ENVIRONMENTAL MONITORING IN CANADA

prepared for

Fisheries and
Environment Canada

Volume 1

SUMMARY REPORT

August 1977

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PHILIPS ELECTRONICS LIMITED
JAMES F. MacLAREN LIMITED
BRISTOL AEROSPACE LIMITED
COMPUTING DEVICES COMPANY
AIR INDUSTRIES ASSOCIATION OF CANADA
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Scarborough, Ontario
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August 15, 1977.

Dr. M.C.B. Hotz,
Director,
Science Policy Branch,
Office of the Science Advisor,
Planning and Financial Services,
Environment Canada,
Ottawa, Ontario.

Dear Dr. Hotz:

On behalf of our consortium I have pleasure in formally submitting to you this report (in four volumes) entitled

"An Environmental Monitoring
Management Plan for Canada - Phase I"

in fulfillment of our contract SS01-KA 305-5-0020 resulting from an unsolicited proposal.

The layout of the report is outlined in the preface and as per the contract 25 copies have been printed.

I fully endorse the comments made in the James F. MacLaren Limited accompanying letter and believe that the recommendations in the report should be urgently considered.

We are glad of the opportunity to have been of service and trust that the report will be of practical value.

Yours sincerely,

Frank Snape, Ph.D.

/lw

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August 15, 1977

Dr. F. Snape,
Philips Electronics Limited,
601 Milner Avenue,
Scarborough, Ontario.
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Dear Dr. Snape,

We are pleased to submit herewith a four volume report prepared in fulfillment of our commitment to DSS Contract 5501 KA 305-5-0020, entitled "An Environmental Monitoring Management Plan for Canada". Our work on this contract was authorized by Philips Electronics Purchase Order No. 45401. The four volumes of the report are:

Volume 1 - Summary Report

Volume 2 - Main Report

Volume 3 - Directory of Canadian Environmental Monitoring Activities

Volume 4 - Background Information

Examining the many aspects of environmental monitoring in Canada has been an interesting and challenging experience. Monitoring plays an important role in providing data and information to those people who make decisions affecting the quality of the environment and management of resources. To effectively achieve its purpose however, monitoring must be carried out in a comprehensive, coordinated, and integrated fashion.

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We are concerned that Canada's present efforts in environmental monitoring have not yet achieved the level of effectiveness required to form a sound basis for the increasingly difficult decisions that must be made. In this report we have discussed several important issues and concerns related to monitoring, and have also stated the areas in which we feel new initiatives are required.

It should be recognized that the following people contributed significantly to the ideas presented in this report, and their assistance to me, in addition to that provided by you, is gratefully acknowledged.

Mr. J.W. MacLaren
Dr. D.M. Gorber
Mr. C.M. Miller
Ms. N. Krawetz

We wish to acknowledge the cooperation of the many individuals in Canada, Great Britain and the U.S.A. who took time to discuss their views on monitoring with us, the assistance of the Steering Committee, and also the direction and cooperation received from the Scientific Authority.

All of which is respectfully submitted.

Yours very truly,

E. Koczkur, Ph.D.
Project Manager

EK/ld

PREFACE

As a result of an unsolicited proposal, a contract for a study on environmental monitoring was awarded by Supply and Services Canada to a consortium of Canadian companies. The consortium was formed under the auspices of the Air Industries Association of Canada and endorsed by the Electronic Industries Association of Canada. It consisted of the following companies:

Philips Electronics Limited
James F. MacLaren Limited
Computing Devices of Canada
Bristol Aerospace Limited

Philips was the lead company of the consortium. A major portion of the work was subcontracted to James F. MacLaren Limited.

The purpose of the study was to determine what information environmental authorities must have on a regular and systematic basis, in order to make sound decisions regarding management of resources and the quality of the environment in Canada.

The final report is broken into four volumes:

Volume 1 - Summary Report

Volume 2 - Main Report

Volume 3 - Directory of Canadian Environmental Monitoring Activities

Volume 4 - Background Information

The Summary Report briefly reviews the scope and methodology of the study and highlights key issues and concerns about current Canadian environmental monitoring. The conclusions and recommendations of the study are also included in this volume.

