GREAT LAKES RESEARCH ADVISORY BOARD

ANNUAL REPORT TO THE INTERNATIONAL JOINT COMMISSION

PRESENTED
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SUMMARY

During the period that the Great Lakes Water Quality Agreement has been in effect, the Governments of Canada and the United States have worked in a spirit of close cooperation to try to achieve the ultimate goal of this Agreement – to restore and enhance the water quality in the Great Lakes. The Research Advisory Board, which was created under the Agreement as principal scientific advisor to the Commission on Great Lakes water quality, has in this report synthesized and incorporated its past activities within an overview of three critical Great Lakes concerns.

A. Water Quality and the Great Lakes Ecosystem

The Board is concerned about the limited scope by which the Great Lakes are planned and managed. Planning and management of such a priceless resource as the Great Lakes require more than a knowledge of chemical and physical water quality; they require an understanding of the total ecosystem and the diverse interactions which occur within its chemical, physical, biological and societal components. As a result, the Board urges that the Great Lakes be evaluated on the broader concept of "ecosystem quality". To aid in the understanding of the ecosystem and subsequently in the formulation of sound resource management decisions, the Board endorses the development of environmental maps which would display appropriate ecosystem parameters. The results of a workshop on environmental maps for the Great Lakes are discussed.

Following the Board's brief overview of the Great Lakes ecosystem, several initiatives are suggested for the Commission and its institutions formed under the Agreement.

B. Phosphorus Limitation

The Board has examined various facets of phosphorus control programs and eutrophication in the Great Lakes. The eutrophication models, used previously by the Water Quality Board to provide information on the possible range of water quality responses to various nutrient input conditions, were evaluated by one Committee of the Research Advisory Board. The preliminary results of the evaluation are discussed in this report. Also the findings of two Task Forces, initiated by the Board, on the health implications and ecological effects of NTA, a phosphorus detergent builder substitute, are presented.
The report also discusses the results of a computer model simulation of costs for 44 municipal wastewater treatment plants within the Great Lakes Basin to achieve various phosphorus concentrations in effluents under different detergent limitation scenarios. The simulation determined the relative costs of achieving levels of 1.0, 0.5, 0.3 and 0.1 mg P/l assuming various restrictions on phosphorus in detergents. Brief discussions follow on innovative sludge disposal techniques, wastewater treatment processes, and operation of wastewater treatment plants. On the basis of the overview, several relevant recommendations are presented.

C. Toxic Substances

The problems associated with toxic substances in the Great Lakes were assessed and some possible courses of action that may lead toward the resolution of major problems were identified by the Research Advisory Board. The Board brings to the attention of the IJC: the large lag between input and equilibrium in the Great Lakes, indicating that it may be years before concentrations of toxic substances are large enough to be detected by existing analytical methods; the virtual lack of knowledge on the metabolism or breakdown of toxic substances in the Great Lakes; the question of the permanency of toxic materials in the sediments and whether these residues can be safely ignored or considered as potentially biologically available; the need for more distinct identification of contaminants and the quantities that are being discharged to the Great Lakes; and the capabilities of current analytical methodology to detect chemical contaminants in the waters.

Several specific Board activities with regard to toxic substances are discussed, including: the determination of organic chemical residues in tissues of people from the Great Lakes Basin; the development of an inventory of chemicals used, manufactured and/or discharged to the Great Lakes; prediction of which chemicals in the inventory may be problem chemicals within the Great Lakes; and, evaluation of the significance to human health in the consumption of Great Lakes fishes which contain several to many chemical residues.
The Great Lakes Research Advisory Board recommends that the Commission:

A. Water Quality and the Great Lakes Ecosystem

1. recognize that the degradation of the Great Lakes must not be evaluated on just "water quality", but also on all aspects of the lakes' ecology. Furthermore, the Research Advisory Board believes that continued emphasis on "water quality" will be to the detriment of the eventual restoration of the lakes and therefore urges the IJC to adopt the broader concept of "ecosystem quality";

2. encourage the Parties to the Agreement to initiate environmental mapping of a sub-area of the Great Lakes to determine the cost/benefits, the potentials, and the liabilities of such an effort, as a basis for future mapping;

3. articulate the specific goals of the Parties for and the desired uses of the Great Lakes so that more direct efforts can be formulated to reach these expectations.

B. Phosphorus Limitation

1. encourage additional efforts to remove phosphorus, even if more stringent regulations on phosphate levels in detergents are implemented;

2. urge the Governments to improve treatment plant operations by increasing operator training, increased monitoring of plant operations, consideration of economic incentives, and through public education and pressure;

3. initiate studies through the IJC institutions to identify the most cost-effective programs for reducing phosphorus loadings by examining the potential control of other sources such as urban run-off and agricultural drainage and as well examine lower cost alternatives for municipal discharges;

4. urge Great Lakes surveillance efforts to be in part directed towards the provision of adequate data to enable development and verification of improved eutrophication models;

5. bring to the attention of the United States and Canadian Governments the Board's report on the health implications of NTA and the Board's conclusion that on the basis of health hazard there is no reasonable cause for restricting the use of NTA as a replacement for phosphate in detergents in the Great Lakes Basin.
B. Toxic Substances

1. urge all jurisdictions to develop loading data for each lake for toxic substances which will aid in obtaining accurate mass balances for these substances;

2. urge the Governments to adopt water quality objectives for metals on the basis of total concentrations of each metal in water, and ensure that the objectives are conservative with a reasonable margin of safety due to the potential interconversions of the metals to hazardous forms;

3. urge Governments to undertake studies to determine the exchange of persistent toxic materials between air, water, sediment, and biota;

4. request from jurisdictions more complete information on toxic or potentially toxic chemical substituents of complex effluents, especially for discharges from installations using or making many types of chemicals;

5. urge jurisdictions to assure appropriate funding for expanded fish tissue monitoring programs for toxic chemicals;

6. urge jurisdictions to support increased research to develop better analytic methods for toxic organic chemicals;

7. ask the Governments to assure that agencies with responsibilities for toxic substances control, be guaranteed access to precise information (IUPAC name, quantities, etc.), for all chemicals currently in use.
The Great Lakes Water Quality Agreement has been in effect for a period of five years. During this period, Governments have worked in a spirit of close cooperation to achieve the ultimate goal of this Agreement — to restore and enhance water quality in the Great Lakes.

The Research Advisory Board, in this Annual Report, emphasizes the need to address water quality issues in a holistic manner with a broad perspective which incorporates many different disciplines such as chemistry, physics, biology, sociology and economics, and has structured this report accordingly.

This report addresses three critical Great Lakes issues: toxic substances; phosphorus limitation; and, water quality and the Great Lakes ecosystem. The holistic approach utilizes as its components, the previous activities of the Research Advisory Board, such as workshops and task force deliberations. Following an overview of each of the three issues, the Research Advisory Board as scientific advisor to the Commission, provides recommendations to the Commission which could aid in future management decisions related to the issues.
Within the 1972 Great Lakes Water Quality Agreement, the Governments of Canada and the United States agreed to develop and implement programs and other measures to restore and enhance the water quality in the Great Lakes System. Extensive surveillance programs have been undertaken since to evaluate the progress of the Agreement. These programs have stressed predominantly chemical and physical water quality parameters. Planning and management of such a priceless resource as the Great Lakes requires more than a knowledge of the chemical and physical water quality; it requires an understanding of the total ecosystem and the diverse interactions which occur within its chemical, physical, biological and societal components (Figure 1). Although water quality is a part of such an understanding, by itself it can be misleading and can hinder us from achieving the full understanding required for effective management and restoration of the lakes.

Figure 1. The Great Lakes – An Ecosystem Perspective
Consider, for example, nutrient inputs and their effects, to which an enormous amount of attention has been given over the past decade. These inputs have presumably resulted in effects such as increased growths of algae in Lake Erie including *Cladophora* and a consequent depletion of deep water oxygen. However, other effects possibly had their roots elsewhere. It has been suggested for example, that eutrophication of the lakes has probably been much less of a factor in the changes of the Great Lakes fish species composition than have either overfishing or the influence of such exotic species as the sea lamprey and alewife. It has been suggested to the Board that the changes in fish species composition, while not resulting from eutrophication, may themselves be responsible for increases in algal abundance. The changes in fish community structure have left the lakes with large numbers of such fish as rainbow smelt and alewife. These fish to a large degree feed primarily on zooplankton and their abundance is therefore likely to have a negative effect on the numbers and sizes of the zooplankton. Because zooplankton consume algae, and algal abundance results from a dynamic balance between growth and consumption, this reduction in herbivorous zooplankton might have been responsible for the increases in algae.

That is, the following simplified scenario could have potentially occurred within the Great Lakes:

1. increases in lamprey which are parasitic to fishes such as lake trout;
2. decreases in lake trout the larger of which are almost entirely piscivorous (feed on smaller fish);
3. increases in alewives which feed primarily on zooplankton;
4. decreases in zooplankton which consume algae;
5. increases in algae.

