ENVIRONMENTAL MONITORING IN CANADA

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MAIN REPORT

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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 Monitoring

In introducing the issue of environmental monitoring, it is essential to establish an acceptable definition of the term within the context of this study. Monitoring is defined in several reports on national, international and global environmental monitoring systems (1, 2, 3, 4)*. While the definitions vary in many respects there are several common points. The most important of these are:

1. Monitoring involves repeated measurements or observations of certain elements, indicators, or parameters.

2. The measurements or observations are carried out for defined purposes, and are done in a systematic manner.

3. Monitoring provides data that can be used in determining trends in environmental behaviour.

The major questions arising out of the differences in the definitions are:

1. Is monitoring concerned only with pollutants?

2. Does monitoring include measurements carried out for the purpose of determining relationships amongst various components of the environment, or causal factors of environmental behaviour? Or, are these simply "research studies"?

* Numbers at the end of a sentence refer to references given in Appendix 1.

3. What is the difference between monitoring and surveillance?

4. Does monitoring include the evaluation of data collected in the measurement programs?

In the context of this study, monitoring cannot refer only to pollutants; it must also include measurements of the quantity and quality of resources for purposes related to the management of these resources, and measurements of relevant social and economic indicators.

The question of a distinction between monitoring and measurements undertaken for research studies was raised frequently during the study. Although measurements for research fall under many definitions of monitoring, the emphasis of this study is on information that is gathered as a regular input to the decision-making process. Therefore, it was decided to consider monitoring mainly as those data-gathering activities that are initiated with a view to being continued more or less indefinitely, and that are designed to directly serve continuing environmental or resource management programs. Measurements intended primarily for research purposes, such as determining relationships amongst various components of the environment, or causal factors of environmental behaviour are not included in the considerations of this report. Although they develop the knowledge base for monitoring systems, they cannot be considered part of the ongoing program.

There is no general agreement on the meaning of the term "surveillance". MacKay and MacDonnel in "Environmental Monitoring" (4) suggest that surveillance deals with temporal trends and the relation of such trends to various causes. A contrary definition appears in an internal Environment

Canada report, "Post-Stockholm Institutional Arrangements for Global Environmental Monitoring": "surveillance is defined as the assessment of patterns of distribution of environmental pollutants (and other variables) in space, so as to identify where concentrations are highest and problems potentially most severe". (5)

To make a distinction between monitoring and surveillance here does not seem worthwhile or necessary, especially since there is such a lack of agreement on the exact meaning of surveillance. There are several definitions of monitoring which are broad enough to encompass the various meanings of surveillance.

The 1971 Intergovernmental Working Group on Monitoring or Surveillance defined monitoring as "a system of continued observation, measurement, and evaluation for defined purposes". (6) In SCOPE* Report 3, "Global Environmental Monitoring System (GEMS) - Action Plan for Phase 1", a distinction is made between monitoring and assessment (or evaluation). The definitions of these terms given in SCOPE Report 3 are the most appropriate for this study. They are 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 pre-arranged schedules in space and time, and using comparable methodologies for environmental sensing and data collection. Monitoring provides factual information concerning the present state and past trends (over the period of record) in environmental behaviour. As examples, monitoring could include hourly observations of trace gases, daily measurements of water-quality indicators, annual surveys of forest cover, and periodic

* SCOPE - Scientific Committee on Problems of the Environment (International Council of Scientific Unions)

sampling (at 5- to 10- year intervals) of the heavy metal concentrations in food or seaweed.

The observations need not be made at fixed times or at fixed locations. The system could include, for example, a mechanism for activation of supplementary data collections whenever pre-designated criteria were met, e.g. during high pollution episodes, during natural disasters, or whenever a few cases of cholera were detected in a region. The system could also include random or cluster sampling (of biota) according to standardized procedures. An important constraint, however, is that the observations be made in a systematic way.

Assessment is defined as the process of interpretation of data obtained from monitoring networks and diverse other sources. The word assessment has three distinct meanings in the context of monitoring:

(a) quality control,
(b) examination of the efficiency of networks, including optimization of space and time densities of observations so that interpolations between between observations can be made with the desired accuracy,
(c) examination of the state of the environment, the determination of trends, and the prediction of future states, often for use in comparisons with environmental criteria or standards". (1)

The subject of this study therefore, is monitoring and assessment as defined in SCOPE Report 3. The SCOPE 3 definition is considered to include sampling and analysis of effluents and emissions for the purpose of enforcing existing regulations or developing new regulations or guidelines.

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.

At the federal level, Fisheries and Environment Canada takes the most active role in monitoring, although other departments such as Health and Welfare, Energy, Mines and Resources, Indian and Northern Affairs, and Agriculture are also involved. Provincially, environment and natural resource departments carry out monitoring, with some responsibilities being assigned to agriculture and health departments.

Many types of monitoring are done by more than one group or level of government. For example, both air and water quality measurements are made by federal, provincial and municipal agencies, as well as by industrial associations and utilities. In cases such as this, the degree of cooperation between the groups is variable. There is certainly no overall monitoring policy or plan in which the role of each group is specified. As a result, monitoring activities are not always effectively coordinated so as to avoid duplication or gaps in the total monitoring effort.

There is little doubt that the investment of resources in environmental monitoring must be planned wisely if environmental crises are to be averted. This requires a <u>comprehensive</u>, <u>integrated</u>, <u>coordinated</u> monitoring effort that involves the cooperation of governments, other public institutions, industry, universities and all other related interests. An explanation of these three critical adjectives is important to the understanding of this report.

Comprehensive: A comprehensive monitoring scheme could be interpreted as one in which every single environmental component must be monitored continuously. The very idea is overwhelming and, of course, highly impracticable. In this report, a comprehensive system is one in which certain environmental components are specifically chosen to be monitored, because the data obtained from them is interrelated and therefore can provide a firm indication of the state of the system.

A comprehensive system for monitoring contaminants would involve a detailed analysis of sources, of all pathways and dosages to the most sensitive receptor, including man. The most significant pathways would be selected for subsequent monitoring. The many remaining pathways found to be non-critical by analysis, would not be monitored.

Integrated: Integrated monitoring permits the data from a variety of environmental elements to be analyzed and interpreted in a consistent manner, so that a clear picture of the total environment can be obtained. In Canada and the United States, monitoring systems do not provide this picture. In both countries many types of data are gathered in many different ways in the hope that the sum of the parts will add up to the whole. However, this accounting theory approach to data collection fails, largely because it is not compatible with current analytical methods. "Most, if not all, of the available methods for handling numerical data assume the statistical theory of data collection, management and manipulation. The statistical theory insists on the essential interdependence between the ways in which data are collected and the methods of analysis which are appropriate for these data". (7)

Thus, while current monitoring schemes give forth voluminous quantities of data, only those systems which incorporate clearly defined objectives are collecting data in a way which satisfies their users.

The essential interdependency between analysis of data and data collection demands an integrated monitoring system.