The Main Report contains a more detailed account of important issues and concerns about monitoring in Canada. Monitoring objectives, information needs, and data acquisition and management are among the issues addressed. A discussion of monitoring for contaminants and environmental assessment is also presented, followed by the study's conclusions and recommendations.

Volume 3 is an inventory of monitoring activities in Canada. It contains information related to departments involved, parameters monitored, availability of data, and users of data. It also contains a discussion of the term "monitoring".

Volume 4 outlines the history of the project and the approach used in carrying it out. A summary of Canadian interviews which were conducted as part of the study is included here, along with descriptions of monitoring programs carried out by the U.S.A., U.K., and the U.N.

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INTRODUCTION 1

1.1 General

Nature's capacity to absorb the impact and consequences of our use of the environment is limited. Thus, we must be prepared to establish an approach to our development planning that allows us to become fully aware of the consequences of an action. In the past, a resource that costs nothing was considered infinite in its availability. During the past 25 years, the effects of compounding population growth rates, concentration in urban areas and the exponential growth of industry have forcibly demonstrated the error in that philosophy. Environmental disasters, potential resource scarcities and excessive pollution have shown the need for a significant change in environmental management processes.

As yet, we are not sufficiently aware of the enormity of the problem. We need a different solution from the piecemeal approach of the past and we must analyse the problem as a systemic whole consisting of integrated components. The essential base to the development of such an approach is factual information gleaned from a comprehensive and integrated environmental monitoring system.

The study that is the subject of this report therefore was directed to the preliminary identification of the nature and scope of environmental information which must be available on a systematic basis to permit sound decisions

about environmental management. It also addressed several other important issues related to environmental monitoring in Canada, underlining weaknesses in current efforts and suggesting strategies for improvement.

1.2 Definition of Environmental Monitoring

Monitoring is defined in several reports on national, international, and global environmental monitoring systems. The definition of monitoring most appropriate for this study, however, is taken from SCOPE* Report 3, "Global Environmental Monitoring System (GEMS) - Action Plan for Phase 1".(1) The SCOPE report defines monitoring and assessment separately; nevertheless, both are considered as the subject of this study and are defined as follows:

> "Monitoring is defined here as the process of repetitive observing, for defined purposes, of one or more elements or indicators of the environment according to prearranged schedules in space and time, and using comparable methodologies for environmental sensing and data collection".
>
> "Assessment is defined as the process of interpretation of data obtained from monitoring networks and diverse other sources".

1.3 Environmental Monitoring in Canada

Environmental monitoring is carried out in Canada by many agencies at several levels of government, by industry, by research institutes, universities and technical institutions, and by individuals. The investment of resources in monitoring is large and must be planned wisely if environmental crises are to be averted. This requires a comprehensive, integrated,

* Scientific Committee on Problems in the Environment

coordinated monitoring effort that involves the cooperation of governments, other public institutions, and all other related interests.

This volume is the Summary Report of a study on environmental monitoring in Canada. It outlines the purpose and scope of the study, the organization and approach taken in carrying it out, and summarizes the Main Report's discussion of important issues and concerns related to monitoring in Canada. The study's conclusions and recommendations are given in full.

PURPOSE AND SCOPE

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2.1 General

The purpose of this study was to review current Canadian environmental monitoring and to suggest approaches to an integrated monitoring scheme which would supply appropriate information to persons having to make decisions affecting environmental quality and the management of resources. An interdepartmental committee of the federal government developed terms of reference to broadly define the purpose and scope of the study, with the understanding that these would be narrowed as the study progressed. The terms of reference developed by the committee are set out in Section 2.2.

2.2 Terms of Reference

1. Prepare a detailed CPM/PERT activity diagram at the start of the work and submit it to the Scientific Authority for his approval.