Thus, the result (increases in abundance in algae) could have resulted from either or both of two causes: an increase in the supply of nutrients or a change in the trophic structure of the biota.

The Board draws attention to this plausible sequence to illustrate the need for an appreciation of the many inter-relationships operating within the ecosystem. The above sequence represents only a small fraction of the immense system which is composed of interacting chemical, physical, biological and societal components. Management of the Great Lakes ecosystem must combine holism with reductionism if it is to succeed (reductionism is the consideration of individual segments such as nutrient/algal growth). The success or failure of the Great Lakes Water Quality Agreement in restoring and enhancing Great Lakes water quality hinges on whether or not governments at all levels are able to understand and ascertain the real impact and environmental significance of changes within the system.

To aid in the planning and management of the Great Lakes, the Research Advisory Board has undertaken various activities which will contribute to an understanding of the Great Lakes' ecosystem. Furthermore, the Board through its Task Force on Scientific Basis for Water Quality Criteria has considered a technique to display appropriate ecosystem parameters by which sound resource management decisions might be formulated. The technique is the use of environmental mapping.
ENVIRONMENTAL MAPPING

In 1976, the Task Force on the Scientific Basis for Water Quality Criteria of the Research Advisory Board sponsored a workshop to evaluate the possibility of developing environmental maps for the Great Lakes which could be used to improve the understanding of the complicated Great Lakes ecosystem and aid the conservation and rehabilitation of its essential elements. Environmental maps are essentially "snapshots-in-time" of an ecosystem whereby such parameters as fish distribution, spawning grounds, lake circulation patterns, cultural development and activities, chemical qualities, wildlife distribution, etc. are displayed. Such maps have been produced for the Chesapeake Bay, the New York Bight, some rivers in Great Britain and to a limited extent, the Lower Great Lakes. The efforts have all had specific purposes which included: contingency planning; illustration to the public of existing situations such as extent of shoreline erosion, fishless rivers, overcrowding and conflicting uses, and water quality; design of research and surveillance efforts; identification of habitats which must be protected, preserved or restored; selection of management objectives; evaluation of environmental impact; understanding of trends; and, future planning.

The workshop concluded that environmental mapping holds promise in aiding governments in restoring and enhancing the Great Lakes. The most common identified broad applications of environmental maps were:

1. impact minimization (e.g. site selection, waste treatment controls, load limitations, dredging operations, mixing zone determinations, preparation of environmental impact statements);

2. rehabilitation (e.g. the historic changes and future projections will provide guidelines for rehabilitation of excessively degraded areas);

3. conservation and preservation (e.g. development of sanctuaries, protection of fish stocks);

4. resource management (e.g. renewable resources could be better defined and managed for optimum sustained yield, water supplies and recreational facilities would be better protected, wetlands could be better defined and protected);

5. development of increased support for good management decisions (e.g. the public will be better informed concerning the environment and why certain actions are proposed).

High priority information for inclusion in an environment mapping effort on the Great Lakes was defined, and it was determined that considerable information is presently available to initiate the immediate development of such maps. During the workshop several participants expressed concern that such mapping might be used to the detriment of the lakes. Their reason was that once certain areas were designated as less significant or valuable, this in effect would be license for further degradative uses. This clearly is not
the intent of the mapping which is to improve the ecological understanding and to protect ecologically sensitive areas. The majority of the participants felt that this misuse could be prevented. Thus, the Board endorses the development of environmental maps which can aid in formulating sound resource management decisions, in informing and involving the public concerning the conservation and protection of the Great Lakes ecosystem, and in advancing our scientific knowledge of its status.

The Board is concerned with the inconsistencies within jurisdictions by which mixing zones (or areas of non-compliance) are designated in the Great Lakes, sometimes without regard to existing biological, chemical and physical conditions. The Board sees no existing alternative mechanism to environmental maps, by which sizes, shapes and locations of mixing zones can be designated with minimum impact to the environment. The Board's Task Force on Scientific Basis for Water Quality Criteria is therefore proceeding to develop draft guidelines and a working example for the allocation of mixing zones on a water body basis.

FUTURE "ECOSYSTEM" INITIATIVES FOR GREAT LAKES WATER QUALITY

SUGGESTED INITIATIVES FOR THE INTERNATIONAL JOINT COMMISSION

In a response to a recommendation by the Research Advisory Board, the International Joint Commission in 1976 assisted in the support of an international symposium to evaluate those factors which contribute to the maintenance of natural healthy populations of percid fish species such as perch, sauger and walleye. The symposium was of great interest to the Commission because in part, the symposium addressed the possible role of water quality to the declining percid fish stocks in some Great Lakes areas as well as the virtual extinction of the "blue pike", a previously major commercial fish in the Lower Great Lakes.

The conclusions of the symposium when available in late 1977, will be evaluated by the Research Advisory Board with regard to future water quality management of the Great Lakes. Furthermore, continuing liaison between the International Joint Commission and the Great Lakes Fishery Commission will be required, as "water quality" and the "fisheries" cannot be separated into distinct management strategies.

SUGGESTED INITIATIVES FOR THE GREAT LAKES WATER QUALITY BOARD

Understanding of the Great Lakes ecosystem necessitates an indepth knowledge of the present chemical, physical and biological characteristics of the waters. In its 1975 report to the IJC, the Great Lakes Water Quality Board proposed an International Great Lakes Surveillance Program to "provide the information required to identify water quality issues and to assess achievement of water quality objectives". The Research Advisory Board notes that there is still not adequate funding to support this internationally coordinated program. Portions of the program which require additional support include the evaluation of nearshore areas of the Great Lakes and biological monitoring.
It is important to note that nearshore areas represent the most critical areas of ecological concern for they contain the greatest diversity of aquatic biota and are the areas which receive the direct impact of pollution. Furthermore, these areas are most highly utilized by man for purposes such as fishing, recreation and water supply.

With regard to the biological component of the International Great Lakes Surveillance Program, the Board recognizes that many of the existing, new and revised water quality objectives are based on the protection of aquatic life in the Great Lakes. It is difficult for the Research Advisory Board to comprehend how compliance with the objectives and adequacy of the objectives can be assessed without an appropriately funded biological monitoring program. The Board emphatically endorses the need for improved biological information to complement chemical monitoring programs in the Great Lakes.

ANTICIPATED INITIATIVES FOR THE RESEARCH ADVISORY BOARD

In the past five years within the Research Advisory Board there has been a sharpening of focus which has lead to the recognition of the need for an ecosystem integrity approach for assessing and managing environmental quality of the Great Lakes. The workshops sponsored by the Board have contributed significantly to this awareness. For example, in two previous Research Advisory Board workshops on lake dynamics, the large time scale for retention of pollutants was illustrated, indicating the possibility of considerable time lags before any effect is noted due to improved remedial measures. Techniques were discussed which would enable the development of circulation models to predict the direction, fates and rates of dispersal of introduced materials. A Board workshop on the alga *Cladophora* in the Great Lakes: showed that it existed in Lake Superior in immense quantities as early as 1871; described its distribution, physical and chemical requirements; reviewed control measures and its economic impact to the Great Lakes; and reviewed existing knowledge of the relationship of *Cladophora* to the quantities of invertebrate species produced and fish species benefiting therefrom. Early in 1975, the Board also sponsored a workshop which evaluated techniques in obtaining public involvement within political and management decisions relating to water quality. In the future, the Board anticipates undertaking similar projects which will further expand the knowledge of various facets of the Great Lakes ecosystem.

It is most essential that the Research Advisory Board and Water Quality Board work closely together to continually evaluate the changing physical-chemical-biological-societal components of this ecosystem to assure appropriate and timely management decisions. With the greatly increasing costs of remedial programs to meet the increasing numbers of water quality objectives which have resulted from increasing scientific sophistication, it becomes necessary to have supportive information to justify such expenditures in common sense and accurate terms which legislators, administrators, polluters and users can relate to and understand.
RECOMMENDATIONS

The Great Lakes Research Advisory Board recommends that the Commission:

1. recognize that the degradation of the Great Lakes must not be evaluated on just "water quality", but also on all aspects of the lakes' ecology. Furthermore, the Research Advisory Board believes that continued emphasis on "water quality" will be to the detriment of the eventual restoration of the lakes and therefore urges the IJC to adopt the broader concept of "ecosystem quality";

2. encourage the Parties to the Agreement to initiate environmental mapping of a sub-area of the Great Lakes to determine the cost/benefits, the potentials, and the liabilities of such an effort, as a basis for future mapping;

3. articulate the specific goals of the Parties for and the desired uses of the Great Lakes so that more direct efforts can be formulated to reach these expectations.
The control of phosphorus inputs to the Great Lakes is one of the major activities under the Great Lakes Water Quality Agreement. The institutions under the IJC have placed emphasis on: point source control by the one milligram per liter phosphorus limitation placed on effluents from large municipal wastewater treatment plants in the Lower Great Lakes Basin; reducing the phosphorus content of detergent formulations; and, evaluation of nonpoint source discharges and their possible remedial measures.