Coordinated: A coordinated system bridges and transcends the various domains which "administer" the environment. A current monitoring system, by a particular jurisdiction, in a specific medium, results in information adequate to the limits of a specific jurisdictional/medium problem. However, with this approach, no one is responsible for the interrelationships, as the environmental element crosses media and jurisdictions. This is a serious deficiency, because the decision-maker at the policy level is usually faced with a complex problem involving the environmental system. The current fragmentation of responsibilities of governments, among and within departments, undermines a coordinated effort.

If we are to have a national environmental monitoring plan, or policy, it must be coordinated at the national level (although not necessarily by the federal government). The realities of implementing such a system are formidable, even if approached in stages. But without this kind of cohesive planning, government will continue its reactive response to environmental crises, for it cannot take the offensive in uncovering environmental surprises, before they become serious problems.

This report addresses several important issues related to environmental monitoring in Canada. In Chapter 2, aspects discussed are: monitoring objectives, information needs, monitoring priorities, data acquisition and handling, and cost effectiveness. In Chapter 3, monitoring as it relates to two particularly important issues, contaminants and environmental impact assessment, is discussed in light of Chapter 2. Finally in Chapter 4, preliminary conclusions and recommendations with respect to an environmental monitoring system for Canada are set out.

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ENVIRONMENTAL MONITORING IN CANADA: ISSUES & CONCERNS 2

2.1 Introduction

Beginning with the setting of objectives for monitoring and ending with determining the cost effectiveness of monitoring programs, this chapter attempts to present the issues and concerns most important to achieving effective environmental monitoring in Canada as revealed through interviews and a literature search conducted for this study.

The primary purpose of environmental monitoring is to provide information on the state of the environment to persons who must make decisions or take actions affecting environmental quality and resource management. Three levels of decision-making can be identified:

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. For example, data on the hourly emission releases from a power plant at a particular location are of vital interest to a utility since, under adverse weather conditions, it may be necessary to alter the plant's operation. The data are also of interest to the agency responsible for enforcing emission regulations. For planning at a provincial or national level, however, the data hardly assume the same importance. Instead, the longer term averages which can be related to persistent exposure effects are of greater concern, and are needed for measuring the success of abatement programs and for modifying policies.

Making a decision on monitoring requirements involves 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.

2.2 Monitoring Objectives

Monitoring objectives must be consistent with an environmental and resource management plan or policy. If such a plan does not exist, then objectives will be ill-defined or inappropriate to current or future needs. This leads to waste in gathering data which are of little or no use in making decisions, particularly on a regional or national scale. Thus a clear statement of monitoring objectives must include definitions of:

1. Short term and long term objectives of the environmental and resource management plan.

2. Particular problems to which solutions are sought.

3. Limitations on the time required for program implementation.

Specific monitoring objectives can be grouped under one or more of the following: (8)

1. Determine Background:
   - Characterize Present Quality, Productivity, Quantity.
   - Determine Causative Factors.

2. Detect Trends:
   - Measure Changes.
   - Assess Effectiveness of Control Policies.

3. Detect Non-compliance:
   - Evaluate Degree of Compliance with Standards and Limitations (both pre- and post- enforcement action).
   - Measure Effectiveness of Control Tactics.

4. Document Non-compliance:
   - Provide Legally Acceptable Evidence of Non-compliance.

5. Estimate Conditions:
   - Develop Prediction Procedures for Non-observed (present and future) Conditions for Planning and Management.

6. Increase Understanding:
   - Establish and Refine Basis for Standards, Control Procedures, and Management Policies.
   - Understand Transport, Fate, and the Effects of Pollutants in the Environment.

2.3 Information Needs

To illustrate the range of information required to support an environmental management plan, the six general monitoring objectives can be combined in a simple matrix with the three levels of decision making identified previously.

Objective \ Function	a) Policy Planning	b) Program Planning	c) Enforcement
1. Determine Background			
2. Detect Trends			
3. Detect Non-Compliance			
4. Document Non-Compliance			
5. Estimate Conditions			
6. Increase Understanding			

In this matrix not all objectives will be applicable to each function; for example, there will be no monitoring intended to document non-compliance for policy planning purposes. Documentation of non-compliance applies mainly to the enforcement function.

This report is concerned primarily with the information needs of the decision maker at the levels of policy and program planning, who is responsible for making decisions affecting environmental quality and management of resources. A sound basis for such decisions comprises much information beyond the physical, chemical, and biological environment that is the prime interest of natural resource and environment agencies within governments:

> "Knowledge of existing conditions is a prerequisite for the formulation of sound plans. Studies to acquire this background knowledge should encompass not only the physical components and processes of the environment,

but should also focus on the relevant social and economic factors". (9)

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

1. <u>Physical, chemical and biological</u>
   - Resource characteristics.
   - Sources of pollutants in water, in air and on land.

2. <u>Socio-economics</u>
   - Uses of the resource.
   - 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, national, or possibly international scale. Other parameters must be selected to deal with specific regional problems. Methods of data collection and analysis may vary depending upon available finances, expertise, facilities, etc., but should be comparable for any one parameter.

2.3.1 Physical, Chemical and Biological

A characterization of the region's resources is fundamental. This will involve assessments of the quality, quantity, continuity, and distribution of all resources, including: air, water, land, people, fish and wildlife. For example, the characterization of fresh water resources will involve hydrometric measurements to determine quantity, continuity, and distribution, and physical, chemical and bacteriological analyses of water samples to determine quality. It is essential that these measurements be made so that quantity, continuity and distribution within a region can be established for various classifications of water quality.

Note that population quality refers primarily to socio-economic and age groupings. However, it may be useful to differentiate between indigenous (Indian and Inuit) and non-indigenous peoples as well. Land quality refers to land use capability.

A knowledge of the characteristics of sources of contaminants, including both sources from a native state and discharges resulting from human activities, is essential in planning strategies for environmental management. While it is not feasible to monitor all sources or all contaminants, an initial inventory of sources and emissions will allow the selection of the most critical sources, based upon the concept of an integrated source-pathway-receptor model. This concept is presented in Chapter 3.

2.3.2 Socio-economics

A resource such as water has multiple uses, many of which require different qualities and quantities. Measurements according to use should be made with respect to human activities (e.g. water uses such as domestic, industrial, agricultural, hydroelectric, recreational) and, to other users (across uses) such as vegetation, wildlife, birds and fish. Both withdrawal and non-withdrawal uses should be measured.

Transportation systems play an important role in human impact on the environment, far beyond the direct physical effects of the system itself. Transportation systems influence the nature and locations of development, and thus are associated with a wide range of impacts.

Resources must also be considered from the perspective of the users. The relationship between the users' ways of life and their use of a resource should be monitored, in terms of the degree of support or threat it represents to the user. A characteristic relevant to all users, human and non-human, is physical health (e.g. public health records - incidence of disease).

With respect to humans, measurement of psychological and economic stress must also be considered. All these are aggregations. For example, physical health would include: all diseases (epidemiological and other) and incidences of deaths and genetic abnormalities. Psychological stress includes: psychiatric admissions, incidence of mental illness, divorce, marriage, crime, accidents and drug abuse. Economic stress includes: cost of living index, and employment figures and statistics on average wages.

