

However, the IJC in its Second Biennial Report under the 1978 Agreement noted several areas where coordination of programs and initiatives had been recommended previously to the parties, but, as judged by the Commission, progress has been inadequate. The prior recommendations for implementing a comprehensive toxic substances control strategy, as one example, were judged to "have not advanced far enough," and the Commission urged "governments to increase their efforts in support of a coordinated strategy which addresses the problem of manufacture and continuing on through the transport, use and life of these substances" (International Joint Commission, 1984).

Regarding management of the scientific enterprise under the Agreement, the Commission has asserted that the "scheduling and allocation of funds and available expertise have not always been well coordinated" (International Joint Commission, 1984). Continuing, they

noted "uncertain levels of support, timing of awards and receipt of funds have affected the ability to keep essential levels of personnel in certain activities and have inhibited coordinated research programs" (International Joint Commission, 1984).

As a result of its review, the committee finds that the Water Quality Board's efforts to coordinate pollution-control programs between the appropriate federal, provincial and state agencies adversely affects the ability of the IJC, with the assistance of its Boards, to offer independent advice to the parties. The parties are responsible for program implementation, part of which involves the coordination of control programs. (The word "coordination" is used here to mean the efforts that lead to the development in the affected jurisdictions of control programs with similar effectiveness and implementation schedules.) Since, as noted at the beginning of this chapter the Board's members represent their home agencies, by undertaking this function the Board is brought directly into the implementation process. This role is inconsistent with the Board's role of providing independent expert advice to the Commission on the implementation of the Agreement. Since the Water Quality Board appears to spend considerable effort on such coordination, these activities divert limited Board, IJC, and Regional Office resources from evaluation of the implementation of the Agreement.

Similar concerns have been voiced by the IJC. For example, in its Second Biennial Report, the Commission highlighted the recent tendency for Commission resources to be used to implement parts of the toxic chemicals control strategies on behalf of the parties. The IJC went on to note that this practice compromises the ability of the IJC to comment on the effectiveness of programs and strategies under the Agreement while removing the obligation for implementation from the responsible agencies (International Joint Commission, 1984).

The committee therefore recommends that the coordinating responsibilities for the control programs that implement the Agreement be left to the parties, rather than the Water Quality Board. Coordination should be handled through bilateral government-to-government meetings.

Investigations The 1978 Agreement assigns two specific responsibilities for investigations to the IJC. Under Article VII 1 (g), the Commission is to investigate subjects related to the Great Lakes basin ecosystem, "as the parties may from time to time refer to it." Article VII 3 in the Agreement establishes that the IJC may "at any time make special reports to the parties, to the state and provincial governments and to the public concerning any problem of water quality in the Great Lakes system." In addition, the Water Quality Board and the Science Advisory Board may conduct investigations pursuant to their general terms of reference.

Since the signing of the 1978 Agreement, the parties have not asked the IJC to conduct any investigations. Rather, all investigation activities have been initiated by the Water Quality Board and the Science Advisory Board. Within the two Boards, investigations are

assigned to various committees or ad hoc task forces. The Regional Office should provide technical and financial assistance to task forces.

The 1983 Report of the Water Quality Board does not explicitly identify its investigational activities, but they appear to be oriented to the responsibilities of program coordination and the collation and dissemination of data.

The investigations of the Science Advisory Board are tied to its evaluation of research needs in the Great Lakes. During 1982, for example, the Board identified eight areas of significant gaps in scientific knowledge. These gaps were then addressed by task forces and committees created by the Board (Science Advisory Board, 1983).

These positive aspects of the investigative function, however, belie a lack of coordination within the IJC. The Boards' investigative initiatives seem to be self-initiated rather than responses to specific problems or issues raised by the Commission. Furthermore, the standing committees within the Science Advisory Board structure (e.g., Aquatic Ecosystems Objective Committee) appear to be largely autonomous units, their agenda and membership being determined by the task force chairperson. This situation runs counter to the Agreement which establishes these Boards as advisors to the IJC and not as independent entities (see beginning of this chapter).

The committee believes it would be useful for the IJC to assert itself more and initiate specific investigations, as needed. The Agreement allows such studies as special reports (i.e., the special report on Niagara River Pollution, International Joint Commission, 1981c), and at least one Commissioner has noted that the IJC should conduct these types of studies without waiting for a reference (Seaborn, 1984).

Public Information The 1978 Agreement assigns responsibility for "public information service" for the programs of the International Joint Commission, the Water Quality Board and Science Advisory Board to the Regional Office (Article VIII 3). Both the 1982 and 1984 biennial reports of the IJC have stressed the value of public information and education in building support for the Agreement's goals. Still, limited resources have been committed to public information, and results have been irregular. Ongoing public information efforts have depended on extraordinary staff efforts and the interests of individual commissioners.

Only one full-time permanent staff position has been continuously committed to public information since the Regional Office was established. The public information director has been responsible for producing the highly esteemed, quarterly newsletter, Focus, and other information materials such as a slide show and brochures about the 1978 Agreement and the IJC. The director also responds to requests for information from the public and the news media and makes arrangements for events that are open to the public as well as for many special workshops of the boards and committees.

The greatest effort to obtain public involvement in an IJC program was made during the mid-1970s for the PLUARG study. This is the only

instance of which the committee is aware in which a full-time staff position was dedicated to promoting public involvement in a major IJC study. As part of this study, the Commission created 17 public advisory panels, 9 in the United States and 8 in Canada. Both the PLUARG report to the IJC (International Reference Group on Great Lakes Pollution from Land use Activities, 1978) and the IJC's report on PLUARG to the parties (International Joint Commission, 1980a) noted the contributions of the advisory panels to the final conclusions and recommendations of the study. There were, however, shortcomings as well as strengths to this process, as noted by Grima and Mason (1983).

Public involvement in a single IJC event resulted from extensive efforts of an IJC commissioner for the 1983 IJC meeting in Indianapolis. Special events included exhibits visited by many school groups and a poster contest in elementary and high schools. Hundreds of persons including whole university classes traveled to Indianapolis to participate in a workshop on Great Lakes issues.

In response to an IJC directive to increase public participation, reported in the second biennial report (International Joint Commission, 1984), the Science Advisory Board has held public sessions as part of three different meetings.

While the public information programs of the IJC and its joint institutions have been useful, the committee believes that better programs with more continuity are needed. Public involvement seems to occur only in response to special attempts to stimulate it. Furthermore, it appears to the committee that the public at large has little knowledge of the Agreement and its purposes and effects. The success of the Agreement depends not only on scientific and technical expertise but ultimately on an aware public concerned about the issues involved.

New Responsibility--Dispute Resolution

One important issue in implementing any Agreement is the resolution of disputes concerning alleged violations of the Agreement. To date disputes over the implementation of the 1978 Agreement have been few. Indeed there has been only one important dispute over an alleged violation of the Agreement, the Niagara River controversy. At issue was whether the United States was in violation of the 1978 Agreement because of seepage of pollutants from landfills into the Niagara River and, hence, into Lake Ontario. This dispute was addressed outside the framework of the Agreement and the IJC in the ad hoc intergovernmental Niagara River Toxics Committee.

The committee is concerned that these disputes will increase. As indicated in Appendix A and B, the 1978 Agreement sets forth highly detailed obligations of the parties relating to the control of water pollution in the Great Lakes. Moreover, as scientific knowledge advances, there may be more specific standards incorporated into the Agreement. Also, the inclusion into the Agreement of implementation deadlines may become more necessary and frequent.

The 1978 Agreement makes no provision for the final resolution of these disputes. Article X does provide for notification of and consultation with the other party on problems of joint concern that require an "immediate response." But, there is no provision for either formal or informal procedures that could be followed should parties disagree as to whether a violation may exist.

Early in this century when there was intense concern about the pollution along the shores of the Detroit and Niagara Rivers and about inclusion of a formal dispute resolution mechanism in the Agreement, the IJC recommended to both countries that it be given the authority to regulate this pollution. The United States and Canada asked the Commission to draft a convention or reciprocal legislation to accomplish this which was to include "proper provisions for the enforcement of such orders, needs, and directions" (Bilder, 1972). While both governments considered the resulting IJC draft convention, they never reached agreement on it. In particular, the United States objected to the provision that would have made the findings of the Commission with regard to facts "final and conclusive."

Article X of the 1909 Boundary Waters Treaty provides the only formal binational procedure for the resolution of these disputes. It provides that

> . . . questions or matters of difference arising between the . . . parties involving the rights, obligations, or interests of the United States or of the Dominion of Canada either in relation to each other or to their respective inhabitants may be referred for decision to the International Joint Commission by the consent of the parties, it being understood that on the part of the United States any such action will be by and with the advice and consent of the Senate and on the part of His Majesty's Government with the consent of the Governor General in Council.

If the Commission is unable to reach a decision, the Commissioners must make either a joint report or separate reports to their Governments, and the questions at issue shall be referred to an umpire for settlement. The umpire is to be chosen in accordance with Article XLV of the 1907 Hague Convention for the pacific settlement of international disputes. To date no disputes have come to the IJC under this provision of the 1909 Treaty.

Disputes under the Agreement are highly unlikely to rise to the level of a dispute that the parties would submit to the IJC under Article X of the Boundary Waters Treaty. Since the United States can only submit such disputes with the advice and consent of the Senate, this provision will not be used frequently especially for disputes that need immediate resolution. Moreover, for many disputes it would not be appropriate to use such a formal procedure.

Disputes over alleged violations of the 1978 Agreement's provisions are significant as they directly influence the continued effectiveness

of the Agreement. As a result of the lack of effective dispute resolution mechanisms, the committee recommends that the Agreement provide processes through which parties can resolve disputes arising over the implementation of the Agreement. The procedures should include informal and formal means.

In considering dispute resolution mechanisms for the Great Lakes Water Quality Agreement, it is important to focus on both those that might assist in averting or minimizing disputes and those that are intended primarily to resolve the dispute after it has arisen. These processes are of two general kinds: those that relate to procedures that would be available within the framework of the joint institutions and those that focus on the potential role of the joint institutions in assisting national enforcement mechanisms, by providing scientific expertise or by filing amicus curae briefs on behalf of the Commission.

In the former, there are several informal and formal procedures that could be explicitly made available under the Agreement to aid in preventing or minimizing disputes. These range from consultation between the parties to the appointment of mediators, either Commission members as in the Skagit Valley dispute between Seattle and British Columbia (Stein and Grenville-Wood, 1984) or experts from one of the Boards, to the use of a panel of experts established on an ad hoc basis independent of the Commission to settle the dispute.

The Committee believes that it would be useful for the parties to establish, as part of the joint institutions, an additional mechanism to settle disputes such as an independent commission of experts who would be available to the parties for use on an ad hoc basis to assist in resolving disputes. The Commission could proceed in a manner somewhat similar to the way the IJC now functions in responding to a traditional reference and establishing facts through impartial investigation. We characterize this body as a Commission of Enquiry, an institution that dates to the Hague Conventions of 1899 and 1907 and has been used recently in one international agreement. The Organization for Economic Cooperation and Development Report on "Responsibility and Liability of States in Relation to Transfrontier Pollution," which both Canada and the United States approved, recommends "the establishment of procedures for the settlement of disputes in regard to transfrontier pollution problems which would not be resolved by negotiation," and notes "the possibility as need be of setting up enquiry commissions responsible for establishing the facts on an objective and impartial basis" (Organization for Economic Cooperation and Development, 1984d).

A commission of enquiry for major disputes over the Great Lakes Water Quality Agreement could be developed as a separate, independent joint institution under the Agreement. Structural independence from the Boards and the Regional Office is essential to protect the Commission from political interference and to ensure that it does not become burdened with the normal operations of these institutions. The virtue of establishing a formal procedure for addressing major disputes is that it commits parties to resolving their disputes in good faith, is immediately available when needed, and may help to prevent disputes from materializing.

OTHER BINATIONAL ARRANGEMENTS IN THE GREAT LAKES

As noted in the Introduction to this chapter, the IJC and the joint institutions established under the Agreement are part of a complex set of institutional arrangements relating to the management of the Great Lakes. Many other binational governmental and nongovernmental institutional arrangements for governance of Great Lakes resources exist.

Table 6-1 identifies binational governance arrangements that are independent of the IJC. This table also describes the purpose and membership of these institutions and briefly summarizes their activities, staffing, and financing. Table 6-2 is similar to Table 6-1; it identifies IJC Boards that were created outside of the framework of the Agreement but that have responsibilities relating to the management of the Great Lakes. Some of the institutions and organizations identified in these tables existed or developed independently of the Great Lakes Agreement process, some have been fostered by the international processes that the Agreement requires. Some, like the Great Lakes Fishery Commission and Migratory Bird Treaty of 1916, grew out of formal efforts between the two federal governments. Other initiatives, such as the Great Lakes Charter and the Niagara River Toxics Committee, illustrate binational cooperation initiated outside formal diplomatic channels in response to concerns of mutual interest.

In many cases, no special staff is provided for the binational activities. Almost all activities are financed by participating agencies or organizations. IJC Boards are financed by the IJC. Even when there is a formal arrangement for federal government financing, such as for the Great Lakes Fishery Commission, cooperating agencies largely support their own activities.

The very existence of these activities underscores the fact that many organizations and programs, in addition to those carried out under the 1978 Agreement, influence or are influenced by Great Lakes water quality. Clearly, some coordination is desirable. For example, any program under the Agreement addressing the effects of airborne contaminants on the Great Lakes should be coordinated with the appropriate work efforts under the Memorandum of Intent on Transboundary Air Pollution. This coordination is even more important for successful Great Lakes management based on the ecosystems approach outlined in Chapter 3 when the management involves more uses of the Lakes, larger spatial scales, and longer time intervals.

As evidenced by the number of recently created binational arrangements identified in Tables 6-1 and 6-2, there appears to be a pattern of binational cooperation that could be called on to support institutional changes required for an operational ecosystem approach to Great Lakes issues. There is an openness and flexibility in both countries in designing cooperative arrangements that are creative and pragmatic.

This trend toward more cooperation among various intergovernmental entities in the Great Lakes basin bodes well for the Great Lakes. In practice, however, at present the committee has found there to be

TABLE 6-1 Binational Governance Arrangements Outside the Great Lakes Agreement

Binational Institutions Independent of IJC

Institution	Purpose	Members	Activities/History	Staff/Finances
Great Lakes Fishery Commission	Coordinate maintenance of fisheries	4 from each side, named by Privy Council and President	Coordinate sea lamprey control and advise on other fishery matters	Lamprey costs split 69%/31% U.S./Canada; other costs evenly
Council of Great Lakes Governors	Provide a forum on mutual interests	Governors, with premiers as associate members	Developed Great Lakes Charter and seek to promote economic development in region	$20,000 annual dues, plus foundation and private support for special projects
G.L./St. Lawrence Maritime Forum	Promote trade and commerce	includes govt. and nongovt. organizations	Promotes use of Seaway but has no formal agenda	Funds raised ad hoc for projects
Internatl. Assoc. of G.L. Ports	Promote G.L. shipping	4 U.S., 5 Canadian port authorities	Lobby on impediments to use of Seaway	Annual dues of $500
Niagara River Toxics Committee	Investigate toxic chemical problems	2 each EPA, N.Y., Ontario, and Environment Canada	Formed by agencies to recommend actions on Niagara toxics	Staffed and financed by initiating agencies
Upper G.L. Connecting Channels Study Committee	Assess toxics in rivers and Lake St. Clair	Fisheries and management agencies, with IJC observer	Formed in 1984, with study to be completed in 1988	Staffed and fianance by initiating agencies
Coordinating Committee on Hydraulic and Hydrologic Data	Coordinate methodology for data collection	Environment Canada, Fisheries and Oceans Corps, and NOAA	Formed in 1953 to assure compatibility of data	Staffed and financed by initiating agencies
Michigan-Ontario Transboundary Air Pollution Committee	Develop cooperative program for air pollution	Wayne County, Michigan, DNR, and 2 from Ministry of Environ.	Initiated by governors and premiers; worked closely with IJC air board to 1983	Staffed and financed by participating agencies
Memorandum of Intent on Transboundary Air Pollution	Develop basis for negotiating agreement especially on acid rain	Govt. scientists organized in 5 technical working groups	Committee work stalled, with negotiations now by formal diplomatic procedures	Expenses covered by governments through participating agencies

TABLE 6-1 Binational Governance Arrangements Outside the Great Lakes Agreement (continued)

Binational Institutions Independent of IJC

Institution	Purpose	Members	Activities/History	Staff/Finances
Migratory Birds Convention	Control killing of migratory game	No formal body for implementation	Signed 1916	
Internatl. Migratory Birds Committee	Foster cooperation under 1916 convention	Resource ministers and cabinet secretaries	Established 1960s, has not met since 1970s	
Canada-U.S. Programme Review Committee	Advise govts. on protection of migratory birds	3 each from federal govts.	Developing North American Waterfowl Management Plan	Research and participation financed by agencies
Mississippi Flyway Council	Recommend hunt regulations	1 from each state and province	Recommends regulations to federal governments	Staffed and financed by participating agencies
St. Lawrence Seaway Authority and Development Corp.	Coordinate construction, operation of seaway	Administrators appointed by federal govts.	Determine policies jointly for separate implementation	95% financed by tolls, balance by federal transportation agencies
Seaway Internatl. Bridge Corp.	Operate bridge at Cornwall	8 members, most from Canada	Maintains bridges and collects tolls	95% by tolls, balance by Seaway agencies

TABLE 6-2 IJC Boards Outside Great Lakes Water Quality Agreement

Institution	Purpose	Members	Activities/History	Staff/Finances
4 Internatl. Boards of Control	Assist IJC decisions on levels and flows	Equal members from each side named by IJC commissioners	Develop and implement regulation plans, since 1909	Staffed by agencies; report publication financed by IJC
Internatl. G.L. Levels Advisory Bd.	Advise IJC on levels and public information	16 members, 8 per side, with half members from public	Carries out studies, reports twice a year	Financed by agencies and IJC
Internatl. G.L. Technical Info Network Bd.	Study adequacy of levels and flows measurements	Environment Canada, Fisheries and Oceans Corps, and NOAA	Reported to IJC 1984 on user needs and adequacy of data	Financed by agencies involved in study and data collection
Internatl. Air Pollution Bd.	To advise govts. about air quality	EPA, 1 N.Y., and 3 Environment Canada	Reports twice yearly on transboundary pollution	
Joint Response Team for the Great Lakes	Spill clean up of oil/hazardous materials	Canada and U.S. Coast Guards and other agencies	Maintains Joint Contingency Plan invoked 9 times since 1971	Staffed by agencies; cleanup costs where spill occurs

little formal liaison and coordination between the IJC and other binational institutions. This situation arises in spite of Article VII 6 in the 1978 Agreement, which directs the Commission to "ensure liaison and coordination between the institutions established under this Agreement and other institutions which may address concerns relevant to the Great Lakes basin ecosystem," including both those within its purview, such as those Boards related to Great Lakes levels and air pollution matters, and other international bodies, as appropriate. The existence of formal mechanisms and procedures for coordination would increase the likelihood that effective exchange of information and minimization of program duplication will take place.

Other observers have voiced similar concerns. For example, the Great Lakes Governors Task Force on Water Diversion and Great Lakes Institutions recently noted that a problem facing policy-makers in the Great Lakes region is the lack of an "integrated institutional arrangement" or even an "administrative means to better coordinate the existing arrangement" for addressing Great Lakes resource management issues (Great Lakes Governors Task Force on Water Diversion and Great Lakes Institutions, 1985). The Task Force stated that this problem results in a "failure to set resource management concerns in a regional, or basin-wide context" (Great Lakes Governors Task Force on Water Diversion and Great Lakes Institutions, 1985).

To reinforce the perceived trend toward cooperation among various binational institutions, the committee recommends that the Commission provide for a formal channel of communication between itself and other binational institutions having responsibilities relating to the water quality of the Great Lakes. Such channels could include a requirement for regular meetings between the IJC and other binational institutions or creation of a standing committee to assist in the coordination function. These formal channels should be more explicit than the general coordination mandate, cited above, that is at present in the 1978 Agreement.

Additionally, the absence of any spokesperson for the Great Lakes basin as an ecosystem leads the committee to find that there is a need to take additional steps now to facilitate our learning about the ecosystem and to ensure that the mandate for an ecosystem approach in the 1978 Agreement is carried forward as effectively as possible. Accordingly, the committee suggests that one way to achieve this would be to establish an ombudsman for the Great Lakes basin ecosystem.

The ombudsman could identify and warn of adverse impacts on water quality and the Great Lakes ecosystem from actions in the basin and elsewhere. The office of the ombudsman could provide a focus for both enhancing the productivity of the ecosystem and sustaining its renewal. It could facilitate public participation in carrying out ecosystem objectives and send an important signal to individuals and communities that the Great Lakes basin must be viewed as an ecosystem. Ombudsmen are common to many states in the United States, to most provinces of Canada, and to a variety of nongovernmental institutions.

FEDERAL, PROVINCIAL, AND STATE GOVERNMENTS

Under the terms of the Agreement, the parties, the United States and Canada, made a number of significant commitments including being responsible for adopting the joint objectives and implementing the programs and measures called for in the Agreement. Though they are not signatories, in practice the 8 Great Lakes states and the Province of Ontario also have significant responsibilities for program implementation. They have subsequently made substantial efforts toward meeting those commitments, as documented elsewhere in this report. Not all the commitments made, however, have in fact been met, as indicated in the summary given in Appendix B.

Some of the reasons why actions have fallen short are not difficult to identify. There is a lack of adequate scientific knowledge about many pollutants and environmental effects but not to the extent that all remedial actions should be held in abeyance. Governmental resources are limited, and there are competing demands for these resources, and regulatory action in the environmental area is often controversial. To note these constraints though is not to excuse the failure to meet commitments, which, in the case of the Agreement, are enshrined in an international accord frequently referenced and publicized by the governments themselves. Noting their persistence as constraints makes clear the need for better mechanisms to be built into the Agreement to ensure to the maximum extent possible that not only the signatory parties but all governments involved meet the commitments that they have undertaken.

The Parties

There is no provision in the present Agreement for the federal governments themselves to report on their progress in implementing the Agreement or to meet together to discuss their programs and progress.

Although a short series of so-called "stocktaking" Canada-U.S. meetings was held under the 1972 Agreement, these have not been continued. Rather, virtually all such communication and all coordination of programs is carried out under the auspices of the IJC, in the meetings of the Water Quality Board and Science Advisory Board. This creates a conflict, because the government officials who are members of these Boards formally participate in them as advisors to the IJC, not as government spokesmen, even though they may be appointed, as in the case of the Water Quality Board, as representatives from their governments.

In addition, the committee is not aware of either the United States or Canada releasing detailed public statements of the status of the implementation in their respective countries of Agreement-related programs. The parties do respond to some points raised in IJC biennial reports under the 1978 Agreement, but these responses do not address all their commitments. Similarly, other public documents, such as the March 1985 issue of EPA Journal on the Great Lakes (Environmental Protection Agency, 1985a) and papers prepared for the

June 1985 "Dialogue on Great Lakes Water Quality" (Center for the Great Lakes et al., 1985), are useful accountings but are not complete.

It should be clear where responsibility for implementation rests. The committee therefore recommends that the Agreement should direct the Canadian and United States governments each to prepare reports biennially for the purpose of reviewing the progress achieved in implementing the Agreement and to hold bilateral meetings regularly at the ministerial level with respect to the Agreement. The reports by each government should be made public at least 90 days before the scheduled date of the next meeting, and the meetings should involve, in addition to the two federal governments, all state and provincial governments in the Great Lakes basin. The meetings should be publicized in advance through mechanisms such as a joint press conference held at their conclusion.

The committee believes that such an arrangement would allow and facilitate more informed public scrutiny of progress under the Agreement, ensure a higher degree of public accountability, and foster a fuller understanding of factors in both countries that may be limiting progress.

State and Provincial Governments

Even though the Agreement is between the federal governments of Canada and the United States, Article XI of the 1978 Agreement states that the "parties commit themselves to seek the cooperation of the State and Provincial Governments in all matters relating to this Agreement" as well as to seek appropriation of the necessary funds and to enact needed legislation. To date, the two federal governments have pursued different mechanisms for formally securing this cooperation. The task is complicated by the fact that in the United States there are 8 states within which the federal government must coordinate, whereas in Canada there are only two provinces involved.

After reviewing these arrangements, the committee finds that, for different reasons, it is difficult for the interested public to review the details of programs and activities that are called for in the Agreement and undertaken by Ontario and the Great Lakes states.

In Canada, the British North American Act of 1867 gives primary regulatory responsibility for water-quality aspects of the Great Lakes to Ontario (but not for fish). The terms of cooperation between the provincial and federal governments are spelled out formally in the Canada-Ontario Agreement on Great Lakes Water Quality, which is revised periodically. The Agreement seeks to establish adherence to Agreement objectives as a mutual goal of the federal and provincial governments. Ontario's relative autonomy makes federal initiatives difficult. The Agreement specifies financial contributions from both sources, but even large federal funding gives the national government limited power to cause Ontario to do more than provincial policy calls for.

While the Canada-Ontario Agreement is explicit on the roles of these two governments, many important details of Ontario's program

implementation and enforcement are kept confidential and not made available to the public or to other governments. For example, a "control order" issued by the Ontario Ministry of Environment (OME) to an individual company to control pollutant discharges is public information, but the basis of the order is not. Also, the OME apparently often withholds from public disclosure studies that it conducts relating to the Great Lakes.

In light of this, the committee recommends that all of the jurisdictions involved with programs and activities called for in the Agreement ensure the complete public disclosure of reports, documents and other records related to these programs and activities.

In the United States, there is no separate state-federal agreement for Great Lakes programs. National policy and environmental legislation give the lead role to the federal government in the United States, a role that is reinforced by the prohibition of the U.S. Constitution against state involvement in setting foreign policy. To date, the Agreement is not explicitly recognized in any U.S. environmental law. Although federal policy generally seeks delegation of authority to the states under the approximately dozen applicable major laws, delegation depends on state compliance with federal requirements. Each law establishes a distinct program under which a different state-federal program plan for each state is negotiated annually to specify program objectives and federal and state funding contributions.

In the United States, the problem in understanding states' activities is not the lack of open records; it is the multiplicity of relevant programs and the difficulty of identifying all of them. In the past, Great Lakes problems were chiefly recognized in water programs administered by the EPA. Though the Federal Clean Water Act remains the chief vehicle for satisfying United States obligations, the ecosystem perspective of the 1978 Agreement extends Great Lakes concerns to air, hazardous and solid wastes, and drinking water programs under several additional laws. The Great Lakes National Program Office was established by EPA to provide internal coordination for integration of Agreement obligations with the federal legislative mandates. Currently, this Office negotiates separately with each EPA program for recognition of Agreement obligations in the annual state programs and grants. However, most communication with the states is through other EPA offices.

As a result of this arrangement, the committee believes that it is difficult for anyone to secure a thorough accounting of the programs and resources of the States devoted to implementing the Agreement. A single annual state-federal program report (with a summary of currently authorized and ongoing activities and of program plans) for the U.S. part of the Great Lakes would clarify intergovernmental arrangements for meeting agreement obligations in the United States and would foster public understanding of these arrangements. The Great Lakes National Program office attached to EPA Region V in Chicago is at present coordinating development of a single program plan that integrates requirements of all federal environmental programs with the initiatives needed for U.S. implementation of the

Great Lakes Agreement (Environmental Protection Agency, 1985b). The committee endorses this effort.

In addition, the committee recommends that the U.S. EPA direct its Great Lakes National Program Office to assemble and publish on a regular basis the portions of state-federal program plans for each of the eight Great Lakes states relating to the states' activities under the Agreement. A similar accounting of provincial and federal program plans should be published regularly.

7

ECOSYSTEM APPROACH AND SUSTAINABLE DEVELOPMENT

INTRODUCTION

The 1978 Agreement appears to be the first major international treaty or agreement to embrace the ecosystem approach to the management of large regional resources. Commitments in the Agreement concerning control strategies for nutrients and toxic chemicals and the monitoring across several levels of the trophic structure of each lake are clearly ecosystemic in nature.

The Agreement recognizes the significance of the diverse pathways by which pollutants reach significant endpoints in the basin (e.g., human foods), as well as the importance of a long-term perspective in managing pollutant threats. There are two classes of measures for achieving sustainable development of regional ecosystems: reactive measures to eliminate introduction of undesirable substances and to remediate the effects of past mistakes and anticipate measures to assure full renewal of the resources following their normal use (Holling, 1978). The 1978 Agreement recognizes the need for both reactive and preventive measures to control the buildup of substances in the management of the lakes and the transport of materials from the land to the water and from the air to the water. However, the great difficulties evident in trying to achieve concerted action among the 11 jurisdictions for even the reactive measures seems to have left little room for progress on forward-looking measures.

In this final chapter, therefore, the committee has sought to look broadly at the depth and regional scope of managing large-scale source/receptor problems and related intergenerational issues. Chapter 2 of this report outlines both the physical and institutional settings of the basin and the 1978 Agreement, while Chapter 3 traces the emergence of an ecosystem approach to protecting regional resource systems. Three components central to the Agreement, nutrient enrichment, toxic contaminants, and the International Joint Commission (IJC) family of joint institutions, were reviewed in Chapters 4 through 6. This chapter provides an examination of intersecting questions that transcend the previous chapters, questions that, for the most part, are concerned with the possibility of implementing more comprehensive anticipatory measures to assure the future availability of the resources of the Great Lakes basin ecosystem.

DEPTH AND BREADTH OF THE PROBLEMS: REGIONAL SCOPE

Since the 1870s, pollution of some form has been recognized by various groups as a problem in at least parts of the Great Lakes and their connecting channels. Initially, the effects of pollution appeared to be local and the difference from natural runoff were qualitative: animal wastes became significant locally, erosion from cleared lands increased gradually, effluents rich in iron and alkalis from small industries increased, as did waste from sawmills, shipping, and manufacturing. The attempts to correct these sources of pollution even then were generally insufficient to solve the problems.

A pattern of unintended degradation followed by only partially successful remedial action has been evident for a number of pollutant issues over more than a century. The pollutants that concerned the two countries three or four generations ago are still with us. The large loadings of nutrients and toxic substances of concern in the 1978 Agreement are different in scale, primarily, but now also involve more complex and more numerous pathways of input. For decades, toxic materials were primarily discharged directly into receiving water. More recently many of these materials were discharged into urban sewer systems to which treatment plants were eventually appended. Many of these substances are now subjected to incineration (sometimes incomplete), a practice that also produces new forms of toxic substances. Release into air and subsequent transport leads to even larger-scale contamination of the Great Lakes without relationship to recognizable "sources."

Over time, the untreated wastes from many minor sources, together with the pollutants that remain in sediment after partial remediation of the major sources, have come to affect the water, soil, and biota of the entire basin. Untreated sewage also still enters the lakes and their tributaries where it is most offensive and dangerous--in urban streams and along urban waterfronts. Partially treated industrial effluents and runoff from industrial and agricultural lands still adversely affect large bays in the Upper Lakes, the entire Lower Lakes, and the connecting channels. The long-term effects of certain of these chemicals are of particular concern because they cause developmental defects in indicator organisms such as trout fry and gull chicks and present a significant risk for human infants. Other effects may be greatly delayed, as in the case of certain cancers in humans.