The Research Advisory Board has undertaken an in-depth analysis of phosphorus and its various control strategies in the Great Lakes from a research point of view. The Board has worked within a conceptual overview to address many concerns which will hopefully aid in the formulation of appropriate management decisions with regard to phosphorus and as well define areas for further research if necessary. The recent activities of the Board have focussed on the facets of the conceptual approach illustrated in Figure 2.

Figure 2. Conceptual approach undertaken by Research Advisory Board to address phosphorus control in the Great Lakes.
LAKE RESPONSE AND AVAILABILITY

In its 1974 report to Governments, the IJC stated that "the ultimate assessment of the effectiveness of phosphorus reduction programs must be made in terms of the changes in algal biomass in the Great Lakes". The Commission further indicated that "current open lake conditions result from phosphorus loads that entered the lakes years ago". In the case of Lake Ontario lake response times of 15-20 years were indicated, while in Lake Erie the impact on open lake algal biomass might be evident from three to five years after phosphorus loadings have changed.

The above observations are based on one particular eutrophication model which was developed to aid in water quality management, planning and decision-making. Accurate models are required to provide managers with information on the possible range of water quality responses to various input conditions to aid in the formulation of planning strategies for phosphorus reductions to the environment. Furthermore, the models could explain to the public when the results of the large expenditures on remedial measures would become apparent.

The Water Quality Board in its 1975 report to the IJC presented the results of two Lake Ontario mathematical model studies. Both models relate phosphorus input to concentrations of chlorophyll a (as representative of phytoplankton biomass). It was noted in the Water Quality Board report that one model predicted "peak chlorophyll levels may increase under the Water Quality Agreement load reductions" and, "substantial load reductions must be accomplished in the next ten years to prevent an increase in present biomass levels". The other model predicted "that conditions comparable to 1966-67 should exist" although it was not currently "possible to show a trend toward a more oligotrophic condition". The Water Quality Board therefore recommended that "continued support be given to the development of lake effect models".

The Research Advisory Board recognizes the importance of such models in developing pollution abatement strategies. Furthermore, the Board is aware of the many assumptions which are inherent to the development of such models as well as the conflicting interpretations that have resulted from these models. The Board therefore assigned its Expert Committee on Ecosystem Aspects to provide an up-to-date review of the assumptions and conclusions of the eutrophication model upon which the Commission based its 1974 report to Governments and to clarify if necessary the results on the model studies reported in the 1975 Water Quality Board report.

A final report on the Committee's evaluation of the eutrophication models is expected later this year. Based on recently available chlorophyll a trend information, the Committee's preliminary assessment suggests that an optimistic kinetic response of Lake Ontario may be a realistic expectation. From this preliminary assessment, it appears that the time estimate for Lake Ontario to achieve 95% of equilibrium in response to a phosphorus loading change may be in the order of eight years rather than the previously predicted 15-20 years.
To aid in the verification and further development of models, additional information such as synoptic data on nutrient and chlorophyll \( \alpha \) levels may be required. The Research Advisory Board encourages frequent communications, intercalibration of methods and an interchange of relevant data between U.S. and Canadian modellers and experimentalists, to assure that such information is obtained from current Great Lakes surveillance efforts. The Board notes that with such eutrophication models, many of the verified assumptions could potentially be used to develop other environmental effect models which could, for example, predict the fate and possible effects of toxic persistent compounds within the Great Lakes.

One major question which has not been resolved but is essential to the development of an eutrophication model is an understanding of biological availability of phosphorus entering the lakes. Predominantly, phosphorus enters the lakes from tributaries and nonpoint sources adsorbed to or included in suspended inorganic particles. In lakes it would be in a mixture of: dissolved inorganic and organic forms; that incorporated in living or dead organisms; and, that associated with the lake sediment. There is presently no general agreement among scientists concerning the forms of phosphorus which are biologically available. Analysis for phosphorus is currently based on such parameters as "total phosphorus", "molybdate reactive phosphorus", and "soluble unreactive phosphorus", all of which tell very little about its biological availability. At a workshop, sponsored by the Research Advisory Board on nutrient and contaminant transport by sediments, this concern was reiterated. The Board foresees the need to review possible methods for determining biological availability of phosphorus and notes that little attention has been given to a bioassay method recommended at its Cladophora workshop in 1975.

EVALUATION OF AN ALTERNATIVE TO DETERGENT PHOSPHORUS BUILDERS - NTA

With phosphorus acknowledged as the nutrient which limits algal growth, one of the programs under the Agreement to control the input of phosphorus is directed towards the reduction of "phosphorus content of detergents, the amount of detergent used and replacement of phosphorus compounds in detergents by less harmful substances as soon as possible".

A ban or limitation on phosphorus in detergents will require alternative builder compounds. Concern has been expressed in both countries over the potential health and environmental effects which might result with the use of such alternate substances. Prior to 1970, sodium nitrilotriacetate (NTA) by virtue of its chemical properties as a builder and its cost was considered as a likely substitute, but little was known about its other properties such as environmental and health effects, and behaviour in the environment. By 1970, sufficient NTA was used in both countries and studies were implemented to examine drinking, river and lake water for NTA.

In December 1970, in response to concerns expressed by the Surgeon General of the United States Public Health Service, the major detergent manufacturers in the U.S. voluntarily discontinued the use of NTA pending further study and evaluation of the potential hazard to human health.
Although NTA is not used in U.S. detergent formulations, it has various other industrial uses and currently NTA consumption in the United States is estimated to be 10 million pounds annually.

In January 1975, the Canadian Government after due consideration, further lowered the maximum phosphorus levels in detergents from 20% to 5% (as P₂O₅). A large part of the phosphorus reduction has been made up through NTA substitution. In early 1972, industry-wide NTA content in detergents averaged 6% and in 1975, 250 million pounds of detergents were purchased with an average NTA content of 15%. It has been estimated that the current annual consumption of NTA in Canada is 60 million pounds.

Noting that the 1975 Annual Report of the Water Quality Board to the International Joint Commission recommended that all Great Lakes States should impose phosphorus limitations on detergents sold in the basin; that the Surgeon General's concerns of 1970 are still being observed in the United States; and that the details of new studies have recently been made available, the Research Advisory Board appointed two task forces: one to evaluate the health implications of NTA and another to evaluate the ecological effects of non-phosphate detergent builders. The task force chairmen, who are also members of the Board, were instructed to try to obtain the best possible expertise for their task forces. Current data were also received from groups such as the Soap and Detergent Associations of Canada and the United States, as well as from researchers associated with leading detergent manufacturers and various United States and Canadian Government agencies. The Board expresses its gratitude to the industrial representatives for their openness in providing the task forces with unpublished and privileged working documents and research findings.

HEALTH IMPLICATIONS OF NTA

The Task Force with the responsibility to address this topic carefully reviewed the reports upon which the Surgeon General's concerns were expressed and also reviewed the Progress Report on the Canadian Monitoring Program and the results of animal feeding studies by the National Cancer Institute and the National Institute of Environmental Health Sciences which were recently made available.

On the basis of its review, the Task Force concluded:

1. There is no evidence that NTA has any teratogenic (i.e. developmental malformations and monstrosities) or mutagenic (i.e. changes in hereditary material affecting chromosome relations) potential either alone or in combination with heavy metals. NTA did not show any compound-related effects on reproduction, fetal survival, or neonatal (i.e. affecting the newborn during the first month after birth) viability.

2. NTA single dose acute and subacute toxicity are very low and comparable to that of sodium tripolyphosphate which it would replace in detergent formulations.
3. The only concern of exposure to NTA of the population at large or of occupationally exposed persons, stems from findings of carcinogenesis of the urinary tract of rats and mice given large doses of NTA over their lifetimes.

The three recent carcinogenicity studies on rats and mice utilized doses of: sodium NTA from 200 to 20,000 ppm in diet; sodium NTA and acid form NTA at 5,000 and 15,000 ppm in diet; and, acid NTA at 1,000 ppm in drinking water. It was concluded that the principal human exposure to NTA is by drinking water and a report of the Canadian Monitoring Program puts public water supply levels at 10 ppb with an occasional maximum of 50 ppb (96% of all samples contained less than 25 ppb). With statistically significant tumor incidence in the kidney and urinary tract in all three rat and mice carcinogenicity studies, the Task Force then attempted to extrapolate from the high doses given to animals to the low doses to which humans may be exposed.

4. Such extrapolations or algorithms are extremely complex and provide only estimates of environmental risk. The complexity is in part a result of the metabolic differences between the test rodent species and man. For example, NTA is readily absorbed by the rat, mouse or dog, but poorly absorbed within the intestinal tract of monkey or man. Also the chemical speciation of the compound used in laboratory tests may differ from that to which humans may be exposed. The estimate of maximum risk for the environmental doses found by the Canadian Monitoring Program are generally within an order of one possible incident of tumor formation due to NTA per 2 million population.