2. Identify the nature, scope and detail of information on the environment which must be obtained or made available on a regular and systematic basis, in order that sound decisions can be made on the management of resources and the quality of the environment; comment on the effectiveness of present systems for gathering such information in the light of present and projected

needs. This review should cover socio-economic, biological, physical, chemical parameters relevant to water, air and land, and should indicate the way in which such information might be integrated so as to support management systems.

3. Identify relevant ongoing data collection and long-term monitoring systems and programs from the following operating departments: Environment Canada, Agriculture Canada, Health and Welfare, National Research Council and appropriate provincial ministries. Identify inadequacy of data collection and monitoring systems.

4. Identify the method of utilization of the data: where, whom and for what purpose.

5. Assess the adequacy and impact for the user of the various data collected.

6. Suggest approaches to an integrated overall environmental monitoring scheme for a mutually agreed upon area highlighting the interaction of the various monitoring activities for the whole spectrum of air, water and land.

7. The liaison between the contractor and provincial agencies might be made through Environment Canada. This scheme must be compatible not only with national but also international systems such as UNEP-GEMS, Man and the Biosphere, etc.

8. No effort should be spent on defining instruments or their systems.

ORGANIZATION AND APPROACH 3

3.1 Organization

At the beginning of the study three participating groups, and their responsibilities, were defined.

A Consortium Group was responsible for forming a project team to undertake the work to satisfy terms of reference, and to submit a report on its work. The major participants in this group were Philips Electronics Limited and James F. MacLaren Limited, with other members of the consortium being called upon whenever their expertise was required.

A second group comprised the Scientific Authority appointed for the study and members of Fisheries and Environment Canada staff who were to assist the Consortium Group in making contact with persons in international, foreign, national, provincial, and regional agencies. This group was also to help in gathering information on existing monitoring activities.

A third group was represented as a Steering Committee on Environmental Monitoring, whose task was to assist and guide the Consortium Group in carrying out the study. This was a federal interdepartmental committee, chaired by the Scientific Authority, with members from the Departments of Environment, Agriculture, Health and Welfare, and Indian and Northern Affairs, and from the National Research Council.

3.2 Approach

At the outset, the project team prepared an activity plan diagram which was subsequently approved by the Scientific Authority. It was agreed that the study's broad terms of reference would be redefined and limited as the work proceeded. As the study progressed the project team and the Scientific Authority met on several occasions to redefine the study's scope and direction.

Work on the study commenced with the preparation of a procedure for interviewing persons involved with environmental monitoring in various federal and provincial departments. The purpose of the interviews was to identify current federal and provincial monitoring activities, and to discuss several aspects of these activities, including: objectives, jurisdiction, rationale, and integration. A list of proposed questions for the interviews was developed and forwarded, in draft form, to the Steering Committee for approval.

The project team began, in July 1976, by interviewing several members of the Steering Committee and others who had been identified by the Scientific Authority. In August 1976, the Deputy Minister of Fisheries and Environment Canada wrote to the Chairmen of the five Regional Boards, to enlist their help in carrying out the study. The nature and objectives of the study were outlined and the Chairmen were requested to contact the project team to arrange for interviews with members of Fisheries and Environment Canada's regional offices and with provincial officials.

During September and early October, the project team made presentations to each of the Regional Boards to explain the

study further and to seek assistance in arranging interviews.

Steering Committee meetings were held in October and November. At both meetings the project team presented a progress report and requested guidance from the Committee. At the November meeting the team submitted a first draft of a directory of Canadian environmental monitoring activities. The Steering Committee members reviewed the directory individually and suggested corrections and additions.

The interviews continued until February 1977, and by that time, representatives of the following had been interviewed:

> Fisheries and Environment Canada, Agriculture Canada, Health and Welfare Canada, the National Research Council, and provincial resource and environment departments.

In addition to the interviews conducted in Canada, authorities in the United States and Britain were visited. These included members of:

> The United States Environmental Protection Agency (EPA) in Washington, D.C. and Las Vegas, Nevada; the Center for Short-Lived Phenomena, Cambridge, Massachusetts; and the Monitoring and Assessment Research Centre (MARC) at Chelsea College, London, England.