The scope of the alterations in Great Lakes water quality in recent decades is evident in the dichotomy between "whole-lake studies" and "nearshore" effects discussed in the previous chapters. During the 1970s much of the monitoring and modeling with respect to water quality in the lakes was focused in the offshore areas, a characterization of the lake as a whole. The offshore domain responses are strongly influenced by external processes, i.e., atmospheric inputs and influences by major tributaries, nearshore waters, and connecting channels.

The natural systems in the nearshore domains, on the other hand, which once possessed important self-regulatory capability, have lost

it as a consequence of human interventions. Remediation of the "areas of concern" identified in the reports of the Water Quality Board (1985) may foster recovery of self-regulatory capabilities in the nearshore, but the time frames for a response are uncertain. A feasibility study of fostering recovery of Southern Green Bay and of sustaining the health of Long Point Bay was recently completed (Francis et al., 1979, 1985; Harris et al., 1982).

With recognition of the interrelationships among hydrology, chemical inputs, tributaries, offshore waters, nearshore waters, connecting channels, and the lands adjacent to the basin, the Great Lakes basin as an ecosystem has much potential to develop fully in the next decade.

The committee finds that the past century presents a record of resource degradation expanding in area, extending in the duration of the impairment, and intruding more deeply into ecosystemic processes. The causes of the impairments are now more complex with respect to causal linkages and have become less evident to the public as well as to scientists. Risks seem to affect much larger populations. The sequence of environmental degradation, corrective measures, and then the creation of new environmental threats has not been brought under control by the 1978 Agreement. Three types of future events are likely to occur in the Great Lakes:

- The certain ones that we can predict and understand;
- The uncertain ones that we cannot predict but can understand; and
- The surprising ones that we can neither predict nor understand.

The first allows the possibility for traditional control. The second requires flexibility in order to adopt and design for the uncertain. The third requires an atmosphere for learning. Looking to the future, water diversions and the possible consequences of climate change have the potential to produce additional region-wide alterations of the system, and another round of reactive measures will be needed.

The committee recommends that the United States and Canada manage the Great Lakes basin ecosystem, not only reactively to mitigate unintended impairments, but to try to anticipate and prevent any further diminishment of the resource.

INTERGENERATIONAL EQUITY

The history of concern for the Great Lakes also shows a shift from an initial focus on effectiveness of arrangements for controlling pollution to a focus on both the costs and the effectiveness of these measures. Since, even under the most favorable economic conditions, there are limits as to the funding available for a given objective, governments try to adopt those measures that ensure the greatest benefit in pollution control at the least cost. With the increase in scientific understanding of the causes of pollution and its long-term impacts, it is now important to consider another dimension: the

interests of future generations in water quality of the Great Lakes and the quality of their consumable products.

As we exploit the resources of the Great Lakes, whether directly or as a depository for wastes, we also affect the use that future generations will be able to make of the resource. While some actions of the present generation will enhance the utility of the resource to future generations (e.g., navigational aids), others will impose significant costs to them (e.g., disposal of toxic substances). Since future generations are not represented when decisions are made, we usually ignore their interests.

Problems in intergenerational equity relating to the quality of the Great Lakes arise from some uses that may trigger costly and sometimes essentially irreversible changes in the quality of the Lakes and those that reduce the variety of uses of the Lakes and their harvestable products (Weiss, 1984a).

Changes in the quality of the Great Lakes may occur either because of the direct inflow of wastes into the Lakes or because of waste disposal actions taken elsewhere that result in the transport of the contaminants into the Lakes. Toxic contaminants represent the greatest immediate threat to the interests of future generations, because the time necessary to remove them from the Lakes through natural processes is exceedingly long, particularly for Lakes Superior and Michigan. Sometimes the impact of the deterioration in the quality of the environment can be reversed, for example, through the removal of hazardous contaminants from the bottoms of lakes, rivers, and landfill sites. However, this reversal could only be achieved at great financial costs.

Some actions of the present generations so degrade the quality of the Lakes that future generations will have less flexibility in using the resource. For example, waters in areas of concern have become so polluted that certain uses, such as contact recreation and municipal water supplies, are precluded.

Actions taken in the Great Lakes basin ecosystem may also directly deplete the utility of resources from the Great Lakes by causing the contamination of fisheries and the destruction of forms of plant and animal life in the basin. Although this may be compensated for in part through introductions and invasions from elsewhere, the overall effect is a decline in the diversity and quality of the resources available in the Great Lakes community, a form of resource depletion by present generations at the expense of future generations. While valued resources are not entirely destroyed, they may become scarce in the sense that there will be a real price increase of the resources to future generations.

Probably the greatest current long-term danger to the Great Lakes is from persistent toxic contaminants. Present generations may reap short-lived benefits from exploiting this natural resource as a sink for waste chemicals, only to pass along the costs of doing so to future generations. The present generation should more explicitly adopt programs that would remedy past abuses and avoid adverse impacts for future users of the Great Lakes basin. The committee recommends that the interests of future generations be considered more explicitly

in the Agreement. Two principles should guide consideration of intergenerational equity: the first is conservation of quality, defined as leaving the Great Lakes basin ecosystem in no worse condition than it was received from previous generations; the second is to conserve options, defined as conserving the diversity of the natural resource base of the Great Lakes.

These guiding principles (Weiss, 1984b) do not require that the present generation make excessive sacrifices in well-being to benefit future generations, nor do they require that we predict in advance the values held by future generations. Rather they are intended to ensure that we fulfill the present generations obligation as temporary custodians of the Great Lakes to pass the resource on to future generations for their development and use. Present generations inherited a basin ecosystem that was less degraded than it is at present. Application of these principles requires correction of the abuses that led to the degradation and prevention of similar processes in the future.

THE INFORMATION BASE: RELATIONSHIP TO EFFICACY, COST-EFFECTIVENESS, AND EQUITY

Up to the present in the history of the Great Lakes, each major issue requiring corrective action has been addressed mostly in isolation of other such issues, whether they preceded or accompanied the particular issue of concern. As the magnitude of the water-quality alterations have increased, the various issues have developed more interlinkages, not only ecologically but also economically, socially, and politically, leading to the call for an ecosystem approach in the 1978 Agreement. However, the broad range of measurements required for an ecosystem approach across the various jurisdictions has presented a difficult challenge.

With respect to water-quality issues, "monitoring" has long been the primary form in which information is obtained and applied. A balanced information system for the purposes of remediating areas of concern around the Great Lakes, however, should place about equal emphasis on four kinds of information: time series of monitored data, maps of key features of the ecosystem and of its use and abuse by humans, models of causal relationships among human uses and ecosystem responses, and case studies of management actions and their responses to demonstrate what has worked and what has not.

With attention now being directed to remediation of areas of concern and other complex sources of nutrient and contaminant inputs, it is urgent that a balanced information system be created to provide these four types of information. It should be developed at two levels: the regional level, to include all areas of concern, and the local level, where the regional information base is interpreted and augmented with respect to management of particular substances or areas of concern. Such an information system should also provide a basis for considering a program's efficacy, cost-effectiveness, and equitability.

The phosphate enrichment issue has now been partially corrected, mostly through expenditures on remedial practices such as construction and improvement of sewage works. By comparison, the contaminants issue is much more "political"; even the disposal of contaminated dredge spoils in so-called "secure" containment dykes has become controversial. The issue of long-range transport of atmospheric pollutants has become even more political.

All these difficulties have at their bases questions such as: what is reasonable use of an ecosystem such as the Great Lakes basin; what is reasonable determination of causality or source attribution; what is a reasonable expense for correcting prior abuses; and what is fair and equitable with respect to sharing the benefits or rebuilding a healthy and sustainable ecosystem?

Consideration of such questions has become more open as the information base has become more complete, and it is unlikely that this trend will be reversed. Even better access to information services will be needed, including information on cost-effectiveness and equity.

The committee recommends that interdisciplinary information developed by the jurisdictions be recast to place equal emphasis on four kinds of information: time series of monitored data, maps of key features of the ecosystem and of its use and abuse by humans, models of causal relationship integrating human uses and ecosystem responses, and case studies of management actions to demonstrate what has worked and what has not. (See related recommendation for Great Lakes data clearinghouse, Chapter 6.)

ECONOMIC SIGNIFICANCE

To date most studies of the benefits of environmental policies have focused on the benefits of damages avoided. Studies should be redesigned to evaluate benefits related to option value, pointing to significant benefits associated with environmental health as an asset to economic development in a broader multiple use sense (Organization for Economic Cooperation and Development, 1984a). For example, as a direct result of subtle improvements in water quality, major economic benefits have occurred in many shoreline communities of the Great Lakes.

The Center for the Great Lakes (1985) recently conducted a survey of 50 shoreline communities and found that 38 of them had new waterfront developments in operation, under construction or in advanced planning stages. Of the various uses served in these 38 communities, industrial interests are involved in 21 percent of them, offices 24 percent, cultural activities 36 percent, residential 45 percent, parkland 52 percent, retail 57 percent, marinas 71 percent and recreational 71 percent.

Based on the committee's own survey, Toledo, Ohio is an example of a community that has undertaken economic revitalization of the downtown and waterfront areas. According to R. A. Boezi of the Toledo-based Sea Gate Community Development Corporation: "Improved

river and lake quality . . . and the abundant return of sport fishing to western Lake Erie . . . has played an important role in this revitalization."

These human responses to ecological changes are recent. The full economic benefits are as yet unknown. Economic benefits are not just confined to major planned developments of the type documented in the cities. Smaller communities have also experienced economic benefits, but these are not so easy to document as the larger planned type of investments occurring in the major cities. Regardless of where these developments have occurred, continued success and value of these waterfront investments is intimately linked to the maintenance of the improved levels of water quality.

The other side of the economic issue relates to the consequences of not dealing with toxic chemicals pollution. Significant economic cost may be increased human morbidity and mortality and anguish about health risks; adverse effects on agricultural productivity; decreased use of the resources of the Great Lakes. It is conceivable that further insult to the already degraded Great Lakes basin ecosystem may result in loss of the Lakes as a source of drinking water, which would result in a tremendous cost. The health and cleanup costs to future generations may be substantially greater than they are to the present generation in that the toxic substances may have become distributed more widely. Without a sustainable ecosystem, it is difficult to envision a sustainable economy in the long term.

The Organization for Economic Cooperation and Development Environment Ministers meeting in Paris in 1979 agreed that even if further economic developments were only moderate, the potential environmental consequences in many sectors could be considerable. For this reason, there should be no relaxation of effort and rehabilitation to protect the environment. Indeed, strengthened measures, designed with a view to their economic efficiency and cost effectiveness, focused on prevention as well as on remedial action, will be needed to maintain and improve present levels of environmental quality. These measures will also promote the concept of qualitative growth, fostering partnership between environmental and economic concerns (Organization for Economic Cooperation and Development, 1984a).

EARLY WARNINGS AND SURPRISES

The 1978 Agreement sought an early warning system (Appendix 12) as a means of anticipating problems with toxic substances. The need for such a system was apparent because of the number of new concerns appearing almost annually and the long time period for the significance of effects to be determined. The early warning system has tended to emphasize traditional measurements, including inventories of the use and production of chemicals, the establishment of a repository or archive of fish tissue and sediments, and other environmental samples for retrospective analysis.

However, the proposed warning system is not fundamentally compatible with the concepts of ecosystem management outlined in Chapter 3. For example, the early warning system applies only to toxic substances and, more specifically, deals with measures needed to predict the toxicity of new chemicals that might be used in the Great Lakes basin. Little attention is given to the impact of the toxic substances on the ecosystem itself.

Early warning indicators are important as a means of reducing the degree of surprise as new problems emerge in the basin ecosystem. Dealing with surprise in a ecosystemic context almost certainly requires nontraditional approaches. Holling (1985) shows that traditional resource management policies have inadvertently generated many ecological surprises. Occasionally they emerge from slow, almost inperceptible changes in the organization of the ecosystem; at other times they result from a single short-period phenomenon such as the introduction of a new species. The Great Lakes have been subject to many surprises over the past century, and many of these surprises could have served more effectively as an early warning for other regions of the world.

Traditional short-term management practices rarely permit the detection of change in the system, often because of their apparent initial success in dealing with some of the early symptoms. Management systems, institutions, or socioeconomic systems develop to be dependent on the conventional approach and thus resist change. For example, in the Great Lakes the early success of the salmonid stocking program made it difficult to control the transmission of contaminants into the families of the fishermen; there are fishing interests (management, institutional, and socioeconomic) that resist the posting of consumption advisories or controls on ingestion of contaminated fish. The discovery of DDT in salmon in the 1960s created concern and contributed to the DDT ban in 1970; similar concerns about other contaminants in salmon and other Great Lakes fish is working, on a much smaller scale, to support initiatives for controlling related substances. Thus, the development of a new salmonid fishery in the Great Lakes, with some immediate benefits, has brought with it ecological and political problems (surprises?) that were not foreseen and that are not yet resolved.

If traditional tools in support of management, such as the early warning elements in the 1978 Agreement, fall short of ecosystem management needs for anticipating surprises, what can be done? How might one better anticipate, monitor, and respond to surprise? How does one design management in the face of uncertainty?

One aspect of the response to these questions is to focus on understanding of the resilience of the system and the management policies (including institutional, social, and economic policies) that affect resilience. One must know whether they predispose the system to produce a major crisis or surprise under some circumstances from which it may not be able to recover fully. The studies done for the Great Lakes Fishery Commission on the feasibility of rehabilitating and restoring the Great Lakes ecosystem provide background for such a program (Francis et al., 1979; Magnuson et al., 1980).

There are several other notable examples of interventions, both deliberate and unanticipated, that have affected the whole Great Lakes ecosystem. Examples are water-level regulation, navigational developments, fish species invasions and introductions, pollution abatement and remedial measures, and reduction of eutrophication through phosphorus loading controls. Much is to be learned about ecosystem structures and functions from such perturbations, which constitute large-scale experiments; but the full opportunity of using these experiments to gain deeper understanding has yet to be grasped. Most of these experiments when completed will have involved very large expenditures of public funds, billions in terms of 1985 dollars, supported by public concern; but the scientific harvest reaped from that seed has yet to be fully weighed.

Each of the various interventions were directed to specific and isolated targets for resource recovery and responses throughout the interacting physical, chemical, and biological variables that make up the ecosystem. Thus, each represents experiments of ecosystem management with the goal of re-establishing natural renewal mechanisms and addition of new ones controlled by humans in order to achieve a sustainable system.

Looking to the future, there are now issues that could trigger further interventions or actions:

- Consumptive water use within and outside the basin that will raise demand for water removal and perhaps diversion;
- Transient and persistent toxic substances in land, water, and air;
- Aging of existing capital infrastructures and progressive obsolescence of conventional techniques for pollution control;
- Possible climate change; and
- Continuing abrupt changes in the fish and plankton communities as the consequences of fisherman and salmonid interactions.

Therefore, the committee recommends that the parties to the Agreement carry out a focused binational study addressing questions as to what has been the consequence of a number of remediative management actions or interventions, as disclosed by subsequent surveys, monitoring, and research. The aim would be to mine the existing data base so as to advance understanding of the Great Lakes basin ecosystem most effectively, an activity for which past support has been minimal in comparison with the costs of the interventions. This recommendation may be best carried out through the IJC reference procedure.

THE NETWORK OF GREAT LAKES ECOSYSTEM RESEARCHERS AND MANAGERS

With the benefit of hindsight we note that an "invisible college" of Great Lakes experts of many disciplines emerged about 1960. Originally much of the leadership of this community came from some of the basin's major universities; researchers from these institutions

had collaborated only irregularly on studies of various lake problems during the preceding 50 years or so (see Chapter 3). Some of these university researchers developed close working relationships with researchers and managers from government agencies of various levels as well as with others in the universities.

Over the years various formal references by the two countries to the IJC have helped to strengthen and broaden this network of researchers and administrators. Participation in the family of IJC institutions that developed with respect to the 1972 and 1978 Agreements has also contributed. Among important nongovernmental initiatives are the International Association of Great Lakes Research, Great Lakes Tomorrow, various binational universities and other seminar series and symposia over the years, and recently the emergence of the Center for the Great Lakes and Great Lakes United. Meanwhile, the universities have continued to foster the network through ad hoc interuniversity arrangements of various kinds.

This invisible college has long transcended jurisdictional boundaries. For those in the college a sense of regional loyalty to the Great Lakes appears to counterbalance jurisdictional, governmental, and even disciplinary loyalties. However, a number of these individuals have advised the committee that the research community in the Great Lakes basin is "marking time," seemingly waiting for an opportunity to mobilize again and undertake new developments in understanding and managing a large regional ecosystem. Consistent with recommendations elsewhere in this review, the committee finds that research on a series of topics of concern to the region is urgently needed and could be accomplished by the interdisciplinary groups in and near the Great Lakes basin. Included are:

- Completing the shift from a relatively static to a dynamic characterization of our understanding of the basin ecosystem, especially with respect to the coastal waters;
- Interlinking more effectively major issues such as lake-level fluctuations, land use, phosphate enrichment, toxic contamination, fisheries management, and harvest;
- Developing a comprehensive basin-wide strategy for management of toxic wastes;
- Developing a balanced interdisciplinary information system for considering the efficacy, cost-effectiveness, and equitability of remedial programs, whether proposed or under way; and
- Assessing the likely effects of climate change on the Great Lakes basin and addressing how regional management might adapt to them.

DEEPENING THE UNDERSTANDING OF SOCIETAL COMPONENTS OF THE BASIN

Not surprisingly, as the ecosystem perspective enhanced technical understanding of the interrelated problems being faced in the Great Lakes basin, more individuals have begun to ask that this perspective also inform us more fully about the social consequences of the choice

to be made. There appears to be general acceptance of the principle of taking an ecosystem approach to basin management, but many steps in implementation are lagging. Genuine uncertainty and disagreement remain about the full scope and implications of what is being advocated.

The notion of an ecosystem approach involves the adoption and further elaboration of ecological knowledge about environments and human uses of them and an encompassing set of beliefs and values that an ecosystem approach seems to entail. The latter guide human actions and decisions on resource use as well as promote new knowledge.

A central philosophical issue was posed by Naess (1973) when he distinguished between "the shallow and the deep long-range ecology movement." The "shallow approach," which perhaps more appropriately should be termed the pragmatic approach, adheres to the dominant ideology of "industrialism" in its various forms. This he calls a "commitment to narrowly utilitarian scientific/technological management of nature" for purely human ends (Devall and Sessions, 1984, 1985). It is an anthropocentric view (Livingston, 1985) that seeks progress through exploitation of environments for their resource products and values and that implies control of abuses of many kinds. Environmental impact studies and regulatory pollution control are examples. This approach is also consistent with conventional resource development, viewed as the adoption of technological changes that permit wider and deeper utilization of resources of lower and lower quality (Regier and Baskerville, 1985).

The alternative approach or long range ecology of the entire system is less coherently articulated than are analyses of the pragmatic approach. In place of the ideology of industrialism it strives to elaborate an alternative that leads to a "harmonious dynamic balance of man-in-nature" (Devall and Sessions, 1984, 1985). It is explicitly biocentric--it focuses on life--in recognizing ethical obligations toward ecosystems in their own right, rather than just as systems to be managed as integral to human life-support systems. It promotes changes in human behavior including the elimination of certain industrial commodities (such as toxic contaminants) because they are destructive of life. It urges personal and societal adaptation as an appropriate response, not simply more conventional, expert-dominated management.

The full social implications of this approach are not clear, but discussion of the related issues has engaged a widening array of participants. Among the issues attracting attention are the need to re-examine the nature of conventional development, the need to incorporate resource sustainability into development, and the ethical obligations humans may have toward nonhuman species (Francis et al., 1985).

To date, the strategies pursued to implement the intent of the 1978 Agreement encompass only the pragmatic approach. However necessary these strategies were as a means of getting started, their shortcomings are now becoming apparent. They are inadequate also when judged by an ecosystem approach utilizing any of the premises of the long range ecology of the entire system.

One can also consider the region's institutional ecology as it relates to the complexity of the institutions and governance in the Great Lakes basin. There are two constitutional federalisms, eight state/provincial jurisdictions, and hundreds of constituent administrative agencies each with some responsibilities for the management of water, shore zones, or associated land uses. In addition to the governance arrangements, the basin is densely populated by organizations whose activities affect the Great Lakes ecosystem. The dynamics of institutional ecology are not understood in terms of its overall congruence with the dynamics of the ecosystems affected by the many human uses. The problems identified in this review imply that critical incongruities exist.

The need now may be to encourage appropriate changes in the functioning of the institutions so as to reverse practices that have undermined elements of resource sustainability in the basin. This might be done through greater use of "socioecological principles" (Trist, 1983) to develop the necessary complementary capabilities to the expertise of existing institutions.

General guidelines also can be identified for moving the Great Lakes institutional system closer to a socioecological behavior pattern. One has to start with the "givens" of the existing arrangements, including the fact that they derive their authority from prevailing conventions associated with a pragmatic approach. Nevertheless, measures to foster appropriate changes would

- Insist on full documentation of the mandates and/or policies of governing institutions that may have, in practice, narrowed their interpretations, e.g., of the various binational boards and committees and "environment" agencies;
- Forge the links between organizations necessary to address ecosystemic issues, e.g., toxic contaminants, nonpoint sources of pollutants, regional public health, and fisheries;
- Recognize that whatever is done will be first of all a social learning process, not "authoritative" management;
- Develop ecological performance guidelines to which organizations might be held accountable--these should be referenced to the 1909 Boundary Waters Treaty, the 1972 and 1978 Agreements, and the 1955 Fisheries Convention and the goals of the World Conservation Strategy of the International Union for the Conservation of Nature and of Natural Resources (i.e., maintenance of essential ecological processes, preservation of biotic diversity, sustainable utilization of ecosystems, and species)--and that make the greatest use possible of indicators which the public can understand;
- Make the existing governance structures much more supportive and facilitative of efforts by nongovernmental groups to adopt self-governing husbandry practices in their use of Great Lakes ecosystems, guided by the principles of sustainability, and, where necessary, rehabilitation of degraded ecosystems; and
- Develop a balanced supporting network of information sources that would serve to backstop initiatives consistent with these

directions and provide the basis for periodic evaluation and accountability.

FURTHER EXPLORATION OF REFORMS

For the past century, human activities in the Great Lakes basin have been dominated by industrialization, commercialization, and urbanization. In the course of industrial development, severe ecological and social blights have occurred. The degraded areas of concern of Great Lakes coastal waters have counterpart degraded locales on land, where both ecological and social degradation are intense. Less severe impacts are apparent throughout the Great Lakes basin and beyond it in the hemisphere, perhaps to the entire biosphere.

The population of the Great Lakes basin has been particularly caught up by the pattern of development in the basin. Although the basin ecosystem was by nature quite resilient, many of its capabilities to adapt to human interventions have been overridden. The resulting degradation has tended to come as a surprise; our understanding of the impairment process has not developed to the point where we anticipate the degradation processes. Political capabilities for correcting mistakes are inadequate.

The people of the Great Lakes basin have taken advantage of their resources to an excess and are concerned to correct the abuses. The basin is now a recipient of degrading influences from outside the region, including acid rain and toxic fallout. In turn, the people of the basin are exporting substances downwind and downstream of the basin.

In 1982, Charles Ross, a highly respected Commissioner of the IJC for many years prior to 1980, proposed a binational process and conference modeled on the 1972 Stockholm Conference on the Human Environment. The committee approves this proposal for the Great Lakes today.

A conference like the Stockholm Conference (Caldwell, 1984) would focus attention on the importance of the Great Lakes as a resource and on the severity of the problems facing it. It could send an important signal to communities in both countries and to the world that the sustainable development of the Great Lakes basin ecosystem still needs urgent attention and that there are important lessons that others can gain from our experience in the Great Lakes. If the preparatory work is properly done, the conference could be a catalyst for insightful analysis of critical issues and a vehicle for building a new consensus supporting social and institutional reform, much as the Stockholm Conference stimulated pathbreaking analysis of development and environmental problems.

The committee therefore recommends that the parties hold a binational conference on the Great Lakes and that in preparation they establish a Preparatory Committee to develop a draft statement of principles and a draft action plan to be acted on formally at the Conference.

Substantial further reforms are needed in the Great Lakes basin, far beyond the programs specified in the 1972 and 1978 Agreements. Now is an appropriate time to face that challenge.

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GLOSSARY

Agreement - the 1978 Great Lakes Water Quality Agreement.

Anoxia - devoid of oxygen; in application to lakes, anoxia is likely to occur in sediments and in the hypolimnion (defined below) when enriched with plant nutrients and/or putrescible organic matter.

Areas of Concern - geographic locations identified by the IJC where water, sediment, or fish quality are degraded and the Great Lakes Agreement water quality objectives or jurisdictional criteria, standards, or guidelines are not met.

Assimilative Capacity - capacity of a system to accept a waste product or foreign substance and render it innocuous, but with some politically accepted adverse effects to the ecosystem and to some humans.

Boundary Waters Treaty - the Treaty between the United States and Great Britain relating to boundary waters, and questions arising between the United States and Canada, signed at Washington on January 11, 1909 (from 1978 Agreement).

Cladophora - a genus of branched filamentous septate green algae, usually firmly attached to solid substrates, as on Great Lakes shores, where nutrient levels trigger growth; occasionally washed loose by storms to accumulate as a "nuisance" on beaches; an indication of eutrophication.

Ecosystem - a set of interacting elements and processes that exhibits some integrative and self-regulatory capabilities; the set includes hierarchic networks of organisms (including humans) and a network of nonliving phenomena in the environment.

Ecosystem Approach - see Chapter 3 for discussion.

Epilimnion - the layer of warm surface waters in a stratified lake in summer.

Eutrophication - the process of stimulation of biological production by increase of plant nutrient input arising either naturally or from agricultural, municipal, or industrial sources; often accompanied by undesirable changes in aquatic species composition.

Great Lakes Basin Ecosystem - the interacting components of air, land, water, and living organisms, including humans, within the drainage basin of the St. Lawrence River at or upstream from the point at which this river becomes the international boundary between Canada and the United States (from 1978 Agreement).

Hazardous Polluting Substance - any element or compound identified by the parties that, if discharged in any quantity into or upon receiving waters or adjoining shorelines, would present an imminent and substantial danger to public health or welfare; for this purpose, "public health or welfare" encompasses all factors affecting the health and welfare of man including but not limited to human health, and the conservation and protection of flora and fauna, public and private property, shorelines, and beaches (from 1978 Agreement).

Hypolimnion - the lower cooler layer of water in a stratified lake. Exchange between the lower and upper layers of water is impeded by a gradient that acts as a partial barrier in thermally stratified lakes; this gradient is called a thermocline.

In-place Pollutants - pollutants that have accumulated, usually in sediments, from which they may be released by physical or biological processes.

International Hydrological Decade (1965-1975) - an international program of the International Council of Scientific Unions, Paris.

International Joint Commission - the International Joint Commission established by the 1909 Boundary Water Treaty. A binational Commission with responsibility for decisions regarding obstruction or diversion of boundary waters and to which other questions or matters of difference can be referred for examination and report. The Commission also has powers to resolve differences arising over the common frontier. In 1972 the Commission was also given responsibility for assisting and monitoring the two governments' implementation of the Great Lakes Water Quality Agreement.

Mass-Balance Approach - a management approach in which the aim is to eliminate accumulation of pollutants that will degrade water quality or have adverse affects on living organisms. This approach requires establishment of a mass-balance budget in which the amounts of contaminants entering the system less the quantities stored, transformed, or degraded within the system must equal amounts leaving the system. Application of this approach depends on quantification of sources and effects of contaminants and mathematical modeling to simulate probable long-term consequences.

Nearshore Waters - the waters in the nearshore zone of a lake directly affected by discharges from onshore and that interact with land by wind and wave action.

Oligotrophic lakes - those poorly provided with the basic nutrients required for plant and animal production; poorly nourished in contrast to eutrophic lakes.

Parties - the governments of Canada and the U.S.; signatories to the Agreement.

Phosphorus - the element phosphorus present as a constituent of various organic and inorganic complexes and compounds; the initial limiting nutrient in most freshwater systems; when phosphate phosphorus is abundant other chemical substances may become limiting to aquatic plants.

Project "HYPO" - a joint U.S./Canadian study of the hypolimnion of the Central Basin of Lake Erie.

Reference - a formal request to the International Joint Commission by one or both parties to the Agreement for information and advice on an issue of transboundary importance; in Article VII of the 1978 Agreement certain Commission responsibilities have also been specified in the context of a Reference.

Science Advisory Board - the Great Lakes Science Advisory Board of the International Joint Commission, established pursuant to Article VIII of the Great Lakes Water Quality Agreement of 1978. The Board provides advice on research to the Commission.

Structure/Activity Relationship - the concept that toxicity is determined by the mobility of the substance across a biological barrier and the mobility can be determined by the structure of the substance which can be related to solubility in various media. This mobility is often defined by the octanol-water partitioning value, which is the ratio of the solubility of a substance in octanol compared with its ratio of solubility in water; the higher the ratio the more mobile in a biological medium and the more potential toxicity.

TCDD - is a particularly hazardous group of 75 chemicals of the chlorinated dioxin family. 2,3,7,8-TCDD or 2,3,7,8-tetrachloro-dibenzo-*para*-dioxin is a dangerous member of this group.

Terms of Reference - the Terms of Reference for the Water Quality Board, Science Advisory Board, and Great Lakes Regional Office established pursuant to the Great Lakes Water Quality Agreement, which are attached to and form an integral part of that Agreement (from 1978 Agreement).

Toxic Substance - a substance that can cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological or reproductive malfunctions, or physical deformities in any organisms or its offspring or that can become poisonous after concentration in the food chain or in combination with other substances (from 1978 Agreement).

Water Quality Board - the Great Lakes Water Quality Board of the International Joint Commission established pursuant to Article VIII of the Great Lakes Water Quality Agreement of 1978 is the principal advisory body to the Commission.

Xenobiotic Chemicals - not produced in nature; usually applied to man-made chemicals.

ABBREVIATIONS

AEOC - Aquatic Ecosystem Objectives Committee

BOD - Biological Oxygen Demand

DDE - a decomposition product of DDT

EPA - U.S. Environmental Protection Agency

GLBC - Great Lakes Basin Commission

GLFC - Great Lakes Fishery Commission

GLISP - Great Lakes International Surveillance Plan

GLWQA - Great Lakes Water Quality Agreement

IFYGL - International Field Year of the Great Lakes

IJC - International Joint Commission

ISHOW - Information System for Hazardous Organics in Water

MAB - Unesco's Man and the Biosphere Program

MGD - million gallons per day

NOAA - National Oceanic and Atmospheric Administration (U.S.)