5. To aid in the understanding of the significance of the above risk assessment, the Board requested comparisons with carcinogenicity data of compounds in common use. However, it was soon recognized that the error in risk assessment from high dose in animals to low dose in humans is much greater than the difference in the potential for tumor production of the materials under test and it is difficult to make relative comparisons of risks between materials.

ECOLOGICAL EFFECTS OF NTA

A Task Force was formed to evaluate the ecological effects of all non-phosphate detergent builders. However due to the immediacy of the problem and current usage in Canada, the environmental implications of NTA were given initial consideration. Other detergent builders will be evaluated in late 1977. In addressing NTA, the Task Force critically evaluated both the published and non-published literature available in government, industry, and private institutions. In addition, selected known experts in NTA research were consulted on their respective research findings.

The Task Force reached the conclusion that there is nothing in the literature or from the Canadian experience to indicate that the use of NTA would constitute an obvious environmental hazard. The members did, however, express concern over certain gaps in knowledge of the behaviour
of NTA. As a result, the Task Force recommended: that NTA not be prohibited from continued use in Canada; and if it is put into widespread use in the U.S. and the Great Lakes Basin, studies be conducted during the first five years on the aspects listed below, and the results of these studies be used as a guide to the continuing usage of NTA.

(1) Under aerobic biological wastewater treatment regimes and in most circumstances in fresh water systems, NTA degrades rapidly. However the Canadian monitoring experience did reveal that low concentrations of NTA may be found in the aquatic environment. The Task Force felt that the forms in which NTA exists at these low concentrations should be investigated.

(2) Degradation of NTA in marine and estuarine systems appears to be very slow. The Task Force felt that because of the versatility of microorganisms, it is likely that NTA will not remain in such systems. Further study is required however.

(3) No investigations have been conducted to determine the concentrations of NTA in anaerobically digested sludges. Canadian studies have shown that in primary treatment, about one third of the NTA appears to be settled out with the sludge. Because sludge is frequently deposited in the sea and on land, investigation is necessary.

(4) Review of the literature indicates that acute toxicity to aquatic organisms resulting from environmental concentrations of NTA is unlikely. Similar studies on chronic toxicity suggest the same. Elucidation of the mode of toxicity at higher concentrations would allow a better evaluation of the likelihood of chronic toxicity to organisms not specifically tested.

(5) Although NTA degrades rapidly in most aerobic environments, studies on its ability to degrade during anaerobic waste treatment or under anaerobic environmental conditions are inconclusive. The Task Force feels the question needs further study.

(6) NTA does not solubilize and transport heavy metals to an appreciable extent under most circumstances. However, the Task Force felt that its behaviour in systems of high inorganic turbidity and/or high metal content needs investigation.

(7) Although NTA does degrade in aerobic wastewater treatment systems, the Task Force felt that its behaviour in physical-chemical treatment processes which is unknown needs elucidation.

(8) NTA degradation has been studied at intermediate pH values (5-9) and at temperatures in the low to moderate range. The behaviour of NTA at low and high environmental pH values and at temperatures expected in thermophilic waste treatment processes should be evaluated.
(9) NTA is not expected to increase eutrophication by providing nutrients from its decomposition. Furthermore, most experiments with simple systems indicate that it does not stimulate algal growth. However, long term studies using whole ecosystems have not been performed to the extent of satisfying the Task Force that NTA will not cause significant changes in aquatic community structure. Such experiments are necessary.

The Task Force also reported to the Research Advisory Board that many studies in the above area had been initiated at one time or another. However, due to the lack of appropriate long range planning by various research agencies, some projects which indicated promising results but required additional funding were not extended to allow their completion.

PHOSPHORUS REMOVAL

ASSOCIATED COSTS

Even if phosphorus were completely removed from detergents, municipal wastewater treatment plant effluent will still be a source of phosphorus because detergents are not the only contributors. Fecal phosphorus discharge per person per year is estimated to be 0.5 kilograms, an amount equivalent to that which would be discharged (per person per year) with the use of detergents containing 5.6% phosphorus. Therefore much emphasis has been placed on phosphorus removal at municipal wastewater treatment plants in addition to detergent phosphorus limitations and/or bans.

A study was undertaken to aid the Board's Task Force on Water and Wastewater Treatment to evaluate, in a rigorous manner as practical, the implications of alternative legislative restrictions on the allowable concentrations of phosphorus in laundry detergents and in the effluents of municipal wastewater treatment plants, and on the costs of building and operating these plants. A contract was awarded to develop, utilizing computer model simulation technology, the relative capital and operating costs for various phosphorus removal strategies at 44 major municipal wastewater treatment facilities in the Lake Erie and Lake Ontario drainage basins.

Computer models, such as that used in this study, provide an excellent means to compare on a consistent basis the relative costs of various phosphorus control strategies. However, the actual costs for any part or all of a specific program may be considerably different from those predicted by the computer model due to factors which have not been included in the model and/or local conditions which vary significantly from the average values for design parameters and unit costs used in the program. This study provided a capability to comprehensively assess the overall costs of various alternatives. The methodology and results of this study have not been reviewed by the Board's recently formed Expert Committee on Engineering and Technological Aspects but will be in the forthcoming year.

The phosphorus control strategies evaluated included various combinations of laundry detergent phosphorus limitations and final effluent requirements.
The treatment alternatives and costs were evaluated assuming (1) no detergent phosphorus content limitation, (2) present limitations in the various jurisdictions, and (3) a complete ban on phosphates in the detergents utilized in the Great Lakes Basin (i.e. 0.5% by weight of total phosphorus as P). For each of the above detergent phosphorus limitation scenarios, several alternative wastewater treatment options and their costs were determined for each municipality to achieve various effluent phosphorus concentrations (e.g. 1.0, 0.5, 0.3 and 0.1 mg P/l, as well as no P limitation).

In addition the amount of phosphorus discharged to the Great Lakes system under each of the assumed conditions was computed. The simulation indicated that the banning of phosphorus in detergents would have saved an estimated 25% of the additional capital, operating and maintenance costs which are required to achieve 1.0 mg P/l compared to the costs associated with no detergent controls in effect. This estimate is based on a detergent phosphorus content of 12.9% which was indicative of phosphorus limitations prior to 1972. The current detergent phosphorus levels are significantly lower because of limitations or bans in some jurisdictions in the basin. The economic benefits accruing from banning phosphorus detergents are largely the result of reduced operating costs. The relative costs to achieve effluents with 1.0, 0.5, 0.3 and 0.1 mg P/l assuming "past", "present" and "ban" conditions for restrictions on phosphorus in detergents are presented in Table 1.

### Table 1

RELATIVE TOTAL COSTS TO 2001*

(BOTH LAKE BASINS - ALL JURISDICTIONS)

<table>
<thead>
<tr>
<th>Phosphorus Effluent Limitations</th>
<th>Uncontrolled &quot;P&quot;</th>
<th>1.0</th>
<th>0.5</th>
<th>0.3</th>
<th>0.1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mg/l</td>
<td>mg/l</td>
<td>mg/l</td>
<td>mg/l</td>
<td>mg/l</td>
</tr>
<tr>
<td>No detergent controls</td>
<td>1.0</td>
<td>1.26</td>
<td>1.37</td>
<td>1.70</td>
<td>3.99</td>
</tr>
<tr>
<td>Present Controls</td>
<td>1.0</td>
<td>1.22</td>
<td>1.30</td>
<td>1.63</td>
<td>3.99</td>
</tr>
<tr>
<td>Ban on &quot;P&quot; in detergents</td>
<td>1.0</td>
<td>1.19</td>
<td>1.26</td>
<td>1.57</td>
<td>3.99</td>
</tr>
</tbody>
</table>

*Relative costs based on unity representing total costs (Capital, Operating and Maintenance) with "P" Removal.
The total simulated treatment costs to achieve certain alternative phosphorus load reductions are shown in Figure 3. Under present detergent phosphorus limitations, significant reductions in load are predicted for a moderate increase in total cost with an effluent limitation of 1.0 mg P/l. Under present detergent formulations, achieving 1.0 mg/l effluent P in all the plant studies would impose additional operating and maintenance costs of 31% over those incurred without phosphorus removal. A capital cost increase of 5% would also occur relative to the cost of sewage treatment without phosphorus removal. It can be noted that the cost of achieving 1.0 and 0.5 mg P/l are of the same order of magnitude.

The Board's interpretation of the study indicates that while it is technically feasible to achieve effluent phosphorus levels less than 0.5 mg/l, the relatively high costs of doing so indicates that means of reducing other inputs or developing lower cost point source technology should be considered. The information on costs developed here provides a means for comparing the costs with those associated with reducing other inputs, to achieve water quality objectives for the Lower Great Lakes. The Board also recognizes that this study did not consider cost-effective strategies to achieve specific phosphorus loadings to the Great Lakes from municipal point sources. For example, a certain detergent phosphorus content along with low effluent phosphorus level specifications at the larger municipal wastewater treatment plants and less restrictive limitations at the smaller plants may be the most cost-effective method of achieving specific phosphorus loadings.