ENVIRONMENTAL MONITORING IN CANADA: ISSUES AND CONCERNS 4

4.1 Introduction

Environmental monitoring focuses on providing information about the state of the environment to persons who must make decisions or take actions affecting environmental quality and resource management at three levels:

1. Policy Planning
2. Program Planning
3. Establishment and Enforcement of Laws and Regulations

The nature of information required at each level will differ, primarily in regard to detail, aggregation of data, and the time frame in which it is needed.

Specific monitoring objectives concern: the determination of background, the detection of trends, the detection and documentation of non-compliance, the estimation of conditions, and the increasing of understanding.

Making a decision on what to monitor requires four preliminary steps:

1. Determination of specific monitoring objectives.

2. Identification of information needs within each objective.

3. Assignment of priorities to objectives and information needs.

4. Selection of techniques and procedures for acquisition and management of data.

Monitoring objectives must be consistent with an environmental and resource management plan or policy so that they will be appropriate to present or future needs. A clear statement of monitoring objectives must include definitions of: short term and long term objectives of the environmental and resource management plan; particular problems to which solutions are sought; and limitations on the time required for program implementation.

4.2 Information Needs

A sound basis for environmental decisions comprises much information beyond the physical, chemical, and biological environment that is the prime interest of natural resource and environment agencies within governments.

Thus the information needs for environmental and resource management may be outlined as follows:

1. Physical, chemical and biological

   - Resource characteristics
   - Sources of pollutants in water, in air and on land

2. Socio-economics

   - Uses of resources
   - Their transport

- Consequences of resource use
- Perception of resource use

Categories of essential information include:

1. Quantity, how much of something there is in a region.

2. Quality.

3. Continuity, how long it will last (direction of trend), and its rate of change.

4. Distribution, where within a region it is found.

Within each component category, parameters are selected. The same core of parameters must be used in each region, to allow aggregation of data on a multi-regional or national scale. Other parameters must be selected to deal with specific regional problems. Methods of data collection and analysis should be comparable for any one parameter.

A network of consistently defined regions based first on the river basin is recommended as the foundation for coordinated national environmental monitoring and management plans. Since the total information required for environmental management is vast, an interpretive summary for each region, including a matrix form of data presentation that highlights interrelationships, is suggested.

Communication of data and information needs is essential in such a vast field to avoid duplication of effort or monitoring that is effective in meeting the information needs of those not involved in the actual data collection. Currently, a mechanism whereby the information requirements of many users

are recognized and coordinated in a monitoring scheme, is lacking. Thus a central system of monitoring control, operated in the national interest, appears necessary.

4.3 Monitoring Priorities

With limited resources available and extensive monitoring requirements, priorities must be assigned in the context of an environmental management plan or policy with clearly defined information needs. Within each area selected for monitoring, further priorities must be set to decide on the parameters to be monitored using consistent standardized criteria and factors.

Currently within the federal government, monitoring priorities are not set within a broad context, although the need to do this has been recognized.(2)

4.4 Data Acquisition and Management

An effective monitoring system must provide data that are: comparable with data collected at other times and in other programs, where necessary; appropriate for their intended uses; and accurate and reliable.

Coordinated processing from different environmental information flows is necessary to provide a timely response to information needs.

With the widening and increasing interest in the environment shown by the scientific community and by the public as a whole, and with a dramatic increase in the number of crises (or apparent crises) Canadians seem to be facing each day, the need for freely available environmental data has become ever more important. Unfortunately, governments and industry

often unnecessarily restrict the dissemination of important data, which hinders our ability to deal with serious environmental problems and reduces the efficiency of the overall Canadian effort in environmental monitoring.

4.5 Cost Effectiveness

Estimates place the annual amount spent on monitoring in Canada, at the federal level alone, at well in excess of two hundred million dollars. It is therefore prudent to see that these resources are well employed. However, few monitoring activities appear to be subject to a periodic reivew in which costs for present and alternative means of obtaining information required to meet specific objectives are updated and reviewed.