The final set of measurements refers solely to humans' preferences regarding resource use. Preference is a measure of the importance and magnitude attached to a particular resource or use. Of the variety of ways it can be measured, polling is the most preferable in the context of long-term planning and management. This indicates the demand for a resource or a particular use of it. Measured over time, it indicates trends in resource demand.

2.3.3 Geographical Scale

A regionally based network is recommended as the foundation for coordinated national environmental monitoring and management plans. Regions delineated for environmental planning and management must be defined in a consistent manner. On many occassions, the river basin has been selected as the fundamental geographic boundary for an area of study (10, 11) and the Canada Water Act is based on that principle. The river basin should be the first component considered because it can be clearly articulated; then the boundaries of other factors which affect the basin (e.g. urban centres, industries, the presence of other resources) should be superimposed. The environmental monitoring and management program then is applied to the lumped version of the originally articulated feature.

2.3.4 Presentation of Data

As outlined in the previous section, the total information required by various decision-makers involved in environmental and resource management is vast. A suggested method for presenting the data in each information category (except transport) is in matrix form. The main advantages to such a method of presentation are:

1. It provides sufficient interpretation so that it is understandable to decision-makers with various levels of technical expertise.

2. It is concise, clear, and highlights important points, thereby avoiding information overload.

The information needs for resource characteristics of water can be used to illustrate this approach. As mentioned previously, categories of essential information include:

1. Quantity.
2. Quality.
3. Continuity.
4. Distribution.

For a region, it is possible to have data pertinent to each of these categories. However, the decision-maker also requires an indication of the interrelationships among these categories. In other words, information on overall water quantity for a region is required, as well as information on the various qualities, e.g. drinkable, fishable, etc.; but an indication is also needed of the amount of available water of a particular quality (e.g. how much drinkable water, as opposed to how much fishable). Moreover, it is necessary to know if the present availability of water is related to future availability, i.e. if trend measures indicate that the amount of drinkable water is increasing or decreasing over time. Furthermore, distributional information is essential so that the decision-maker can determine where the various qualities of water are located.

This approach takes the data beyond the level of simple tabular presentation, for it shows the interrelationships among quantity, quality, continuity and distribution of a resource. This type of presentation can be used for the other categories of information previously specified: sources, uses, transport, consequences of use, perception of use resulting in six matrices of information.

Based on these matrices, the decision-maker can examine interrelationships among matrices through the use of simple mathematical models. For example, the interrelationship of sources and water quality can be ascertained. Similarly, all other pairs of matrices may be compared to extract much useful data. These comparisons will provide a picture of the existing situation and allow extrapolation to the future. Through the use of simulation models, the environmental consequences of actions can be estimated.

2.3.5 Other Information

As mentioned previously, monitoring satisfies only a part of the information needs of environmental management planning. Additional information specifically relevant to the interpretive summary includes any notations regarding:

1. Aspects in which insufficient data was gathered to obtain adequate measurement;

2. Aspects monitored whose results have significance beyond the quantitative measure;

3. Resource uses or users which are competitive (increase in use of one results in decrease to another) or mutually exclusive.

2.3.6 Communication of Information Needs

As outlined in the previous section the total information needs of decision-makers involved in environmental and resource management are vast. It is therefore essential that users of information at all levels and in all disciplines communicate their data and information needs to each other and to those responsible for carrying out monitoring. This requires the participation of government agencies at all levels as well as private industry, universities, other research institutions, and the public. Without good communication there will likely be duplication of effort or monitoring that is ineffective in meeting the information needs of those not involved in the actual data collection. For example, a presumptive user of data might require more detailed information on certain conditions than the agency responsible for the immediate control of the data collection. The more detailed information could possibly be made available at little or no extra cost, but this cannot occur unless those doing the monitoring are aware of this need. The alternative virtually is to carry out duplicate monitoring.

The issue of duplicate monitoring activities has been addressed in at least two Environment Canada reports. In 1972, Dr. Peter Meyboom prepared a short paper entitled "National Networks, Environmental Monitoring, Surveys and Surveillance", in which he wrote:

"The widespread use of the term 'environmental monitoring' may have created the impression that all parts of the department are essentially doing the same thing, for the same reasons and without much coordination. ...however, there are many types of environmental measurements, and it has been explained that these measurements can be taken in many different ways."

"Thus, the 'issue' of duplication in data networks and environmental monitoring is essentially one of semantics. In fact, there seems to be very little overlap of activities, which does not mean of course, that there is automatic institutional harmony and professional rapport." (12)

In 1977, the Steering Committee on Aquatic Environmental Quality prepared a report entitled "Aquatic Environmental

Quality - The Role of the Department of Fisheries and the Environment". Although restricted to considering matters related to the aquatic environment only, the report's comments on overlap in field measurement programs are nevertheless important:

"It is also evident that with the exception of wildlife measurements, considerable overlap occurs among the DFE services in the measurement of water and biota, and among (EMS, EPS, AES) in precipitation. This overlap may be more apparent than real and may have developed on a basis of specific regional needs. However, since field measuremnt programs account for a significant portion of the DFE budget and since many elements of field programs are common to DFE objectives, close coordination and review of these problems are essential to avoid needless duplication and expenditure of resources". (13)

During the interviews conducted for the current study, one senior federal official expressed the view that there is a lack of common understanding of federal and provincial programs, resulting in overlap and monitoring schemes that are not known among the various monitoring agencies.

Also, as part of the current study, a directory of monitoring activities in Canada was compiled (Volume 3). The purpose of this directory is to promote an awareness of the monitoring activities carried out by federal, provincial and municipal agencies, industrial associations, and utilities. Examination of this directory does not reveal significant overlap among monitoring systems. The directory is not an in-depth review of each activity, however, and there may indeed be more duplication than is apparent.

It appears that a more serious problem than duplication or overlap of monitoring activities is the lack of a mechanism whereby the information requirements of many users are recognized and coordinated in a monitoring scheme. This concern was expressed by a number of people interviewed during the study.

In 1975, Environment Canada's Planning and Finance Service published a report entitled "Environmental Monitoring - A Compendium of Data Gathering Activities of Environment Canada". In this report it is stated that:

"Several people commented on the good inter-service cooperation developing at the operating level in the regions. They pointed out that data which had been collected was usually willingly exchanged. However, the structure of the existing programs (each designed to serve its service) made it difficult to acquire *new* data which would be of interest to people not in the service operating the program". (14)

Communications between government departments and between various levels of government do not seem to provide the common awareness of needs that is essential if monitoring efforts as a whole are to be effective from technical and cost points of view. For example, despite the great amount of water chemistry data collected by many agencies throughout the country, it is difficult to relate these data to other environmental concerns, e.g. aquatic organisms and their water quality requirements. It has been recommended that effort be devoted towards solving this problem. (15)

As a further example, a federal official pointed out (during an interview for this study) that the acquisition of land use data is not well integrated; each department acquires data to meet only its own objectives. If these departments discussed their information requirements with each other, it might be possible to satisfy them with fewer resources in a combined monitoring program.