NPDES - National Pollutant Discharge Elimination System

NRC - U.S. National Research Council

OECD - Organization for Economic Cooperation and Development

OME - Ontario Ministry of Environment

PCBs - polychlorinated biphenyls

PAH - polyaromatic hydrocarbons

ppb - parts per billion

RSC - Royal Society of Canada

SAB - Science Advisory Board

SAR - Structure/Activity Relationships

TCDD - a form of dioxin

WQB - Water Quality Board

APPENDIX A

TEXT OF THE 1978 GREAT LAKES WATER QUALITY AGREEMENT

Agreement, with annexes and terms of reference,
between the United States of America and Canada
signed at Ottawa, November 22, 1978

International Joint Commission
Canada and the United States

Great Lakes Water Quality Agreement of 1978

Agreement, with annexes
and terms of reference,
between the
United States of America and Canada
signed at Ottawa
November 22, 1978

International Joint Commission
Canada and the United States

GREAT LAKES WATER QUALITY AGREEMENT OF 1978

AGREEMENT BETWEEN CANADA AND THE UNITED STATES OF AMERICA ON GREAT LAKES WATER QUALITY, 1978

The Government of Canada and the Government of the United States of America,

Having in 1972 entered into an Agreement on Great Lakes Water Quality;

Reaffirming their determination to restore and enhance water quality in the Great Lakes System;

Continuing to be concerned about the impairment of water quality on each side of the boundary to an extent that is causing injury to health and property on the other side, as described by the International Joint Commission;

Reaffirming their intent to prevent further pollution of the Great Lakes Basin Ecosystem owing to continuing population growth, resource development and increasing use of water;

Reaffirming in a spirit of friendship and cooperation the rights and obligations of both countries under the Boundary Waters Treaty, signed on January 11, 1909, and in particular their obligation not to pollute boundary waters;

Continuing to recognize the rights of each country in the use of its Great Lakes waters;

Having decided that the Great Lakes Water Quality Agreement of April 15, 1972 and subsequent reports of the International Joint Commission provide a sound basis for new and more effective cooperative actions to restore and enhance water quality in the Great Lakes Basin Ecosystem;

Recognizing that restoration and enhancement of the boundary waters can not be achieved independently of other parts of the Great Lakes Basin Ecosystem with which these waters interact;

Concluding that the best means to preserve the aquatic ecosystem and achieve improved water quality throughout the Great Lakes System is by adopting common objectives, developing and implementing cooperative programs and other measures, and

assigning special responsibilities and functions to the International Joint Commission;

Have agreed as follows:

ARTICLE I

DEFINITIONS

As used in this Agreement:

(a) "Agreement" means the present Agreement as distinguished from the Great Lakes Water Quality Agreement of April 15, 1972;

(b) "Annex" means any of the Annexes to this Agreement, each of which is attached to and forms an integral part of this Agreement;

(c) "Boundary waters of the Great Lakes System" or "boundary waters" means boundary waters, as defined in the Boundary Waters Treaty, that are within the Great Lakes System;

(d) "Boundary Waters Treaty" means the Treaty between the United States and Great Britain Relating to Boundary Waters, and Questions Arising Between the United States and Canada, signed at Washington on January 11, 1909;

(e) "Compatible regulations" means regulations no less restrictive than the agreed principles set out in this Agreement;

(f) "General Objectives" are broad descriptions of water quality conditions consistent with the protection of the beneficial uses and the level of environmental quality which the Parties desire to secure and which will provide overall water management guidance;

(g) "Great Lakes Basin Ecosystem" means the interacting components of air, land, water and living organisms, including man, within the drainage basin of the St. Lawrence River at or upstream from the point at which this river becomes the international boundary between Canada and the United States;

(h) "Great Lakes System" means all of the streams, rivers, lakes and other bodies of water that are within the drainage basin on the St. Lawrence River at or upstream from the point at which this river becomes the international boundary between Canada and the United States;

(i) "Harmful quantity" means any quantity of a substance that if discharged into receiving water would be inconsistent with the achievement of the General and Specific Objectives;

(j) "Hazardous polluting substance" means any element or compound identified by the Parties which, if discharged in any quantity into or upon receiving waters or adjoining shorelines, would present an imminent and substantial danger to public health or welfare; for this purpose, "public health or welfare" encompasses all factors affecting the health and welfare of man including but not limited to human health, and the conservation and protection of flora and fauna, public and private property, shorelines and beaches;

(k) "International Joint Commission" or "Commission" means the International Joint Commission established by the Boundary Waters Treaty;

(l) "Monitoring" means a scientifically designed system of continuing standardized measurements and observations and the evaluation thereof;

(m) "Objectives" means the General Objectives adopted pursuant to Article III and the Specific Objectives adopted pursuant to Article IV of this Agreement;

(n) "Parties" means the Government of Canada and the Government of the United States of America;

(o) "Phosphorus" means the element phosphorus present as a constituent of various organic and inorganic complexes and compounds;

(p) "Research" means development, demonstration and other research activities but does not include monitoring and surveillance of water or air quality;

(q) "Science Advisory Board" means the Great Lakes Science Advisory Board of the International Joint Commission established pursuant to Article VIII of this Agreement;

(r) "Specific Objectives" means the concentration or quantity of a substance or level of effect that the Parties agree, after investigation, to recognize as a maximum or minimum desired limit for a defined body of water or portion thereof, taking into account the beneficial uses or level of environmental quality which the Parties desire to secure and protect;

(s) "State and Provincial Governments" means the Governments of the States of Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Wisconsin and the Commonwealth of Pennsylvania, and the Government of the Province of Ontario;

(t) "Surveillance" means specific observations and measurements relative to control or management;

(u) "Terms of Reference" means the Terms of Reference for the Joint Institutions and the Great Lakes Regional Office established pursuant to this Agreement, which are attached to and form an integral part of this Agreement;

(v) "Toxic substance" means a substance which can cause death, disease, behavioural abnormalties, cancer, genetic mutations, physiological or reproductive malfunctions or physical deformities in any organism or its offspring, or which can become poisonous after concentration in the food chain or in combination with other substances;

(w) "Tributary waters of the Great Lakes System" or "tributary waters" means all the waters within the Great Lakes System that are not boundary waters;

(x) "Water Quality Board" means the Great Lakes Water Quality Board of the International Joint Commission established pursuant to Article VIII of this Agreement.

ARTICLE II

PURPOSE

The purpose of the Parties is to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem. In order to achieve this purpose, the Parties agree to make a maximum effort to develop programs, practices and technology necessary for a better understanding of the Great Lakes Basin Ecosystem and to eliminate or reduce to the maximum extent practicable the discharge of pollutants into the Great Lakes System.

Consistent with the provisions of this Agreement, it is the policy of the Parties that:

(a) The discharge of toxic substances in toxic amounts be prohibited and the discharge of any or all persistent toxic substances be virtually eliminated;

(b) Financial assistance to construct publicly owned waste treatment works be provided by a combination of local, state, provincial, and federal participation; and

(c) Coordinated planning processes and best management practices be developed and implemented by the respective jurisdictions to ensure adequate control of all sources of pollutants.

ARTICLE III

GENERAL OBJECTIVES

The Parties adopt the following General Objectives for the Great Lakes System. These waters should be:

(a) Free from substances that directly or indirectly enter the waters as a result of human activity and that will settle to form putrescent or otherwise objectionable sludge deposits, or that will adversely affect aquatic life or waterfowl;

(b) Free from floating materials such as debris, oil, scum, and other immiscible substances resulting from human activities in amounts that are unsightly or deleterious;

(c) Free from materials and heat directly or indirectly entering the water as a result of human activity that alone, or in combination with other materials, will produce colour, odour, taste, or other conditions in such a degree as to interfere with beneficial uses;

(d) Free from materials and heat directly or indirectly entering the water as a result of human activity that alone, or in combination with other materials, will produce conditions that are toxic or harmful to human, animal, or aquatic life; and

(e) Free from nutrients directly or indirectly entering the waters as a result of human activity in amounts that create growths of aquatic life that interfere with baneficial uses.

ARTICLE IV

SPECIFIC OBJECTIVES

1. The Parties adopt the Specific Objectives for the boundary waters of the Great Lakes System as set forth in Annex 1, subject to the following:

(a) The Specific Objectives adopted pursuant to this Article represent the minimum levels of water quality desired in the boundary waters of the Great Lakes System and are not intended to preclude the establishment of more stringent requirements.

(b) The determination of the achievement of Specific Objectives shall be based on statistically valid sampling data.

(c) Notwithstanding the adoption of Specific Objectives, all reasonable and practicable measures shall be taken to maintain or improve the existing water quality in those areas of the boundary waters of the Great Lakes System where such water quality is better than that prescribed by the Specific Objectives, and in those areas having outstanding natural resource value.

(d) The responsible regulatory agencies shall not consider flow augmentation as a substitute for adequate treatment to meet the Specific Objectives.

(e) The Parties recognize that in certain areas of inshore waters natural phenomena exist which, despite the best efforts of the Parties, will prevent the achievement of some of the Specific Objectives. As early as possible, these areas should be identified explicitly by the appropriate jurisdictions and reported to the International Joint Commission.

(f) Limited use zones in the vicinity of present and future municipal, industrial and tributary point source discharges shall be designated by the responsible regulatory agencies within which some of the Specific Objectives may not apply. Establishment of these zones shall not be considered a substitute for adequate treatment or control of discharges at their source. The size shall be minimized to the greatest possible degree, being no larger than that attainable by all reasonable and practicable effluent treatment measures. The boundary of a limited use zone shall not transect the international boundary. Principles for the designation of limited use zones are set out in Annex 2.

2. The Specific Objectives for the boundary waters of the Great Lakes System or for particular portions thereof shall be kept under review by the Parties and by the International Joint Commission, which shall make appropriate recommendations.

3. The Parties shall consult on:

(a) The establishment of Specific Objectives to protect beneficial uses from the combined effects of pollutants; and

(b) The control of pollutant loading rates for each lake basin to protect the integrity of the ecosystem over the long term.

ARTICLE V

STANDARDS, OTHER REGULATORY REQUIREMENTS, AND RESEARCH

1. Water quality standards and other regulatory requirements of the Parties shall be consistent with the achievement of the General and Specific Objectives. The Parties shall use their best efforts to ensure that water quality standards and other regulatory requirements of the State and Provincial Governments shall similarly be consistent with the achievement of these Objectives. Flow augmentation shall not be considered as a substitute for adequate treatment to meet water quality standards or other regulatory requirements.

2. The Parties shall use their best efforts to ensure that:

(a) The principal research funding agencies in both countries orient the research programs of their organizations in response to research priorities identified by the Science Advisory Board and recommended by the Commission; and

(b) Mechanisms be developed for appropriate cost-effective international cooperation.

ARTICLE VI

PROGRAMS AND OTHER MEASURES

1. The Parties shall continue to develop and implement programs and other measures to fulfil the purpose of this Agreement and to meet the General and Specific Objectives. Where present treatment is inadequate to meet the General and Specific Objectives, additional treatment shall be required. The programs and measures shall include the following:

(a) Pollution from Municipal Sources. Programs for the abatement, control and prevention of municipal discharges and urban drainage into the Great Lakes System. These programs shall be completed and in operation as soon as practicable, and in the case of municipal sewage treatment facilities no later than December 31, 1982. These programs shall include:

(i) Construction and operation of waste treatment facilities in all municipalities having sewer systems to provide levels of treatment consistent with the achievement of phosphorus requirements and the General and Specific Objectives, taking into account the effects of waste from other sources;

(ii) Provision of financial resources to ensure prompt construction of needed facilities;

(iii) Establishment of requirements for construction and operating standards for facilities;

(iv) Establishment of pre-treatment requirements for all industrial plants discharging waste into publicly owned treatment works where such industrial wastes are not amenable to adequate treatment or removal using conventional municipal treatment processes;

(v) Development and implementation of practical programs for reducing pollution from storm, sanitary, and combined sewer discharges; and

(vi) Establishment of effective enforcement programs to ensure that the above pollution abatement requirements are fully met.

(b) Pollution from Industrial Sources. Programs for the abatement, control and prevention of pollution from industrial sources entering the Great Lakes System. These programs shall be completed and in operation as soon as practicable and in any case no later than December 31, 1983, and shall include:

(i) Establishment of waste treatment or control requirements expressed as effluent limitations (concentrations and/or loading limits for specific pollutants where possible) for all industrial plants, including power generating facilities, to provide levels of treatment or reduction or elimination of inputs of substances and effects consistent with the achievement of the General and Specific Objectives and other control requirements, taking into account the effects of waste from other sources;

(ii) Requirements for the substantial elimination of discharges into the Great Lakes System of persistent toxic substances;

(iii) Requirements for the control of thermal discharges;

(iv) Measures to control the discharge of radioactive materials into the Great Lakes System;

(v) Requirements to minimize adverse environmental impacts of water intakes;

(vi) Development and implementation of programs to meet industrial pre-treatment requirements as specified under sub-paragraph (a) (iv) above; and

(vii) Establishment of effective enforcement programs to ensure the above pollution abatement requirements are fully met.

(c) Inventory of Pollution Abatement Requirements. Preparation of an inventory of pollution abatement requirements for all municipal and industrial facilities discharging into the Great Lakes System in order to gauge progress toward the earliest practicable completion and operation of the programs listed in sub-paragraphs (a) and (b) above. This inventory, prepared and revised annually, shall include compliance schedules and status of compliance with monitoring and effluent restrictions, and shall be made available to the International Joint Commission and to the public. In the initial preparation of this inventory, priority shall be given to the problem areas previously identified by the Water Quality Board.

(d) Eutrophication. Programs and measures for the reduction and control of inputs of phosphorus and other nutrients, in accordance with the provisions of Annex 3.

(e) Pollution from Agricultural, Forestry and Other Land Use Activities. Measures for the abatement and control of pollution from agricultural, forestry and other land use activities including:

(i) Measures for the control of pest control products used in the Great Lakes Basin to ensure that pest control products likely to have long-term deleterious effects on the quality of water or its biota be used only as authorized by the responsible regulatory agencies; that inventories of pest control products used in the Great Lakes Basin be established and maintained by appropriate agencies; and that research and educational programs be strengthened to facilitate integration of cultural, biological and chemical pest control techniques;

(ii) Measures for the abatement and control of pollution from animal husbandry operations, including encouragement to appropriate agencies to adopt policies and regulations regarding utilization of animal wastes, and site selection and disposal of liquid and solid wastes, and to strengthen educational and technical assistance programs to enable farmers to establish waste utilization, handling and disposal systems;

(iii) Measures governing the hauling and disposal of liquid and solid wastes, including encouragement to appropriate regulatory agencies to ensure proper location, design, and regulation governing land disposal, and to ensure sufficient, adequately trained technical and administrative capability to review plans and to supervise and monitor systems for application of wastes on land;

(iv) Measures to review and supervise road salting practices and salt storage to ensure optimum use of salt and all-weather protection of salt stores in consideration of long-term environmental impact;

(v) Measures to control soil losses from urban and suburban as well as rural areas;

(vi) Measures to encourage and facilitate improvements in land use planning and management programs to take account of impacts on Great Lakes water quality;

(vii) Other advisory programs and measures to abate and control inputs of nutrients, toxic substances and sediments from agricultural, forestry and other land use activities; and

(viii) Consideration of future recommendations from the International Joint Commission based on the Pollution from Land Use Activities Reference.

(f) Pollution from Shipping Activities. Measures for the abatement and control of pollution from shipping sources, including:

(i) Programs and compatible regulations to prevent discharges of harmful quantities of oil and hazardous polluting substances, in accordance with Annex 4;

(ii) Compatible regulations for the control of discharges of vessel wastes, in accordance with Annex 5;

(iii) Such compatible regulations to abate and control pollution from shipping sources as may be deemed desirable in the light of continuing reviews and studies to be undertaken in accordance with Annex 6;

(iv) Programs and any necessary compatible regulations in accordance with Annexes 4 and 5, for the safe and efficient handling of shipboard generated wastes, including oil, hazardous polluting substances, garbage, waste water and sewage, and for their subsequent disposal, including the type and quantity of reception facilities and, if applicable, treatment standards; and

(v) Establishment by the Canadian Coast Guard and the United States Coast Guard of a coordinated system for aerial and surface surveillance for the purpose of enforcement of regulations and the early identification, abatement and clean-up of spills of oil, hazardous polluting substances, or other pollution.

(g) Pollution from Dredging Activities. Measures for the abatement and control of pollution from all dredging activities, including the development of criteria for the identification of polluted sediments and compatible programs for disposal of polluted dredged material, in accordance with Annex 7. Pending the development of compatible criteria and programs, dredging operations shall be conducted in a manner that will minimize adverse effects on the environment.

(h) Pollution from Onshore and Offshore Facilities. Measures for the abatement and control of pollution from onshore and offshore facilities, including programs and compatible regulations for the prevention of discharges of harmful quantities of oil and hazardous polluting substances, in accordance with Annex 8.

(i) Contingency Plan. Maintenance of a joint contingency plan for use in the event of a discharge or the imminent threat of a discharge of oil or hazardous polluting substances, in accordance with Annex 9.

(j) Hazardous Polluting Substances. Implementation of Annex 10 concerning hazardous polluting substances. The Parties shall further consult from time to time for the purpose of revising the list of hazardous polluting substances and of identifying harmful quantities of these substances.

(k) Persistent Toxic Substances. Measures for the control of inputs of persistent toxic substances including control programs for their production, use, distribution and disposal, in accordance with Annex 12.

(l) Airborne Pollutants. Programs to identify pollutant sources and relative source contributions, including the more accurate definition of wet and dry deposition rates, for those substances which may have significant adverse effects on environmental quality including the

indirect effects of impairment of tributary water quality through atmospheric deposition in drainage basins. In cases where significant contributions to Great Lakes pollution from atmospheric sources are identified, the Parties agree to consult on appropriate remedial programs.

(m) Surveillance and Monitoring. Implementation of a coordinated surveillance and monitoring program in the Great Lakes System, in accordance with Annex 11, to assess compliance with pollution control requirements and achievement of the Objectives, to provide information for measuring local and whole lake response to control measures, and to identify emerging problems.

2. The Parties shall develop and implement such additional programs as they jointly decide are necessary and desirable to fulfil the purpose of this Agreement and to meet the General and Specific Objectives.

ARTICLE VII

POWERS, RESPONSIBILITIES AND FUNCTIONS OF THE INTERNATIONAL JOINT COMMISSION

1. The International Joint Commission shall assist in the implementation of this Agreement. Accordingly, the Commission is hereby given, by a Reference pursuant to Article IX of the Boundary Waters Treaty, the following responsibilities:

(a) Collation, analysis and dissemination of data and information supplied by the Parties and State and Provincial Governments relating to the quality of the boundary waters of the Great Lakes System and to pollution that enters the boundary waters from tributary waters and other sources;

(b) Collection, analysis and dissemination of data and information concerning the General and Specific Objectives and the operation and effectiveness of the programs and other measures established pursuant to this Agreement;

(c) Tendering of advice and recommendations to the Parties and to the State and Provincial Governments on problems of and matters related to the quality of the boundary waters of the Great Lakes System including specific recommendations concerning the General and Specific Objectives, legislation, standards and other regulatory requirements, programs and other measures, and intergovernmental agreements relating to the quality of these waters;

(d) Tendering of advice and recommendations to the Parties in connection with matters covered under the Annexes to this Agreement;

(e) Provision of assistance in the coordination of the joint activities envisaged by this Agreement;

(f) Provision of assistance in and advice on matters related to research in the Great Lakes Basin Ecosystem, including identification of objectives for research activities, tendering of advice and recommendations concerning research to the Parties and to the State and Provincial Governments, and dissemination of information concerning research to interested persons and agencies;

(g) Investigations of such subjects related to the Great Lakes Basin Ecosystem as the Parties may from time to time refer to it.

2. In the discharge of its responsibilities under this Reference, the Commission may exercise all of the powers conferred upon it by the Boundary Waters Treaty and by any legislation passed pursuant thereto including the power to conduct public hearings and to compel the testimony of witnesses and the production of documents.

3. The Commission shall make a full report to the Parties and to the State and Provincial Governments no less frequently than biennially concerning progress toward the achievement of the General and Specific Objectives including, as appropriate, matters related to Annexes to this Agreement. This report shall include an assessment of the effectiveness of the programs and other measures undertaken pursuant to this Agreement, and advice and recommendations. In alternate years the Commission may submit a summary report. The Commission may at any time make special reports to the Parties, to the State and Provincial Governments and to the public concerning any problem of water quality in the Great Lakes System.

4. The Commission may in its discretion publish any report, statement or other document prepared by it in the discharge of its functions under this Reference.

5. The Commission shall have authority to verify independently the data and other information submitted by the Parties and by the State and Provincial Governments through such tests or other means as appear appropriate to it, consistent with the Boundary Waters Treaty and with applicable legislation.

6. The Commission shall carry out its responsibilities under this Reference utilizing principally the services of the Water Quality Board and the Science Advisory Board established under Article VIII of this Agreement. The Commission shall also ensure liaison and coordination between the institutions established under this Agreement and other institutions which may address concerns relevant to the Great Lakes Basin Ecosystem, including both those within its purview, such as those Boards related to Great Lakes levels and air pollution matters, and other international bodies, as appropriate.

ARTICLE VIII

JOINT INSTITUTIONS AND REGIONAL OFFICE

1. To assist the International Joint Commission in the exercise of the powers and responsibilities assigned to it under this Agreement, there shall be two Boards:

(a) A Great Lakes Water Quality Board which shall be the principal advisor to the Commission. The Board shall be composed of an equal number of members from Canada and the United States, including representatives from the Parties and each of the State and Provincial Governments; and

(b) A Great Lakes Science Advisory Board which shall provide advice on research to the Commission and to the Water Quality Board. The Board shall further provide advice on scientific matters referred to it by the Commission, or by the Water Quality Board in consultation with the Commission. The Science Advisory

Board shall consist of managers of Great Lakes research programs and recognized experts on Great Lakes water quality problems and related fields.

2. The members of the Water Quality Board and the Science Advisory Board shall be appointed by the Commission after consultation with the appropriate government or governments concerned. The functions of the Boards shall be as specified in the Terms of Reference appended to this Agreement.

3. To provide administrative support and technical assistance to the two Boards, and to provide a public information service for the programs, including public hearings, undertaken by the International Joint Commission and by the Boards, there shall be a Great Lakes Regional Office of the International Joint Commission. Specific duties and organization of the Office shall be as specified in the Terms of Reference appended to this Agreement.

4. The Commission shall submit an annual budget of anticipated expenses to be incurred in carrying out its responsibilities under this Agreement to the Parties for approval. Each Party shall seek funds to pay one-half of the annual budget so approved, but neither Party shall be under an obligation to pay a larger amount than the other toward this budget.

ARTICLE IX

SUBMISSION AND EXCHANGE OF INFORMATION

1. The International Joint Commission shall be given at its request any data or other information relating to water quality in the Great Lakes System in accordance with procedures established by the Commission.

2. The Commission shall make available to the Parties and to the State and Provincial Governments upon request all data or other information furnished to it in accordance with this Article.

3. Each Party shall make available to the other at its request any data or other information in its control relating to water quality in the Great Lakes System.

4. Notwithstanding any other provision of this Agreement, the Commission shall not release without the consent of the owner any information identified as proprietary information under the law of the place where such information has been acquired.

ARTICLE X

CONSULTATION AND REVIEW

1. Following the receipt of each report submitted to the Parties by the International Joint Commission in accordance with paragraph 3 of Article VII of this Agreement, the Parties shall consult on the recommendations contained in such report and shall consider such action as may be appropriate, including:

(a) The modification of existing Objectives and the adoption of new Objectives;

(b) The modification or improvement of programs and joint measures; and

(c) The amendment of this Agreement or any Annex thereto.

Additional consultations may be held at the request of either Party on any matter arising out of the implementation of this Agreement.

2. When a Party becomes aware of a special pollution problem that is of joint concern and requires an immediate response, it shall notify and consult the other Party forthwith about appropriate remedial action.

3. The Parties shall conduct a comprehensive review of the operation and effectiveness of this Agreement following the third biennial report of the Commission required under Article VII of this Agreement.

ARTICLE XI

IMPLEMENTATION

1. The obligations undertaken in this Agreement shall be subject to the appropriation of funds in accordance with the constitutional procedures of the Parties.

2. The Parties commit themselves to seek:

(a) The appropriation of the funds required to implement this Agreement, including the funds needed to develop and implement the programs and other measures provided for in Article VI of this Agreement, and the funds required by the International Joint Commission to carry out its responsibilities effectively;

(b) The enactment of any additional legislation that may be necessary in order to implement the programs and other measures provided for in Article VI of this Agreement; and

(c) The cooperation of the State and Provincial Governments in all matters relating to this Agreement.

ARTICLE XII

EXISTING RIGHTS AND OBLIGATIONS

Nothing in this Agreement shall be deemed to diminish the rights and obligations of the Parties as set forth in the Boundary Waters Treaty.

ARTICLE XIII

AMENDMENT

1. This Agreement, the Annexes, and the Terms of Reference may be amended by agreement of the Parties. The Annexes may also be amended as provided therein, subject to the requirement that such amendments shall be within the scope of this Agreement. All such amendments to the Annexes shall be confirmed by an exchange of notes or letters between the Parties through diplomatic channels which shall specify the effective date or dates of such amendments.

2. All amendments to this Agreement, the Annexes, and the Terms of Reference shall be communicated promptly to the International Joint Commission.

ARTICLE XIV

ENTRY INTO FORCE AND TERMINATION

This Agreement shall enter into force upon signature by the duly authorized representatives of the Parties, and shall remain in force for a period of five years and thereafter until terminated upon twelve months' notice given in writing by one of the Parties to the other.

ARTICLE XV

SUPERSESSION

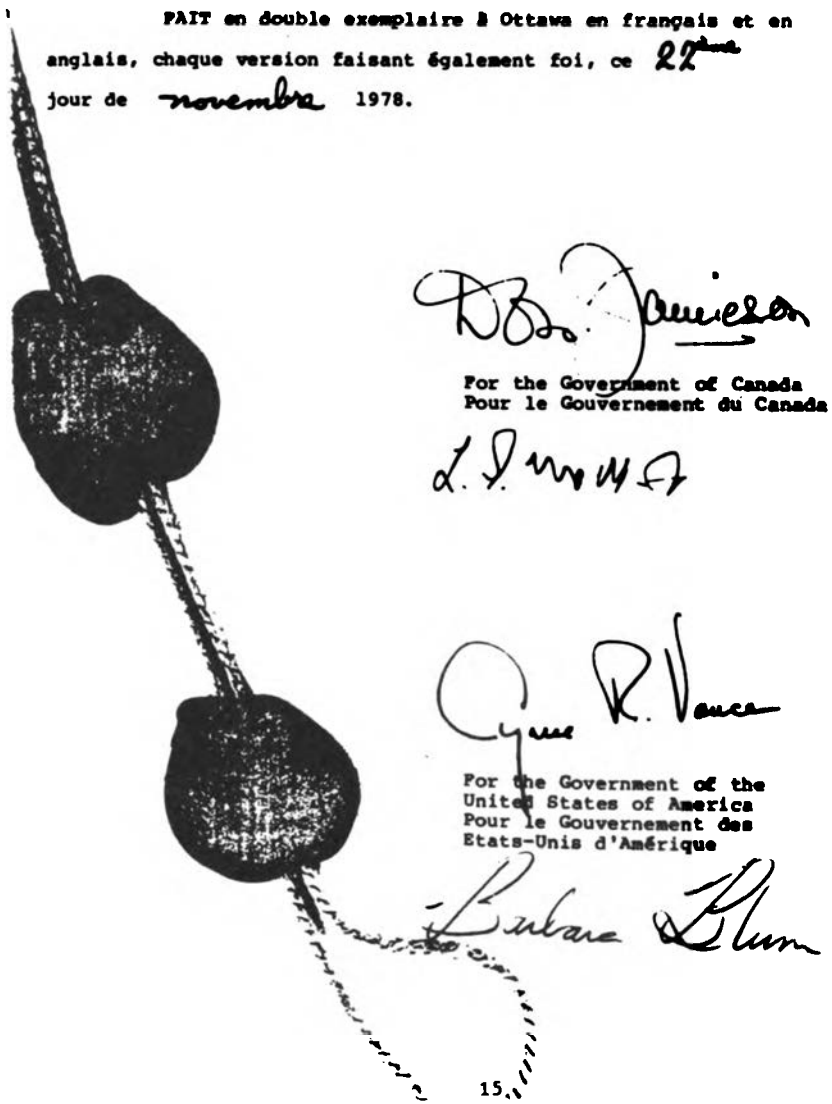
This Agreement supersedes the Great Lakes Water Quality Agreement of April 15, 1972, and shall be referred to as the "Great Lakes Water Quality Agreement of 1978".

IN WITNESS WHEREOF the undersigned representatives, duly authorized by their respective Governments, have signed this Agreement.

DONE in duplicate at Ottawa in the English and French languages, both versions being equally authentic, this 22nd day of November 1978.

EN FOI DE QUOI, les représentants soussignées, dûment autorisés par leur Gouvernement respectif, ont signé le présent Accord.

FAIT en double exemplaire à Ottawa en français et en anglais, chaque version faisant également foi, ce 22ème jour de novembre 1978.



For the Government of Canada
Pour le Gouvernement du Canada

For the Government of the United States of America
Pour le Gouvernement des Etats-Unis d'Amérique

ANNEX 1

SPECIFIC OBJECTIVES

These Objectives are based on available information on cause/effect relationships between pollutants and receptors to protect the recognized most sensitive use in all waters. These Objectives may be amended, or new Objectives may be added, by mutual consent of the Parties.

I. CHEMICAL

A. Persistent Toxic Substances

1. Organic

(a) Pesticides

Aldrin/Dieldrin

The sum of the concentrations of aldrin and dieldrin in water should not exceed 0.001 microgram per litre. The sum of concentrations of aldrin and dieldrin in the edible portion of fish should not exceed 0.3 microgram per gram (wet weight basis) for the protection of human consumers of fish.

Chlordane

The concentration of chlordane in water should not exceed 0.06 microgram per litre for the protection of aquatic life.

DDT and Metabolites

The sum of the concentrations of DDT and its metabolites in water should not exceed 0.003 microgram per litre. The sum of the concentrations of DDT and its metabolites in whole fish should not exceed 1.0 microgram per gram (wet weight basis) for the protection of fish-consuming aquatic birds.

Endrin

The concentration of endrin in water should not exceed 0.002 microgram per litre. The concentration of endrin in the edible portion of fish should not exceed 0.3 microgram per gram (wet weight basis) for the protection of human consumers of fish.

Heptachlor/Heptachlor Epoxide

The sum of the concentrations of heptachlor and heptachlor epoxide in water should not exceed 0.001 microgram per litre. The sum of the concentrations of heptachlor and heptachlor epoxide in edible portions of fish should not exceed 0.3 microgram per gram (wet weight basis) for the protection of human consumers of fish.

Lindane

The concentration of lindane in water should not exceed 0.01 microgram per litre for the protection of aquatic life. The concentration

of lindane in edible portions of fish should not exceed 0.3 microgram per gram (wet weight basis) for the protection of human consumers of fish.

Methoxychlor

The concentration of methoxychlor in water should not exceed 0.04 microgram per litre for the protection of aquatic life.

Mirex

For the protection of aquatic organisms and fish-consuming birds and animals, mirex and its degradation products should be substantially absent from water and aquatic organisms. Sustantially absent here means less than detection levels as determined by the best scientific methodology available.

Toxaphene

The concentration of toxaphene in water should not exceed 0.008 microgram par litre for the protection of aquatic life.

(b) Other Compounds

Phthalic Acid Esters

The concentration of dibutyl phthalate and di(2-ethylhexyl) phthalate in water should not exceed 4.0 micrograms per litre and 0.6 microgram per litre, respectively, for the protection of aquatic life. Other phthalic acid esters should not exceed 0.2 microgram per litre in waters for the protection of aquatic life.