Attainment of a 0.5 mg/l level implies the need for precise operational controls. The addition of another unit process such as tertiary filtration may be required at specific plants that have inadequate solid-liquid separation capability due to hydraulic overload or poor design.

It is disturbing that in 1976 only nine of the 44 municipal wastewater treatment plants included in this study achieved an annual average concentration of 1.0 mg/l or less of phosphorus in their effluents. This may be due to inadequate facilities or problems with the operation of municipal wastewater treatment plants.

**EVALUATION OF PROCESSES FOR WASTEWATER TREATMENT AND SLUDGE DISPOSAL**

Recognizing that phosphorus removal efforts at wastewater treatment plants and subsequently costs of phosphorus removal as analyzed above are subject to possible limitations in current technology, the Research Advisory Board's Task Force on Water and Wastewater Treatment is undertaking a brief review of current research efforts which may lead to new municipal wastewater treatment processes. One alternative phosphorus removal process under development, with limited data currently available from pilot plant studies which would allow analyses of its economic feasibility, is the PhoStrip process. The Board's Expert Committee on Engineering and Technological Aspects will keep abreast of developments in the technology which show promise for applicability to the Great Lakes.
Note: Assuming "Present" Detergent Phosphorus Limitations

Simulated load assuming no detergent phosphorus control and phosphorus removal at municipal wastewater treatment facilities.

**FIGURE 3.** TOTAL PHOSPHORUS LOADS AND WASTEWATER TREATMENT COSTS OVER A 25 YEAR PERIOD (1975 - 2000) FOR 44 MAJOR MUNICIPAL WASTEWATER TREATMENT FACILITIES IN THE LAKE ONTARIO AND LAKE ERIE BASINS.
The Task Force is also evaluating innovative sludge utilization processes as well as innovative wastewater treatment processes which may remove nutrients while minimizing the amount of sludge to be disposed of. As well, the Task Force is reviewing existing guidelines for sludge disposal within the Great Lakes Basin, to aid in the determination of why "sludge disposal is a significant problem in the Great Lakes" (Appendix C of the 1974 Water Quality Board report). The Task Force report on guidelines for sludge disposal, and their adequacy, will be reviewed later this year by the Board and its Expert Committee on Engineering and Technological Aspects.

**OPERATION OF WASTEWATER TREATMENT PLANTS**

As noted previously, few municipal wastewater treatment plants are meeting the Great Lakes Water Quality Agreement objective of 1.0 mg P/l. With the multi-billion dollar investment of resources in the total construction and operation of such plants in the Great Lakes Basin, the Research Advisory Board in its 1976 Research Needs Report, identified as critical needs, a review of the operational efficiency of municipal wastewater treatment facilities in the Great Lakes Basin and the consideration of specific management and technical alternatives which could lead to their improved performance.

Approval for expenditure of funds for a workshop was given by the Board in February 1977 to address the concern of inadequate phosphorus removal as well as the other operational processes. However, the workshop is in abeyance, as the key regulatory agencies in Canada and United States wish the workshop to be held under their sponsorship rather than under the International Joint Commission.

After some deliberation, the Board concurred with the agencies' wishes. However, it expresses the desire that planning for the workshop be initiated without delay and that the workshop program be sufficiently broad in perspective so that appreciable and viable alternatives to existing policies and procedures of operation and maintenance will be considered. For example, extensive attention is generally given by the government agencies to operator training, while alternative management options such as centralized management or methods of inducing incentives for proper operation are infrequently considered. Economic incentives (not financial assistance) such as effluent charges, performance bonds, pricing schemes and surcharges on polluting products were discussed at a recent Board workshop on economic and legal mechanisms for achieving environmental quality objectives. Effluent charges, for example, were suggested whereby the total quantity discharged per unit time, i.e. lbs. BODs per day, in excess of maximum allowable effluent standards, would be penalized by levying a charge on the municipality, creating a financial incentive for progress in abatement technology.
RECOMMENDATIONS

The Great Lakes Research Advisory Board recommends that the Commission:

1. encourage additional efforts to remove phosphorus, even if more stringent regulations on phosphate levels in detergents are implemented;

2. urge the Governments to improve treatment plant operations by increasing operator training, increased monitoring of plant operations, consideration of economic incentives, and through public education and pressure;

3. initiate studies through the IJC institutions to identify the most cost-effective programs for reducing phosphorus loadings by examining the potential control of other sources such as urban run-off and agricultural drainage and as well examine lower cost alternatives for municipal discharges;

4. urge Great Lakes surveillance efforts to be in part directed towards the provision of adequate data to enable development and verification of improved eutrophication models;

5. bring to the attention of the United States and Canadian Governments the Board's report on the health implications of NTA and the Board's conclusion that on the basis of health hazard there is no reasonable cause for restricting the use of NTA as a replacement for phosphate in detergents in the Great Lakes Basin.
GENERAL OVERVIEW

Beginning with the occurrence of residues of the persistent chlorinated pesticides in aquatic animals including fishes and the subsequent occurrence of residues of phthalates, PCBs, methyl mercury and other organic chemicals, growing concern has been expressed on the presence of hazardous materials in the surface waters of the North American continent. Concerns for human health have caused the closure of some commercial and sport fisheries on a few Great Lakes. Warnings by various jurisdictions that certain fishes from some of the Great Lakes should not be eaten more than once a week or should not be eaten at all, have heightened the concern on the control of toxic substances in the Great Lakes Basin.

It is recognized that man frequently and deliberately exposes himself to cancer causing agents through, for example, smoking and sunbathing. However, man is further exposed to other carcinogens from his environment. For example, his diet may contain high residues of foreign chemicals especially if fish and fish-eating birds are consumed. The Environmental Contaminants Act of Canada and the Toxic Substances Control Act of the United States have been passed, with the support of many research and health specialists, in response to concerns on environmental contaminants. It is important and timely, therefore, for the Research Advisory Board to assess the toxic materials situation in the Great Lakes and identify some possible courses of action that will lead toward the resolution of major problems.

During the past two years, the Commission has been instrumental in initiating responses by the Governments to specific environmental contaminants, especially PCBs and mirex. The Commission has not been alone in its plea to identify toxic materials before emergencies occur. As a result of implementation of the toxic substances control acts of the two countries, there should be a decrease in the related problems because more premarket testing will be required along with improved methods for controlling the release of these materials.

Measures for controlling toxic substances are at least generically the same for most of the surface waters of both Canada and the United States. However, additional considerations must be addressed in any program to effectively and rapidly control toxic chemicals in the Great Lakes. Relatively recent findings with regard to the transport and deposition of PCBs indicate that atmospheric input may be a very significant contributing source of some toxic materials to the Great Lakes. With their large surface area, the Great Lakes may receive large quantities of undesirable contaminants directly from rainfall, snowfall and dustfall.
A second special consideration for the Great Lakes is their immense volume of water and the attendant lag before equilibrium is reached between the input and the concentrations of chemicals in the Great Lakes. It takes many thousands of pounds of a toxic material to achieve a part per billion in any of the Great Lakes. Even if toxic materials are not degraded or deposited in sinks, the time required to reach equilibrium with a change in input will be substantial. This time lag poses difficult regulatory decisions for the Commission and the jurisdictions in establishing acceptable loadings. For example, the Lake Michigan Toxic Substances Committee, which functioned during the early part of the '70's was well aware of the PCB problem in Lake Michigan. After completing a rather extensive tributary and effluent sampling program, the Committee achieved a good estimate of the amounts (loadings) of PCBs being discharged from various sources. The Committee was then faced with the problem of predicting the future effects of that loading on the PCB concentrations which were then observed in the water, biota and sediments. Today, we are still unable to predict such effects. Furthermore, the present state of the art for calculating mass balances in bodies of water as large as the Great Lakes is tenuous at best. Efforts must be placed on obtaining accurate mass balances of toxic substances for each Great Lake to enable appropriate regulatory decisions to be made.

The Board feels that the Commission should be keenly aware of the lags between input and equilibrium concentrations in the Great Lakes since the basis of the Water Quality Agreement is that of water quality objectives. In the open lakes, an extended period of time, perhaps even years, may pass before the concentrations of toxic materials become high enough to be reliably and consistently detected by existing analytical methods. The Board suggests that surveillance and monitoring activities may need to pay considerably more attention to the loadings as well as to measurement of concentrations in the water and biota of open lakes. Given the variability of measurements and the observed annual cycles, the surveillance program in any one year provides only a snapshot or an instantaneous reading of the conditions in the lake. It does not give a picture of the dynamic changes which are occurring in biomass, storage capacity or the loading rates of hazardous materials to the lakes. Thus, water quality objectives for toxic materials may be met this year, but they may be exceeded next year or a few years hence without changes in the loading to the lakes. If such were to happen, then it would be an equivalently long period of time before concentrations of persistent toxic materials could be reduced, even if discharges were abated quickly.