An important question then is, how might a greater awareness of information needs be established, so that monitoring can be better coordinated and satisfy the needs of a greater number of data users? A central system of monitoring control operated in the national interest and not for federal, provincial, industrial or any specific interest, appears necessary. This system could be responsible for identifying common and complementary information needs of all agencies and the public concerned with environmental management, and provide liaison with all agencies involved in collecting or using data on the environment.

2.4 Monitoring Priorities

Throughout the course of this study, many persons identified gaps in the information available to them from existing monitoring activities. These information requirements included such things as:

1. Data on land use change and ownership through registries, zoning changes, satellite and airborne imagery.

2. Contaminant investigations in biota in the Great Lakes.

3. Data on pesticide use and distribution.

4. Baseline biological data.

5. Baseline data to serve the needs of the Environmental Assessment Review Process (EARP).

6. More and improved monitoring of toxic substances in many areas, both geographical and ecological.

The resources required to carry out the monitoring suggested by these requirements would be extensive and likely more than available. How then, is it decided which of these gaps should be filled? What information is most important?

With limited resources available there must be a procedure for assigning priorities to information needs. Priorities must be assigned in the broad context of an environmental management plan or policy with clearly defined information needs. Without such a plan, priorities will be set in too narrow a context and the total monitoring effort will be fragmented and uncoordinated, serving only the needs identified by individual departments or groups.

Within the federal government currently, monitoring priorities are not set within a broad context. The need to do this has been recognized. In the report of the Steering Committee on Aquatic Environmental Quality, the following is included in a list of recommended Fisheries and Environment Canada activities:

"<u>Sub-sub-strategy</u>

Coordination and Priorities

... Determine priorities for the surveillance and assessment programs and coordinate these programs amongst agencies.

Activities

1. ...

2. Develop priorities for the design and objectives of surveillance programs by use of a multi-disciplinary approach and with reference to protection of beneficial uses". (16)

It is important to realize those statements referred only to the aquatic environment's quality and therefore in themselves are not multi-purpose.

Within each area selected for monitoring, further priorities must be set to decide on the parameters to be monitored, using certain criteria and factors. To demonstrate, the setting of priorities for monitoring contaminants and resources are discussed in the following subsections 2.4.1 and 2.4.2.

2.4.1 Contaminants

The number of substances to be monitored is so numerous, that the task of repeated measurement would be overwhelming. Therefore, it is important to establish monitoring priorities, such that technical and monetary resources are allocated to measure those substances which are most harmful.

The present methods of establishing priorities are variable and subjective. For example, Fisheries and Environment Canada's new priority list of problem chemicals was established on the basis of a national survey of over 100 specialists. Each was given "Excerpts from the list of criteria for assessing ecotoxicity (prepared by OECD)" to assist in the development of a list. (17) However, the specialist could include other factors for consideration and it is not possible to determine if these factors were weighted consistently by all concerned. Moreover, it is doubtful whether this priority list has any relationship to those used by other government departments and businesses involved in chemical investigation.

Therefore, there is a need to establish common substance selection priorities based on a consideration of relevant factors, weighted in a standard way, used consistently by all agencies and disciplines involved. This is not to say that one of the priorities may be that of national significance over regional significance. The emphasis is on standardization and consistency.

Also the nature of the substance and the nature of the problem must be considered in establishing monitoring priorities.

In considering each substance, four characteristics must be evaluated:

1. Its persistence, defining the duration of effect.

2. Its mobility and pervasiveness.

3. The quantity of the substance in the environment.

4. Its toxicity, or extent to which it is harmful.

Two categories of factors determine the nature of the problem:

1. Type and level of hazard and the consequences thereof.

2. Other factors, indirectly related to the substance.

Hazard refers to the likelihood of a substance affecting a living organism. There are several factors relevant here:

1. Magnitude of effect including habitat impact.

2. Whether the effect is acute.

3. Whether the effect is chronic
   a) mutagenic
   b) carcinogenic
   c) teratogenic.

4. Time required for the effect to manifest itself.

5. Reversibility.

6. Number (and kind) of organisms likely to be affected.

7. Possibility of effect being transmitted through the food chain.

8. Synergy.

Other factors related to the nature of the problem include:

1. Technological complexity.

2. Research needs.

3. Economic consequences.

4. Public concern.

5. Legal and political considerations.

Ranking the factors is a difficult task, weighting is even more so. There has been a significant amount of work done on this issue (17, 18). The lists are variable reflecting the different ranks and weights of criteria.

For an integrated monitoring system to be effective, one standard method for establishing priorities must be used by all government departments, industries and research concerns dealing with environmental monitoring activities so that the many existing priority lists are combined into one that reflects wider needs. Hence the need for central control in the national interest, as suggested in subsection 2.3.6.

2.4.2 Resources

In comparison with contaminants, the criteria for establishing the priorities for monitoring resources relate more to long term planning requirements. While the list of possible criteria presented here is by no means exhaustive, it is meant to outline some of the factors which should be considered. Resource criteria are grouped into two categories: the nature of the resource, and related factors. Those in the former category include:

1. The quantity of the resource.

2. The quality of the resource.

3. The distribution of the resource.

4. Whether the resource is renewable.

Factors relevant to the latter category include:

1. The continuity of the resource, based on present patterns of use and trends.

2. Ecological consequences.

3. Economic consequences.

4. Number and kind of organisms dependent on it.

5. Technological complexity.

6. Research needs.

7. Public perception of the resource.

8. Legal and political considerations.

Again, there is a need for a procedure by which these criteria can be weighted in a consistent manner.

2.5 Data Acquisition and Management

2.5.1 Data Acquisition

An effective monitoring system must provide data that are:

1. Comparable with data collected at other times and in other programs, where necessary.

2. Appropriate for their intended uses.

3. Accurate and reliable.

Obviously, if trends are to be detected it must be possible to compare data collected at various times or locations. This requires uniform (or comparable), consistent, and reliable methods of sample collection and analysis. If either of these is changed, the effect of the change upon the data must be known and documented. To assure continuity of data over time, adequate reference methods and sample banks should be established. With improvements in methods and instrumentation, analysts will abandon older methods. By using reference methods and sample banks, however, it will be possible to continually relate past, present and future environmental measurements. (19)

Concern has been expressed about the comparability of data gathered in different jurisdictions and by different agencies. Analytical methods vary from one country to another, as well as from one agency to another, within the same country. (20) This variation is of particular concern where air sheds, water bodies, wildlife, etc., cross jurisdictions and are monitored by more than one agency.

In Canada, the collection of data on the forest resources is a case where the differences in methods used by the provinces have made it difficult or impossible to aggregate the data to present a national picture. Fortunately, however, the need for a national inventory of forest resources has been recognized, and as a result federal-provincial inititatives will shortly be undertaken to remedy the current situation.

In a recent report, Harvey viewed the Canadian situation on this matter (for aquatic based monitoring) somewhat pessimistically:

"At this late date, the opportunities for federal research initiatives are limited. Each province has its own laboratory. Almost all have developed their own data bases, incompatible with the federal one. ...In short, in the absence of early federal initiatives, the provinces went their own way. Provincial monitoring organizations will not easily change their methodology or data bases in response to federal initiatives now". (21)

One noticeable example of variation in analytical techniques between federal and provincial agencies concerns dissolved Radium-226 analysis. In Ontario three government laboratories analyze water samples for Radium-226: the Ontario Ministry of Labour Radiation Protection Laboratory, the Department of National Health and Welfare Radiation Protection Bureau, and the Wastewater Technology Centre at Canada Centre for Inland Waters.