Polychlorinated Biphenyls (PCBs)

The concentration of total polychlorinated biphenyls in fish tissues (whole fish, calculated on a wet weight basis), should not exceed 0.1 microgram per gram for the protection of birds and animals which consume fish.

Unspecified Organic Compounds

For other organic contaminants, for which Specific Objectives have not been defined, but which can be demonstrated to be persistent and are likely to be toxic, the concentrations of such compounds in water or aquatic organisms should be substantially absent, i.e., less than detection levels as determined by the best scientific methodology available.

2. Inorganic

(a) Metals

Arsenic

The concentrations of total arsenic in an unfiltered water sample should not exceed 50 micrograms per litre to protect raw waters for public water supplies.

Cadmium

The concentration of total cadmium in an unfiltered water sample should not exceed 0.2 microgram per litre to protect aquatic life.

Chromium

The concentration of total chromium in an unfiltered water sample should not exceed 50 micrograms per litre to protect raw waters for public water supplies.

Copper

The concentration of total copper in an unfiltered water sample should not exceed 5 micrograms per litre to protect aquatic life.

Iron

The concentration of total iron in an unfiltered water sample should not exceed 300 micrograms per litre to protect aquatic life.

Lead

The concentration of total lead in an unfiltered water sample should not exceed 10 micrograms per litre in Lake Superior, 20 micrograms per litre in Lake Huron and 25 micrograms per litre in all remaining Great Lakes to protect aquatic life.

Mercury

The concentration of total mercury in a filtered water sample should not exceed 0.2 microgram per litre nor should the concentration of total mercury in whole fish exceed 0.5 microgram per gram (wet weight basis) to protect aquatic life and fish-consuming birds.

Nickel

The concentration of total nickel in an unfiltered water sample should not exceed 25 micrograms per litre to protect aquatic life.

Selenium

The concentration of total selenium in an unfiltered water sample should not exceed 10 micrograma per litre to protect raw water for public water supplies.

Zinc

The concentration of total zinc in an unfiltered water sample should not exceed 30 micrograms per litre to protect aquatic life.

(b) Other Inorganic Substances

Fluoride

The concentration of total fluoride in an unfiltered water sample should not exceed 1200 micrograms per litre to protect raw water for public water supplies.

Total Dissolved Solids

In Lake Erie, Lake Ontario and the International Section of the St. Lawrence River, the level of total dissolved solids should not exceed 200 milligrams per litre. In the St. Clair River, Lake St. Clair, the Detroit River and the Niagara River, the level should be consistent with maintaining the levels of total dissolved solids in Lake Erie and Lake Ontario at not to exceed 200 milligrams per litre. In the remaining boundary waters, pending further study, the level of total dissolved solids should not exceed present levels.

B. Non-Persistent Toxic Substances

1. Organic Substances

(a) Pesticides

Diazinon

The concentration of diazinon in an unfiltered water sample should not exceed 0.08 microgram per litre for the protection of aquatic life.

Guthion

The concentration of guthion in an unfiltered water sample should not exceed 0.005 microgram per litre for the protection of aquatic life.

Parathion

The concentration of parathion in an unfiltered water sample should not exceed 0.008 microgram per litre for the protection of aquatic life.

Other Pesticides

The concentration of unspecified, non-persistent pesticides should not exceed 0.05 of the median lethal concentration on a 96-hour test for any sensitive local species.

(b) Other Substances

Unspecified Non-Persistent Toxic Substances and Complex Effluents

Unspecified non-persistent toxic substances and complex effluents of municipal, industrial or other origin should not be present in concentrations which exceed 0.05 of the median lethal concentration in a 96-hour test for any sensitive local species to protect aquatic life.

Oil and Petrochemicals

Oil and petrochemicals should not be present in concentrations that:

(i) can be detected as visible film, sheen or discolouration on the surface;

(ii) can be detected by odour;

(iii) can cause tainting of edible aquatic organisms; and

(iv) can form deposits on shorelines and bottom sediments that are detectable by sight or odour, or are deleterious to resident aquatic organisms.

2. Inorganic Substances

Ammonia

The concentration of un-ionized ammonia (NH_3) should not exceed 20 micrograms per litre for the protection of aquatic life. Concentrations of total ammonia should not exceed 500 microgrsms per litre for the protection of public water supplies.

Hydrogen Sulfide

The concentration of undissociated hydrogen sulfide should not exceed 2.0 microgrsms per litre to protect aquatic life.

C. Other Substances

1. Dissolved oxygen

In the connecting channels and in the upper waters of the Lakes, the dissolved oxygen level should not be less than 6.0 milligrsms per litre at any time; in hypolimnetic waters, it should be not less than necessary for the support of fishlife, particularly cold water species.

2. pH

Values of pH should not be outside the range of 6.5 to 9.0, nor should discharge change the pH at the boundary of a limited use zone more than 0.5 units from that of the ambient waters.

3. Nutrients

Phosphorus

The concentration should be limited to the extent necessary to prevent nuisance growths of algae, weeds and slimes that are or may become injurious to any beneficial water use. (Specific phosphorus control requirements are set out in Annex 3.)

4. Tainting Substances

(a) Raw public water supply sources should be essentially free from objectionable taste and odour for aesthetic reasons.

(b) Levels of phenolic compounds should not exceed 1.0 microgram per litre in public water supplies to protect against taste and odor in domestic water.

(c) Substances entering the water as the result of human activity that cause tainting of edible aquatic organisms should not be present in concentrations which will lower the acceptability of these organisms as determined by organoleptic tests.

II. PHYSICAL

A. Asbestos

Asbestos should be kept at the lowest practical level and in any event should be controlled to the extent necessary to prevent harmful effects on human health.

B. Temperature

There should be no change in temperature that would adversely affect any local or general use of the waters.

C. Settleable and Suspended Solids, and Light Transmission

For the protection of aquatic life, waters should be free from substances attributable to municipal, industrial or other discharges resulting from human activity that will settle to form putrescent or otherwise objectionable sludge deposits or that will alter the value of Secchi disc depth by more than 10 per cent.

III. MICROBIOLOGICAL

Waters used for body contact recreation activities should be substantially free from bacteria, fungi, or viruses that may produce enteric disorders or eye, ear, nose, throat and skin infections or other human diseases and infections.

IV. RADIOLOGICAL

The level of radioactivity in waters outside of any defined source control area should not result in a TED_{50} (total equivalent dose integrated over 50 years as calculated in accordance with the methodology established by the International Commission on Radiological Protection) greater than 1 millirem to the whole body from a daily ingestion of 2.2 litres of lake water for one year. For dose commitments between 1 and 5 millirem at the periphery of the source control area, source investigation and corrective action are recommended if releases are not as low as reasonably achievable. For dose commitments greater than 5 millirem, the responsible regulatory authorities shall determine appropriate corrective action.

ANNEX 2

LIMITED USE ZONES

1. The Parties, in consultation with the State and Provincial Governments, shall take measures to define and describe all existing and future limited use zones, and shall prepare an annual report on these measures. The measures shall include:

(a) Identification and quantitative and qualitative description of all point source waste discharges (including tributaries) to boundary waters;

(b) Delineation of boundaries for limited use zones assigned to identified discharges;

(c) Assessment of the impact of the proposed limited use zones on existing and potential beneficial uses; and

(d) Continuing review and revision of the extent of limited use zones to achieve maximum possible reduction in size and effect of such zones in accordance with improvements in waste treatment technology.

2. Limited use zones within the boundary waters of the Great Lakes System shall be designated for industrial discharges, and for municipal discharges in excess of 1 million gallons per day before January 1, 1980, in accordance with the following principles:

(a) The boundary of a limited use zone shall not transect the international boundary.

(b) The size, shape and exact location of a limited use zone shall be specified on a case-by-case basis by the responsible regulatory agency. The size shall be minimized to the greatest possible degree, being no larger than that attainable by all reasonable and practicable effluent treatment measures.

(c) Specific Objectives and conditions applicable to the receiving water body shall be met at the boundary of limited use zones.

(d) Existing biological, chemical, physical and hydrological conditions shall be defined before considering the location of a new limited use zone or restricting an existing one.

(e) Areas of extraordinary natural resource value shall not be designated as limited use zones.

(f) Limited use zones shall not form barriers to migratory routes of aquatic species or interfere with biological communities or populations of important species to a degree which damages the ecosystem, or diminishes other beneficial uses disproportionately. Routes of passage for specific organisms which require protection and which would normally inhabit or pass through limited use zones shall be assured either by location of the zones, or by design of conditions within the zones.

(g) Conditions shall not be permitted within the limited use zones which:

(i) are rapidly lethal to important aquatic life;

(ii) cause irreversible responses which could result in detrimental post-exposure effects; or

(iii) result in bioconcentration of toxic substances which are harmful to the organism or its consumers.

(h) Concentrations of toxic substances at any point in the limited use zone where important species are physically capable of residing shall not exceed the 24-hour LC_{50}.

(i) Every attempt shall be made to insure that the zones are free from:

(i) objectionable deposits;

(ii) unsightly or deleterious amounts of flotsam, debris, oil, scum and other floating matter;

(iii) substances producing objectionable colour, odour, taste or turbidity; and

(iv) substances and conditions or combinations thereof at levels which produce aquatic life in nuisance quantities that interfere with other uses.

(j) Limited use zones may overlap unless the combined effects exceed the conditions set forth in other guidelines.

(k) As a general condition, limited use zones should not overlap with municipal and other water intakes and recreational areas. However, knowledge of local effluent characteristics and effects could allow such a combination of uses.

3. Candidate areas for designation as limited use zones shall be reported, in all available detail, by the responsible regulatory agencies to the International Joint Commission. Within 60 days, the Commission may comment upon the extent of the area proposed for designation as a limited use zone, or any other aspect or measure to promote the attainment of the General and Specific Objectives of this Agreement. The responsible regulatory agency will take the comments of the Commission into account prior to making a formal designation of the area as a limited use zone. If no comment is received from the Commission within 60 days, it may be assumed that the Commission agrees with the proposed designation.

4. The Parties shall consult to develop more definitive procedures to delineate the extent of individual limited use zones and to develop scientific guidelines for determining the maximum portions of the boundary waters of each of the Great Lakes and connecting channels which may be occupied by limited use zones.

ANNEX 3

CONTROL OF PHOSPHORUS

1. The purpose of the following programs is to minimize eutrophication problems and to prevent degradation with regard to phosphorus in the boundary waters of the Great Lakes System. The goals of phosphorus control are:

(a) Restoration of year-round aerobic conditions in the bottom waters of the Central Basin of Lake Erie;

(b) Substantial reduction in the present levels of algal biomass to a level below that of a nuisance condition in Lake Erie;

(c) Reduction in present levels of algal biomass to below that of a nuisance condition in Lake Ontario including the International Section of the St. Lawrence River;

(d) Maintenance of the oligotrophic state and relative algal biomass of Lakes Superior and Huron;

(e) Substantial elimination of algal nuisance growths in Lake Michigan to restore it to an oligotrophic state; and

(f) The elimination of algal nuisance in bays and in other areas wherever they occur.

2. The following programs shall be developed and implemented to reduce input of phosphorus to the Great Lakes:

(a) Construction and operation of municipal waste treatment facilities in all plants discharging more than one million gallons per day to achieve, where necessary to meet the loading allocations to be developed pursuant to paragraph 3 below, or to meet local conditions, whichever are more stringent, effluent concentrations of 1.0 milligram per litre total phosphorus maximum for plants in the basins of Lakes Superior, Michigan, and Huron, and of 0.5 milligram per litre total phosphorus maximum for plants in the basins of Lakes Ontario and Erie.

(b) Regulation of phosphorus introduction from industrial discharges to the maximum practicable extent.

(c) Reduction to the maximum extent practicable of phosphorus introduced from diffuse sources into Lakes Superior, Michigan, and Huron; and reduction by 30 per cent of phosphorus introduced from diffuse sources into Lakes Ontario and Erie, where necessary to meet the loading allocations to be developed pursuant to paragraph 3 below, or to meet local conditions, whichever are more stringent.

(d) Reduction of phosphorus in household detergents to 0.5 per cent by weight where necessary to meet the loading allocations to be developed pursuant to paragraph 3 below, or to meet local conditions, whichever are more stringent.

(e) Maintenance of a viable research program to seek maximum efficiency and effectiveness in the control of phosphorus introductions into the Great Lakes.

3. The following table establishes phosphorus loads for the base year (1976) and future phosphorus loads. The Parties, in cooperation with the State and Provincial Governments, shall within eighteen months after the date of entry into force of this Agreement confirm the future phosphorus loads, and based on these establish load allocations and compliance schedules, taking into account the recommendations of the International Joint Commission arising from the Pollution from Land Use Activities Reference. Until such loading allocations and compliance schedules are established, the Parties agree to maintain the programs and other measures specified in Annex 2 of the Great Lakes Water Quality Agreement of 1972.

Basin	1976 Phosphorus Load in Metric Tonnes Per Year	Future Phosphorus Load in Metric Tonnes Per Year
Lake Superior	3600	3400*
Lake Michigan	6700	5600*
Main Lake Huron	3000	2800*
Georgian Bay	630	600*
North Channel	550	520*
Saginaw Bay	870	440**
Lake Erie	20000	11000**
Lake Ontario	11000	7000**

* These loadings would result if all municipal plants over one million gallons per day achieved an effluent of 1 milligram per litre of phosphorus.

** These loadings are required to meet the goals stated in paragraph 1 above.

ANNEX 4

DISCHARGES OF OIL AND HAZARDOUS POLLUTING SUBSTANCES FROM VESSELS

1. Definitions. As used in this Annex:

(a) "Discharge" includes, but is not limited to, any spilling, leaking, pumping, pouring, emitting or dumping; it does not include unavoidable direct discharges of oil from a properly functioning vessel engine;

(b) "Harmful quantity of oil" means any quantity of oil that, if discharged from a ship that is stationary into clear calm water on a clear day, would produce a film or a sheen upon, or discolouration of, the surface of the water or adjoining shoreline, or that would cause a sludge or emulsion to be deposited beneath the surface of the water or upon the adjoining shoreline;

(c) "Oil" means oil of any kind or in any form, including, but not limited to, petroleum, fuel oil, oil sludge, oil refuse, oil mixed with ballast or bilge water, and oil mixed with wastes other than dredged material;

(d) "Tanker" means any vessel designed for the carriage of liquid cargo in bulk; and

(e) "Vessel" means any ship, barge or other floating craft, whether or not self-propelled.

2. General Principles. Compatible regulations shall be adopted for the prevention of discharges into the Great Lakes System of harmful quantities of oil and hazardous polluting substances from vessels in accordance with the following principles:

(a) The discharge of a harmful quantity of oil or hazardous polluting substance shall be prohibited and made subject to appropriate penalties; and

(b) As soon as any person in charge has knowledge of any discharge of harmful quantities of oil or hazardous polluting substances, immediate notice of such discharge shall be given to the appropriate agency in the jurisdiction where the discharge occurs; failure to give this notice shall be made subject to appropriate penalties.

3. Oil. The programs and measures to be adopted for the prevention of discharges of harmful quantities of oil shall include:

(a) Compatible regulations for design, construction, and operation of vessels based on the following principles:

(i) Each vessel shall have a suitable means of containing on board cargo oil spills caused by loading or unloading operations;

(ii) Each vessel shall have a suitable means of containing on board fuel oil spills caused by loading or unloading operations, including those from tank vents and overflow pipes;

(iii) Each vessel shall have the capability of retaining on board oily wastes accumulated during vessel operation;

(iv) Each vessel shall be capable of off-loading retained oily wastes to a reception facility;

(v) Each vessel shall be provided with a means for rapidly and safely stopping the flow of cargo or fuel oil during loading, unloading or bunkering operations in the event of an emergency;

(vi) Each vessel shall be provided with suitable lighting to adequately illuminate all cargo and fuel oil handling areas if the loading, unloading or bunkering operations occur at night;

(vii) Hose assemblies used on board vessels for oil loading, unloading, or bunkering shall be suitably designed, identified, and inspected to minimize the possibility of failure; and

(viii) Oil loading, unloading, and bunkering systems shall be suitably designed, identified, and inspected to minimize the possibility of failure; and

(b) Programs to ensure that merchant vessel personnel are trained in all functions involved in the use, handling, and stowage of oil and in procedures for abatement of oil pollution.

4. Hazardous Polluting Substances. The programs and measures to be adopted for the prevention of discharges of harmful quantities of hazardous polluting substances carried as cargo shall include:

(a) Compatible regulations for the design, construction, and operation of vessels using as a guide the Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk as established through the Inter-Governmental Maritime Consultative Organization (IMCO), including the following requirements:

(i) Each vessel shall have a suitable means of containing on board spills caused by loading or unloading operations;

(ii) Each vessel shall have a capability of retaining on board wastes accumulated during vessel operation;

(iii) Each vessel shall be capable of off-loading wastes retained to a reception facility;

(iv) Each vessel shall be provided with a means for rapidly and safely stopping the flow during loading or unloading operations in the event of an emergency; and

(v) Each vessel shall be provided with suitable lighting to adequately illuminate all cargo handling areas if the loading or unloading operations occur at night;

(b) Identification of vessels carrying cargoes of hazardous polluting substances in bulk, containers, and package form, and of all such cargoes;

(c) Identification in vessel manifests of all hazardous polluting substances;

(d) Procedures for notification to the appropriate agency by the owner, master or agent of a vessel of all hazardous polluting substances; and

(e) Programs to ensure that merchant vessel personnel are trained in all functions involving the use, handling, and stowage of hazardous polluting substances; the abatement of pollution from such substances; and the hazards associated with the handling of such substances.

5. Additional Measures. Both Parties shall take, as appropriate, action to ensure the provision of adequate facilities for the reception, treatment, and subsequent disposal of oil and hazardous polluting substances wastes from all vessels.

ANNEX 5

DISCHARGES OF VESSEL WASTES

1. Definitions. As used in this Annex:

(a) "Discharge" includes, but is not limited to, any spilling, leaking, pumping, pouring, emitting, and dumping;

(b) "Garbage" means all kinds of victual, domestic, and operational wastes, excluding fresh fish and parts thereof generated during the normal operation of the ship and liable to be disposed of continually or periodically;

(c) "Sewage" means human or animal waste generated on board ship and includes wastes from water closets, urinals, or a hospital facility;

(d) "Vessel" means any ship, barge or other floating craft, whether or not self-propelled; and

(e) "Waste water" means water in combination with other substances, including ballast water and water used for washing cargo holds, but excluding water in combination with oil, hazardous polluting substances, or sewage.

2. General Principles. Compatible regulations shall be adopted governing the discharge into the Great Lakes System of garbage, sewage, and waste water from vessels in accordance with the following principles:

(a) The discharge of garbage shall be prohibited and made subject to appropriate penalties;

(b) The discharge of waste water in amounts or in concentrations that will be deleterious shall be prohibited and made subject to appropriate penalties; and

(c) Every vessel operating in these waters that is provided with toilet facilities shall be equipped with a device or devices to contain, incinerate, or treat sewage to an adequate degree; appropriate penalties shall be provided for failure to comply with the regulations.

3. Critical Use Areas. Critical use areas of the Great Lakes System may be designated where the discharge of waste water or sewage shall be limited or prohibited.

4. Containment Devices. Regulations may be established requiring a device or devices to contain the sewage of pleasure craft or other classes of vessels operating in the Great Lakes System or designated areas thereof.

5. Additional Measures. The Parties shall take, as appropriate, action to ensure the provision of adequate facilities for the reception, treatment, and subsequent disposal of garbage, waste water, and sewage from all vessels.

ANNEX 6

REVIEW OF POLLUTION FROM SHIPPING SOURCES

1. Review. The Canadian Coast Guard and the United States Coast Guard shall continue to review services, systems, programs, recommendations, standards, and regulations relating to shipping activities for the purpose of maintaining or improving Great Lakes water quality. The reviews shall include:

(a) Review of vessel equipment, vessel manning, and navigation practices or procedures, and of aids to navigation and vessel traffic management, for the purpose of precluding casualties which may be deleterious to water quality;

(b) Review of practices and procedures regarding waste water and their deleterious effect on water quality;

(c) Review of practices and procedures, as well as current technology for the treatment of vessel sewage; and

(d) Review of current practices and procedures regarding the prevention of pollution from the loading, unloading, or on board transfer of cargo.

2. Consultation. Representatives of the Canadian Coast Guard and the United States Coast Guard, and other interested agencies, shall meet at least annually to consider this Annex. A report of this annual consultation shall be furnished to the International Joint Commission prior to its annual meeting on Great Lakes water quality. The purpose of the consultation shall be to:

(a) Provide an interchange of information with respect to continuing reviews, ongoing studies, and areas of concern;

(b) Identify and determine the relative importance of problems requiring further study; and

(c) Apportion responsibility, as between the Canadian Coast Guard and the United States Coast Guard, for the studies, or portions thereof, which were identified in subparagraph 2(b) above.

3. Studies. Where a review identifies additional areas for improvement, the Canadian Coast Guard and the United States Coast Guard, and other interested agencies, will undertake a study to establish improved procedures for the abatement and control of pollution from shipping sources, and will:

(a) Develop a brief study description which will include the nature of the perceived problem, procedures to quantify the problem, alternative solutions to the problem, procedures to determine the best alternative, and an estimated completion date;

(b) Transmit study descriptions to the International Joint Commission and other interested agencies;

(c) Transmit the study, or a brief summary of its conclusions, to the International Joint Commission and other interested agencies; and

(d) Transmit a brief status report to the International Joint Commission and other interested agencies if the study is not completed by the estimated completion date.

4. Responsibility. Responsibility for the coordination of the review, consultation, and studies is assigned to the Canadian Coast Guard and the United States Coast Guard.

ANNEX 7

DREDGING

1. There shall be established, under the auspices of the Water Quality Board, a Subcommittee on Dredging. The Subcommittee shall:

(a) Review the existing practices in both countries relating to dredging activities, as well as the previous work done by the International Working Group on Dredging, with the objective of developing, within one year of the date of entry into force of this Agreement, compatible guidelines and criteria for dredging activities in the boundary waters of the Great Lakes System;

(b) Maintain a register of significant dredging projects being undertaken in the Great Lakes System with information to allow for the assessment of the environmental effects of the projects. The register shall include pertinent statistics to allow for the assessment of pollution loadings from dredged materials to the Great Lakes System;

(c) Encourage the exchange of information relating to developments of dredging technology and environmental research.

2. The Subcommittee shall identify specific criteria for the classification of polluted sediments of designated areas of intensive and continuing dredging activities within the Great Lakes System. Pending development of criteria and guidelines by the Subcommittee, and their acceptance by the Parties, the Parties shall continue to apply the criteria now in use by the regulatory authorities; however, neither Party shall be precluded from applying standards more stringent than those now in use.

3. The Parties shall continue to direct particular attention to the identification and preservation of significant wetland areas in the Great Lakes Basin Ecosystem which are threatened by dredging and disposal activities.

4. The Parties shall encourage research to investigate advances in dredging technology and the pathways, fate and effects of nutrients and contaminants of dredged materials.

5. The Subcommittee shall undertake any other activities as the Water Quality Board may direct.

ANNEX 8

DISCHARGES FROM ONSHORE AND OFFSHORE FACILITIES

1. Definitions. As used in this Annex:

(a) "Discharge" means the introduction of polluting substances into receiving waters and includes, but is not limited to, any spilling, leaking, pumping, pouring, emitting or dumping; it does not include continuous effluent discharges from municipal or industrial treatment facilities;

(b) "Harmful quantity of oil" means any quantity of oil that, if discharged into clear calm waters on a clear day, would produce a film or sheen upon, or discolouration of the surface of the water or adjoining shoreline, or that would cause a sludge or emulsion to be deposited beneath the surface of the water or upon the adjoining shoreline;

(c) "Facility" includes motor vehicles, rolling stock, pipelines, and any other facility that is used or capable of being used for the purpose of processing, producing, storing, disposing, transferring or transporting oil or hazardous polluting substances, but excludes vessels;

(d) "Offshore facility" means any facility of any kind located in, on or under any water;

(e) "Onshore facility" means any facility of any kind located in, on or under, any land other than submerged land;

(f) "Oil" means oil of any kind or in any form, including, but not limited to petroleum, fuel oil, oil sludge, oil refuse, and oil mixed with wastes, but does not include constituents of dredged spoil.

2. Principles. Regulations shall be adopted for the prevention of discharges into the Great Lakes System of harmful quantities of oil and hazardous polluting substances from onshore and offshore facilities in accordance with the following principles:

(a) Discharges of harmful quantities of oil or hazardous polluting substances shall be prohibited and made subject to appropriate penalties;

(b) As soon as any person in charge has knowledge of any discharge of harmful quantities of oil or hazardous polluting substances, immediate notice of such discharge shall be given to the appropriate agency in the jurisdiction where the discharge occurs; failure to give this notice shall be made subject to appropriate penalties.

3. Programs and Measures. The programs and measures to be adopted shall include the following:

(a) Review of the design, construction, and location of both existing and new facilities for their adequacy to prevent the discharge of oil or hazardous polluting substances;

(b) Review of the operation, maintenance and inspection procedures of facilities for their adequacy to prevent the discharge of oil or hazardous polluting substances;

(c) Development and implementation of regulations and personnel training programs to ensure the safe use and handling of oil or hazardous polluting substances;

(d) Programs to ensure that at each facility plans and provisions are made and equipment provided to stop rapidly and safely, contain, and clean up discharges of oil or hazardous polluting substances; and

(e) Compatible regulations and other programs for the identification and placarding of containers, vehicles and other facilities containing, carrying or handling oil or hazardous polluting substances; and, where appropriate, notification to appropriate agencies of vehicle movements, maintenance of a registry, and identification in manifests of such substances to be carried.

4. Implementation.

(a) Each Party shall submit a report to the International Joint Commission outlining its programs and measures, existing or proposed, for the implementation of this Annex within six months of the date of entry into force of this Agreement.

(b) The report shall outline programs and measures, existing or proposed, for each of the following types of onshore and offshore facilities:

(i) land transportation including rail and road modes;

(ii) pipelines on land and submerged under water;

(iii) offshore drilling rigs and wells;

(iv) storage facilities both onshore and offshore; and

(v) wharves and terminals with trestle or underwater pipeway connections to land and offshore island type structures and buoys used for the handling of oil or hazardous polluting substances.

(c) The report shall outline programs and measures, existing or proposed, for any other type of onshore or offshore facility.

(d) Upon receipt of the reports, the Commission, in consultation with the Parties, shall review the programs and measures outlined for adequacy and compatibility and, if necessary, make recommendations to rectify any such inadequacy or incompatibility it finds.

ANNEX 9

JOINT CONTINGENCY PLAN

1. The Plan. The "Joint Canada-United States Marine Pollution Contingency Plan for the Great Lakes (CANUSLAK)" adopted on June 20, 1974, shall be maintained in force, as amended from time to time. The Canadian Coast Guard and the United States Coast Guard shall, in cooperation with other affected parties, identify and provide detailed Supplements for areas of high risk and of particular concern in augmentation of CANUSLAK. It shall be the responsibility of the United States Coast Guard and the Canadian Coast Guard to coordinate and to maintain the Plan and the Supplements appended to the Plan.

2. Purpose. The purpose of the Plan is to provide for coordinated and integrated response to pollution incidents in the Great Lakes System by responsible federal, state, provincial and local agencies. The Plan supplements the national, provincial and regional plans of the Parties.

3. Pollution Incidents.

(a) A pollution incident is a discharge, or an imminent threat of discharge of oil, hazardous polluting substance or other substance of such magnitude or significance as to require immediate response to contain, clean up, and dispose of the material.

(b) The objectives of the Plan in pollution incidents are:

(i) To develop appropriate preparedness measures and effective systems for discovery and reporting the existence of a pollution incident within the area covered by the Plan;

(ii) To institute prompt measures to restrict the further spread of the pollutant; and

(iii) To provide adequate cleanup response to pollution incidents.

4. Funding. The costs of operations of both Parties under the Plan shall be borne by the Party in whose waters the pollution incident occurred, unless otherwise agreed.

5. Amendment. The Canadian Coast Guard and the United States Coast Guard are empowered to amend the Plan subject to the requirement that such amendments shall be consistent with the purpose and objectives of this Annex.

HAZARDOUS POLLUTING SUBSTANCES

1. The Parties shall:

(a) Maintain a list, to be known as Appendix 1 of this Annex (hereinafter referred to as Appendix 1), of substances known to have toxic effects on aquatic and animal life and a risk of being discharged to the Great Lakes System;

(b) Maintain a list, to be known as Appendix 2 of this Annex (hereinafter referred to as Appendix 2), of substances potentially having such effects and such a risk of discharge, and to give priority to the examination of these substances for possible transfer to Appendix 1;

(c) Ensure that these lists are continually revised in the light of growing scientific knowledge; and

(d) Develop and implement programs and measures to minimize or eliminate the risk of release of hazardous polluting substances to the Great Lakes System.

2. Hazardous polluting substances to be listed in Appendix 1 shall be determined in accordance with the following procedures:

(a) Selection of all hazardous substances for listing in Appendix 1 shall be based upon documented toxicological and discharge potential data which have been evaluated by the Parties and deemed to be mutually acceptable.

(b) Revisions to Appendix 1 may be made by mutual consent of the Parties and shall be treated as amendments to this Annex for the purposes of Article XIII of this Agreement.

(c) Using the agreed selection criteria, either Party may recommend at any time a substance to be added to the list in Appendix 1. Such substance need not previously have been listed in Appendix 2. The Party receiving the recommendation will have 60 days to review the associated documentation and either reject the proposed substance or accept the substance pending completion of appropriate procedural or domestic regulatory requirements. Cause for rejection must be documented and submitted to the initiating Party and may be the basis for any further negotiations.

3. The criteria to be applied to the selection of substances as candidates for listing in Appendix 1 are:

(a) Acute toxicological effects, as determined by whether the substance is lethal to:

(i) One-half of a test population of aquatic animals in 96 hours or less at a concentration of 500 milligrams per litre or less; or

(ii) One-half of a test population of animals in 14 days or less when administered in a single oral dose equal to or less than 50 milligrams per kilogram of body weight; or

(iii) One-half of a test population of animals in 14 days or less when dermally exposed to an amount equal to or less than 200 milligrams per kilogram body weight for 24 hours; or

(iv) One-half of a test population of animals in 14 days or less when exposed to a vapour concentration equal to or less than 20 cubic centimeters per cubic meter in air for one hour; or

(v) Aquatic flora as measured by a maximum specific growth rate or total yield of biomass which is 50 per cent lower than a control culture over 14 days in a medium at concentrations equal to or less than 100 milligrams per litre.

(b) Risk of discharge into the Great Lakes System, as determined by:

(i) Gathering information on the history of discharges or accidents;

(ii) Assessing the modal risks during transport and determining the use and distribution patterns;

(iii) Identifying quantities manufactured or imported.

4. Potentially hazardous polluting substances to be listed in Appendix 2 of this Annex shall be determined in accordance with the following procedures:

(a) Either Party may add new substances to Appendix 2 by notifying the other in writing that the substance is considered to be a potential hazard because of documented information concerning aquatic toxicity, mammalian and other vertebrate toxicity, phytotoxicity, persistence, bio-accumulation, mutagenicity, teratogenicity, carcinogenicity, environmental translocation or because of documented information on risk of discharge to the environment. The documentation of the potential hazard and the selected criteria upon which it is based will also be submitted.