Another important concern, not unique to the Great Lakes, is that of the transformation of chemicals into forms that may be more or less toxic or may behave in a different fashion, biologically or chemically. For example, the conversion of inorganic mercury to methyl mercury within the Great Lakes is a story so often quoted that the Commission need not be reminded of it again. However, there are literally thousands of chemicals which are produced and transported or used in the Great Lakes for which the pathway of metabolism or breakdown is virtually unknown. The Board wishes to emphasize to the Commission that even when a full knowledge of the toxic materials manufactured or used in the basin is achieved, it will be necessary to ascertain that these materials are not adversely affecting the natural systems.
In 1976 the Commission, in its hearings on water quality objectives, was briefed on the problem of establishing objectives for metals. Metals are each capable of assuming various forms or species, some of which are less hazardous than others. An objective for a metal based on its biologically hazardous species might be much less stringent than an objective based on that metal's total concentration. At the last annual meeting of the Commission, the Research Advisory Board advised the Commission not to delay in recommending metal objectives for the Great Lakes simply because the various forms of each metal and their subsequent biological activity were not known. The Board stresses to the Commission that while there is no question that certain forms of a metal may be biologically inactive, there is currently no reason to deviate from objectives based on the metal's total concentration. Information is currently lacking on the pathways and rates at which metals may each transform from one form to another, and how these transformations are affected by different physical and biological conditions. In addition, the relationship between metal forms and their toxicity must be firmly established, and there must be reliable methods for monitoring such forms. Therefore, objectives for metals cannot be solely based on biologically active forms. To do so may result in the discharge of large quantities of metals to boundary waters and their tributaries in possibly harmless forms, which through as yet unknown rates of transformation may become biologically active. This is precisely what happened with the mercury discharges to the Great Lakes and other water bodies, a mistake we certainly want to avoid in the future.

The Board's third concern about toxic materials in the Great Lakes is in regard to natural transport and deposition. It is not enough to know the concentration of toxic materials in the water; the sediments of the Great Lakes may form sinks for storage and eventual return transport of toxic materials to water and biota as illustrated by PCBs, DDT and mercury. Unfortunately very little is known about the role that sediments may play in contributing toxic materials to the overlying water column or to the organisms. Indeed, the organisms themselves represent another sink by their ability to store fat-soluble, water-insoluble organic compounds produced and used by our modern industrial society. While supporting data are limited, it is the Board's impression that concentrations of PCBs in Lake Superior fishes appear to be higher with a relatively smaller loading as compared to Lake Erie. If such is the case, the implications for regulatory programs are that discharges of such materials to the oligotrophic Lake Superior and Lake Huron must be relatively smaller than for the eutrophic Lake Erie. The Board wishes to emphasize its concern that more effort must be devoted to ascertaining the permanency of toxic materials in the sediments, and whether these sediment sources can be safely ignored or if they must be considered as sources contributing to the biologically available concentrations in the water.

Finally, another broad area of the Board's concern centers on toxic materials in complex effluents from industry and municipalities which receive varying degrees of treatment. During the past year, the Board has been involved in activities to identify major contaminants discharged to the Great Lakes, and these activities are discussed in more detail later in this report.
We wish to emphasize now the paucity of information about the components of these complex wastes. Indeed, while great progress has been made in establishing permissible discharge concentrations and loadings through such programs as the National Pollutant Discharge Elimination System, the Commission should be aware that these permits place few specific limits on individual toxic contaminants. The Board emphasizes that we cannot be content with information only on chemicals used or produced by industry. Particularly in certain types of industry, such as chemical manufacturing, a high probability exists that side reactions may produce chemical products in addition to those specifically desired. Usually the subsequent degree of removal of the by-products within the plant's waste treatment facility is an unknown. For chemicals that are persistent, commonly used measures of waste treatment efficiency such as BOD or TOC may not be adequate to limit unacceptable quantities of these materials in the discharge, especially if they are highly toxic. For chemicals which are highly toxic to bacteria, the BOD may be low simply because bacteria are unable to grow in the wastes at a sufficient rate to generate a biochemical oxygen demand.

The Board also wishes to express concern about variability in the composition of many effluents, even those which have relatively long detention times in waste treatment plants. This variation affects the frequency of sampling needed to characterize the effluents, and erroneous picture of the characteristics of a discharge could result from inadequate sampling.

**BOARD ACTIVITIES TO ADDRESS SPECIFIC PROBLEM AREAS**

The knowledge of organic chemical residues accumulated by the human population of the Great Lakes Basin is considerably more limited than is desirable. For the most part, determination of chemical residues in human tissues has been confined to measurements for pesticides and selected chemicals contained in foodstuffs or drugs. There has been relatively little effort to search for other categories of organic chemicals, in particular those that might accumulate from exposure through drinking water, eating of fish, or miscellaneous other environmental sources. Through the combined efforts of EPA and the Research Advisory Board, work is underway at the University of Minnesota-Duluth with the cooperation of several medical centers in the Great Lakes states to sample human tissues from residents of the Great Lakes Basin for the purpose of identifying organic chemical residues. Several specific tissues from autopsies are being analyzed by a gas chromatograph mass spectrometer-computer system. It is anticipated this effort will identify residues of organic chemicals which have not as yet been recognized as contaminants. While the Board had hoped to have preliminary information available to the Commission in this report, delays in funding and other unforeseen problems have slowed the work more than expected. A preliminary assessment of the organic chemical residues in the human population of the Great Lakes Basin will be presented to the Commission when adequate information is available.

The Research Advisory Board also undertook a joint effort with the Water Quality Board to develop an inventory of chemical substances used in and discharged to the Great Lakes. The Research Advisory Board is
concerned about the limited information available on toxic substances released through any of several pathways into the Great Lakes as a result of the use of chemicals in our industrial society. The Board feels that there is little hope that future emergencies can be averted by well-timed actions unless we have some way of forecasting the contaminants that could reach the Great Lakes.

In the past year, the Implementation Committee of the Water Quality Board established selection criteria to identify which toxic contaminants should be monitored in Lake Ontario. One criterion was that the compounds under consideration be identified previously in the waters, sediments or biota of Lake Ontario. Therefore, the list may have limitations, since the effort did not consider the many other compounds used, manufactured or discharged in the Basin. The Research Advisory Board recognizes that if chemicals are made or sold in the Great Lakes Basin, there is an increased probability that they will find their way into the waters of the Great Lakes. The Board therefore requested through the Water Quality Board, information from the jurisdictions to enable the preparation of a list of compounds used in the Basin, and/or discharged to the Great Lakes, the approximate quantities and the locations. The information available to the Research Advisory Board for this most important purpose was inadequate for reasons varying from, the release of information being illegal due to its proprietary nature, to inadequate staff to gather the requested information. In some cases, the information does not appear to exist. This was not really a surprise. The joint Department of Fisheries and Environment/Department of National Health and Welfare, Environmental Contaminants Committee noted similar problems in obtaining data on compounds manufactured or imported in Canada. Nonetheless, on the basis of the limited information sources available, the Board attempted to develop a list of compounds made or sold in the Great Lakes Basin. To date, this activity is far from complete, however, the Board's list currently consists of about 2,000 chemicals manufactured or sold in significant quantities (in excess of 1,000 pounds) within the Great Lakes Basin. We anticipate additional data from the comprehensive survey the State of New York has underway to identify chemicals which are being used and/or discharged in the New York portion of the Great Lakes Basin. Similar surveys by other states would be of immense value.

In gathering the above data, the Board recognized the need to reduce to a manageable level the task of predicting the adverse effects for the myriad of organic chemicals that may enter the Great Lakes. The Commission will recall that the Board sponsored a workshop to bring together people knowledgeable about the use of structural and physical characteristics of chemicals to predict their toxic effects and their bioaccumulation potential. The concept, referred to as "structure-activity correlations", has a long established period of use in classical toxicology, but is relatively new to environmental work. By relating chemical structure to biological activity for different chemical compounds, it is possible to make some general predictions about the toxicity of untested compounds. This is roughly equivalent on a chemical level to saying that animals with sharp front teeth and long claws should not be approached too closely as they are likely to be predacious.
Since the workshop, there has been considerable progress on the subject and soon through the initiation of a program by the Environmental Research Laboratory-Duluth, an easily expandable data base will exist at the University of Minnesota, which can be accessed from remote locations by jurisdictions. This data base will provide information to predict the bioaccumulation potential or toxic effect of specific chemicals. In the coming year, it will be expanded to include the chemical and physical characteristics of the compounds in the Board's inventory and subsequently identify potential toxic chemicals in use in the Great Lakes Basin. As with the human tissue residue study, work has not proceeded as fast as expected but within the forthcoming year the Board anticipates providing the Commission with names of some chemicals, in addition to those of which you may already have heard, which are likely to be in the Great Lakes and are likely to pose a problem.