In its analysis each laboratory uses a filter of different pore size from the other two, and to date no efforts have been made in determining if the data obtained using the different filters are comparable. Given the important nature of monitoring Radium-226 concentrations in water, it seems obvious that steps should be taken to ensure that the efforts of all agencies involved are complementary and will lead to forming a broad, reliable data base. But no agency is eager to change its analytical techniques, for all wish to maintain the continuity of their existing data bases.

Methods of sampling and analysis must, of course, be chosen so that the data provided will be of the type required by the data users. In the interviews conducted for this study, examples were cited where existing data are incompatible with a perceived need. In such cases, it is likely that these perceived needs are simply not recognized, or are judged unimportant, by the agency controlling the data collection. The incompatibility thus does not result from inadequate or poorly chosen methods. As an example, air quality measurements made in the work place are so different from those made in normal ambient air, that it is almost impossible to compare exposure dosages with any confidence. This situation has arisen because two agencies have for a time collected data for their individual uses, and these data are inappropriate to a newly identified need, i.e. the determination of total human exposure to various contaminants.

Data used in making important decisions must be accurate, and the decision maker must have confidence in its accuracy. This requires reliable and consistent sample collection and handling; accurate, sensitive, and reliable standard analysis methods; and a good data quality assurance program.

In an interview for this study, one federal official involved with water quality monitoring stated quite emphatically that too much money has been spent on improving analytical techniques, whereas nothing has been done in the area of sampling and sample handling. This seems to be widely recognized in the water quality field at the federal level, as demonstrated by the following statement from the report of the Steering Committee on Aquatic Environmental Quality:

"With regard to quality control programs, ...new resources are needed to extend this [national quality control] program to cover field sample collection, sample preservation, and handling, where the sources of error seem now to be of more significance than analytical errors". (22)

Whether these comments apply solely to federally sponsored monitoring of the aquatic environment or to the national scene has not been determined in this study.

Methods of analysis appropriate to the objective of a monitoring program need to be chosen carefully. The methods must be capable of appropriate accuracy and sensitivity, but should not be more accurate and sensitive than necessary, for this will involve greater resources for no gain. It is essential, therefore, that the planners and analytical experts collaborate to define quantitatively any requirements to be satisfied by analytical methods. This will require a decision on the inaccuracy tolerable in analytical results, and frequently, particularly for trace impurities, a decision on the smallest concentration of interest. These decisions will lead to the selection of suitable analytical methods. (23)

It is important, both for reasons of continuity and expense, that unnecessary effort not be devoted to developing new analytical methods. It has been recommended that the country-wide efforts expended on new methods be reduced. During a study in 1976, Harvey found that:

"In almost every lab visited, the statement was made that the existing methods were no good and a large amount of effort had to be devoted to developing new methods". (15)

An active quality control program is necessary to assure the accuracy of monitoring data. A total program would consist of four principal elements:

1. Development and issuance of procedures;
2. Intralaboratory quality control program;
3. Interlaboratory quality control program;
4. Monitoring program evaluation. (24)

Although the national laboratory quality control program operated from the Canada Centre for Inland Waters has been judged adequate, the Steering Committe on Aquatic Environmental Quality recommended that:

"In order to ensure reliable data, establish an overall quality control program (including training) to cover the complete measurement activity including both field collection, sample preservation, handling, and laboratory analysis". (25)

An adequate laboratory quality control program should include replicate samples, spiked samples, reference samples, and performance samples. (26) It is also essential that sampling conditions and analysis methods (and changes in them) are clearly documented.

The cost of gathering samples and data in the field should be minimized by using field staff and instruments to serve more than one program, wherever possible. This is particularly important where measurement locations are in remote regions, since the costs of transporting field staff are usually high. Two examples that were cited during the interviews for this study are:

1. It may be possible to make better use of field personnel (Water Survey of Canada) by expanding their responsibilities or by adding to the measurement capability of hydrometric monitoring stations, i.e. by the addition of water temperature measurement.

2. Atmospheric Environment Service field personnel often have surplus time available and could be used for making other measurements or observations. (This program has already been instituted to some extent.)

The Steering Committee on Aquatic Environmental Quality has also recognized a need for greater coordination of sampling programs. In its report the Committee states:

"Sampling programs are partially coordinated now, both with the provinces and between Services and other federal departments. Regional managers could, however, do more. No new resources are likely required and in fact some savings could be made. In fact, more extensive water quality measurement programs could be achieved by having hydrometric field staff collect samples for water quality determinations". (27)

Changes in instrumentation will undoubtedly have dramatic effects on methods of obtaining data. The use of satellites and telemetry has the potential to greatly reduce the number of field staff required in a variety of sampling programs.

2.5.2 Data Storage

A system for storing monitoring data (data bank) must be capable of timely response to a great variety of data needs.

The nature of the data bank should, of course, be determined by the needs of its users, e.g. different time needs, detail, level of aggregation. For example, a policy planner may require certain information only on an annual basis and at a high degree of aggregation, whereas an official responsible for enforcing effluent regulations will require more detailed and specific information every day or week.

There are a great many data banks in Canada, which store data collected in many environmental monitoring programs. These data banks serve the needs of several jurisdictions and many different disciplines. There is little doubt that these data banks are useful to the agencies or groups that designed them. What is a matter of concern, however, is that these data banks could be more widely useful if they were coordinated in some way. For example, many provincial data banks are incompatible with federal data banks, and it is not possible to exchange raw data between them. Where data are exchanged, it is usually after at least a preliminary interpretation has been performed, thus transforming raw observations into potentially biased form.

As new data uses arise, it is important to have access to data in their raw form, with sufficient referencing parameters. This allows past data to be reinterpreted using newly developed or revised methods. In the same vein, it is important that all data in their various forms be accommodated in a catalogue of holdings so potential users may be aware of the scope of data.

A coordinated data storage system does not require common physical storage of all the information in a single data bank, but rather that the system be designed so as to facilitate coordinated processing of information from different environmental information flows. (28) A single data bank would likely be undesirable since the ability of individual systems to serve specific needs would likely be sacrificed for the sake of having a common system.

The Steering Committee on Aquatic Environmental Quality has recognized the need for greater coordination of data systems at the federal level. In its report, the Committee states:

"Integration of these data systems into a single departmental system is not considered to be desirable, provided the data in these systems are accessible. All existing systems serve a legitimate need for users, who require a specific and immediate response. However, there is a need to improve existing systems and maximize their collective utility to all sectors of the Department". (29)

The Committee recommends the following activity:

"Identify requirements of data users, and evaluate data management systems capable of providing data in the form of which it is of the greatest value to users". (30)

2.5.3 Data Accessibility and Dissemination

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. Under present conditions, however, important data are often kept secret or restricted, or their availability is known only to a few. Furthermore, even some unrestricted, public data are unavailable when needed because of delays in publishing them. Fortunately, some agencies are making good progress in speeding up the publication process.