(b) Removal of substances from Appendix 2 shall be by mutual consent of the Parties.

(c) The Parties shall give priority to the examination of substances listed in Appendix 2 for possible transfer to Appendix 1.

5. Programs and measures to control the risk of pollution from transport, storage, handling and disposal of hazardous polluting substances are contained in Annexes 4 and 8.

APPENDIX 1

HAZARDOUS POLLUTING SUBSTANCES

Acetaldehyde
Acetic Acid
Acetic Anhydride
Acetone Cyanohydrin
Acetyl Bromide
Acetyl Chloride
Acrolein
Acrylonitrile
Aldrin
Allyl Alcohol
Allyl Chloride
Aluminum Sulfate
Ammonia
Ammonium Acetate
Ammonium Benzoate
Ammonium Bicarbonate
Ammonium Bichromate
Ammonium Bifluoride
Ammonium Bisulfite
Ammonium Carbamate
Ammonium Carbonate
Ammonium Chloride
Ammonium Chromate
Ammonium Citrate, Dibasic
Ammonium Fluoborate
Ammonium Fluoride
Ammonium Hydroxide
Ammonium Oxalate
Ammonium Silicofluoride
Ammonium Sulfamate
Ammonium Sulfide
Ammonium Sulfite
Ammonium Tartrate
Ammonium Thiocyanate
Ammonium Thiosulfate
Amyl Acetate
Aniline
Antimony Pentachloride
Antimony Potassium Tartrate
Antimony Tribromide
Antimony Trichloride
Antimony Trifluoride
Antimony Trioxide
Arsenic Disulfide
Arsenic Pentoxide
Arsenic Trichloride
Arsenic Trioxide
Arsenic Trisulfide
Barium Cyanide
Benzene
Benzoic Acid
Benzonitrile
Benzoyl Chloride
Benzyl Chloride
Beryllium Chloride
Beryllium Fluoride
Beryllium Nitrate
Butyl Acetate
Butylamine
Butyric Acid
Cadmium Acetate
Cadmium Bromide

Cadmium Chloride
Calcium Arsenate
Calcium Arsenite
Calcium Carbide
Calcium Chromate
Calcium Cyanide
Calcium Dodecylbenzenesulfonate
Calcium Hydroxide
Calcium Hypochlorite
Calcium Oxide
Captan
Carbaryl
Carbon Disulfide
Chlordane
Chlorine
Chlorobenzene
Chloroform
Chlorosulfonic Acid
Chlorpyrifos
Chromic Acetate
Chromic Acid
Chromic Sulfate
Chromous Chloride
Cobaltous Bromide
Cobaltous Formate
Cobaltous Sulfamate
Coumaphos
Cresol
Cupric Acetate
Cupric Acetoarsenite
Cupric Chloride
Cupric Nitrate
Cupric Oxalate
Cupric Sulfate
Cupric Sulfate, Ammoniated
Cupric Tartrate
Cyanogen Chloride
Cyclohexane
2,4-D Acid
2,4-D Esters
Dalapon
DDT
Diazinon
Dicamba
Dichlobenil
Dichlone
Dichlorvos
Dieldrin
Diethylamine
Dimethylamine
Dinitrobenzene (mixed)
Dinitrophenol
Diquat
Disulfoton
Diuron
Dodecylbenzenesulfonic Acid
Endosulfan
Endrin
Ethion
Ethylbenzene
Ethylenediamine
EDTA
Ferric Ammonium Citrate
Ferric Ammonium Oxalate
Ferric Chloride
Ferric Fluoride
Ferric Nitrate
Ferric Sulfate

Ferrous Ammonium Sulfate
Ferrous Chloride
Ferrous Sulfate
Formaldehyde
Formic Acid
Fumaric Acid
Furfural
Guthion
Heptachlor
Hydrochloric Acid
Hydrofluoric Acid
Hydrogen Cyanide
Isoprene
Isopropanolamine Dodecylbenzenesulfonate
Kelthane
Lead Acetate
Lead Arsenate
Lead Chloride
Lead Fluoborate
Lead Fluoride
Lead Iodide
Lead Nitrate
Lead Stearate
Lead Sulfate
Lead Sulfide
Lead Thiocyanate
Lindane
Lithium Chromate
Malathion
Maleic Acid
Maleic Anhydride
Mercuric Cyanide
Marcuric Nitrate
Mercuric Sulfate
Mercuric Thiocyanate
Mercurous Nitrate
Methoxychlor
Methyl Mercaptan
Methyl Methacrylate
Methyl Parathion
Mevinphos
Mexacarbate
Monoethylamine
Monomethylamine
Naled
Naphthalene
Naphthenic Acid
Nickel Ammonium Sulfate
Nickel Chloride
Nickel Hydroxide
Nickel Nitrate
Nickel Sulfate
Nitric Acid
Nitrobenzene
Nitrogen Dioxide
Nitrophenol (mixed)
Paraformaldehyde
Parathion
Pentachlorophenol
Phenol
Phosgene
Phosphoric Acid
Phosphorus
Phosphorus Oxychloride
Phosphorus Pentasulfide
Phosphorus Trichloride
Polychlorinated Biphenyls
Potassium Arsenate

Potassium Arsenite
Potassium Bichromate
Potassium Chromate
Potassium Cyanide
Potassium Hydroxide
Potassium Permanganate
Propionic Acid
Propionic Anhydride
Pyrethrins
Quinoline
Resorcinol
Selenium Oxide
Sodium
Sodium Arsenate
Sodium Arsenite
Sodium Bichromate
Sodium Bifluoride
Sodium Bisulfite
Sodium Chromate
Sodium Cyanide
Sodium Dodecylbenzenesulfonate
Sodium Fluoride
Sodium Hydrosulfide
Sodium Hydroxide
Sodium Hypochlorite
Sodium Methylate
Sodium Nitrite
Sodium Phosphate, Dibasic
Sodium Phosphate, Tribasic
Sodium Selenite
Strontium Chromate
Strychnine
Styrene
Sulfuric Acid
Sulfur Monochloride
2,4,5-T Acid
2,4,5-T Esters
TDE
Tetraethyl Lead
Tetraethyl Pyrophosphate
Toluene
Toxaphene
Trichlorfon
Trichlorophenol
Triethanolamine Dodecylbenzenesulfonate
Triethylamine
Trimethylamine
Uranyl Acetate
Uranyl Nitrate
Vanadium Pentoxide
Vanadyl Sulfate
Vinyl Acetate
Xylene (mixed)
Xylenol
Zinc Acetate
Zinc Ammonium Chloride
Zinc Borate
Zinc Bromide
Zinc Carbonate
Zinc Chloride
Zinc Cyanide
Zinc Fluoride
Zinc Formate
Zinc Hydrosulfite
Zinc Nitrate
Zinc Phenolsulfonate
Zinc Phosphide
Zinc Silicofluoride

Zinc Sulfate
Zirconium Nitrate
Zirconium Potassium Fluoride
Zirconium Sulfate
Zirconium Tetrachloride

APPENDIX 2

POTENTIAL HAZARDOUS POLLUTING SUBSTANCES

Acridine
Allethrin
Aluminum Fluoride
Aluminum Nitrate
Ammonium Bromide
Ammonium Hypophosphite
Ammonium Iodide
Ammonium Pentaborate
Ammonium Persulfate
Antimony Pentafluoride
Antimycin A
Arsenic Acid
Barban
Benfluralin
Bensulide
Benzene Hexachloride
Beryllium Sulfate
Butifos
Cadmium
Cadmium Cyanide
Cadmium Nitrate
Captafol
Carbophenothion
Chlorflurazole
Chlorothion
Chlorpropham
Chromic Chloride
Chromium
Chromyl Chloride
Cobaltous Fluoride
Copper
Crotoxyphos
Cupric Carbonate
Cupric Citrate
Cupric Formate
Cupric Glycinate
Cupric Lactate
Cupric Paraamino Benzoate
Cupric Salicylate
Cupric Subacetate
Cuprous Bromide
Demeton
Dibutyl Phthalate
Dicapthon
2,4-Dinitrochlorobenzene
p-Dinitrocresol
Dinocap
Dinoseb
Dioxathion
Dodine
EPN
Gold Trichloride
Hexachlorophene
Hydrogen Sulfide
m-Hydroxybenzoic Acid
p-Hydroxybenzoic Acid
Hydroxylamine
2-Hydroxyphenazine-1-Carboxylic Acid
Lactonitrile
Lead Tetraacetate
Lead Thiosulfate
Lead Tungstate
Lithium Bichromate
Malachite Green
Manganese Chloride, Anhydrous
MCPA
Mercuric Acetate
Mercuric Chloride
Mercury
Metam-Sodium
p-Methylamino-Phenol
2-Methyl-Napthoquinone
Neburon
Nickel Formate
Phenylmercuric Acetate
n-Phenyl Naphthylamine
Phorate
Phosphamidon
Picloram
Potassium Azide
Potassium Cuprocyanide
Potassium Ferricyanide
Propyl Alcohol
Pyridyl Mercuric Acetate
Rotenone
Silver
Silver Nitrate
Silver Sulfate
Sodium Azide
Sodium 2-Chlorotoluene-5-Sulfonate
Sodium Pentachlorophenate
Sodium Phosphate, Monobasic
Sodium Sulfide
Stannous Fluoride
Strontium Nitrate
Sulfoxide
Temephos
Thallium
Thionazin
1,2,4-Trichlorobenzene
Uranium Peroxide
Uranyl Sulfate
Zinc Bichromate
Zinc Potassium Chromate
Zirconium Acetate
Zirconium Oxychloride

ANNEX 11

SURVEILLANCE AND MONITORING

1. Surveillance and monitoring activities shall be undertaken for the following purposes:

(a) Compliance. To assess the degree to which jurisdictional control requirements are being met.

(b) Achievement of General and Specific Objectives. To provide definitive information on the location, severity, areal or volume extent, frequency and duration of non-achievement of the Objectives, as a basis for determining the need for more stringent control requirements.

(c) Evaluation of Water Quality Trends. To provide information for measuring local and whole lake response to control measures using trend analyses and cause/effect relationships, and to provide information which will assist in the development and application of predictive techniques for assessing impact of new developments and pollution sources. The results of water quality evaluations will be used for:

(i) assessing the effectiveness of remedial and preventative measures and identifying the need for improved pollution control;

(ii) assessing enforcement and management strategies; and

(iii) identifying the need for further technology development and research activities.

(d) Identification of Emerging Problems. To determine the presence of new or hitherto undetected problems in the Great Lakes Basin Ecosystem, leading to the development and implementation of appropriate pollution control measures.

2. A joint surveillance and monitoring program necessary to ensure the attainment of the foregoing purposes shall be developed and implemented among the Parties and the State and Provincial Governments. The Great Lakes International Surveillance Plan contained in the Water Quality Board Annual Report of 1975 and revised in subsequent reports shall serve as a model for the development of the joint surveillance and monitoring program.

3. The program shall include baseline data collection, sample analysis, evaluation and quality assurance programs (including standard sampling and analytical methodology, inter-laboratory comparisons, and compatible data management) to allow assessments of the following:

(a) Inputs from tributaries, point source discharges, atmosphere, and connecting channels;

(b) Whole lake data including that for nearshore areas (such as harbours and embayments, general shoreline and cladophora growth areas), open waters of the Lakes, fish contaminants, and wildlife contaminants; and

(c) Outflows including connecting channels, water intakes and outlets.

ANNEX 12

PERSISTENT TOXIC SUBSTANCES

1. Definitions. As used in this Annex:

(a) "Persistent toxic substance" means any toxic substance with a half-life in water of greater than eight weeks;

(b) "Half-life" means the time required for the concentration of a substance to diminish to one-half of its original value in a lake or water body;

(c) "Early warning system" means a procedure to anticipate future environmental contaminants (i.e., substances having an adverse effect on human health or the environment) and to set priorities for environmental research, monitoring and regulatory action.

2. General Principles.

(a) Regulatory strategies for controlling or preventing the input of persistent toxic substances to the Great Lakes System shall be adopted in accordance with the following principles:

(i) The intent of programs specified in this Annex is to virtually eliminate the input of persistent toxic substances in order to protect human health and to ensure the continued health and productivity of living aquatic resources and man's use thereof;

(ii) The philosophy adopted for control of inputs of persistent toxic substances shall be zero discharge.

(b) The Parties shall take all reasonable and practical measures to rehabilitate those portions of the Great Lakes System adversely affected by persistent toxic substances.

3. Programs. The Parties, in cooperation with the State and Provincial Governments, shall develop and adopt the following programs and measures for the elimination of discharges of persistent toxic substances:

(a) Identification of raw materials, processes, products, by-products, waste sources and emissions involving persistent toxic substances, and quantitative data on the substances, together with recommendations on handling, use and disposition. Every effort shall be made to complete this inventory by January, 1982;

(b) Establishment of close coordination between air, water and solid waste programs in order to assess the total input of toxic substances to the Great Lakes System and to define comprehensive, integrated controls;

(c) Joint programs for disposal of hazardous materials to ensure that these materials such as pesticides, contaminated petroleum products, contaminated sludge and dredge spoils and industrial wastes are properly transported and disposed of. Every effort shall be made to implement these programs by 1980.

4. Monitoring. Monitoring and research programs in support of the Great Lakes International Surveillance Plan should be established at a level sufficient to identify:

(a) Temporal and spatial trends in concentration of persistent toxic substances such as PCB, mirex, DDT, mercury and dieldrin, and of other substances known to be present in biota and sediment of the Great Lakes System;

(b) The impact of persistent toxic substances on the health of humans and the quality and health of living aquatic systems;

(c) The sources of input of persistent toxic substances; and

(d) The presence of previously unidentified persistent toxic substances.

5. Early Warning System. An early warning system consisting of, but not restricted to, the following elements shall be established to anticipate future toxic substances problems:

(a) Development and use of structure-activity correlations to predict environmental characteristics of chemicals;

(b) Compilation and review of trends in the production, import, and use of chemicals;

(c) Review of the results of environmental testing on new chemicals;

(d) Toxicological research on chemicals, and review of research conducted in other countries;

(e) Maintenance of a biological tissue bank and sediment bank to permit retroactive analysis to establish trends over time;

(f) Monitoring to characterize the presence and significance of chemical residues in the environment;

(g) Development and use of mathematical models to predict consequences of various loading rates of different chemicals;

(h) Development of a data bank for storage of information on physical/chemical properties, toxicology, use and quantities in commerce of known and suspected persistent toxic substances.

6. Human Health. The Parties shall establish action levels to protect human health from the individual and interactive effects of toxic substances.

7. Research. Research should be intensified to determine the pathways, fate and effects of toxic substances aimed at the protection of human health, fishery resources and wildlife of the Great Lakes Basin Ecosystem. In particular, research should be conducted to determine:

(a) The significance of effects of persistent toxic substances on human health and aquatic life;

(b) Interactive effects of residues of toxic substances on aquatic life, wildlife, and human health; and

(c) Approaches to calculation of acceptable loading rates for persistent toxic substances, especially those which, in part, are naturally occurring.

TERMS OF REFERENCE

FOR THE JOINT INSTITUTIONS AND THE GREAT LAKES REGIONAL OFFICE

1. Great Lakes Water Quality Board

(a) This Board shall be the principal advisor to the International Joint Commission with regard to the exercise of all the functions, powers and responsibilities (other than those functions and responsibilities of the Science Advisory Board pursuant to paragraph 2 of these Terms of Reference) assigned to the Commission under this Agreement. In addition, the Board shall carry out such other functions, related to the water quality of the boundary waters of the Great Lakes System, as the Commission may request from time to time.

(b) The Water Quality Board, at the direction of the Commission, shall:

(i) Make recommendations on the development and implementation of programs to achieve the purpose of this Agreement;

(ii) Assemble and evaluate information evolving from such programs;

(iii) Identify deficiencies in the scope and funding of such programs and evaluate the adequacy and compatibility of results;

(iv) Examine the appropriateness of such programs in the light of present and future socio-economic imperatives; and

(v) Advise the Commission on the progress and effectiveness of such programs and submit appropriate recommendations.

(c) The Water Quality Board, on behalf of the Commission, shall undertake liaison and coordination between the institutions established under this Agreement and other institutions and jurisdictions which may address concerns relevant to the Great Lakes Basin Ecosystem so as to ensure a comprehensive and coordinated approach to planning and to the resolution of problems, both current and anticipated.

(d) The Water Quality Board shall report to the Commission periodically as appropriate, or as required by the Commission, on all aspects relating to the operation and effectiveness of this Agreement.

2. Great Lakes Science Advisory Board

(a) This Board shall be the scientific advisor to the Commission and the Water Quality Board.

(b) The Science Advisory Board shall be responsible for developing recommendations on all matters related to research and the development of scientific knowledge pertinent to the identification, evaluation and resolution of current and anticipated problems related to Great Lakes water quality.

(c) To effect these responsibilities the Science Advisory Board shall:

(i) Review scientific information in order to:

a. examine the impact and adequacy of research and the reliability of research results, and ensure the dissemination of such results;

b. identify additional research requirements;

c. identify specific research programs for which international cooperation is desirable; and

(ii) Advise jurisdictions of relevant research needs, solicit their involvement and promote coordination.

(d) The Science Advisory Board shall seek analyses, assessments and recommendations from other scientific, professional, academic, governmental or intergovernmental groups relevant to Great Lakes Basin Ecosystem research.

(e) The Science Advisory Board shall report to the Commission and the Water Quality Board periodically as appropriate, or as required by the Commission, on all matters of a scientific or research nature relating to the operation and effectiveness of this Agreement.

3. The Great Lakes Regional Office

(a) This Office, located at Windsor, Ontario, shall assist the Commission and the two Boards in the discharge of the functions specified in subparagraph (b) below.

(b) The Office shall perform the following functions:

(i) Provide administrative support and technical assistance for the Water Quality Board and the Science Advisory Board and their sub-organizations, to assist the Boards in discharging effectively the responsibilities, duties and functions assigned to them.

(ii) Provide a public information service for the programs, including public hearings, undertaken by the Commission and its Boards.

(c) The Office shall be headed by a Director who shall be appointed by the Commission in consultation with the Parties and with the Co-Chairmen of the Boards. The position of Director shall alternate between a Canadian citizen and a United States citizen. The term of office for the Director shall be determined in the review referred to in subparagraph (d) below.

(d) The Parties, mindful of the need to staff the Great Lakes Regional Office to carry out the functions assigned the Commission by this Agreement, shall, within six months from the date of entry into force of this Agreement, complete a review of the staffing of the Office. This review shall be conducted by the Parties based upon recommendations of the Commission after consultation with the Co-Chairmen of the Boards. Subsequent reviews may be requested by either Party, or recommended by the Commission, in order to ensure that the staffing of the Regional Office is maintained at a level and character commensurate with its assigned functions.

(e) Consistent with the responsibilities assigned to the Commission, and under the general supervision of the Water Quality Board, the Director shall be responsible for the management of the Regional Office and its staff in carrying out the functions described herein.

(f) The Co-Chairmen of the Boards, in consultation with the Director, will determine the activities which they wish the Office to carry out on behalf of, or in support of the Boards, within the current capability of the Office and its staff. The Director is responsible to the Co-Chairmen of each Board for activities carried out on behalf of, or in support of such Board, by the Office or individual staff members.

(g) The Commission, in consultation with the Director, will determine the public information activities to be carried out on behalf of the Commission by the Regional Office.

(h) The Director shall be responsible for preparing an annual budget to carry out the functions of the Boards and the Regional Office for submission jointly by the two Boards to the Commission for approval and procurement of resources.

PHOSPHORUS LOAD REDUCTION
SUPPLEMENT TO ANNEX 3 OF THE 1978 AGREEMENT BETWEEN THE UNITED STATES OF AMERICA AND CANADA ON GREAT LAKES WATER QUALITY

1. The purpose of this Supplement is to outline measures to fulfill the commitments undertaken pursuant to paragraph 3 of Annex 3 of the 1978 Great Lakes Water Quality Agreement which requires that:

> . . . The parties, in cooperation with the state and provincial governments, shall within eighteen months after the date of entry into force of this Agreement confirm the future phosphorus loads, and based on these establish load allocations and compliance schedules, taking into account the recommendations of the International Joint Commission arising from the Pollution from Land Use Activities Reference . . .

2. Phosphorus Target Loads

Table 1 establishes the recommended phosphorus target loads which represent planning guides for the parties. Table 1 replaces the table contained in paragraph 3 of Annex 3 of the 1978 Great Lakes Water Quality Agreement (GLWQA).

Table 1

Basin	Phosphorus Target Loads (metric tons per year)
Lake Superior	(see section 3 (b) below)
Lake Michigan	(see section 3 (b) below)
Main Lake Huron	(see section 3 (b) below)
Georgian Bay	(see section 3 (b) below)
North Channel	(see section 3 (b) below)
Saginaw Bay	440 (Note 1)
Lake Erie	11000 (Note 2)
Lake Ontario	7000 (Note 2)

Notes:

(1) Target load designed to alleviate drinking water taste and odor problems.

(2) Target loads proposed to meet ecosystem objectives in Annex 3. The allocation of the phosphorus target loads between the two countries shall be consistent with the equal rights of both parties in the use of their boundary waters.

3. Phosphorus Load Reductions

(a) Lower Lakes:

Table 2 summarizes the estimated phosphorus loadings that will be discharged to the Lower Lakes basins when all municipal waste treatment facilities over one million gallons per day achieve compliance with the one milligram per liter (1 mg/l) effluent concentration (on a monthly average basis) as required by Article VI, 1 (a) of the 1978 GLWQA. The table also shows the further reductions required to meet the Phosphorus Target Loads.

Table 2 Phosphorus Load Reduction Targets - metric tons per year

Basin	Estimated Loadings at 1 mg/l (Note 1)	Phosphorus Target Load	Estimates of Further Reductions Required
Lake Erie	13,000	11,000	2,000
Lake Ontario	8,210	7,000	1,210

Note (1) Estimated loading when all municipal waste treatment facilities of over one million gallons/day achieve 1 mg/l phosphorus effluent target levels.

(b) Upper Lakes:

Load reductions for the Upper Lakes will be accomplished by achieving the 1 mg/l phosphorus effluent concentration (on a monthly average) at municipal waste treatment facilities discharging more than one million gallons per day. The parties further agree to maintain the present oligotrophic state of the open waters and relative algal biomass of Lake Superior and Huron. In addition, the United States agree to undertake efforts to achieve the substantial elimination of algal nuisance growths in Lake Michigan. Further measures will be implemented as required for Saginaw Bay, various localized nearshore problem areas and Green Bay.

(c) Table 3 presents the distribution of further reductions in phosphorus loading required for Lake Erie (in metric tons/year) in order to achieve the estimated target loads. These figures will be used by the parties in the development of detailed plans for achieving further phosphorus reductions as described in 4 (a) and (b) below.

Table 3 Allocation of Reductions to Meet Target Loads for Lake Erie as Shown in Table 1

Canada	U.S.	Total
300	1700	2000

(d) For Lake Ontario, the parties, in cooperation and full consultation with state and provincial governments, agree to review the measures to achieve further phosphorus reductions in this basin and will, within one year, meet to allocate the further phosphorus reductions between the parties. Plans to achieve the required reductions set out in Table 2 will be developed using these figures in accordance with the procedures described in 4 (a) and (b) below.

4. Phosphorus Load Reduction Plans

(a) Phosphorus load reduction plans will be developed and implemented by the parties in cooperation and full consultation with state and provincial governments to achieve the phosphorus reductions for Lake Erie and Ontario described in Table 2. The Plans will include phosphorus control programs and other measures as outlined in Section 5 and will describe any additional measures which will be undertaken to evaluate and review progress in achieving the phosphorus load reductions. A staged approach, incorporating target dates for achieving further reductions will be included in the plans to provide the parties and state and provincial governments with a framework for implementing and evaluating the effectiveness of controls.

(b) These detailed plans shall be tabled by the parties with the International Joint Commission eighteen months after agreement on this Supplement to Annex 3. The parties will provide the Commission with progress reports and annual updates of these plans.

5. Programs and Other Measures

The following phosphorus control programs and measures will be developed and implemented by the parties in cooperation and full consultation with state and provincial governments to achieve the required reductions in accordance with the plans developed pursuant to Section 4. The parties recognize that the responsibility for the control of nonpoint sources is shared between the parties and the state and provincial governments.

(a) Municipal Waste Treatment Facilities

(i) Priority will be given to the continuation and intensification of efforts to ensure that municipal waste treatment facilities discharging more than one million gallons per day achieve an effluent concentration of 1 mg/l total phosphorus on a monthly average.

(ii) Where necessary, consideration will be given to operating facilities capable of greater phosphorus reduction at higher levels of phosphorus removal than that required in 5 (a) (i).

(iii) Where necessary, municipal waste treatment facilities designed, built expanded or modified after October 1, 1983 should allow for later modification to provide for greater removal of phosphorus than that required under 5 (a) (i).

(b) Detergent Phosphorus Limitation

Priority will be given to continuing efforts to limit phosphorus in household detergents.

(c) Industrial Discharges

Reasonable and practical measures will be undertaken to control industrial sources of phosphorus.

(d) Nonpoint Source Programs and Measures

Priority management areas will be identified and designated for application of urban and agricultural programs and measures which include:

(i) Urban drainage management control programs where feasible consisting of level 1 measures throughout the Great Lakes basin; and level 2 measures where necessary

to achieve reductions or where local environmental conditions dictate (note 1); and

(ii) Agricultural nonpoint source management programs where feasible consisting of level 1 measures throughout the basin and level 2 measures where necessary to achieve reductions or where local environmental conditions dictate (note 1).

(e) Research

Pursuant to the provisions of paragraph 2 (e) of Annex 3, the parties will make special efforts to assure that their research activities will be responsive to the Programs and Other Measures described herein.

(f) Monitoring and Surveillance

The parties will develop and implement surveillance and monitoring measures to determine the progress of the Phosphorus Load Reduction Plans for the Lower Lakes as called under Section 4 above, and to evaluate efforts taken by the parties to reduce phosphorus in the Great Lakes basin. These measures will include an inventory of areas treated, watershed modelling and improved measurement of tributary

Note (1): Level 1 nonpoint source control options include:

Agricultural: adoption of management practices such as: animal husbandry control measures, crop residue management, conservation tillage, no-till, winter cover-crops, crop rotation, strip cropping, vegetated buffer strips along stream and ditch banks, and improved fertilizer management practices.

Urban: adoption of management practices such as: erosion controls, use of natural storage capacities and street cleaning.

Level 2 nonpoint source controls include Level 1 plus

Agricultural: adoption of intensive practices such as contour plowing, contour strip-cropping, contour diversions, tile outlet-terraces, flow control structures, grassed waterways, sedimentation basins and livestock manure storage facilities.

Urban: adoption of practices such as: artificial detention and sedimentation of stormwater and runoff, and reduction of phosphorus in combined sewer overflows.

loadings to the Lower Lakes for the purpose of providing improved nonpoint source loading estimates and the monitoring of mass-loadings to the Upper Lakes to maintain or improve the environmental conditions described in Section 3 (b).

6. Review

The parties shall meet no later than December 31, 1988, to review the effectiveness of the programs and measures described herein, and any remaining load reduction measures required to achieve the target loads.

APPENDIX B

TABLE - PROGRESS ON COMMITMENTS

STATUS OF IMPLEMENTATION OF THE 1978 GREAT LAKES WATER QUALITY AGREEMENT BETWEEN THE UNITED STATES AND CANADA

Introduction

To provide a systematic framework as to the commitments made by the parties in the 1978 Great Lakes Water Quality Agreement and to assess what was the status of their implementation, the committee, with contracted staff assistance, reviewed the entire text of the 1978 Agreement and listed the commitments as shown in the following table. It lists only specific targets or actions required by the Agreement, not including the broad Purpose in Article II or the General Objectives in Article III. The entire set of commitments is organized around four categories: general commitments, nutrient abatement goals, toxic controls, and land/lake relationships.

One of the important parts of the table is the column indicating the most recent information on the status of the commitment. This status was determined by review of the annual reports of the Science Advisory Board and the Water Quality Board to the International Joint Commission from 1978 to 1985. Supplementary reports to the board reports were reviewed when there was a specific reference to them in the board reports. The First and Second Biennial Reports of the International Joint Commission (IJC) to the governments were also reviewed, together with the formal responses of the governments to the first of the two reports. No response had been made to the second report at the time of the review.

The aim of the committee was to determine what the various joint institutions regard as the current status of progress toward what had been agreed to by the two governments when the Agreement was signed. The information in the table serves as supporting evidence for a number of the findings and recommendations in the report.

The staff of the Great Lakes Regional Office of the IJC was consulted for clarification of dates of publication or information about what appeared to be gaps in reporting. The terms used to describe the current status and entries into the table were made by the committee and their supporting staff.