The ability to predict bioaccumulation potential is much more advanced and certain than the ability to predict toxicity. Before we are in a situation where toxicity can be predicted, a substantial amount of research work must be completed. Some is now underway in Duluth, Corvallis and other centers elsewhere in the world to develop an adequate data base which may enable a correlation of physical characteristics of chemical molecules such as electronegativity and field resonance, with toxicity to aquatic organisms. The use of these characteristics is well established in the field of pharmacology and there does not appear to be any reason why such characteristics or similar ones could not be used to gain a first-cut estimate of the toxicity to aquatic organisms of organic chemicals.

As well as attempting to forecast the potential Great Lakes' contaminants, the Research Advisory Board is also concerned about the methodology used to detect such contaminants. The research community of the Great Lakes has examined the levels of residues in Great Lakes fishes periodically over the past ten years. Known residues, most notably DDT, PCBs, dieldrin and mercury, have fluctuated in degree of concern as each was identified in Great Lakes fish, and as biological inferences, especially health effects of their accumulation in the fish, were delineated. A review of the open literature shows fragmentary and piecemeal evidence on trends with concentrations of residues in fish tissues and essentially nothing on levels found at the present time. For example, within the 1975 Surveillance Subcommittee Report and Volume I of the Upper Lakes Reference Group, we find trend information limited to mercury, PCBs, total DDT, dieldrin and mirex. Within the 1975 Surveillance Subcommittee Report, it is noted that: "There has not been an overall design for surveillance of fish contaminants in the Great Lakes, and in most cases, information suitable for interpretation of significant trends is not available. With the exception of the continuous trend-through-time data provided by GLECS (Great Lakes Environmental Contaminants Survey) and the Ontario Ministry of the Environment data on mercury in Lake St. Clair fish, most of the information is local and sporadic".

The inadequate information on these residues and the need for such data to assess the effectiveness of programs for abatement, leads the Research Advisory Board to urge the IJC to recommend that jurisdictions assure appropriate support to comprehensive fish tissue monitoring programs such as the Great Lakes International Fish Contaminant Surveillance Program which is being developed by the Surveillance Subcommittee of the Water Quality Board.
Periodic review of these programs to assure their continuing adequacy is recommended. Measurements of contaminant levels in fish tissue may be of more value than those of water because the questions of biological availability are avoided. Furthermore, aquatic animals such as fish, give an integrated picture free of short term fluctuations and the effects of infrequent sampling of water for analysis. Fish residues are also more meaningfully related to health considerations.

Although many of the chemicals present in Great Lakes fish at concentrations greater than one ppm have been identified, there are many other chemicals below this level which have been observed in the analytical technique of gas chromatography but not specifically identified. Furthermore, the large chromatographic peaks due to major contaminants such as chlorinated benzenes, PCBs, DDT and DDE may overlap the peaks of chemicals in smaller quantities, such as mirex, polychlorinated styrenes and chlorinated toluenes and obscure their detection. Extensive efforts have been required to modify the analytical methodologies to eliminate the problems and interferences due to the major contaminants. Some of the modified and subsequent elaborate analytical procedures are tedious and require extensive laboratory facilities, and confirmation of compounds such as mirex and polychlorinated styrenes may be beyond the current capabilities of most survey organizations. Of the revised analytical methodology, which includes recently developed sophisticated techniques, the Commission may in the future hear frequent reference to: "selected ion summation" which applies computer logic to analyses data from the mass spectrometer and accepts only the spectral characteristics of, for example, mirex and photomirex even in the presence of excess PCBs; and, the "Hall electrolytic conductivity detector" which shows significant promise for use in routine monitoring of compounds such as mirex.

Increased efforts are required to identify the "unidentified" chemicals in Great Lakes fish. Furthermore, analytical methods must be developed for many specific compounds and where existing methods are available, there is a need in some instances, to improve their accuracy. These efforts are a matter of high priority.

SPECIFIC PROBLEMS CONSIDERED BUT NOT BEING ADDRESSED

During Research Advisory Board meetings over the past year, the Board has discussed the problem of evaluating the tolerances of humans who consume fish containing many different chemical residues. Individual tolerance levels based on single chemicals have limited applicability to such situations. Currently the problem of different jurisdictional tolerance levels (i.e. acceptable levels of contaminants in fish) is of more political and economic than scientific substance. It is the responsibility of the standard setting regulatory agencies to identify levels of risk associated with different social use patterns. To aid these agencies, the attendant problems with multiple chemical residues in human footstuffs, particularly the fishes of the Great Lakes, need considerably more scientific examination.

During the year the expertise of the Board in the area of human health has been substantially increased and it is the Board's intent to pay more
attention to this problem area and provide the Commission with more definitive advice in the coming year. The Board, for example, intends to address the need for long term feeding studies (two years or more) using mammalian test species with a diet of edible portions of Great Lakes fish to evaluate the risk associated with eating Great Lakes fish. This study and others should aid in providing the necessary information on which to base regulatory actions. It is the intent of the Board to provide as much deliberation and guidance as it possibly can to this situation.

RECOMMENDATIONS

The Great Lakes Research Advisory Board recommends that the Commission:

1. urge all jurisdictions to develop loading data for each lake for toxic substances which will aid in obtaining accurate mass balances for these substances;

2. urge the Governments to adopt water quality objectives for metals on the basis of total concentrations of each metal in water, and ensure that the objectives are conservative with a reasonable margin of safety due to the potential interconversions of the metals to hazardous forms;

3. urge Governments to undertake studies to determine the exchange of persistent toxic materials between air, water, sediment, and biota;

4. request from jurisdictions more complete information on toxic or potentially toxic chemical substituents of complex effluents, especially for discharges from installations using or making many types of chemicals;

5. urge jurisdictions to assure appropriate funding for expanded fish tissue monitoring programs for toxic chemicals;

6. urge jurisdictions to support increased research to develop better analytical methods for toxic organic chemicals;

7. ask the Governments to assure that agencies with responsibilities for toxic substances control, be guaranteed access to precise information (IUPAC name, quantities, etc.), for all chemicals currently in use.
The Great Lakes Water Quality Agreement has had a significant and beneficial impact on the existing condition, understanding, and subsequently, the management of the Great Lakes. The Governments of Canada and the United States have both made great strides in their awareness of and support to the restoration of the lakes. To accommodate the changing perceptions associated with Great Lakes water quality, the Board has increased its overall prospective on Great Lakes water quality by dissolving its seven specialized Standing Committees and forming three multidisciplinary Expert Committees. Several Task Forces were also formed on an ad hoc basis to address specific issues of concern to Great Lakes water quality. Since its 1976 report to the IJC, the Board also held three workshops on selected topics of concern to the Great Lakes. The following is a brief discussion of the workshops and the recent activities of the Board's Expert Committees and Task Forces. The highlights of these activities have been synthesized within the overview of the three issues already described in this report. The progress of the Board's effort to define research needs, subsequent to its report in July 1976 to the Commission, is also briefly reviewed.

EXPERT COMMITTEES

The three Expert Committees were charged by the Board to provide continuing independent advice and synthesis of scientific opinion on new and continuing Great Lakes water quality related programs. Further, the Committees were requested to identify oversights, weaknesses, and opportunities in Great Lakes water quality research activities in Canada and the United States. The following is a summary of the Committees' scopes and activities which were initiated in February 1977:

EXPERT COMMITTEE ON ENGINEERING AND TECHNOLOGICAL ASPECTS OF THE GREAT LAKES WATER QUALITY

Its scope of activities encompass in part the technological procedures and treatments of the effects of man's activities undertaken either prior to or after entry into receiving waters. The Committee includes expertise on industrial waste treatment, municipal waste treatment, agriculture, land use, and hazardous materials.

The Committee has met with the Chairmen of the Water Quality Board's Subcommittees to define the current Great Lakes water quality issues and problems which could be resolved by appropriate engineering and technological procedures and treatments. The meeting aided in defining the Committee's priorities and assured that the Committee's activities would
address the most urgent Great Lakes problems. The Committee subsequently met with representatives of major federal research agencies to determine the scope of current research which is supportive of the concerns expressed by the Water Quality Board's Subcommittees.

EXPERT COMMITTEE ON ECOSYSTEM ASPECTS OF GREAT LAKES WATER QUALITY

The Committee's activities encompass the ecosystem effects of man's activities undertaken either prior to or after entry into receiving waters. Expertise is representative of microbiology, planktonology, fisheries biology, physical processes, modelling, geochemistry (water chemistry), toxicology, and human health.

As its initial activity, the Committee is currently evaluating selected eutrophication models and their ability to predict lake response time to phosphorus limitations.

EXPERT COMMITTEE ON SOCIETAL ASPECTS OF GREAT LAKES WATER QUALITY

The jurisdictional, political, institutional, legal, educational and other nonmaterial measures influencing the effects of man's activities on receiving waters are to be considered by this Committee. The Committee includes expertise representative of economics, energy issues, planning, citizen/public interest, political science, human behaviour, legal aspects, and regulatory activities. The appointment of members was only recently completed and the Committee is initiating its activities.