MONITORING FOR CONTAMINANTS AND ENVIRONMENTAL ASSESSMENT 5

5.1 Introduction

In this chapter, monitoring for contaminants and environmental impact are considered as topics of current concern to government, the scientific community and the general public. Monitoring, especially the use of appropriate monitoring systems, is particularly relevant to both.

5.2 Contaminants

The current approach to monitoring contaminants is inadequate. At present almost all source and environmental quality monitoring relates to a specific contaminant or is single-medium oriented. To deal with contaminant measurement an integrated monitoring system crossing jurisdictional and media boundaries is needed.

Monitoring contaminants deals with several objectives:

1. Application of a systems approach to identify needed information.

2. Policy planning to reveal the broad conditions requiring policy action to control or ban certain activities and material use.

3. Information providing an accurate link between cause and effect.

A monitoring system must consider all of the critical related medical, biological and other relevant data. The U.S. Environmental Protection Agency identified the necessity for such a monitoring system and has initiated its development. A relatively new concept of an integrated monitoring system approach which simultaneously considers critical sources, critical pathways and critical receptors is being applied. The term "critical" is used to select a specific and important risk and the significant transport pathways from the important sources which impact a receptor.

Several steps are involved in this approach. First, the conceptual framework identifying the various pieces of the system is prepared, followed by analysis to identify the interrelationships and obvious gaps. Second, the system is described wherein the components are related by mass balance and input-output behaviour. Third, a hypothetical multimedia model is developed; and finally, a pilot study is undertaken to verify and, if necessary, modify the hypothetical design.

Based on the quantification established in the conceptual analysis, a hypothetical multimedia model can be developed to provide satisfying responses to the separate objectives of policy planning, programs, and enforcement. The specific objectives will define the form of the output and the acceptable level of error.

Time-dependent models are potentially superior in estimating the real effects of contaminant releases into the environment. Monitoring and modelling are complementary. They are valuable in identifying critical pathways and provide a basis for selecting specific points for measurement in the monitoring strategy. Without modelling it will not be possible to forecast the effects of new and yet undeveloped substances.

If a reasonably complete understanding of the existing contaminants problems is to be obtained, the integrated systems approach preceded by adequate advanced analysis is the logical way to proceed. Modelling, monitoring, inventories, and similar activities in a single medium, by themselves, are inadequate.

5.3 Environmental Assessment

Monitoring plays an important role in providing information upon which an environmental assessment is based. Such monitoring should be dependent on the nature and scope of the proposed action. Thus monitoring for background, trends and non-compliance may be required.

Data from these three kinds of monitoring should be compatible, for it is on the basis of background and trend data that standards are formulated. Careful consideration must be given to compliance monitoring at the initial stages, i.e. when background and trend data are being gathered. Background and trend data should be gathered over sufficient area such that even if changes are made to the original proposal, there will be adequate data upon which to base standards.

At present, environmental assessment cannot be placed within a framework of long-term environmental management. It is suggested that a regional management plan would provide that context.

CONCLUSIONS AND RECOMMENDATIONS 6

6.1 Conclusions

Although the broad nature of this study was not directed to revealing all issues relating to environmental monitoring, it did permit an analysis in a preliminary fashion of the state of environmental monitoring in Canada. It revealed that despite its great size and vast natural resources, Canada through its many public agencies has established a high level of useful monitoring services with respect to the environment. However, the study also disclosed the weaknesses and inadequacies of these systems in providing environmental authorities required information on a regular and systematic basis to permit sound and comprehensive decisions regarding the management of resources and the protection and improvement of environmental quality in Canada.

The major conclusions of this overview study were as follows:

1. No coordinated policy for a nation-wide environmental monitoring service exists in Canada. The specifically assigned responsibilities within departments of a government and the ill-defined divisions of responsibilities between provincial and federal authorities under the terms of the British North America Act are the major apparent impediments to the development of such a policy.

2. Because of the lack of an overall policy as well as budgetary restrictions, it has not been possible generally to develop monitoring objectives that reflect user requirements in more than specific problem areas.