MAIN SUBJECT; AGREEMENT CITATION	SPECIFIC TOPIC WITHIN MAIN SUBJECT	TYPE OF COMMITMENT IN MAIN SUBJECT OR SPECIFIC TOPIC	GUIDANCE OR CRITERIA, IF ANY, IN THE AGREEMENT	SPECIFIED DEADLINE	STATUS OF IMPLEMENTATION	
					CANADA	UNITED STATES
			PART A. GENERALLY APPLICABLE PROVISIONS			
1. Specific Objectives for boundary waters of the Great Lakes Systems; Art. IV 1, intro.	Statement of Specific Objectives	Accept Objectives specified in Annex 1		Not applicable, adopted as part of GLWQA	Adopted in Canada/ Ontario Agreement.[1]	EPA ensures state consideration of GLWQA objectives in water-quality standards.[2]
Art. IV 1 (a)	Conditions on Specific Objectives	Accept conditions	Do not preclude more stringent conditions.	Not applicable, part of GLWQA	Under GLWQA and WQB initiatives, new strategy to protect ecosystem.[3]	
Art. IV 1 (b)			Determine achievement of Objectives of GLWQA, based on statistically valid sampling data.	Not applicable, part of GLWQA	Consistent attention to surveillance and monitoring, with annual reports to IJC.[4]	
Art. IV 1 (c)			Take all reasonable and practicable measures to maintain or improve existing water quality in areas:	Not applicable, part of GLWQA		
			a. Of boundary waters where water quality is better than objectives; and		Nondegradation policy pursued.[5]	
			b. Having outstanding natural resource value.		Dredging guidelines to protect sensitive areas.[6]	
Art. IV 1 (d)			Do not substitute flow augmentation for adequate treatment to meet objectives.	Not applicable, part of GLWQA	Not proposed.	Contrary to U.S. national policy.[7]

MAIN SUBJECT; AGREEMENT CITATION	SPECIFIC TOPIC WITHIN MAIN SUBJECT	TYPE OF COMMITMENT IN MAIN SUBJECT OR SPECIFIC TOPIC	GUIDANCE OR CRITERIA, IF ANY, IN THE AGREEMENT	SPECIFIED DEADLINE	STATUS OF IMPLEMENTATION	
					CANADA	UNITED STATES
Art. IV 1 (e)			Identify and report to IJC natural phenomena in some inshore waters that prevent the achievement of some objectives despite best efforts of parties.	Not applicable, part of GLWQA	Not reported to date by IJC or either party.	
Art. IV 2	Review of Specific Objectives	Keep Objectives under review		None	Revisions for 11 objectives have been recommended by IJC; IJC also recommends development of more comprehensive measures of ecosystem quality.[8] Aquatic Ecosystem Objective Committee established by SAB.[9]	
Art. IV 3 (b)	Establishment of Specific Objectives to protect beneficial uses from pollutants	Consult		None	1st Biennial Report urged governments to consult on revision of objectives and governments agreed, but consultation has not been reported.[10]	
2. Water-quality standards and other regulatory requirements; Art. V 1	Regulatory requirements of parties	Make consistent with achievement of General and Specific Objectives	Do not substitute flow augmentation for adequate treatment.	None	GLWQA objectives are considered as goals only when they are exceeded, ruling out flow augmentation.[11]	
Art. V 1	Regulatory requirements of States and Provinces	Use best efforts to make consistent with achievement of General and Specific Objectives	Prepare an inventory of pollution abatement requirements for all industrial and municipal facilities discharging into the Great Lakes System in	Annual report	Report on current compliance is feature of annual WQB reports. Progress toward reduction of P loadings and other forms of pollution can be tracked. Compliance reports have grown more comprehensive over time. 1985 WQB	

		order to gauge progress toward earliest practicable completion and operation of the programs listed in Art. VI 1 (a), relating to pollution from municipal sources and Art. VI 1 (b), relating to pollution from industrial sources.		report gives current compliance status by jurisdictions. Also compares noncompliance over time.[12] Reports substantial compliance with control of conventional pollutants but points out that lack of reporting on noncompliance for toxics reflects lack of effluent guidelines for many toxic contaminants.[13]
Art. VI 1 (c)		Include in inventory compliance schedules and status of compliance with monitoring and effluent restrictions and give priority in the initial WQB inventory.	Annual report	Inventory submitted in 1981 and updated in 1982; information on inventory available from the IJC regional office. Ontario inventory based on available data. U.S. inventory based on NPDES permits and self-monitoring and compliance data.[14]
Art. VI 1 (c)		Make inventory available to IJC and public.		WQB reports are submitted to IJC and widely distributed to public.
3. Programs and other measures; Art. VI 1 intro.	Develop and implement programs	Develop to fulfill Purpose and to meet General and Specific Objectives, including programs in Art. VI.	None	WQB and SAB annual reports report program initiatives to serve GLWQA. Needed programs are also proposed.
Art. VI 1 intro.		Require additional treatment where present treatment is inadequate to meet General and Specific Objectives.	None	Some municipal systems achieve less than 1 mg/L of P removal in effluents with advanced treatment, others do not.[15] Need for more treatment is identified for areas of concern.[16]
Art. VI 2		Develop additional programs jointly decided to be necessary to fulfill the Purpose	None	Conservation tillage promoted. Special programs for Niagara River and Upper Great Lakes Connecting Channels by parties.[17] Also

MAIN SUBJECT; AGREEMENT CITATION	SPECIFIC TOPIC WITHIN MAIN SUBJECT	TYPE OF COMMITMENT IN MAIN SUBJECT OR SPECIFIC TOPIC	GUIDANCE OR CRITERIA, IF ANY, IN THE AGREEMENT	SPECIFIED DEADLINE	STATUS OF IMPLEMENTATION	
					CANADA	UNITED STATES
			and to meet General and Specific Objectives.			initiatives by SAB and WQB on ecosystem management.[18] IJC questioned U.S. commitment and urges new toxic control policies.[19]
Art. VI 1 (m)	Surveillance and monitoring	Develop and implement programs	Implement coordinated surveillance and monitoring programs in Great Lakes in accordance with Annex 11.	None		A 9-year Great Lakes International Survey Plan was completed and is now superceded by more comprehensive mutimedia, multiobjective surveillance plan.[20]
Annex 11 1 (a)			Undertake to assess compliance with jurisdictional control requirements.	None		Annual reports on areas of concern as well as on municipal and industrial compliance in WQB reports.[21]
Annex 11 1 (b)			Provide information on location, severity, extent, frequency, and duration of nonachievements of Objectives, as a basis for determining need for more stringent control requirements.	None		Annual compliance reports for municipal and industrial sources in WQB reports. Also identification of areas of concern. Remedial action plans now under way for all areas of concern, with plans to be completed by end of 1986.[22]
Annex 11 1 (c)			Undertake to provide information for measuring local and whole-lake response to control measures using trend analyses and cause/effect relationships and to provide information to assist in development of predictive techniques for assessing impact of new pollution sources.	None		Evolution in surveillance and monitoring now provide more complete information. Monitoring now covers water intakes, tributaries, atmosphere, and sampling of fish tissues of migratory and local species, plus measurements of ambient levels for water chemistry. Annual rather than periodic assessments of the status of the lakes and connecting channels are provided in WQB reports.[23]

Annex 11 1 (d)			Undertake to identify new or hitherto undetected problems in the Great Lakes Basin Ecosystem, leading to development of more appropriate pollution control measures.	None	"Emerging problems" are identified in WQB reports and also in SAB and IJC reports. The 1985 WQB report points to fish tumors, reproduction disorders in bird populations, and unexplained rising nitrogen levels as signs of emerging problems.[24]
			Use Great Lakes International Plan, WQB Annual Report of 1975, as revised, as model for program.	None	GLISP plan was carried out but has now been superceded by a more comprehensive surveillance and monitoring approach. The IJC expressed doubts about GLISP adequacy.[25]
Annex 11, 3			Include baseline data collection, sample analysis, evaluation, and quality assurance programs to allow assessments of		From 1981 a Data Quality Work group has carried out various quality assurance activities binationally.[26]
			a. Inputs from tributaries, point-source discharges, atmosphere, and connecting channels;		Data provided by Ontario, by Environment Canada, and by municipalities. Toxics monitored in herring gull eggs.[27] Data provided by states for tributaries, by EPA from NPDES permits and by Fish and Wildlife Service for fish.[27]
			b. Whole-lake data, including nearshore areas, open waters, fish contaminants, and wildlife contaminants; or		
			c. Outflows, including connecting channels, water intakes, and outlets.		Surveillance supplements GLISP sampling program with data from other sources.[28]
Art. VI 1 (g)	Pollution from dredging activities	Develop and implement programs	Develop measures for the abatement and control of pollution from all dredging	None	Dredging Subcommittee of WQB established 1978; dredging guidelines published 1981; activities reported annually.[29]

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			activities; establish a Subcommittee to WQB.			
Annex 7			Develop criteria for the identification of polluted sediments and compatible programs for disposal of polluted dredged material in accordance with Annex 7. Pending development of compatible criteria and programs, dredging operations to be conducted to minimize adverse environmental effects.	None	A register of dredging sites and guidelines for evaluation of projects published, April 1983.[30] Disposal of dredge spoils remains controversial, with concern about disturbance of sediments by dredging and about disposal of contaminated sediments in diked disposal areas. Dredging subcommittee reports annually to WQB and maintains dredging registry.[31]	
			Encourage information exchange on dredging technology and research.		Technical workshops and reports are produced and distributed.[32]	
		Direct particular attention	Continue to direct particular attention to wetland areas threatened by dredging and disposal activities.			Corps of Engineers has experimental projects to protect wetlands.[33]
4. Limited Use Designation Zones; Art. IV 1 (f), Annex 2		Take measures	Have responsible regulatory agencies designate limited use zones where some Specific Objectives may not apply, in accordance with Annex 2.		No zones designated but willing to do so if can be done with U.S.[34]	U.S. considers concept of limited-use zones contrary to U.S. law.[34]
			Define and describe existing and future	Annual report		

	zones and prepare annual report on measures to define and describe, including: a. Identification and quantitative and qualitative description of point-source discharges, including tributaries to boundary waters; b. Delineation of boundaries of zones assigned to identified discharges; c. Assessment of impact of proposed zones on existing and potential beneficial uses; and d. Continuing review and revision of the extent of zones to achieve maximum reduction in size and effect of zones in accordance with waste-treatment technology improvements.	
Annex 2, 2	Designate zones for industrial discharges and for municipal discharges more than 1 mgd according to: a. A zone boundary shall not cross international boundary; b. Case-by-case basis by regulatory agency with size minimized to	Before January 1980

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			maximum possible degree; c. Specific Objectives and conditions applicable for receiving water body shall be set at boundary; d. Existing conditions shall be defined before considering location of a new zone or restricting and existing zone; e. Areas of extraordinary value shall not be designated as limited use zones; f. Zones shall not form barriers to migratory routes of aquatic species, interfere with "biological communities" of important species, or disproportionately damage other beneficial uses; g. Conditions rapidly lethal to aquatic life not permitted, or irreversible responses, or bioconcentration of toxic substances			

		harmful to organism or its consumers; h. Concentrations of toxic substances at any point in zone where important species can physically reside not to exceed 24-hour LD_{50}; i. Every attempt to ensure zones free from objectionable deposits, floating matter; objectionable color, odor, taste, or turbidity; or conditions that produce nuisance quantities of aquatic life that interfere with other uses; j. Zones may overlap unless combined effects exceed conditions set forth in other guidelines; and k. Zones, in general, should not overlap with municipal and other water intakes and recreational areas.		
Report to IJC	Submit report	Candidate areas to be reported by responsible regulatory agencies.	None	
More definitive designation procedures	Consult	Develop: a. More definitive procedures to delineate extent of individual zones;		Environmental mapping considered as an aid to designation of zones[35]

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			b. Scientific guidelines for determining maximum portion of boundary waters and connecting channels to be occupied by zones.			
5. Research programs; Art. V 2 (a)		Use best efforts	Ensure that principal research agencies in both countries orient their research programs to priorities set by SAB and IJC.	None	IJC questions priority given by parties to Great Lakes research; new Council on Great Lakes Research established.[36]	
Art. V 2 (b)	International cooperation				Most international cooperation is occurring through the joint boards, committees, task forces, and work groups set up under the GLWQA process managed by the IJC.[37]	
6. Intergovernmental cooperation; Art. XI 2 (c)	State and Provincial governmental cooperation	Use best efforts	Develop appropriate cost-effective methods for international cooperation.	None	State and provincial participation in special studies and surveillance.[38] IJC sees potential problems.[39] Federal/province agreement.[1]	Federal/state coordination through EPA agreements.[2]
7. Information exchange; Art. IX 3		Make available to other party	Make available any data or other information in party's control relating to water quality in the Great Lakes system.	None	Forum provided by IJC bodies and almost every agreement activity, especially surveillance and reporting.[40]	
8. Review of IJC reports; Art. X 1		Consult	Consult on reports submitted to parties by IJC under Art. VII 3	None		

			and consider appropriate actions, including:			
			a. Modification of existing Objectives and adoption of new Objectives;		No consultation to date on revision of water quality objectives.[41]	
			b. Modification of programs and joint measures; and		Under way continuously.[42]	
			c. Amendments to GLWQA.		None to date.	
9. Consultation between parties; Art. X 1	Any matter arising out of implementation of GLWQA	Consult	Hold at the request of either party.	None	None reported in IJC reports.	
Art. X 2	Special pollution problem of joint concern	Consult	Notify and consult other party.	Forthwith	Action on Niagara is de facto consultation.[43]	
10. Review of GLWQA; Art. X 3		Conduct review	Conduct a comprehensive review of operation and effectiveness of GLWQA.	After 3rd report	3rd Biennial report to be made in 1986; subsequent review anticipated.	
11. Appropriation of funds; Art. XI 1		Condition obligation	Subject obligations under GLWQA to appropriations under constitutional procedures of parties.	None	IJC proposes funding for joint activities through IJC.[44]	
Art. XI 2 (a)		Commit to seek	Seek appropriation of funds required to implement the GLWQA.	None	Substantial investment by both parties in treatment systems and control programs.[45] U.S. chastized by IJC for funding cuts.[46]	
12. Enabling legislation; Art. XI 2 (b)		Commit to seek	Seek enactment of additional legislation necessary to implement programs and measures set forth in Art. VI.	None	Environmental statutes serve GLWQA.[47]	Contends that national laws are adequate.[47] Most states adopt phosphate bans.[48]

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13. Rights and obligations under Boundary Waters Treaty; Art. XII		Condition obligations	Establish that nothing in GLWQA diminishes rights and obligations of parties under Treaty.	None	No evidence of conflict between GLWQA and obligations under Boundary Waters Treaty of 1909.	
			PART B. NUTRIENT-RELATED PROVISIONS			
1. Phosphorus and other nutrients Art. VI 1 (d)	Reduction and control of inputs of phosphorus and nutrients	Develop and implement programs	Establish that purpose of phosphorus control programs is to minimize eutrophication problems and prevent degradation with regard to phosphorus in boundary waters of Great Lakes system. Adopt following goals for phosphorus control:	Not applicable, part of GLWQA	Board and other reports consistently link phosphorus control to reversal or prevention of eutrophication.[49]	
			a. Restoration of year-round aerobic conditions in the bottom waters of Central Basin of Lake Erie;		Anoxia has decreased but still occurs seasonally.[50]	
			b. Substantial reduction in algal biomass below nuisance conditions in Lake Erie;		Evidence of partial reversal of cultural eutrophication includes decreased phytoplankton growth.[51]	
			c. Reduction of algal biomass below nuisance conditions in Lake Ontario including International Section of St. Lawrence River;		Algal growth has decreased in response to decreased loadings; concentrations in open lake may meet target in 1986.[52]	

			d. Maintenance of oligotrophic state and relative biomass of Lakes Superior and Huron;		Lakes Superior and Huron remain oligotrophic except in some nearshore areas.[53]
			e. Substantial elimination of algal nuisance growths in Lake Michigan to restore to oligotrophic state; and		Lake Michigan is oligotrophic in open lake and mesotrophic in some nearshore areas.[54]
			f. Elimination of algal nuisance in bays and other areas.		Changes in algal species indicate improvements in Saginaw and Green bays; improvements still needed in local areas.[55]
Annex 3, 2 (a)	Municipal waste treatment facilities discharging more than 1 mgd	Develop and implement programs	Construct and operate facilities to achieve where necessary, to meet the loading allocations to be developed under Annex 3 3, or to meet local conditions, whichever are more stringent, effluent concentrtions of 1 mg/L total phosphorus maximum for plants in basins of Lakes Superior, Michigan, and Huron and of Lakes Ontario and Erie.	None	Overall, municipal plants in all jurisdictions have achieved the reduction to 1 mg/L of phosphorus of 1972 GLWQA, because some have much lower effluent levels. 7 facilities (2 in Ontario and 3 in Ohio) have not yet achieved 1 mg/L. Erie and Ontario targetloads not yet met under 1978 GLWQA, but trend continues toward lower total loadings, and load reduction plans are to be completed for Erie and Ontario by end of 1986. Plans to include nonpoint-source controls.[56]
Art. VI 1 (a) (i), (ii), (iii), (v), and (vi)	Municipal waste-treatment facilities in municipalities with sewer systems	Develop and implement programs	Construct and operate facilities to provide levels of treatment consistent with achievement of phosphorus requirements and General and Specific Objectives, considering wastes from other sources:	December 31, 1982	Many plans did not meet deadline, but substantial progress had been made. The status of all municipal systems was reported in detail in 1983, and progress has continued.[57]

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			a. Provide necessary financial resources;		All WQB reports update expenditures for municipal systems. From 1971 to 1984, total of $8.8 billion.[58]	
			b. Establish facilities construction requirements and operating standards;		Many facilities achieve better than 1 mg/L phosphorus removal, but some exceed this level.[59]	
			c. Develop and implement practical programs for reducing pollution from storm, sanitary and combined sewer discharges;		New emphasis will be given to reducing pollution in urban runoff in the Remedial Action Plans for areas of concern and in target load reduction plans.[60]	
			d. Establish effective enforcement programs to ensure that above requirements are fully met.		Ontario sets load allocations since Supplement to Annex 3.[61]	Major U.S. enforcement actions.[61]
Annex 3, 2 (b)	Industrial facilities	Develop and implement programs	Regulate phosphorus introduction from industrial discharges to maximum practical extent.	None	Industrial loadings small in comparison with municipal loads but important in certain locations.[62]	
Annex 3, 2 (c)	Diffuse sources	Develop and implement programs	Reduce phosphorus to the maximum extent practicable from diffuse sources into Lakes Superior, Michigan, and Huron and reduce by 30% phosphorus introduced from diffuse sources into Lakes Ontario and Erie where necessary to meet loading allocations under Annex 3 or to meet local conditions,		Target loads are being met for Lake Superior, Huron, and Michigan. More nonpoint-source control needed to meet target loads for Ontario and Erie. Nonpoint controls will be part of phosphorus load reduction plans and Remedial Action Plans for areas of concern.[60,63]	

			whichever are more stringent.			
Annex 3, 2 (d)	Household detergents	Develop and implement programs	Reduce phosphorus in household detergents to 0.5% by weight where necessary to meet target loads.	None	Canada reduced phosphate to 2.2% in household detergents.	U.S. depends on state and local action; Ohio and Pennsylvania lack bans.[64]
	Research on phosphorus controls	Develop and implement programs	Maintain a viable research program to seek maximum efficiency and effectiveness of phosphorus controls for Great Lakes.		Research and modeling laid the groundwork for development of target loads, but now phosphorus research concerns responses to remedial efforts.[65]	
Annex 3, 3	Phosphorus load allocations	Establish load allocations and compliance schedules	Confirm, in cooperation with state and provincial governments, future phosphorus loads in Annex 3 3, for Lakes Superior and Michigan, Main Lake Huron, Georgian Bay, North Channel, Saginaw Bay, Lakes Erie and Ontario.	May 22, 1980	Although three years late, the target loads were agreed to in 1983 in the Supplement to Annex 3.[66]	
Annex 3, 3			Establish load allocations and compliance schedules, taking into account recommendations of IJC from PLUARG. Maintain programs under Annex 2 of 1972 GLWQA until then.	None	Load allocations have been agreed on for Lake Erie but not yet for Lake Ontario. PLUARG recommendations will be used in developing nonpoint-source control plans in load-reduction plans.[67]	
PART C. HAZARDOUS AND TOXIC SUBSTANCE PROVISIONS						
1. Toxic substances not specifically identified; Art. VI, 1 (a) (iv) and (b) (vi) and (vii)	Pretreatment requirements for industrial plants discharging into publicly owned treatment works	Develop and implement programs	Requirements for industrial wastes not amenable to adequate treatment or removal using conventional municipal treatment processes.	December 31, 1982 and December 31, 1983	Ontario is reviewing model by-law; may add pretreatment require-ments.[68]	U.S. has set schedule for pretreatment for 126 priority pollutants.[68]

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			Establish effective enforcement programs to ensure that the pollution abatement requirements are met.	None	Approach to toxics regulation has been "cautious," but momentum appears to be increasing with more enforcement reported.[69]	
2. Persistent toxic substances; Art. VI 1 (k)	General control of inputs of persistent toxic substances	Develop and implement programs	Develop measures including control programs for production, use, distribution, and disposal, in accordance with Annex 12.	None	More comprehensive approach is developing, covering multiple sources.[70]	
Annex 12, 2 (a)		Accept principles	Base regulatory strategies for controlling or preventing the input of persistent toxic substances to the Great Lakes System on following principles:	None	Need for better regulatory strategies for toxic contamination has been addressed continuously under 1978 GLWQA. Comprehensive approach called for in 1981 now appears to be in process of translation into definite programs.[71]	
			a. Intent of Annex 12 is virtually to eliminate input of persistent toxic substances in order to protect human health and to ensure continued health and productivity of living aquatic resources and man's use thereof; and	None	Goal of regulatory measures is described as "to control and ultimately prevent the entry of persistent toxic substances into the Great Lakes in order to protect human health and the aquatic ecosystem."[72]	
			b. The philosophy for control of inputs of persistent toxic substances be zero discharge.		The issue of "zero discharge" has been addressed as "societal judgment" rather than as a scientific or regulatory issue.[73]	

Annex 12, 2 (b)	Rehabilitation of adversely affected portions of Great Lakes System		Take all reasonable and practical measures to rehabilitate portions of Great Lakes system adversely affected by persistent toxic substances:	None	Case studies of rehabilitation have been carried out for Green Bay and Bay of Quinte.[74] SAB attention to in-place pollutants is now being applied to Remedial Action Plans.[75]
Annex 12, 3 (a)	Programs for elimination of discharges of persistent toxic substances	Develop and implement programs	a. Identify raw materials, processes, products, by-products, waste sources, and emissions involving persistent toxic substances, and quantitative data on substances, with recommendations on handling, use, and disposition;	Every effort by January 1982	1982 deadline not met, although partially satisfied by existing inventories. Confidentiality requirements are barrier to establishing a comprehensive inventory on sources. Data quality control is also lacking.[76]
Annex 12, 3 (b)			b. Establish close coordination between air, water, and solid-waste programs of parties and state and provincial governments to assess total input of toxics and define comprehensive integrated controls; and	None	"Compartmentalized" programs and insufficient coordination were seen as problems by the WQB and IJC earlier, but more coordination is said to be developing in conjunction with development of Remedial Action Plans.[77]
			c. Develop joint programs for disposal of hazardous materials to ensure proper transport and disposal.	Use every effort	No joint disposal programs reported to date. EPA to notify Environment Canada of transboundary shipment of hazardous wastes.[78]
Annex 12, 4	Monitoring and research programs	Establish to support GLISP	Establish monitoring and research programs to identify:	None	Annual WQB reports indicate that Surveillance and Monitoring has been a major activity.
			a. Temporal and spatial trends in concentrations of		As with nutrients, surveillance and monitoring for toxic substances has evolved from measurements of ambient

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			persistent toxic substances such as PCB, mirex, DDT, mercury, and dieldrin and other substances known to be present in biota and sediments of Great Lakes system;			levels to biomonitoring in order to measure response to controls, effects on biota and to detect new problems.[79]
			b. The impact of persistent toxic substances on the health of humans and quality and health of living aquatic systems;			New surveillance plan will monitor levels of fish contaminants and possible human exposure by fish consumption; also biota in order to assess ecosystem health.[80]
			c. The sources of input of persistent toxic substances; and			New surveillance plan expands monitoring to groundwater and air as well as point sources.[81]
			d. The presence of previously unidentified toxic substances.			Monitoring under GLWQA has revealed presence of many new toxic contaminants.[82]
		Intensify research	Intensify research to determine pathways, fate, and effects of toxic substances to protect human health, fishery resources, and wildlife in Great Lakes Basin Ecosystem; to determine:	None		Research results have been reported by Human Health Effects Committee and a Health of Aquatic Communities Task Force, through SAB. Since 1980 concern has been expressed about declining support for research, loss of personnel and programs, and need for additional research because of complexity of toxic problems.[83]
			a. Significance of effects of persistent toxic substances on human health and aquatic life;			Annual reports from Human Health Effects Committee. Report on literature review for Aquatic Communities Task Force.[84]
			b. Interactive effects of residues of toxic			Little information to date. New surveillance plan is reported to

			substances on aquatic life, wildlife, and human health; and		be designed to provide information on interactive effects.[85]
			c. Approaches to calculation of acceptable loading rates for persistent toxic substances, especially those occurring naturally.		Health Effects Committee reports on exercise to develop Interim Maximum daily exposure limits for some substances. Also limits are being set in NPDES permits in U.S.[86]
Annex 12, 5	Early warning system	Establish system	Establish system to anticipate toxic substances problems with following elements:	None	
			a. Development and use of structure-activity correlations to predict environmental characteristics of chemicals;		ISHOW data base by EPA Duluth lab demonstrated ability to predict bioaccumulation in environment of chemicals based on structure/ activity.[87]
			b. Compilation and review of trends in production, import, and use of chemicals;		No organized activity in this area reported in SAB or WQB reports.
			c. Review of results of environment testing on new chemicals;		Some information available under U.S. Toxics Substances Control Act but no special Great Lakes information.[88]
			d. Toxicological research on chemicals and review of research conducted in other countries;		Steering committee formed to develop a symposium/workshop to address methodologies for assessing effects of toxic substances.[89]
			e. Maintenance of biological tissue ban and sediment bank to permit retroactive analysis to establish trends over time;		1983 task force found 48 tissue banks exist with 14 classes of tissue samples; recommended study of desirability of centralized data base and recommended study of centralized data base on samples.[90]

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			f. Monitoring to characterize presence and significance of chemical residues in the environment;		In 1983 the IJC regional office reported presence of 800 chemicals in Great Lakes ecosystem based on literature search; monitoring expanded to in-place pollutants, groundwater, and atmosphere.[91]	
			g. Development and use of mathematical models to predict consequences of various loading rates of different chemicals; and		Modeling task force has reviewed models in current use and recommended use of modeling to develop controls for toxic contaminants.[92]	
			h. Development of a data bank for storage of information on physical/chemical properties, toxicology, use, and quantities in commerce of known and suspected persistent toxic substances.		Status of a centralized data bank is unclear, but establishment of a centralized system continues to be recommended; meanwhile EPA's Storet system is being used.[93]	
Annex 12, 6		Establish action levels	Establish action levels to protect human health from individual and interactive effects of toxic substances.	None	All states and Ontario issue public health advisories for fish consumption owing to presence of certain toxic substances; no advisories are based on interactive effects.[94]	
Art. VI, 1 (b) (ii)	Industrial discharges	Develop and implement programs	Develop requirements for substantial elimination of industrial discharges of persistent toxic substances into Great Lakes system.	December 31, 1983	Less compliance for industrial discharges than municipalities but decline in total loadings.[95]	80% compliance for industries in 1982 but no limits yet set for many toxic substances.[95]
			Establish enforcement programs to meet above requirements fully.	December 31, 1983	Many toxic substances not subject to controls but enforcement under existing controls is increasing.[96]	

3. Hazardous polluting substances; Art. VI i (j) and Annex 10, 1 (a) and 2	Identification of hazardous polluting substances	Maintain a list	List in Annex 10, Appendix 1, hazardous polluting substances, i.e., substances known to have toxic effects on aquatic and animal life and a risk of being discharged to the Great Lakes System, based on following procedures:	None	Over 800 chemicals found in Great Lakes ecosystem were reported by WQB in 1983. In 1985, WQB, reported agreement on 11 Critical Pollutants, some representing groups, or families, of substances known to be toxic. Also, a two-track control strategy, with a second list of substances that would be further investigated and moved to the list of Critical Pollutants if shown to be toxic in ecosystem. Two tracks are Primary and Comprehensive.[97]
			a. Selection of all hazardous substances listed in Appendix 1 based on documented data evaluated and accepted by parties;		SAB and WQB have agreed to coordinate efforts to refine listing of critical toxic pollutants.[98]
			b. Revisions to Appendix 1 may be made by mutual consent and treated as amendments for Art. XIII; and		The toxic substances control strategy reported in 1985 includes procedures for revision of list of Critical Pollutants.[97]
			c. Using agreed on criteria, either party can recommend addition to list. Substances need not have been previously listed. Receiving party has 60 days to respond. Cause for rejection must be documented, and rejection may be further negotiated.		Under 1985 WQB initiative, Critical Pollutants list will be revised "when information has been developed which suggests need to add a substance." "New information" may be evidence of fates and effects of substances on biota.[97]
Annex 10, 3			Select substances as candidates for listing in Appendix 1 based on:		
			a. Acute toxicological effects, as determined		The Toxics Substances Committee will apply criteria or protocol for

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			by whether substances is lethal to: (i) One half of a test population of aquatic animals in 96 hours or less at a concentration of 500 mg/L or less; (ii) One half of a test population of animals in 14 days or less when administered in a single oral dose equal to or less than 50 mg/kg of body weight; or (iii) One half of a test population of animals in 14 days or less when dermally exposed to amount equal to 200 mg/kg body weight for 24 hours; (iv) One half of a test population of animals in 14 days or less when exposed to a vapor concentration equal to or less than 20 cc/cm in air for 1 hour; and (v) Aquatic flora as measured by maximum specific growth rate or total yield of biomass 50% lower than a		adding substances to Critical Pollutants list and report to SAB and WQB.[97]	

		control culture over 14 days in a medium at concentrations equal to or less than 100 mg/L. b. Risk of discharge into Great Lakes system as determined by: (i) Gathering information on history of discharge or accidents; (ii) Assessing the modal risks during transport and determining use and distribution patterns; (iii) Identifying quantities manufactured or imported.		ISHOW data base developed by EPA laboratory in Duluth assembled information on chemicals manufactured and used in basin and classified them by characteristics and structure. ISHOW has not been maintained, and status of a data clearinghouse is unclear in 1985.[99]
Art. VI 1 (j) and Annex 10, 1 (b) and 4	Identification of potentially hazardous polluting substances	List in Annex 10, Appendix 2, potentially hazardous polluting substances, i.e., substances with potential toxic effects on aquatic and animal life and a risk of being discharged to the Great Lakes system and give priority to examination of these substances for possible transfer to Appendix 1 list based on following procedures: a. Either party may add new substances to Appendix 2 by notifying the other that	None	Substances identified for Comprehensive Track in 1985 WQB report is a list of potentially dangerous toxic substances. The 1983 inventory list has been sorted into two sets: "verified" as present in the ecosystem and "other." Other includes substances whose presence may be doubtful and innocuous salts of some metals.[97] Notification has not been given to date between the parties. Rather, it appears that agreement is being reached jointly through the

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			substances is considered a hazard because of documented information that is also submitted;		agreement process, i.e., the SAB and WQB, as reported in 1985.[98]	
			b. Removal of substances from Appendix 2 list by mutual consent of the parties; or		See above.	
			c. Parties shall give priority to examination of substances listed in Appendix 2 for possible transfer to Appendix 1.		Council of Great Lakes Research has been formed to assist setting of research priorities.[36]	
Annex 10 (c)	Revision of lists of hazardous substances and potentially hazardous substances	Revise lists	Ensure that the lists in Annex 10, Appendixes 1 and 2, are continually revised in light of growing scientific knowledge.	None	Refinement of the 1983 inventory of substances present in the Great Lakes ecosystem responds to this provision.[97]	
Annex 10, . 1 (d) and 5	Programs and measures to control risks of release of hazardous polluting substances	Develop and implement programs	Develop and implement programs to minimize or eliminate risk of release of hazardous polluting substances to the Great Lakes system. Annexes 4 and 8 contain programs and measures to control risk of pollution from transport, storage, handling, and disposal of hazardous polluting substances.	None	Ontario has new public corporation to establish integrated disposal system for hazardous wastes. Also manifest systems.[100]	U.S. has new laws to clean up toxic waters and to control future disposal of hazardous wastes. Also state and federal manifest systems, but these systems may not be adequate.[100]

Annex 9	Contingency plan	Develop and implement programs	Maintain a joint contingency plan, the Joint Canada-United States Marine Pollution Contingency Plan for the Great Lakes (CANUSLAK) for use in the event of a discharge of oil or hazardous polluting substances, in accordance with Annex 9.	None	Contingency plan has been in effect since 1974. Coast Guards have assumed joint responsibility for plan and work together directly. Plan has been updated twice (most recently in 1984). Coast Guards meet together annually to review plan and report annually to WQB on how and when the plan was invoked in the previous year.[101]
Annex 9, 1			Direct Coast Guards, in cooperation with other affected parties, to provide supplements for high-risk areas and to coordinate and maintain the Plan.	None	Detailed supplementary plans have been completed for the St. Lawrence and St. Clair rivers and a similar plan is being developed for the St. Mary's River.[102]
Annex 9, 2			Establish purpose of Plan to provide coordinated response to pollution incidents in Great Lakes as supplement to other plans.	None	Plan appears to have been adequate in instances in which it has been invoked, including an oil spill in the St. Lawrence.[103]
Annex 9, 3 (b)			Establish objectives of Contingency Plan to be: a. Develop appropriate preparedness measures and systems to discover and report incidents; b. Institute prompt measures to restrict pollution spread; and c. Provide adequate clean-up response to pollution incidents.		