When environmental data are not publicly available or when the existence of public data is not widely known, some potentially costly problems can occur. These include:

1. Important trends in environmental behaviour go undetected, often because those who have the data lack the resources to adequately interpret them;

2. The public, informed of potential crises only at the last moment (usually by the media itself and not through government reports released to the media), forces government into reactive, defensive postures; governments usually respond with actions that would likely have been unnecessary if the public had been informed properly;

3. Agencies mount programs to collect data that already exist but are unavailable to them, or, lacking the resources to do this, must rely on a data base that is inadequate for their needs.

An explanation of each of these occurrences appears timely:

1. Important Trends Go Undetected

A frequent criticism of monitoring activities is that agencies which collect data on the environment do not allocate sufficient resources to their interpretation, and do not make the data freely available to scientists outside of government. This situation tends to thwart the achievement of one of the most frequently expressed desires of environmental agencies - an "early warning system". The hope is that such a system will be our DEW line of the environment, warning us of the oncoming attacks by the next letters in our alphabet soup of chemical contaminants. But no one has demonstrated a formal system of this type, and Hamilton has pointed out that "individual scientists constitute early warning systems and the issue may be to ensure that they have better access to data....". (31)

Harvey has said: "Within Environment Canada excessive and unnecessary secrecy surrounds much of the data on the environment. This is viewed as a major constraint in the search for understanding of the effects of contaminants on the aquatic environment". (32)

Governments, however, are not the only ones which may be accused of unnecessary secrecy. Industry has also kept much important data secret: data on such things as raw materials, chemical composition of products, and unaccountable losses of product. Industry's defence for not releasing data often rests on the statement that the data are proprietary and would hurt the competitive advantage of an individual company if released publicly. It is quite possible that in many cases industry's unwillingness to cooperate was heightened by the often seemingly endless flow of questionnaires and requests for data from innumerable government agencies. To circumvent this practice at the federal level, regulations now limit surveys by individual departments to ten organizations; anything in excess of this must be processed through and with the approval of Statistics Canada.

In many cases, however, industry's secrecy cannot be justified and may even be an obstruction to solving serious environmental problems. One example given is:

"An example is the Domtar plant in northwestern Quebec. The amount of mercury lost from the plant has been estimated at 16,000 pounds (Canadian Press, Oct. 16, 1975). Domtar alone knows how much mercury was purchased to replace losses, has not made this information public, is under no legal obligation to do so, and accepts no moral obligation to do so. The suggestion has been made that the 8 tons of mercury might have "evaporated" (Ottawa Citizen, Oct. 16, 1975). It is difficult to imagine how this could have happened without endangering the health of the plant workers or why the company would permit mercury worth a third of a million dollars to evaporate. It has also been suggested that the mercury in fishes of the area, being organic mercury, could not have come from the inorganic mercury that escaped from the plant. That micro-organisms convert inorganic to organic mercury has been known since 1969. Knowledge of the amount of mercury lost into the environment is essential to understand the problem, most particularly the preparation of a mercury budget for the basin and preparation of a predictive model of recovery". (32)

But why all the secrecy by government? Frequently the reason is that the data cannot be released because they are proprietary to a company and were collected in confidence. But this does not apply in all cases certainly. Meyboom has suggested two reasons why government scientists "suppress" information:

i. "Both government scientists and academics seek data and information, and their quests can be viewed as an effort to improve their status, for data may lead to publications, and publications are rewarded. Consequently, the academician is anxious to obtain data and the government scientist is reluctant to pass them on."

ii. "Another reason may indeed be fear on the part of the government scientist: fear that 'his' information will be misunderstood or misinterpreted, fear for political repercussions that may affect his career, fear that the data he has are insufficient, unreliable, or downright wrong, which would leave him open to professional criticism." (33)

Meyboom concludes that neither reason seems sufficient to justify withholding information, and further explains:

"To place the problem in perspective we can take the simple situation of 'basic data', such as rainfall or stream flow. No one expects 'political repercussions' from the fact that Ottawa received 10 inches of rain in July. The data are collected and published, and everyone is free to interpret them as he sees fit. At the same time, no one is overly concerned that some of these data, such as the evaporation measurements for the prairies or the daily discharge of the St. Lawrence River, may be wrong. The same goes for data on air quality. Although there may be questions in Parliament about the high level of particle matter in the air over Sidney, Nova Scotia, the data are freely available and the reasons for government action or inaction are discussed in Parliament. (House of Commons Debates, Sept. 29, 1971, p. 8278)". (33)

Finally however, it should be pointed out that middle managers who essentially direct monitoring programs may be the culprits for holding back data. They may be afraid of consequences arising from their release or more probably, they do not have the necessary funds to cover the cost of producing and distributing voluminous responses to requests for data.

2. Last Minute Surprises

Unfortunate incidents occur from time to time in which data leaked to the media suggest that they were withheld from public view for fear of public criticism of government mismanagement. Two significant repercussions can be felt:

i. The situation becomes sensationalized out of all proportion to its true importance, and governments take unnecessary steps to quiet the public outcry (thereby diverting resources from more crucial issues).

ii. The government is forced into taking action that it should have taken earlier when the situation first became known to it. As a result of the delay, however, the action required is much more expensive and may not be well planned.

Both situations are undesirable and inefficient ways of attempting to avoid or remedy environmental crises. The need to improve communications with the public is critical.

To share technical knowledge with the media and the public is not without problems however. It requires that environmental data be made public as quickly as possible but with interpretation in some form and that the public have an appreciation of that interpretation or decision process. The public's lack of understanding of this process is a key issue:

"With some over-simplification, the decision-making process in a typical science-related public issue might look something like this. In the first stage, the possible risks or benefits of the proposed action are evaluated, a highly technical process begins with the collection of scientific evidence and ends with the derivation, on the basis of the evidence, of a table of risks and benefits. Then, in the second stage, a policy decision of whether or not to take the action is made on the basis of the risk-benefit table. Such a policy decision requires no technical training."