3. It is estimated that a minimum of two hundred and fifty million dollars is spent annually within governments alone, in the maintenance of various forms of monitoring information systems having environmental implications.

4. Data gathering activities without firm objectives have reflected a compromise between policy, program and enforcement requirements, and these uncoordinated approaches have mitigated seriously against opportunities for establishing systems to assist in the long-term management of resources.

5. The overall effectiveness of current monitoring efforts also is hindered by the lack of a common, consistent procedure for assigning priorities to the objectives and information needs.

6. Standardized methods of sample collection and analysis are required so that data collected by several agencies are comparable and may be combined to form broad, regional, national and (where needed) international data bases.

7. There are many cases where insufficient emphasis is given to the interpretation of data, especially in consideration of the significant financial resources devoted to their collection. Modelling techniques, for example, have not yet been developed to the level necessary to improve interpretation of information received from existing monitoring programs.

8. Weaknesses in procedures for the dissemination of information gathered by monitoring systems are partly responsible for the lack of data interpretation. There are many instances where agencies restrict or delay the publication of important environmental data. These are usually unnecessary, and are counterproductive to the detection of important trends in environmental behaviour, the development of solutions to specific problems, and the development of an effective overall environmental monitoring effort. In fact, making environmental data freely available to scientists and the general public may be one of the most important steps towards achieving an "early warning system". No better example exists than in the early detection and corrective procedures required with respect to the persistent toxic materials.

9. Few monitoring activities appear to be subject to a periodic review in which costs for current and alternative data acquisition systems are compared for effectiveness and objective satisfaction. Indeed, some of the newer, more complex contaminants will require entirely new types of monitoring systems to determine pathways and potential receptors.

10. With large financial resources already being devoted to monitoring and with demands for more information rapidly increasing, it is becoming even more important that current monitoring systems are assessed for cost effectiveness, user satisfaction and contribution to the national interest. The role of the following in environmental monitoring is worthy of further study:

- Development of a holistic approach to environmental management
- Development of improved capabilities for predicting environmental behaviour
- Resource/pollution interrelationships
- Pre-testing of chemicals
- Synergy of pollutants
- Epidemiology
- Post production/manufacturing monitoring
- Monitoring of socio-economic parameters
- Selection of biological indicator species
- Requirements for baseline biological data
- A national pesticides monitoring program
- Establishment of sample banks (tissue, sediment, etc.)
- Monitoring of land use change
- Remote sensing
- "Early Warning" systems

11. Despite all of the foregoing, it must be conceded that significant progress has been achieved in developing useful environmental monitoring systems in Canada. However, the current trends in Canada's development indicate that the environment and our resources will now and henceforward come under greater pressure from human activity than ever before. Therefore, a considerable effort in the national interest is now necessary to upgrade our current environmental monitoring program to provide the effective information on the state of the environment and its resources, but in integrated, comprehensive and interpretable modes.

6.2 Recommendations

1. The governments of Canada should recognize the importance and need for establishing a fully integrated and comprehensive environmental management system in the national interest and accept the responsibility for its creation. Canada is a vast land whose future lies in its resource development under strict environmental management. Without a much broader and comprehensive environmental monitoring program, Canadians cannot plan their future course nor hope to avoid major environmental disasters with future progress.

2. Efforts devoted to developing a comprehensive environmental monitoring program should be coordinated on a national level and in the national interest. In response to this need, the Minister of Fisheries and the Environment must take the leadership initiative implicit in the Government Organization Act 1970 and convene a federal-provinical conference to discuss various forms of accord to achieve a national and coordinated approach to environmental monitoring. The participation of the provinces is essential since, in the areas governed by environmental monitoring, the federal government is in isolation and cannot define the national interest on its own.

   The conference should include not only federal and provincial environment departments, but also departments of health, agriculture, natural resources, and any others who have responsibilities pertaining to environmental quality and resource management.

The accords adopted by the conference could vary from a loosely structured coordinated federal-provincial committee designed as a clearing house for data and information to one that might set standards (by agreement), provide information to support decision-makers (whether federal, provincial, industrial or municipal) and continually review developing requirements to serve the national interest.