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Annex 9, 4			Assess the costs of operations of both parties under plan to party where incident. Empower Coast Guards to amend plan consistent with Annex 9.			Plan was updated in 1982-1983 and revised plan issued in 1984.[101]
Annex 9, 5		Develop and implement programs	Develop control measures to control industrial discharges of radioactive materials into Great Lakes system.	December 31, 1983		Periodic reports are made on radionuclide levels in lakes, based on reports on operation of nuclear power plants.[104]
			Establish effective enforcement for radioactivity.	December 31, 1983		The GLWQA objective for radionuclides was not exceeded in most recent monitoring data.[104]
		PART D. BASIN-WIDE/LAND-LAKE PROVISIONS				
1. Control of pollutant loading rates in each lake basin; Art. IV 3 (b)		Consult	Control to protect integrity of the Great Lakes ecosystem.	None		In 1985, the WQB reported surveillance program redesigned to emphasize biological and community status. The SAB recommends changing Art. III. Lake-by-lake status reports made annually.[105]
2. Pollution from agriculture, forestry, and other land-use activities; Art. VI 1 (e) (i)	Pest control products	Develop and implement programs	Develop and implement: a. Controls on use of products likely to have long-term deleterious effects on biota; b. inventory; and c. research on integrated control techniques.	None		Use of pesticides is restricted in both countries, with bans on some persistent chemicals. But new concern has developed about potential water-quality effects from increased use of herbicides and pesticides with conservation tillage techniques and increased use of pesticides generally.[106]

Art. VI 1 (e) (ii)	Animal husbandry	Develop abatement and control of pollution; encourage policies and regulations; strengthen education and technical assistance.	None	Ontario has program to restrict livestock access to waterways to protect fish habitat.[107]	Little attention to animal husbandry as a Great Lakes issue.
Art. VI 1 (e) (iii)	Hauling and disposal of liquid and solid wastes	Develop controls; encourage land-disposal siting design and regulation and land application plan review, supervision, and monitoring.	None	Both parties have new and developing programs on disposal of hazardous wastes in landfills.[100] More attention is being given to landfills as a possible source of pollution in U.S. land disposal guidelines.[108]	
Art. VI 1 (e) (iv)	Road salting and salt storage	Develop a review and supervision measure to optimize salt use "in consideration of long term environmental impact."	None	Mapping by Groundwater Task Force will help identify potential for groundwater contamination by road salt.[108]	
Art. VI 1 (e) (v)	Soil losses	Develop controls for urban, suburban, and rural areas.	None	Most efforts based on results of PLUARG studies.[109]	
Art. VI 1 (e) (vi)	Land-use planning	Develop measures to encourage and facilitate improvements in planning that account for impact on Great Lakes water quality.		In 1981, the WQB discussed Canadian land-use programs,[110] and new attention is being given to connections between water and land in surveillance and monitoring.[111]	
Art. VI 1 (e) (vii)	Advisory programs	Develop other advisory programs and measures to abate and control inputs of nutrients, toxic substances, and sediments from agriculture, forestry, and other land-use activities.	None	Advisory programs to promote integrated pest management and to reduce runoff are carried out in both countries.[112]	

MAIN SUBJECT; AGREEMENT CITATION	SPECIFIC TOPIC WITHIN MAIN SUBJECT	TYPE OF COMMITMENT IN MAIN SUBJECT OR SPECIFIC TOPIC	GUIDANCE OR CRITERIA, IF ANY, IN THE AGREEMENT	SPECIFIED DEADLINE	STATUS OF IMPLEMENTATION	
					CANADA	UNITED STATES
Art. VI 1 (e) (viii)	IJC recommendations		Consider IJC recommendations based on PLUARG reference.	None	WQB urges implementation of PLUARG recommendations.[113]	
3. Pollution from onshore and offshore facilities	Pollution from onshore and offshore facilities	Develop and implement programs	Include programs and regulations to prevent discharges of oil or hazardous polluting substances.	None	EPA and the Corps of Engineers reviewed oil and gas drilling in Lake Erie.[114] Task Force reviewed oil refinery industry.[115] Special report on progress.[116]	
Annex 8, 2 (a)			Prohibit harmful discharges of oil or hazardous substances with appropriate penalties.	None	All the issues related to onshore and offshore facilities are discussed in the special 1982 report.[116]	
Annex 8, 2 (b)			Require immediate notice of harmful discharges.	None		
Annex 8, 3 (a)			Review design, construction, and location of existing and new facilities for adequacy to prevent discharge.	None		
Annex 8, 3 (b)			Review of operation, maintenance, and inspection.	None		
Annex 8, 3 (c)			Develop and implement training programs for safe use and handling of oil and hazardous materials.	None		
Annex 8, 3 (d)			Equipment to stop, contain, and clean up spills.	None		
Annex 8, 3 (e)			Manifest and registry for transport of oil or	None		

			other hazardous substances.		
4. Airborne pollutants; Art. VI 1 (L)	Identification of sources and relative source contributions	Develop and implement programs	Include more accurate definition of wet and dry deposition rates for substances that may affect environmental quality adversely, including indirect effects of impairment of tributary water quality by atmospheric deposition in drainage basins.	None	Intense attention to atmospheric deposition in recent years but controls lacking. New efforts to identify sources with GLAD network and to refine loading and source data. Much effort for development of analytic technology and quality control for sampling program for organic chemicals transported in atmosphere.[117]
Art. VI 1 (L)	Identified sources that are significant contributions to Great Lakes pollution	Consult, in specified situations, on remedial programs	Include more accurate definition of wet and dry deposition rates for substances that may have significant adverse effects on environmental quality including indirect effects of impairment of tributary water quality through atmospheric deposition in drainage basins.	None	Research on loadings continues. While substantial information has developed on loadings, much uncertainty remains and almost no remedial programs have been undertaken in either country to date.
5. Coordinated monitoring and surveillance; Art. VI 1 (m) and Annex 11, 3		Develop and implement programs	Include baseline data collection, sample analysis, and quality assurance programs to assess inputs and measure whole lake and nearshore response to controls.	None	A comprehensive surveillance program continues to evolve and change from early emphasis on water chemistry to include biomonitoring for ecological effects.[25]
6. Shipping; Art. VI, 1 (f) and Annexes 4, 5, and 6		Develop and implement programs	Develop compatible regulations to control and prevent discharges of oil and hazardous polluting substances; also garbage, sewage, waste, and ballast waters.	None	Compatible regulations not yet in place. Coast Guards have basic responsibility and are working toward achieving shipping objectives of 1978 GLWQA.[118]

FOOTNOTES

1. The Canada/Ontario Agreement is the formal agreement in which the respective roles of the federal and provincial governments is spelled out for fulfilling Canadian obligations under the Great Lakes Water Quality Agreement. A separate agreement was signed for the 1972 and 1978 Agreements (1981 WQB, p. 65).

2. Objectives of Annex 1 are recognized in the process by which the states set water-quality standards under the U.S. Clean Water Act (PL 95-217) (1982 WQB, p. 63).

In the United States, the pattern of environmental legislation provides for federal grants to states for implementation and delegation of authority to the states in accordance with federal guidelines. Thus under each of several laws, the Environmental Protection Agency (EPA) negotiates with the states individually on program plans and funding under the Clean Water Act, Clean Air Act, and so forth.

Since the mid-1970s, there has been a single EPA-state annual agreement that integrates program plans under all the laws. State participation in implementation of the Great Lakes Water Quality Agreement is incorporated in the annual agreements. For example, tributary monitoring by the states and the federal share of financing is part of the annual agreement obligations in the state program agreements through internal negotiation with the EPA programs and participation in development of the agreements with the states. The Great Lakes provisions are not necessarily consistent from state to state, however.

Section 108 of the Clean Water Act provides that EPA can also enter into agreement with the states or other public agencies for demonstration projects to clean up Great Lakes pollution. The participating agency must pay 25 percent of the costs. Section 108 grants have supported federal agency projects such as the Soil Conservation Service and the Corps of Engineers promotion of conservation tillage. They have also been made to state and occasionally local agencies for demonstration or special projects, such as demonstration of phosphorus removal technology.

The First Biennial Report of the International Joint Commission (IJC) observed that the agreement between the Canadian federal government and Ontario had "made it possible for Canada to participate fully in Agreement-related activities." At a meeting on Mackinac Island in 1982, the governors of the Great Lakes states passed a resolution requesting establishment of a formal agreement between the U.S. federal government and the states for state participation in meeting the Agreement objectives with adequate funding to the states to maintain essential research, monitoring, and programs. Since 1983, the heads of state environmental agencies have been meeting twice a year as a "Council of Environmental Managers."

3. 1985 WQB, pp. 16-17.

4. The surveillance and monitoring programs have consistently received substantial attention and have been reported on regularly. Over time, the approach has evolved from periodic measurement of water chemistry to ongoing biomonitoring of ecosystem integrity that is to be reported annually (Annual WQB reports on surveillance).

The 1985 report describes how the approach to monitoring and surveillance has evolved historically and gives a lake-by-lake report on current status and evolving trends (1985 WQB, pp. 6-7).

5. A policy of nondegradation has been applied in developing water quality objectives. The objectives serve as the minimum target wherever the water-quality objectives are not being met currently. The Aquatic Ecosystems Objectives Committee (AEOC) was established specifically to carry out continuous review, according to a framework reported in an IJC report on "New and Revised Great Lakes Water Quality Objectives," Volume II, Washington, D.C., and Ottawa, October 1977, pp. 3-7.

6. A concept of protection for most sensitive uses has been applied (1981 AEOC Report to SAB, p. 1).

In April 1983, the Subcommittee on Dredging developed a list of locations where effects from dredging should be avoided, including among others, "Sanctuaries and refuges, breeding, spawning and nursery and feeding habitats, and passage areas for biota" (83 WQB, pp. 86-87). In general, it appears that the policy has been to consider all areas equally valuable and deserving of maximum protection.

7. "Flow augmentation," or dilution of pollution, is contrary to U.S. national policy as set forth in the Clean Water Act. The fundamental objective is to "restore and maintain the chemical, physical and biological integrity of the Nation's waters" by eliminating all discharge of pollutants into navigable waterways.

8. Second Biennial Report, 1984, p. 8.

9. The AEOC reviews the objectives and recommends changes. The Science Advisory Board has developed seven new objectives and recommended revision of 13, but to date the Agreement has not been amended accordingly (1985 SAB, pp. 37-40).

10. First Biennial Report, 1982, pp. 20-21.

11. Government responses to First Biennial Report.

12. 1985 WQB, pp. 65-151.

13. 1985 WQB, p. 134.

14. A full inventory was submitted to the IJC in 1981 and updated in 1982, with information available through the IJC regional office in Windsor. "The Ontario inventory is a summary of available data for major municipal and industrial discharges. The United States inventory contains NPDES permit requirements plus self-monitoring and compliance data for about 5,600 dischargers" (1983 WQB, p. 69).

15. The need for more treatment to achieve Agreement objectives was noted in both biennial reports (First Biennial Report, p. 3; Second Biennial Report, p. 4). Greater success with control of phosphorus than with control of toxic contaminants had been noted earlier by the Water Quality Board (1981 WQB, pp. 8 and 47).

16. 1985 WQB, pp. 44-48.

17. The 1978 Pollution From Land Use Reference Group (PLUARG) report spelled out where necessary reductions of phosphorus would not be achieved by control of direct discharges alone. The promotion of conservation tillage in the Erie, Huron, and Michigan basins was largely in response to this PLUARG finding. Even more attention is now being given to nonpoint-source control as a necessary component to phosphorus reduction plans (1985 WQB, p. 61).

The Niagara River Toxics Committee and the Upper Great Lakes Connecting Channel Study also have been organized bilaterally to address situations in which the objectives of the Agreement have not yet been achieved (1985 WQB, pp. 40-43).

Identification of problem areas beginning in 1974, later known as areas of concern, in part identifies areas of noncompliance with Agreement objectives to date but also areas where current treatment is inadequate to achieve compliance (1985 WQB, pp. 29-44).

18. A workshop on ecosystem management was held in Hiram, Ohio, March 22-24, 1983. Sponsors were the IJC, Great Lakes Fishery Commission, International Association of Great Lakes Research, and Great Lakes Tomorrow.

19. In its First Biennial Report (pp. 7-8), the IJC strongly questioned the U.S. commitment to the Agreement in light of actual and proposed budget cuts. The U.S. government responded that "it would meet its Great Lakes Agreement obligations" but did not make any commitments regarding funding. The IJC also urged more effort to develop programs for control of toxic substances, to which the Canadian government responded that there was an insufficient data base to proceed with controls to reduce the potential for cumulative effects from toxic contamination.

20. In retrospect, the early approaches to surveillance and monitoring did not provide sufficient information to assess ecological health. Under the 1972 Agreement, water chemistry was chiefly measured. The Great Lakes International Surveillance Plan (GLISP) was begun in 1975. It provided for intensive periodic surveys of each lake over a nine-year cycle and included monitoring for fish contaminants. A 1982 report by the General Accounting Office (GAO) concluded that "current water quality monitoring efforts have been hampered by a lack of funds" (GAO, 1982, p. iv).

Concern about surveillance inadequacies led to establishment of a Surveillance Work Group of the Water Quality Program Committee of the Water Quality Board to review GLISP (1982 WQB, p. 69). Concerns included limited funding, doubts about ability to monitor toxic contamination, and inability of GLISP to provide required information "in a timely manner." Then seven task forces were established to develop surveillance and monitoring plans that would be more adequate for determining and monitoring ecosystem health (1983 WQB, pp. 85-87).

The Indicator of Ecosystem Quality Task Force of the Science Advisory Board proposed using the lake trout (or walleye where trout are not common) as an indicator species in a report "A Proposed Approach for the Application of Biological Indicators for the Determination of Ecosystem Quality in the Great Lakes Basin." It was also recommended that a Great Lakes Fishery Commission offer of joint funding for the task force be accepted (1983 SAB, pp. 22-24).

In 1985, the Water Quality Board reports a new approach that aims to assess relationships between human health and well being and the status of the aquatic ecosystem in the Great Lakes basin. The new surveillance approach addresses chemical contamination, eutrophication, microbial contaminants, radioactivity, and the status of biological communities.

In contrast to the original surveillance approach that measured mainly ambient levels of pollutants in water, the new approach calls for measuring loadings from tributaries, municipal and industrial sources, urban and agricultural sources, the atmosphere and connecting channels. Impacts will be measured in the open lakes, nearshore, including areas of concern, at beaches, at water intakes, and in connecting channels in order to relate loadings to responses.

Effects on wildlife and aquatic biota, including fish, will also be measured (1985 WQB, p. 11).

21. In the United States, industrial compliance is based on the NPDES permit conditions and the self-monitoring reports that individual industries make to EPA. In Canada, estimates of industrial compliance are "based largely on ambient information gathered . . . where industrial activity may release toxic substances" (1985 WQB, pp. 132-136).

22. 1985 WQB, pp. 111-113.

23. Each year, more detail has been provided about the problems, sources, and needed programs for each area of concern, although plans for remedial actions did not begin until 10 years after the "problem areas" were first identified. New criteria have been established for classifying areas of concern in order to set priorities for remedial programs (1985 WQB, p. 33).

Remedial action plans are being developed in cooperation with the jurisdictions that aim to restore "a full complement of uses" in all areas of concerns. A schedule calling for completion of remedial actions plans for all areas of concern by the end of 1986 is given (p. 46). Actions already under way in some locations, including Green Bay, Grand Calumet area, and Niagara River, are described. An appendix (pp. 161-120) provides detailed information about 42 areas of concern with charts and maps.

24. Measurements of productivity as well as levels of contamination are now being provided by the surveillance program. Both changes in species of phytoplankton and changes in rate of growth have provided information about changes in trophic status. They are also being observed to determine response to controls of phosphorus. Data from water intakes are being used to determine long-term trends in water chemistry. Also, levels of contaminants in migratory fish are being monitored to determine open, or whole, lake conditions, while small resident species, such as the spottail shiner and smelt, are being sampled to locate "toxic hot spots" (1985 WQB, pp. 73-108).

The surveillance and monitoring process required by the Agreement appears to have fostered an early warning system for Great Lakes problems. Further, the Agreement process appears to offer a forum for interaction between scientists and managers that may facilitate development of management programs. Examples include identification of cultural eutrophication in the lakes; bioaccumulation of persistent toxic contaminants in fish and therefore potential increased human exposure by fish consumption; long range transport of toxic contaminants in the atmosphere; rising chloride levels in the lower lakes due to road salts; increasing nitrogen levels from causes not yet understood; and apparent successful reversal of eutrophic trends in many locations by control of phosphorus loadings.

The surveillance and monitoring process thus appears to support development of successful management or pollution control measures. Examples include the promotion of conservation tillage to reduce agricultural runoff, adoption of phosphorus detergent bans by most Great Lake states, and decreasing levels in fish following controls of mercury, DDT, and PCBs (1985 WQB, pp. 153-155). Further, the Agreement process fostered a holistic or ecosystem perspective in environmental management (1979 SAB report on "The Ecosystem Approach").

25. First Biennial Report, 1982, p. 4.

26. Reports on interlaboratory comparison exercises (1981 WQB, p. 65, 1982 WQB, p. 13, 1983 WQB, p. 86) confirm attention to quality assurance. A workshop was held for chemists involved in phosphorus analysis to promote use of consistent methodologies. In 1985 the Water Quality Board listed nine elements of surveillance plans that improve on GLISP (1985 WQB, p. 71).

27. Reports are included in the annual Water Quality Board reports.

28. Beach closings and fish kills as well as water intake data are being used to establish long-term trends (1985 WQB, p. 69).

29. Annual reports of the Dredging Subcommittee to the Water Quality Board.

30. The Dredging Subcommittee maintains and periodically publishes a register of the significant dredging operations that are undertaken in the Great Lakes System. The subcommittee also developed and published guidelines for evaluating dredging operations and alternatives for disposal. The register and guidelines were published in April 1983 (1983 WQB, p. 86).

Information exchange on dredging issues has been promoted by several technical workshops. The guidelines were used to evaluate disposal of dredge spills in Toledo and Toronto. Open-lake disposal is again being considered, despite prohibitions that were adopted earlier, because of urgent need to dredge navigational channels (1983 WQB, pp. 86-88).

31. The Water Quality Board remains concerned about use of confined disposal areas for disposal of contaminated dredge spoils and expresses continuing concern about the possibility of release of residual chemical compounds in dredging and disposal, operations. This has become an issue in cleanup of harbors designated as sites for Superfund cleanup under the U.S. Superfund program, such as Waukegan Harbor, Illinois. The Army Corps of Engineers is conducting intensive studies of dredging, disposal and management of highly contaminated sediments in the Indiana Harbor and Ship Canal whose results are expected to be applicable at other locations in the Great Lakes and nationally (1985 WQB, pp. 39-42).

32. Workshops are held by the Dredging Subcommittee.

33. The U.S. Army Corps of Engineers has undertaken an experimental approach to confined disposal of dredge spoils at Time Beach near the mouth of the Buffalo River in which the diked area is left half full of water. Long-term studies will be carried out on transfer of pollutants to the environment and effects in the food chain (1985 WQB, pp. 42-43).

34. Limited-use zones have not been designated. The failure to designate limited-use zones was noted in the annual Water Quality Board reports and the Science Advisory Board through 1982, the year of the First Biennial Report of the IJC to the governments under the 1978 Agreement. The IJC noted (p. 23) that the USEPA had declared the concept of limited-use zones to be inconsistent with national policy as declared in the U.S. Clean Water Act. It observed that Canada was apparently willing to designate such zones but did not want to do so unilaterally.

The IJC also noted the Science Advisory Board concern that, without designation of limited-use zones, pollution control would not be invoked until Specific Objectives are exceeded at the international boundary. According to the Aquatic Ecosystems

Objectives Committee, mixing zones, or limited-use zones, must be designated in order to demonstrate loss of beneficial uses due to pollution. This view conflicts with the USEPA view that limited-use zones allow pollution to be continued rather than abated.

The IJC urged the governments either to set limited-use zones or to delete provisions for them from the Agreement. In its response to the IJC, the United States agreed on the need to review Article VI and Annex 2 that deal with limited-use zones in the 1978 Agreement. The United States also stated that designation of "areas of concern" is an adequate way to recognize that Agreement objectives are being exceeded in some locations (First Biennial Report, 1982, pp. 23-25).

To this, Canada responded that some areas of concern would require extraordinary efforts over a long time before the objectives of the Agreement would be achieved. The St. Mary's, St. Clair, and St. Lawrence rivers and Hamilton Harbor were cited as examples. Canada also agreed that the limited use zones provisions might have to be amended if bilateral resolution on the issue proved impossible.

The lack of resolution was noted in the Second Biennial Report (p. 8), when the IJC urged the parties to consult on the issue at the earliest opportunity. The IJC noted that it assumed that, in the absence of definite limited-use zones, the Specific objectives apply throughout the entire Great Lakes system. Pending settlement of the debate, the IJC proposed that at least areas where objectives are not being achieved should be named and the specific deficiencies identified in order to provide a more complete information base about progress under the Agreement. The 1985 Water Quality Board report contains more detailed information about problems in each area of concern.

The limited-use zone debate points up internal inconsistencies in the Agreement between the call for protection of ecosystem integrity and zero discharge and the provision for designation of limited-use zones where neither goal would be achieved. More attention is being given, however, to remedial actions in areas of concern than earlier, when they had merely been named. This is not consistent with the view of limited-use zones that says they are areas where continued degradation would be accepted.

Whether the fuller information provided about areas of concern in the 1983 and 1985 WQB reports is in direct response to the IJC concern about the failure to designate limited-use zones is not clear. Both reports demonstrate, however, that much more attention is being given to remedial actions in these locations. The concept of "areas of concern" as places that will require special and intensive efforts for pollution abatement in order to achieve Agreement objectives is opposite to the concept of limited-use zones as areas where, by one interpretation, continued degradation would be accepted.

35. In the mid-1970s, the limited-use zone controversy was a major factor in consideration and then abandonment of proposals that were considered for environmental mapping. Environmental maps of the Great Lakes system were considered to aid the process of data analysis and communication. Some participants in a Task Force on Environmental Mapping expressed concern, however, that the maps might be used to identify where Agreement objectives could not be achieved, i.e., limited use zones. Others believed mapping would assist protection of especially sensitive areas, a use emphasized by the Science Advisory Board. In the end, however, there was no consensus on the purpose of the audience for environmental mapping, and it did not go forward (1979 SAB, pp. 67-91).

36. The IJC expressed concern about research funding in its Second Biennial Report: "While Agreement-related research funding has remained constant, the scheduling and allocation of funds and available expertise have not always been coordinated. Uncertain levels of support, timing of awards, and receipt of funds have affected the ability to keep essential levels of personnel in certain activities and have inhibited coordinated research programs. . . . There is also a sense that Agreement research needs have not been given adequate priority by federal and jurisdictional agencies" (International Joint Commission, Second Biennial Report, 1984, p. 11).

The Science Advisory Board has expressed continuing concern about decreased support for research in all of its annual reports for the past several years. In 1982, the Board conducted an extensive review of all Great Lakes research programs and reported the results to the IJC. (1982 SAB and Appendix)

A Council on Great Lakes Research has been established with members representing major research agencies in the United States and Canada. Its purposes include review of research, recommendation of research priorities to the Science Advisory Board and IJC, and assistance in coordinating Great Lakes research programs. The council has been established at a time when membership of the Science Advisory Board has changed to include nonscientists and when both federal governments have reduced funding for Great Lakes research agencies (1985 SAB, p. 42; see also membership list).

37. Membership on all IJC bodies is binational.

38. Some international cooperation related to the Great Lakes Agreement process is occurring directly on specific issues. One example is the participation of Ontario and New York in the Niagara River Toxics Committee with Environment Canada and EPA. Ontario, Michigan, and New York are participating in the Upper Great Lakes Connecting Channels Study. Surveillance and monitoring depends heavily on intergovernmental and international cooperation. Most recently, the states and provinces are participating in the Great Lakes Atmospheric (GLAD) network (1985 WQB, pp. 65-110).

39. In its First Biennial Report, the IJC indicated that it perceived problems related to "changing jurisdictional priorities" that might interfere with the ability of staff members of governmental agencies to serve in IJC activities. The United States responded that its representatives would continue to serve IJC bodies "in their personal and professional capacities" and that the forum provided by such participation "helps the jurisdictions to respond." Canada answered less directly that "Canadian Board members serve . . . effectively . . . in the manner expected by the Government of Canada when it entered into the Agreement with the United States" (Government responses to the IJC First Biennial Report, 1982).

40. All the reports to the boards or to the IJC under the Agreement process depend on data provided by numerous agencies at every level of government in both countries. The 1980 Water Quality Board report discussed difficulty in obtaining information in Canada about discharges of toxic substances. Such information can be obtained only directly from the discharger or from the Ministry of the Environment of the province, which will not disclose information when the company claims confidentiality.

In the United States discharge information is available in the National Pollution Discharge Elimination System (NPDES) permits under the Clean Water Act. Compliance data for industrial dischargers is thus more readily available in the United States owing to the difference in regulatory approach. The need for compatibility of data is stressed in the 1985 Water Quality Board report (p. 109).

41. 1985 WQB, p. 38.

42. The evolution of joint activities and programs under the Agreement is laid out in the numerous reports of the boards, task forces, committees, and work groups to the IJC.

43. Consultation between the parties occurred through establishment of the Niagara River Toxics Committee in response to Ontario concern about pollution of Lake Ontario by toxic chemicals from the U.S. side. In May 1985, EPA administrator Lee Thomas and Minister of the Environment Suzanne Blais-Grenier consulted on remedial measures for the Niagara River and committed themselves to present action plans by October 1985.

44. Both the government of Canada and of the United States replied formally to the IJC's First Biennial Report in January and February, respectively. Neither accepted the IJC proposal to fund Agreement activities through the IJC.

45. The annual Water Quality Board reports include information on expenditures for municipal treatment facilities in both countries; in the 1985 report, Table 30, p. 129, shows total expenditures by year from 1971 to 1984. Details of other expenditures are not reported although concern has been expressed about actual and proposed funding cuts for Great Lakes programs. The Science Advisory Board has been especially concerned with cuts in research programs that could reduce ability to deal with toxic contaminants (1983 SAB, pp. xi-xviii).

46. The IJC criticized U.S. budget cuts at length in the First Biennial Report (pp. 7-1). The U.S. response repeatedly stated that the United States would continue to meet its obligations under the Agreement but did not make an explicit commitment on increased funding. The response went on to state that "Shifts in resources to new programmatic activities and steps toward greater integration of national program activities with those of Great Lakes states have and will continue to be made, as necessary.

47. Reports on legislation are included in the annual Water Quality Board reports. The enabling legislation for water pollution control in both countries is discussed in the 1985 Water Quality Board report (pp. 111-112 and p. 125). It is commented that in both countries the legislation serves federal, state, and provincial policies beyond the Great Lakes basin.

48. Phosphate detergent bans have been adopted in the United States by states and municipalities in part to serve objectives of the Agreement, except in Ohio and in Pennsylvania.

49. The discussion of phosphorus control as "the principal means to reverse or prevent symptoms of cultural eutrophication" in the 1985 Water Quality Board report is consistent with all other reports to the IJC under both Great Lakes Agreements (1985 WQB, p. 5).

50. No basin-wide algae blooms have occurred in recent years in Lake Erie, and oxygen depletion is less now than in the 1960s and 1970s (1985 WQB, p. 52, p. 92).

51. Algae growth has declined as concentrations of phosphorus have declined, apparently in response to decreased loadings, but substantial variability from year to year makes interpretation of changes difficult. Overall, there appears to be partial reversal of cultural eutrophication (1985 WQB, p. 92).

52. There is less nuisance algae growth than formerly in Lake Ontario, but nuisance growths may still occur locally. Phosphorus loadings to Lake Ontario have steadily decreased, and phytoplankton species that are more compatible with an oligotrophic status are now being found in more abundance (1985 WQB, p. 53, p. 99).

53. Lakes Superior and Huron remain oligotrophic in open waters, although Saginaw Bay is mesotrophic (1985 WQB, pp. 73, 85-86).

54. 1985 WQB, pp. 52, 75.

55. Several bays and other nearshore areas continue to have heavy algae growth. The need for further reductions in phosphorus loadings in some harbors, bays, and tributaries is reported in connection with discussions of areas of concern in the 1983 and 1985 Water Quality Board reports. There is also a detailed discussion of this issue in the Report of the Surveillance Work Group, Appendix B, to the 1983 report.

56. The several large municipal facilities that have not yet met the 1 mg/L effluent limit are listed in the 1985 Water Quality Board report. Detailed data on reductions in phosphorus loadings are given in every Water Quality Board report. Reductions by jurisdiction are reported in the 1985 report. The report notes that data for every individual facility is available from the IJC Great Lakes Regional Office in Windsor (1985 WQB, pp. 53-59).

57. The December 31, 1982, Agreement deadline was not met by all facilities, but substantial progress had been made and progress continues in further reducing phosphorus loadings from municipal sources. A "Review of the Municipal Abatement Programs in the Great Lakes basin" analyzed data for 1,079 facilities in November 1983.

58. The most recent accounting of funds committed for sewerage works in Ontario and in the United States is shown in Table 30, 1985 WQB, p. 129.

59. Effluent concentrations for all facilities that discharge more than 1 million gallons a day of wastewater are shown in Table 9, WQB, p. 58. Facilities that consistently exceed more than 1 mg/L of phosphorus in their effluents are shown in Table 10, p. 59.

60. Target loads are not yet met for Lakes Ontario and Erie. In 1983, the Water Quality Board states that it would not be possible to meet the target loads under the 1983 Supplement to Annex 3, especially for Lake Erie by point-source controls alone (p. 61). The jurisdictions were urged to provide more financial support to reduce problems from infiltration and combined sewer overflows (p. 70). The 85 WQB report (p. 62) states that the parties are proceeding with phosphorus load reduction plans for Lakes Erie and Ontario that include nonpoint-source control. The plans are to be completed in 1985; plans for Lakes Superior, Michigan, and Huron are already completed. The 1985 WQB report also stresses the need for attention to combined sewer overflow problems in the Remedial Action Plans for areas of concern (pp. 37-39).

61. Before signing of the Supplement to Annex 3 that set target loads, Ontario required treatment only to meet local conditions, which was only primary treatment in some cases. Ontario enforcement is by control orders from the Ministry of the Environment. In the United States, all municipal systems are required to have at least secondary treatment, and major enforcement actions were taken in court against Detroit, Milwaukee, and Cleveland in the 1970s. Effluent limits are set in the NPDES permits (1983 WQB, p. 63, 1985 WQB, p. 49).

62. Estimates of industrial loadings are given in Water Quality Board reports but are considered unreliable because of differences in jurisdictional reporting and control requirements. In the United States, NPDES data are available to the public for every discharger; in Ontario, dischargers report to the Ministry of the Environment. Special attention has been given to the pulp and paper industry because it is believed to provide significant loads. Estimated loading to Lake Superior from Canadian source appeared to increase in 1983, but loading to Lake Ontario decreased substantially. Industrial loadings may be especially significant in some areas of concern. In its 1985 report, the Water Quality Board urges the parties to monitor large industrial sources that discharge more than 3.8 kg/day or more and to give particular attention to increased loadings from the pulp and paper and chemical industries. Estimated industrial loadings are shown in the 1985 report on p. 59.