"One difficulty with science-related issues today is that the layman is often not able to separate the first stage from the second. The situation is not improved when scientists who make pronouncements on public issues do not always bother to point out where science ends and personal opinions begin; and the layman is even more confused when, instead of a single risk-benefit table he finds himself confronted with several contradictory ones, all contending for attention. Whom then is he to believe?" (35)

The effectiveness of current government public information programs is in doubt. The recent report by the Steering Committee on Aquatic Environmental Quality states:

"This level of resources ($261K, 8 M-Y) may, or may not be adequate: there is little doubt it is largely ineffective except for the EMS-Wildlife program. An improved mechanism would involve clearly providing managers of AEQ programs with the responsibility for development of public information programs with special assistance from public information specialists. ...Departmental information on environmental matters should be readily available to all users and the public and interpretated [sic] by DFE specialists as required". (36)

Recommendations to the various governments on means of improving their communications with the public on science and environment related matters have been given in a number of reports. These recommendations suggest such things as:

i. All environmental data should be released and distributed widely, and accompanied by proper explanation.

ii. Scientists should be encouraged to develop skills in communicating with the public through the mass media.

iii. Reports on the state of environmental quality in Canada should be produced for the government and people of Canada. These reports should include the assessment of progress in dealing with current, emerging and potential problems.

iv. Strengthen existing information programs.

v. Provide public access to government information. (36, 37, 38)

3. Restricted Data Causes Duplication

A frequently cited case of secrecy causing duplication of effort concerns data on contaminants in fish gathered by Fisheries and Environment Canada's Fish Inspection Branch. These data would be extremely useful to other agencies, and a significant saving might result if they were available. As an example, the International Joint Commission was refused data on contaminants in Great Lakes fishes, and thus had to start up an expensive and not altogether satisfactory alternative study of contaminants in fish-eating birds and mammals. (32)

The spread of persistent and potentially harmful pesticides through the environment is a matter of considerable concern, yet the Public Hearings into the Use of Pesticides and Herbicides (Alberta Environment Conservation Authority 1974) found that government agencies that have data cannot share them with environmental agencies. (39)

There are many other examples where data are not available to agencies who have a real need for them. The alternatives of mounting separate programs to collect the data or doing without it are not satisfactory; they are wasteful of public funds and hamper the ability of agencies to deal effectively with environmental concerns.

2.6 Cost Effectiveness

The cost of acquiring information on the environment through the use of monitoring networks is substantial. Estimates place the annual amount spent in Canada, at the federal level alone, at well in excess of two hundred million dollars. With so much manpower and other resources dedicated to long term measurement programs, it is prudent to see that these resources are well employed. One method of evaluating monitoring activities would be to calculate a cost-benefit for each component of a monitoring system. However, it does not seem possible to assign a meaningful dollar value to the benefits derived from providing information on the environment. Nevertheless, it is possible to calculate the cost of monitoring systems and their effectiveness in achieving specified objectives.

The calculation of system effectiveness depends on a definition of the system objective and a method of computing the success of the system relative to that objective. Where several candidate systems are being considered for implementation, there must be a method for predicting the success of the systems. As discussed in a previous section, clear definitions of monitoring objectives are essential if monitoring is to provide the information required by decision-makers.

The expanding demands for data will be accompanied by substantial changes in existing monitoring systems. Cost-effectiveness should be a key component in the selection of new systems.

A significant part of the cost of monitoring systems is for sample collection and analysis. With increased emphasis in many areas on analyzing for new chemical contaminants in small concentrations, the portion of cost for analysis is likely to increase. It is therefore important that the number of samples for analysis be specified (the minimum necessary) and then strictly controlled. Harvey recommended that further federal initiatives are warranted "To identify ways to reduce the number of samples being analyzed. It is not uncommon, for example, to find that a field technician, who is permitted to spend up to $5.00 a day on his own authority, can collect and submit to his laboratory in a day water samples that will cost $1500. to analyze. Water chemistry data collection borders on obsession in some instances". (40)

One method of reducing the amount of analyses required is to use indicator parameters so that the frequency of detailed analyses can be reduced.

Data processing costs are small compared to data gathering costs, and are minimized by using computers rather than manual methods. Enhanced information availability and accessibility of computerized data also improves cost performance.

Few monitoring activities appear to be subject to a periodic review in which costs for present and alternative means of obtaining information required to meet specific objectives are updated and reviewed. Given the constraints on resources for all environmental programs and the need to satisfy new demands without additional resources, it is logical and in time will become necessary, to answer the questions: What is the cost of the information? Do I need it, and if so, need I pay that much for it?

MONITORING FOR CONTAMINANTS & ENVIRONMENTAL ASSESSMENT 3

3.1 Introduction

In this chapter, monitoring for contaminants and environmental assessment are considered. These topics have been chosen because they are of current concern not only to government, but also to the scientific community and the general public. A great deal of thought is needed to develop solutions to the problems these issues present. Monitoring, especially the use of appropriate monitoring systems, is particularly relevant to both.

Looking to the future, a prime consideration is the level of need that exists for the measurement of contaminants. The overriding need relates to the effects of the existing environment on human health and well being. To demonstrate this situation, approaches to developing an effective monitoring system with respect to a specific contaminant are discussed in this Chapter.

In respect to environmental assessment, it is recognized that human activities are the prime cause of environmental degradation and that control is therefore a logical start in a staged program of remedial planning and protection. Monitoring is therefore considered as a significant facet in determining the level of impact of human actions. The role of environmental assessment to control human actions is only now coming into vogue and it is therefore important to view its dependence on monitoring as demonstrated in this Chapter.

3.2 Contaminants

3.2.1 General

Currently it is estimated that at least a half million chemical products are produced or used in industry and 3,000 more are added to production lists each year. Presumably most of these substances are not harmful to human or other biological forms. However, an increasing number of incidents give evidence to the fact that there are some products which are dangerous and widely distributed, giving compelling reason for their identification, quantification, and restriction or ban (42).

Until recently there was little interest in identifying the complex chemical pathways of element transfer through the environment. The properties of these substances influence their progress, transformation, destination and effect in the ecosystem. But in view of their complex forms, little is known about their distribution and concentration in the various stages of environmental transfer. To date the monitoring effort has not measured important changes in levels of many substances found in the environment either because we are not aware of the changes and their significance, or because measurement techniques lack sensitivity or are unsuitable.

The current approach to monitoring contaminants in the living and working environment is inadequate. "Only after substantial environmental degradation has become evident" has monitoring been undertaken (41). An illustration of the foregoing is the recent investigation into the matter of lead near specific industrial sources in the Toronto area.

A massive effort by a working group and a lead data analysis task force produced two major reports on medical and non-medical aspects which were discussed in lengthy hearings along with other evidence. Having studied the whole problem in considerable detail, it became obvious that the measurements obtained were not sufficiently conclusive to permit a clear differentiation between the various possible pathways by which the contaminant reached the affected human receptors. It was concluded that external sources rather than those containing lead within a home were mainly responsible for elevated lead levels in the blood of local residents. Thus, despite a significant effort to obtain measurements and conduct a monitoring program, including blood lead sampling from 7000 people, the answers provided were more circumstantial than conclusive. The critical receptor, the child, was identified, but the critical pathways and sources were not. Investigating teams did not have sufficient time or data to integrate their needs into a satisfying, well defined, logical, comprehensive program.

The hearing board reviewing the environmental effect of lead in this specific case presented recommendations on some of the deficiencies.

One of the earliest recommendations accepted was that - "short-term planning to tackle existing problems should include a return to objective scientific data removed from emotional and political influence"(43). To acquire the data it was recommended that:

> "A regular and comprehensive monitoring program should be implemented and maintained to measure lead in ambient air, soil, dust, deteriorating paint surfaces, water, vegetation and food, particularly in areas where hazards are suspected from previous records and experiences at the international level"(44).

Summarizing the monitoring implications of the Public Hearing on Lead Contamination in Metropolitan Toronto, the Board supported recommendations for receptor monitoring in the workplace, and in the nearby community among the persons at risk, especially children and expectant mothers. Monitoring of suspected major pathways and specific indicators was also endorsed. Continuous source monitoring was accepted with qualifications, subject to the reliability of such measurements in view of the present state of instrument technology. The single medium specific contaminant approach used by various agencies was found lacking and in its place a need for an integrated effort amongst ministries was spelled out clearly.