TASK FORCES

To deal with specific issues requiring intensive, interdisciplinary investigation, the Research Advisory Board may establish task forces on an ad hoc basis to examine the available information bases and recommend: scientifically defensible courses of action; practical solutions or management policies; and/or, the investigative direction and research necessary to provide the solutions or policies. The task forces may be established as a result of discussions within the Research Advisory Board, recommendations of the Expert Committees, referrals from the IJC or its groups, as well as referrals from the scientific community or citizen groups. The task forces are dissolved upon acceptance of final reports by the Research Advisory Board.

During 1976, task forces were formed to address:

HEALTH IMPLICATIONS OF NTA

The Task Force was formed in 1976 as a result of the Board's concern on the use of NTA as a phosphorus substitute in laundry detergents. The Task Force's charge was to:

- bring together in an encapsulated form the research data pertaining to the health related research on NTA;
- provide the Research Advisory Board with advice as to the adequacy and validity of the research;

- identify the health implications of the findings; and,

- recommend a course of action for the International Joint Commission to take regarding the United States and Canadian policies on NTA.

The Task Force's report is available upon request from the IJC's Great Lakes Regional Office.

ECOLOGICAL EFFECTS OF NON-PHOSPHORUS DETERGENT BUILDERS

A Task Force was formed to provide information to the Board on potential ecological effects of phosphorus substitutes in detergents. Task Force members were selected for their respective expertise in the fields of biochemistry, waste treatment, environmental modelling, aquatic toxicology, water chemistry and metal transport, and eutrophication. Initial activities of the Task Force were directed towards an ecological assessment of NTA, and its findings were reported to the Board in May 1977. Other proposed phosphorus substitutes (i.e. silicates, carbonates, etc.) will be investigated in late 1977. The types and extent of impacts expected with the use of non-phosphate builders will be compared to that of phosphorus.

SCIENTIFIC BASIS FOR WATER QUALITY CRITERIA

This Task Force was previously a Standing Committee of the Board. Its charge is to supply scientific expertise to the Water Quality Objectives Subcommittee of the Water Quality Board to enable the development of scientifically defensible water quality objectives for the Great Lakes. During the past year, the Task Force and Subcommittee developed objectives for chlorine, dissolved oxygen, silver, and mirex. These objectives were presented to the two Boards and their joint 1976 report is available upon request from the IJC's Great Lakes Regional Office.

A second major activity of the Task Force was the sponsorship of a workshop on environmental mapping of the Great Lakes which is discussed in various sections of this report.

WATER AND WASTEWATER TREATMENT

This Task Force was previously a Standing Committee of the Board, and its charge is to complete four activities undertaken by that Committee: development of a proposal for a workshop to address the operation of municipal wastewater treatment plants; evaluate costs associated to obtain phosphorus levels of 1.0, 0.5, 0.3 and 0.1 mg/l in wastewater treatment plant effluents under various detergent phosphorus level scenarios; review innovative wastewater treatment methods; and, identify the current state-of-the-art of sludge disposal practices and needs for related research. As mentioned previously in this report, the workshop is currently in abeyance. The costs evaluation for phosphorus
reduction was completed by means of an outside contract and the results are also described in this report. The Task Force's reports on innovative wastewater treatment methods and sludge disposal are still under preparation.

CHLORINE OBJECTIVE

An objective of 0.002 mg/L total residual chlorine has been proposed for the boundary waters of the Great Lakes for protection of aquatic life. Several questions arose within the Water Quality Board on the implications of this objective on current municipal wastewater treatment plant disinfection practices within the Great Lakes Basin as well as the ability to monitor such a low level of residual chlorine in the boundary waters of the Great Lakes. An eight member Task Force was formed under the Research Advisory Board and the Water Quality Board to consider several defined issues with the goal of providing the Water Quality Board with sufficient information to make a decision on the adoption of the proposed objective for chlorine. The findings of the Task Force were presented within a working document to the two Boards in December 1976.

WORKSHOPS

Since September 1976, the Board sponsored three workshops to bring together experts from the United States, Canada and occasionally Europe for the purpose of: assembling current information and awareness, developing new information and/or approaches, and describing gaps in current understanding. At the request of the Research Advisory Board, the Commission also supported in part, an international symposium on percid fish communities.

WORKSHOP ON ECONOMIC AND LEGAL MECHANISMS FOR ACHIEVING ENVIRONMENTAL OBJECTIVES

The workshop was held on behalf of the Research Advisory Board to examine the alternative legal and economic policy mechanisms currently being used or which could be applied to achieve environmental quality objectives in jurisdictions of Canada and the United States that border the Great Lakes. The intent of the workshop was to provide a basis for strengthening the air and water pollution control policies of the various governmental units located within the region. The workshop was attended by approximately 110 representatives of government, industry, and academic institutions and held on February 21-22, 1977 in Windsor, Ontario. The proceedings of the workshop are under active preparation and will be available from the IJC's Great Lakes Regional Office in late 1977.

WORKSHOP ON FLUVIAL TRANSPORT OF SEDIMENT ASSOCIATED NUTRIENTS AND CONTAMINANTS

Studies by the Pollution from Land Use Activities Reference Group (PLUARG) of the International Joint Commission indicate that pollution from non-point sources may be a serious threat to the Great Lakes. However, PLUARG has determined that there is a lack of knowledge regarding: the transport of contaminants and nutrients to the lakes; the resulting
changes to the contaminants and nutrients which may occur in the lakes; and their availability, to and effect on the ecosystem. In response to a request by PLUARG, the Research Advisory Board sponsored a two-day workshop to address these concerns. The workshop was held in Kitchener, Ontario on October 20-22, 1976 and attended by approximately 70 experts from North America and Europe. The proceedings are available upon request from the IJC's Great Lakes Regional office.

WORKSHOP ON ENVIRONMENTAL MAPPING OF THE GREAT LAKES

In 1974, the Water Quality Objectives Subcommittee in collaboration with the Task Force on the Scientific Basis for Water Quality Criteria developed a conceptual framework within which water quality objectives could be used to protect and enhance water quality of the Great Lakes. The objectives in accordance to the Agreement would not be applicable to designated mixing zones. The framework identified the need for a mechanism to limit the loss of values to mixing zones and other areas of non-compliance so that the integrity of the waterbody is protected and, in conjunction with establishment of a level of protection, management objectives can be achieved. The Task Force proposed to the Board that a workshop be held to investigate the potential of environmental value mapping of the Great Lakes as a tool for developing this conceptual framework. The Board approved the workshop and a Steering Committee was established to direct the development of the workshop. The Steering Committee recognized that Great Lakes mapping could potentially have a much wider application to other environmental disciplines and the workshop objectives were expanded to incorporate the other disciplines. The workshop was subsequently changed to address environmental mapping of the Great Lakes. The workshop was held November 8-10, 1976 in Windsor, Ontario, and attended by approximately 70 persons from government, industry and academic institutions. Proceedings of the workshop will be available in mid 1977.

PERCID INTERNATIONAL SYMPOSIUM (PERCIS)

Percid fishes are members of the family Percidae, which includes the yellow perch and walleye, important in both commercial and recreational Great Lakes fishing. The Research Advisory Board requested the Commission to aid in the support of an international symposium organized to synthesize the existing, but badly fragmented and scattered knowledge of influences on percid fish communities in inland lakes, including the Great Lakes, to achieve a better understanding of the relationship of percids to their environment and man's impact on them.

The Board recognizes that the success of the Agreement will be best expressed to the public in terms of the quality and usability of resources such as the sport and commercial fisheries. Commercial and recreational catches of highly desirable table fish such as the percids have been irregularly decreasing in the Great Lakes. Because the public may interpret such declines as a reflection of the effectiveness of the Water Quality Agreement, the Research Advisory Board recommended the Commission's financial participation in this multi-agency supported endeavor. The Commission agreed to the Board's recommendation.
The symposium, which included eight presentations dealing directly with the Great Lakes, was held September 24 to October 4, 1976, at Quetico Center in northwestern Ontario, and attended by approximately 100 internationally known fisheries experts. The proceedings of the symposium are being published in 1977 as a special issue of the Journal of the Fisheries Research Board of Canada with the contribution of supporting groups recognized.

RESEARCH NEEDS

In July 1976, the Research Advisory Board forwarded to the Commission a "Great Lakes Water Quality Research Needs" document which reflected the opinions of the Great Lakes Research community as to the research needs relative to water quality problems of the Great Lakes. Since that time the Board has undertaken to determine how responsive the existing research programs are to the identified needs, with the intent of reporting preliminary recommendations to the Commission in July 1977. To undertake this effort, many protocols were required. Although the cooperation of the Canadian Department of External Affairs and the United States State Department has been excellent, inevitable delays associated with following such protocols have extended the estimated time-frame for the study. Because of these difficulties, the Board's recommendations have to be delayed for several months.
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