63. Controls for nonpoint sources have not been achieved. In its Second Biennial Report, the IJC said, "While there have been some successful demonstration programs to control nonpoint sources, a wide-spread, coordinated and systematic approach has not been implemented" (p. 4).

Over time, increasing attention has been given to the need for control of phosphorus from nonpoint sources. The atmosphere appears to be a significant source for Lake Superior, but controls are not available. Promotion of conservation tillage has reduced loadings significantly, and efforts to promote it continue in the Lake Erie, Saginaw Bay, and Green Bay basins, but the Water Quality Board stresses that urban nonpoint sources must also be addressed. The Nonpoint Source Control Task Force report in 1983 discussed available technology but pointed to lack of leadership and commitment for nonpoint-source control. In 1985, the Water Quality Board said diffuse source control will be part of phosphorus load reduction plans (1985 WQB, p. 62).

64. Large loadings continue from some Ohio municipal sources but, this state and Pennsylvania still do not have a phosphate detergent ban. The IJC expressed concern to the parties about possible relaxation of phosphate detergent bans in the First Biennial Report (p. 16) because of lapse of the Wisconsin ban. The United States replied that regulation of detergent phosphates is a state and local decision. The Wisconsin ban has since been reinstated, but comparable controls are still lacking in Ohio and Pennsylvania.

65. The 1985 Water Quality Board report identifies rising nitrogen levels as a cause of concern and recommends research on causes and short- and long-term effects (1985 WQB, p. 109).

66. 1985 WQB, pp. 49-50.

67. 1985 WQB, p. 62.

68. The deadlines for pretreatment were not met although progress is being made, especially on the U.S. side. The difference between the Canadian and U.S. approaches to pollution control is demonstrated by the approaches to pretreatment. The United States has a national program under the Clean Water Act, with a schedule for compliance. The program covers 25 major industrial categories and emphasizes 126 priority pollutants. In Canada, discharges to sewers are controlled by municipal by-laws. Ontario has a model by-law for municipalities that covers 13 heavy metals and 6 conventional pollutants but currently not toxic substances. According to the 1985 report of the Water Quality Board, Ontario will develop more extensive pretreatment programs "if necessary," but what will determine necessity is not explained. Pretreatment compliance to date in the states is shown in tables on pp. 135 to 136, and pretreatment is also discussed on p. 134. The Second Biennial Report of the IJC cited need for research on pretreatment for toxic substances (p. 5).

69. Regulation of toxic chemicals to date has been limited to banning or controlling use of chemicals one substance at a time. The First Biennial Report cited the one-chemical-at-a-time approach as the "Achilles Heel of current control strategies" (p. 6). The U.S. response asserted that the "Best Available Technology" policy of the Clean Water Act would allow adequate toxics control to satisfy Agreement obligations. The Canadian government responded that a Federal-Provincial Toxic Substances Task Force had been formed to develop new programs for toxic control. The Water Quality Board attributes the slowness to address the toxics issue to the large number of chemicals involved, lack of information, and inadequate legislation (1985 WQB, p. 16).

The difficulty of controlling sources for organic chemicals is illustrated by the contrast between the relative ease of controlling mercury and the greater difficulty of controlling DDT and especially PCBs. New U.S. legislation is supporting more aggressive enforcement, which is, however, still at an early stage of development. U.S. enforcement actions on toxic substances are shown in Table 44 and Ontario actions in Table 45 (1985 WQB, pp. 154-155).

70. Both biennial reports of the IJC stressed the need to address control of toxic substances. In the second report in 1984, the IJC said, "In the Commission's opinion, however, these programs [toxic substances control programs] have not advanced far enough . . . the Commission urges governments to increase their efforts in support of a coordinated strategy which addresses the problem of toxic and hazardous substances beginning at their source or manufacture and continuing on through the transport, use and life of these substances" (Second Biennial Report, p. 5).

The 1985 Water quality Board report discusses new directions in thinking about toxic substances control and the attention that is being given to indirect sources such as groundwater and atmospheric deposition as well as to in-place pollutants (p. 1). A foundation for attention to groundwater issues was laid by the report of the Groundwater Contamination Task Force in 1983 that described contamination from past disposal of hazardous wastes as a major regional problem (1983 SAB, pp. 9-14).

71. The 1978 Water Quality Board report discussed the fact that achieving the virtual elimination of toxic substances called for in the 1978 Agreement would require programs and policies that did not exist in either country. The United States had more toxics control legislation but a shortage of laboratory and field personnel to obtain needed information. In 1981, the Water Quality Board proposed a framework for toxic substances control with four components: (1) development of an information base, (2) hazards and risk assessment, (3) development of action plans, and (4) evaluation of results. In 1983, the board reported that three actions were being taken toward a more comprehensive toxics substance control strategy: (1) development of a priority list for tracking in the surveillance program or for development of characteristics information and an inventory of sources, (2) establishment of a data clearinghouse in the regional office of the IJC, and (3) updating a list of chemicals in the Great Lakes ecosystem that had been compiled between 1976 and 1978.

The 1985 Water Quality Board report states that elimination and prevention of persistent toxic substances from the Great Lakes ecosystem is now the focus of the board's efforts. The report describes comprehensive programs and actions under way by federal, state, and provincial agencies.

72. 1985 WQB, p. 15.

73. The 1980 report of the Science Advisory Board discussed assimilative capacity as an ecosystem concept and how a safe level for discharges of toxic substances is more a societal judgment than a question of scientific fact. At the Hiram, Ohio, workshop in 1983 ways to develop appreciation for an ecosystem approach were considered but without concrete results. Both biennial reports of the IJC discussed the need for increased public involvement in development and implementation of programs for control of toxic substances. The 1984 report stated that "Without active community support, it is probably beyond the reach of any agency or government . . . to achieve Agreement objectives" (p. 16). The zero-discharge issue has not been explicitly addressed to date.

74. The Great Lakes Fishery Commission initiated special studies on ecosystem rehabilitation for Green Bay and the Bay of Quinte. The 1985 Science Advisory Board report describes a site visit to Green Bay and exchange with local interests about the consensus management efforts of the Future of the Bay organization (1985 SAB, p. 44).

75. After the Water Quality Board referred the problem of in-place pollutants in sediments to the Science Advisory Board, an Inplace Pollutants Task Force was established to evaluate alternative approaches. In 1984 an international workshop in Wales recommended that rehabilitation efforts should proceed for in-place pollutants in two selected areas of concern. The two areas would provide case studies in management strategies and for measurement of rates of biological responses to control measures. The Science Advisory Board is giving substantial attention to social, economic, and institutional factors in ecosystem rehabilitation with a Committee on Social and Economic Considerations (1985 SAB, pp. 15-16, and pp. 30-36).

Meanwhile, the Water Quality Board has reported that all jurisdictions have been asked to participate in preparing Remedial Action Plans for all 42 areas of concern. The action plans are to include remedial measures "to restore beneficial uses." Separately, the parties are also addressing the issue of in-place pollutants (1985 WQB, pp. 145-146).

76. The 1982 deadline was not met. In 1981 the Water Quality Board reported that the January 1982, deadline for an inventory of toxic substances produced, used, and disposed of in the Great Lakes basin would not be met even though some existing inventories partially satisfied the requirement (1981 WQB, pp. 32-34). The Information System for Hazardous Organics in Water (ISHOW) developed by the USEPA Duluth Environmental Research Laboratory was said to approximate most closely a centralized Great Lakes inventory data base. It was developed to support EPA's structures/activity studies. A similar data base was said to be under development in Canada. According to the IJC regional office, the ISHOW system is no longer active, owing to changes in personnel and program at the Duluth laboratory and changing program priorities (personal communication, May 1985).

The 1985 Water Quality Board report describes the intensive study of the pulp and paper industry carried out by a special task force over several years. Although much progress has been made against conventional pollution from this source, a "paucity of data" precludes evaluation of the toxic character of discharges from pulp and paper sources (1985 WQB, pp. 139-143). Meanwhile, new legislation and programs have provided some of the information required for the inventory. Hazardous-waste disposal sites have been inventoried in the United States under the Superfund and Resource Conservation and Recovery Acts and by Ontario's Ministry of the Environment.

77. Both the Water Quality Board (1981 WQB, pp. 30-32) and the IJC (First Biennial Report, p. 6) earlier stressed their concern about the lack of coordination in management of toxic substances and waste disposal. The 1985 board report asserts, however, that coordination will be achieved with development of the Remedial Action Plans for the areas of concern. The coordination is said to involve both cooperation among jurisdictions and among programs within the jurisdictions (1985 WQB, p. 4, pp. 44-48).

78. The 1984 amendments to the U.S. Resource Conservation and Recovery Act require that regulations within two years be developed governing export of hazardous wastes outside the country. The Act provides that such wastes cannot be transported across an international boundary unless the receiving country agrees in writing to accept them.

79. Separate reports on surveillance and monitoring have been made to the IJC every year. Under the 1978 Agreement, monitoring for trends in the presence of persistent toxic chemicals has been stressed. Canada has monitored herring gull eggs for long-term trends and more recently spottail shiners to identify local areas with high concentrations. U.S. agencies, including the Fish and Wildlife Service and EPA, have monitored concentrations of these contaminants in fish intensively. The annual reports indicate that the surveillance and monitoring program has been carried out bilaterally with full exchange of data.

Problems have been reported, however. In 1981, the Water Quality Board recommended that a centralized mechanism be established to track data because of the multiplicity and complexity of the programs. The board emphasized that it was not proposing a single data system but rather a central system to serve as a clearinghouse on data repositories. The IJC objected to management of such a clearinghouse by the Great Lakes regional office because the ability of the IJC to comment on the effectiveness of Agreement programs would be compromised if the IJC rather than "responsible government agencies" of the parties had responsibility for implementing recommended strategies (Second Biennial Report, 1984, p. 5).

Another problem has been the long lag time between collection of data and the analysis and reporting of results. In 1983, the Water Quality Board noted that data based on sampling in 1980 did not become available until 1983 (1983 WQB, pp. 7-8). Delays in publishing final results of intensive studies were cited by the board in 1985 as a factor in the difficulty that jurisdictions have had in using surveillance results in making annual program plans.

The board also observed, "Surveillance, monitoring, research and other programs have unequivocally demonstrated the widespread presence of many complex organic substances and heavy metals in the Great Lakes ecosystem. . . . It is, however, more important to determine what the presence of these substances means in terms of effects on human health and environmental significance. . . . For some substances the human health and environmental significance has been established. The available scientific and technical information serves as the defensible basis for the Agreement objectives and for discharge limitations. . . . For most other substances present in the Great Lakes ecosystem, deleterious effects are known to occur at high concentrations. However, these substances are found in the Great Lakes ecosystem at very low concentrations. Information about environmental and human health effects at these low levels is often scant, and decisions on the need for remedial measures remain difficult. . . . Moreover, the information base is minimal for most substances, and the hazard and the risk which may be posed by a particular substance has not been established for many concentrations. Consequently, controls cannot even be considered" (1983 WQB, pp. 29-30).

80. 1985 WQB, p. 67.

81. 1985 WQB, p. 69.

82. Use of indicator species has been under consideration for several years. Sampling of tissues of migratory fish and of small resident species is now being done for trend analysis and to identify areas with high concentrations in sediments. Although a special study was made of the possibility of using the lake trout (or walleye where it is the top predator) to measure ecosystem health, the Science Advisory Board has advised that indicator species have not been reported to be used to measure impacts of specific contaminants and that "further development of methodologies is needed" (1985 SAB, pp. 21-25).

83. First Biennial Report, 1982, pp. 8-9.

84. Results of a literature review are reported in "Assessment of Effects of Persistent Toxic Substances on Great Lakes Biota." This report concluded that relatively little is known about effects of persistent toxic substances on the health of Great Lakes aquatic communities because site-specific studies have not addressed this question. Rather most past research has focused on identifying the presence of chemicals and on measuring levels (1985 SAB, pp. 19-20).

85. 1985 WQB, p. 70.

86. 1985 SAB, p. 26. 1985 WQB, pp. 154-160.

87. The ISHOW exercise and its results were discussed in the 1978 Research Advisory Board report (pp. 8-12). The discussion covered the difficulty of obtaining data on use and manufacture of chemicals and the differences in availability and maintenance of data bases in Canada and the United States.

88. The Science Advisory Board has reported that the Toxic Substances Committee "considered the need to prepare toxicity profiles for newly identified contaminants detected in the Great Lakes basin ecosystem and the categorization and prioritization of these chemicals according to previously established procedures. At present over 100 such profiles have been prepared under a contract with Health and Welfare Canada and others are being prepared" (1985 SAB, p. 26).

89. 1983 SAB, pp. 18-19. There is no follow-up mention of this issue in the 1985 board report.

90. The Data Quality Work Group of the Water Quality Board compiled a list of environmental sample banks in the Great Lakes region and reported the result in a report "Great Lakes Basin Tissue and Sediment Bank Compilation" in March 1983.

91. In 1983, the Water Quality Board reported that the IJC regional office, on behalf of the Water Quality and Science Advisory boards and their committees, had prepared a report on "Chemicals Identified in the Great Lakes Ecosystem." The list of more than 800 substances was published in Appendix E of the 1983 board report. Data from more than 350 published and unpublished reports were summarized (1983 WQB, p. 40). The list was further discussed in the 1985 report (1985 WQB, pp. 17-23).

92. Modeling has been used extensively to set target loads for phosphorus and to predict responses to nutrient controls. The recommendations for modeling for toxic substance control propose development of user friendly software to assist use of personal computers by management agency personnel and caution that use of modeling is a long-term venture that depends on the integrity of existing models and their further refinement (1985 SAB, pp. 2-3, pp. 40-41).

93. 1985 WQB, p. 11.

94. Although almost 1,000 chemicals have been identified as present in the Great Lakes ecosystem, public health advisories are issued for only a few individual chemicals, including DDT, PCBs, mirex, chlordane, and dieldrin. Recently the EPA assisted development of uniform standards for fish advisories by the four states around Lake Michigan. (1985 WQB, p. 80, pp. 150-153). In 1981 the Committee on Human Health Effects reported on the large number of chemicals found in the Great Lakes ecosystem for which too little information was available to allow evaluation of human health effects (1981 Report of Committee on Human Health Effects, pp. 3-14).

In 1983, it was reported that the Human Health Effects Committee was considering several topics related to establishing the significance of substances in the Great Lakes ecosystem: (1) estimates of population exposure to contaminants in Great Lakes water, (2) toxicity profiles for contaminants recently identified in the Great Lakes ecosystem, (3) a review of the state of the art of establishing structure/activity relationships, and (4) review of the toxicity of complex mixtures (1983 WQB, p. 42). In 1985, the Science Advisory Board recommended that fish tissues be monitored for lead (1985 SAB, p. 28).

95. Over several years, the Water Quality Board has continued to point to lack of controls for toxic discharges from industry while also reporting for the most part better compliance with existing regulations. Detailed reports on the status of compliance are included in the 1985 board report (pp. 128-143). The IJC echoed the continuing concern about the inadequacy of existing programs in its Second Biennial report. The IJC commented that data from discharge permits and control orders and from the Great Lakes surveillance program "do not establish a firm link between the implementation of programs . . . and achievements of Specific Objectives or other undertakings of the Agreement."

96. Enforcement actions on toxic substances in the United States and Canada are summarized in Tables 44 and 45 of the 1985 Water Quality Board Report (1985 WQB, pp. 154-156).

97. The 1985 Water Quality Board report describes how 11 Critical Pollutants have been selected for immediate action because of agreement that they have been present in the Great Lakes system for some time, "are highly toxic, persistent and can bioaccumulate to levels which can threaten human health and the aquatic ecosystem." The sorting of pollutants into one list for immediate action and a second list for which there is less information is designed to promote a strategic approach to control of toxic substances.

The Appendix E list from the 1983 board report was organized into two groups, Verified and Other. The Verified list will be addressed in a Primary (control) Track and the second list in a Comprehensive Track that includes research to assess the need for controls. In effect, the list designated for action on the Comprehensive Track becomes the Appendix 2 list for Annex 10. As information is developed, a substance may be moved from the Comprehensive Track list to the Critical Track list.

The "Verified" list of chemicals includes 495 organic and 60 inorganic chemicals whose presence in the ecosystem is assured. The other group contains chemicals whose presence is in reasonable doubt, or for which there may have been an error, and innocuous salts.

The verified chemicals have been divided into categories that consider source, use and chemical structure and available use data. The principal use categories are pesticides, petroleum products and detergents. The intention is to select representative chemicals from each group for further fates and effects identification and research. This strategic approach is intended to overcome the difficulty of dealing with the total number of Annex 10 chemicals individually.

98. The much more comprehensive efforts for toxic substances reported in 1985 by the Water Quality Board respond to Annex 10. The Toxic Substances Committee will apply scientific information and modeling to assist the boards in refining the list and setting priorities for action (1985 WQB, p. 23).

99. 1981 WQB, p. 35.

100. The Ontario Waste Management Corporation Act creates a public corporation to develop facilities for treatment and disposal of liquid industrial and hazardous wastes. The United States has two major federal laws to regulate handling and disposal of hazardous wastes. The "Superfund" law establishes a system to clean up wastes from past disposal. The Resource Conservation and Recovery Act regulates disposal of wastes. Amendments in 1984 brought many more sources and substances under the act. There is a federal manifest system for transportation of hazardous wastes, and several states also have special manifest requirements for hazardous wastes, but definitions are not consistent in all the systems. A definition of hazardous wastes proposed by Ontario is consistent with the definition used by USEPA (1985 WQB, pp. 143-145).

101. Joint Marine Pollution Contingency Plan of the U.S. Coast Guard and the Canada Coast Guard, as revised June 1984.

102. Joint Canadian/United States Coast Guard Report of Progress toward Achievement of the Objectives Established by the Great Lakes Water Quality Agreement of 1978. June 1984, p. 12.

103. Ibid, p. 13.

104. 1985 WQB, p. 68. Releases of radioactivity are monitored by the Radioactivity Coordinator for the Water Quality Programs Committee of the Water Quality Board (1983 WQB, p. 88).

105. In 1985, the Science Advisory Board recommended revising Article III to require restoration "to a condition where a balanced and stable community or organisms is present which resemble as much as is feasible and practicable the community that existed before the advent of human intervention" (1985 SAB, p. 3). The 1985 report on the status of each lake covers water quality, contaminants in biota, and emerging issues (1985 WQB, pp. 72-108).

106. The 1985 Water Quality Board reports on state and provincial actions on pesticides for each jurisdiction (1985 WQB, pp. 111-132).

107. 1981 WQB, Appendix III, pp. 32-34.

108. Potential pollution of the Great Lakes from waste disposal sites, road salting, urban runoff, fertilizers and pesticides (1985 SAB, p. 5). A Process Design Manual for Land Treatment of Municipal Wastewater was published jointly by the Army Corps of Engineers, Department of the Interior, Department of Agriculture, and U.S. EPA in 1981.

109. The PLUARG studies focused attention on land runoff, such as a 1979 report, "A Critical Assessment of U.S. Land Derived Pollutant Loadings to the Great Lakes" by the Great Lakes Basin Commission. Promotion of tillage techniques that would minimize soil erosion followed identification of areas where land runoff contributes significant pollution. Demonstration projects were carried out in Ohio, Wisconsin, and Michigan (Saginaw Bay basin). A special project was carried out to reduce erosion of red clay soils into Lake Superior. In 1985, the Water Quality Board reports that target loads for Lakes Erie and Ontario will not be achieved unless even more nonpoint-source control is achieved, including reduction of urban runoff (1985 WQB, p. 15, p. 61).

110. The U.S. land-use program include the coastal-zone management program, the Section 208 water quality planning program under the Clean Water Act, and state programs to slow conversion of prime agricultural land and to protect wetlands. The coastal zone management and 208 programs have declined with reduced federal funding in recent years. Canada has programs to monitor urban land-use change and conversion of agricultural lands. Ontario is said to have extensive legislation on land use guided in part by the Agreement (1981 WQB, Appendix III, pp. 32-34). The Science Advisory Board reports that mapping is to be done by a Groundwater Task Force as a way to address the relationship between land use and pollution sources in its 1985 report (1985 SAB, pp. 9-10).

111. 1985 WQB, pp. 71-77.

112. 1983 WQB, pp. 76-77.

113. In 1983, the Water Quality Board stated that "implementation of nonpoint source remedial practices has not met PLUARG recommendations" (1983 WQB, p. 77). In 1985, the board report urged implementation of PLUARG recommendations (1985 WQB, p. 61).

114. The U.S. EPA and the Army Corps of Engineers carried out an environmental impact analysis for oil and gas drilling in Lake Erie after New York, Pennsylvania, and Ohio changed their policies that had prohibited such drilling (1982 WQB, pp. 81-82).

115. A Petroleum Refinery Point Source Task Force was formed by the Water Quality Programs Committee of the Water Quality Board; the task force reported in 1982 on "A Review of the Pollution Abatement Programs Relating to the Petroleum Refinery Industry in the Great Lakes Basin."

116. Report to the International Joint Commission in Fulfillment of Section 4 (a), Annex 8, Great Lakes Water Quality Agreement of 1978, Existing and Proposed Programs and Measures for Discharges from Onshore and Offshore Facilities, March 1982. Another special report was "The Presence and Implication of Foreign Organisms in Ship Ballast Waters Discharged into the Great Lakes, prepared by Bio-Environmental Services Ltd., for the Water Pollution Control Directorate of Environment Canada, March 1981.

117. Airborne pollution has received increasing attention from both the Science Advisory and the Water Quality boards in recent years. The Science Advisory Board lists as reasons for concern the fact that atmospheric deposition is a significant source of both phosphorus and toxic contaminants to the upper lakes, that it may be the source of the increasing levels of nitrogen that are of concern, and that it is also a significant source of toxic contaminants to the lower lakes. Based on previous activities, the Science Advisory Board has made specific recommendations for research (1985 SAB, pp. 12-14).

The Water Quality Board is concerned that the air pollution control programs of the jurisdictions focus on protection of human health and ignore the impact of air emissions on the chemical quality of other media, including water (1985 WQB, p. 14). Recommendations are made that air quality and water quality relationships be addressed in statutes, regulations, and environmental standards. A Great Lakes Air Deposition (GLAD) network has been established in the basin to identify sources and levels of organic contaminants transported by air (1985 WQB, p. 24).

118. 1983 WQB, pp. 88-89.

APPENDIX C

SUBCONTRACTS

Title	Contractor
Areas of Concern, Case Studies Hamilton Harbor and Green Bay	Alicia Bixby Graduate Student University of Toronto
Bi-National Governance Arrangements in the Great Lakes	John Jackson Jackson and Weller Associates
Management of Urban Waste Water and Runoff: Technology, Economics and Policies	Barry Adams University of Toronto
Explanatory and Interpretive Comments on Bi-National Arrangements and Observation and Comments on IJC Organization and Process	George Francis University of Waterloo 2nd critique - Mike Donahue Center for the Great Lakes
Legal Basis for Ecosystem Rehabilitation in Green Bay	C. Jarrell Yarbrough University of Wisconsin
Study of Governance and Management of Great Lakes Coastal Waters	Jackson and Weller Associates Workshop held March 28
Progress on Commitments in the Great Lakes Water Quality Agreement (Canada)	John Jackson Jackson and Weller Associates
State Attitudes and Intentions Toward the Great Lakes Water Quality Agreement	Lee Botts Center for Urban Affairs and Policy Research
Progress on Commitments in the Great Lakes Water Quality Agreement (United States)	Lee Botts Center for Urban Affairs and Policy Research

A Review of Prospects for Reducing Toxic Loadings to the Great Lakes in the U.S.

Lee Botts
Center for Urban Affairs and Policy Research

APPENDIX D

BIOGRAPHICAL SKETCHES OF COMMITTEE MEMBERS

ORIE LOUCKS

After receiving the B.Sc. and M.Sc. degrees at the University of Toronto, Dr. Loucks earned his Ph.D. in botany at the University of Wisconsin in 1960. He taught at the University of Wisconsin until 1978, where his research interests were in environmental studies, watershed systems modeling, and land/water interactions. He is now director of the Holcomb Research Institute at Butler University in Indianapolis and a member of the NRC's Water Science and Technology Board.

HENRY REGIER

Dr. Regier received his B.A. at Queen's University in 1954, his M.S. at Cornell University in 1959, and his Ph.D. in fishery biology at Cornell in 1962. Since 1966 he has been a professor of zoology and since 1976 a professor of the Institute for Environmental Studies with the University of Toronto. He has been a member of the Great Lakes Fishery Commission since 1980. His areas of interest are in the fields of ecology of aquatic ecosystems, particularly large-scale response of fish communities to major cultural stress.

DALE L. BACON

Mr. Bacon received his B.A. degree (biology major) from the University of Rochester in 1965 and the B.S.C.E. and M.S. (environmental engineering) from the University of Iowa in 1968 and 1969, respectively. Since joining 3M in 1968 he has had assignments of increasing responsibility in the environmental area. His current assignment is Environmental Regulatory Activities manager. Mr. Bacon is a past member of the International Joint Commission Great Lakes Science Advisory Board (1981-1984).

JOHN J. BLACK

Dr. Black received his Ph.D. in experimental pathology from the Roswell Park Division, State University of New York at Buffalo in 1979. From 1962 to the present he has been with the Department of Experimental Biology, Roswell Park Memorial Institute, starting as a junior scientist with promotions in 1973, 1978, and 1980 to his present position in 1982 as senior cancer research scientist IV. His research interests are in fish as field and laboratory models of cancer. Dr. Black was a member of an Advisory Committee for the Great Lakes Laboratory at SUNY, Buffalo.

JENNIFER ELLENTON

Dr. Ellenton received her B.Sc. from the Department of Biology at the University of Waterloo in 1974 and her Ph.D. in cytogenetics from the Department of Biomedical Sciences at the University of Guelph in 1979. She was until recently a research scientist with the Canadian Wildlife Service specializing in genetic toxicology. She is currently raising a family and operating a 100-acre sheep farm. While with the Canadian Wildlife Service she served on the joint Department of Environment/National Health and Welfare Ministers' Advisory Committee on Environmental Mutagenesis in support of the Environmental Contaminants Act.

CRAWFORD S. HOLLING

Dr. Holling received his Ph.D. in zoology in 1957 from the University of British Columbia. He has been a professor at the University of British Columbia since 1967. In 1969 he was made honorary professor, School of Community and Regional Planning. Since 1969 his teaching and service responsibilities at the University have included being director of the Institute of Animal Resource Ecology and several sessions as biology professor since 1976. Dr. Holling's areas of special interest include experimental ecology, systems ecology, mathematical modeling, and ecological policy design.

H. B. NOEL HYNES

Dr. Hynes received his B.Sc. in 1938, his Ph.D. in 1941, and his D.Sc. in 1958, all from the University of London (England). He is a Fellow of the Royal Society of Canada as well as a member of several other scientific societies. He is currently professor emeritus of the University of Waterloo Department of Biology and has served on the editorial board of a number of scientific publications and an expert advisory panel to the World Health Organization. His specialty is freshwater ecology, a subject on which he has published widely.

JOSEPH F. KOONCE

Dr. Koonce received his Ph.D. in zoology with a minor in Water Chemistry in 1972 from the University of Wisconsin at Madison. From 1972-1973 he was assistant scientist at the Institute for Environmental Studies, University of Wisconsin; from 1973-1978 he was assistant professor, Department of Biology, Case Western Reserve University and in 1978 became associate professor in that department. He served on an NRC Advisory Panel on Ecosystem Analysis to the National Commission on Water Quality 1974-1976.

JAMES KRAMER

Dr. Kramer was educated at Massachusetts Institute of Technology (B.Sc.) and the University of Michigan (M.Sc. and Ph.D.) in the field of geology. He is currently at McMaster University; previously he was at Syracuse University, the U.S. Geological Survey and the University of Western Ontario. He has worked on the chemistry and geochemistry of the Great Lakes, asbestiform minerals in Lake Superior, sorption of trace metals on mineral surfaces, and at present, the modeling of small watersheds.

ANDRE MARSAN

President of Andre Marsan and Associe Inc., Dr. Marsan received his B.A. Sc., in chemical engineering from Ecole Polytechnique, University of Montreal in 1960. He obtained his M.Sc. and Ph.D. in chemical engineering in 1962 and 1966, respectively, from the University of Birmingham, England. Since 1973 he has been with Marsan and Associe and is responsible for company management as well as assessment of environmental impacts of a wide range of industrial projects including oil tanker ports, petrochemical plants, and hydroelectric projects.

CLIFFORD MORTIMER

Dr. Mortimer received his B.S. in 1932 and D.Sc. in 1946 from the University of Manchester and his Dr. Phil. in zoology from the University of Berlin. He is a Distinguished Professor emeritus at the University of Wisconsin-Milwaukee, where he directed the Center for Great Lakes Studies 1966-1979. He is a member of the International Association of Great Lakes Research (president 1973-1974). His research areas are in physics, biology, and chemistry of lakes and oceans, in particular water motion in large basins and coastal marine waters.

DONALD J. MUNTON

Dr. Munton is director of research at the Canadian Institute of International Affairs. He was previously a member of the political science department of Dalhousie University in Nova Scotia and has graduate degrees from University of British Columbia and Ohio State University. Most of his academic research has been on international politics and U.S.-Canadian relations, particularly on environmental issues such as Great Lakes water pollution and acid precipitation. He is currently writing a book on the negotiation of the 1972 and 1978 Great Lakes Water Quality Agreements.

WILLIAM SONZOGNI

Dr. Sonzogni received his Ph.D. in water chemistry from the University of Wisconsin in 1974. From 1974 to 1980 he was director of Scientific and Technical Assessment, Great Lakes Basin Commission. He was also head of the Special Projects group at the Great Lakes Environmental Research Laboratory at NOAA from 1980-1983. At present Dr. Sonzogni is associate professor and chief, Environmental Sciences Section, State Laboratory of Hygiene, at the University of Wisconsin-Madison.

JOHN STOLZENBERG

Dr. Stolzenberg received his Ph.D. in environmental studies from the University of Wisconsin-Madison in 1975. He has been with the Wisconsin Legislative Council since 1975. He supervises the science component of the Legislative Council staff; co-staffs the Council's Special Committee on Telecommunications. He also staffs the Senate Energy and Environmental Resources Committee and the Assembly Committee on Economic Development. His major projects at the Legislative Council relate to control of acid rain, management of low-level radioactive waste, development of an air pollution permit program, and solid- and hazardous-waste management.

EDITH BROWN WEISS

Dr. Weiss received her L.L.B. in 1966 from Harvard and her Ph.D. in 1973 from the University of California at Berkeley. She was an assistant professor of civil engineering and politics at Princeton from 1974 to 1978. Dr. Weiss has been an associate professor of law at Georgetown University in Washington, D.C., since 1978. She is vice-chair of the U.S. National Committee for SCOPE and was a member of the NRC Environmental Studies Board (1981-1984) and the NRC study on intergovernmental climate programs. Her interests include environmental law, international law, and water resources law. Dr. Weiss is also a member of the NRC's Water Science and Technology Board.