3. In moving towards an integrated and comprehensive monitoring system, considerable effort should initially be devoted by this federal-provincial committee to improving several aspects of the current monitoring situation. In particular,

   (i) for all monitoring activities, clear objectives which reflect the requirements of decision-makers at the policy, program, and enforcement levels must be established (in addition to those existing objectives that are still valid);

   (ii) consistent procedures for assigning priorities to the objectives and information needs of decision-makers are necessary;

   (iii) appropriate regional geographical, demographical, and resource components of a nation-wide monitoring system should be delineated; decision-making is not confined to any provincial or municipal boundaries and should be recognized as such;

   (iv) systems for data acquisition and management should be upgraded so that the quality of data is assured and data collected by various agencies are comparable and may be combined to form appropriate data bases;

(v) environmental data, accompanied by adequate interpretation, must be made more widely available than at present; in places where interpretive technology has not been established, raw data should be made available;

(vi) the development of integrated systems for monitoring persistent toxic materials and potential synergistic effects should be given a high priority, together with improvements in the ability to make accurate predictions based on environmental data.

Implementation of items (iv), (v), and (vi) would require a substantial investment of new resources. This makes it imperative that implementation be carried out on a priority basis, and that existing monitoring activities be reviewed for cost effectiveness so that funds can be released for high priority activities.

4. It is recommended that the federal-provincial committee move in time toward the establishment of a Canadian Environmental Monitoring Commission, which would carry out and expand on the work initiated by the committee.

(i) This Commission could be created through legislation passed by each of the provinces and the federal government simultaneously. The Commission would be comprised of members from each province and the federal government, with the latter serving as chairman. Appointment would be of a fixed duration and tenure could be staggered, with two provinces appointing commissioners each year. The Commission could be serviced by a modest secretariat but its major work would be undertaken by a series

of technical committees formed from federal and provincial officials loaned from various departments of government, much as is done for the International Joint Commission.

(ii) The major purpose of the Commission would be to set the objectives and priorities for establishing, within a fixed time, a fully comprehensive and integrated environmental monitoring system for Canada. The program of the Commission should be directed to reviewing the monitoring systems existing at the time of its formation and upgrading them to ultimate requirements for policy, program and enforcement.

(iii) The Commission's operations, including the programs it supported, would be funded by monies supplied by the participating governments. The federal government would supply the larger portion of the annual financial requirements, with the remaining portion coming from the provinces.

(iv) It would be made clear that the Commission's role should not reduce the powers or limit jurisdiction of any government. It would be intended to support high level nation-wide comprehensive environmental monitoring systems from which governments and individuals could take data, information or interpretation to suit their individual needs. It would, therefore, direct a system which not only fulfilled Canada's own needs but provided to Canada information necessary to fulfill its international responsibilities, particularly those in North America.

5. The establishment of a comprehensive and integrated monitoring system is of great importance to Canada, and it can best be achieved by implementation of the foregoing recommendations.

REFERENCES

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2. Steering Committee on Aquatic Environmental Quality in Canada. Aquatic environmental quality. The role of the Department of Fisheries and the Environment. Annex 3. Ottawa: Environment Canada, 1976. p. 27.

ACKNOWLEDGEMENTS

The members of the Consortium wish to thank the many individuals who freely gave their time to discuss the subject of environmental monitoring in Canada. In particular, we wish to thank Dr. Marcus Hotz, the Scientific Authority, for his valuable criticism throughout the study. Dr. Harold Harvey also deserves special mention for meeting with us and giving us the benefit of insights he has gained after considerable work in this field.

Special thanks are extended to many people in the Environmental Protection Agency who welcomed us warmly and provided a wealth of information on monitoring in the United States. The members of the Monitoring and Assessment Research Centre at Chelsea College, London, England, also devoted a great deal of time to us in describing monitoring activities in the United Kingdom.

We thank Dr. R.E. Munn of Fisheries and Environment Canada for providing information on the United Nations Environment Programme.