At present almost all source and environmental quality monitoring relates to a specific contaminant or is single medium oriented.

"Measurements of a certain pollutant made in air, for example, are generally not related to measurements of the same pollutant in water or soil. Thus, it is usually not possible to quantify total exposure of important receptors or to separate that exposure into its components. Further, there has been little effort to show the interchange or rate of interchange of pollutants between media. These unintegrated approaches are being used in spite of the fact that the environment is a continuum and any effort to control one kind of environmental pollution without concern for the total environment can well lead to solving one problem at the expense of creating an even greater problem of a different kind"(45).

To deal with contaminant measurement an integrated monitoring system crossing jurisdictional and media boundaries is needed.

3.2.2 Objectives

The broad objective for development of a comprehensive monitoring program involves the application of a systems approach to identify needed information. The systems concept takes into account many facets of the problem simultaneously and identifies specific characteristics and quantities associated with each contaminant.

A second objective for development of the monitoring program would be for policy planning. Specific objectives for policy planning will encompass those presented in Section 2.1 that reveal broad conditions requiring policy action to control or ban certain activities and material use. While remedial measures may be based on clear evidence available from monitored data, decisions on future effects of new substances will rely on estimating conditions using available predictive capability and the information supplied by manufacturers of new substances. An objective must thus include thorough preview of new materials that may potentially become an additional environmental burden. At present this is inadequately achieved because there are few legal requirements for disclosure of detailed information on new substances.

At the other end of the spectrum, enforcement agencies use monitoring data that is source specific, demonstrably related to contaminant releases. The releases may be beyond permitted levels and thus may be proven to produce a certain effect, provided the information is accurately gathered, handled, analyzed and presented.

The information must also provide the accurate link between cause and effect. The applicable objectives of Section 2.1 therefore become very much more local and specific and one single medium monitoring system may not have sufficient flexibility to accommodate policy and enforcement monitoring needs.

Comprehensive measurements in all media and differing environments with all the interrelating measurements involved, are required to make a realistic quantitative assessment of environmental contamination. A relevant monitoring system therefore 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 now has initiated its development.

3.2.3 Integrated Monitoring Systems

The Monitoring Systems Research and Development Division of the Environmental Monitoring and Support Laboratory of the EPA located in Las Vegas is engaged in the design of Pollutant-Oriented Integrated Monitoring Systems. It is applying the relatively new concept of an integrated monitoring system approach which simultaneously considers critical sources, critical pathways and critical receptors. 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.

The first step in developing the integrated monitoring system is the preparation of the conceptual framework that identifies the various pieces of the total system, followed by analyses to identify the interrelationships and obvious gaps. All the known sources, pathways and receptors are identified at this stage and an inventory of available qualitative and quantitative data is assembled.

There are considerable difficulties in assembling this required data as observed by one authority, who stated:

"When we look at Canada, we note marked fragmentation of the occupational safety and health programs. For example, there is the distinction between federal, provincial and municipal responsibilities. Within provinces occupational safety and health programs may be found in Departments of Health, Labour, Mines, Natural Resources, Environment or in the Workmen's Compensation Board. In Saskatchewan and in Alberta, occupational health programs have been transferred from the Department of Health to the Department of Labour"(46).

With programs so diversely assigned, the monitoring will also be fragmented and will not be capable of providing an integrated picture of the total working-living environment.

The existence of overlap and fragmentation in programs, let alone monitoring, poses a major obstacle which must be overcome before proceeding to step two.

The second step in the integrated system development is the system description wherein the components are related by mass balance and input-output behaviour. Step 2 proceeds concurrently with the initial development of a general model and necessary submodels which relate the numerous sources and pathways to receptors.

To make the overall system tractable, the important components must be identified. For the critical receptor population therefore; we must:

1. a) Identify the population with the greatest risk (number of persons exposed to greatest time-concentration product of pollutant).

   b) Identify the population most sensitive with the lowest threshold for effect.

c) Identify the population actually showing the greatest potential for effects(47).

With reference to medical effects we must:

2. a) Determine daily dosage, absorbed dosage, retention, and excretion rates.

   b) Determine minimum threshold of effects of pollutants for both acute high dosage and chronic low dosage in adults and children.

   c) Determine changes and trends in body burden levels and effects with time(47).

Evaluation of critical transport pathways and important portals of entry into a receptor requires:

1. Identify dispersion and dissemination of pollutant into the environment.

2. Identify major transport pathways and special areas of accumulation or concentration of pollutant in the environment.

3. Identify critical pathways from critical sources to critical receptor.

4. Quantify total amounts and rates of flow of pollutant in critical transport pathways to different media.

5. Quantify special pathways and portals of entry, e.g. placental transfer from mother.

6. Quantify amount of pollutant entering (the portals of entry) of the receptor(47).

Critical source identification includes the necessity to:

1. Identify sources, both natural and man made, and develop an emissions inventory.

2. Identify critical sources which are of importance to the critical receptors via identified major transport pathways.

3. Determine mass emission rates for each major type of source, both mobile and stationary.

4. Determine chemical composition of gases of particles and the particle size distribution for each major type of source.

5. Determine changes of sources and trends with time(47).

3.2.4 Models

Based on the quantification established in the conceptual analysis, a hypothetical multimedia model can be developed which should 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.

As an example, dose commitment models having the characteristics of steady state models, wherein the flux of a substance into and out of an environmental compartment is assumed constant, may be employed to account for all sources including the diffuse natural contributions frequently neglected. While dose commitment considerations tie together many multi-media relationships and provide a very useful way of establishing estimates of the background contributions of nature, the long time averaging implications of steady state computation ignore the transient changes affecting living things. For a non-conservative substance with specifically designed short life, such as a pesticide, steady state considerations are unwieldy, if not totally inappropriate. On the other hand, for a conservative substance such as mercury, they may be suitable for preparation of the first quantitative estimate of its location and concentration in the environment. It is likely that our initial understanding of several ubiquitous harmful substances will come not from fragmented monitoring efforts, but from tractable multi-media dose commitment studies.

The far more complex but necessary time-dependent models are potentially superior in estimating the real effects of contaminant releases into the environment. Capable of following the rate changes of short and long-lived substances, they are essential for simulating time dependent episodes, control strategies and effects. Since our understanding of harmful substance behaviour in and among the various media compartments of environment is demonstrably poor, it would be unwise to either discard or to rely solely on modelling. Monitoring and modelling are in fact complementary(48). The models must be verified by monitoring. They are valuable in identifying critical pathways and provide a basis for selecting specific points for measurement in the monitoring strategy.

Without modelling capability it will not be possible to forecast the effects of new and yet undeveloped substances.

3.2.5 Data Acquisition and Management

As with all types of monitoring, an effective system for monitoring contaminants must provide data that are:

1. Comparable with data collected at other times and in other programs.

2. Appropriate for their intended uses.

3. Accurate and reliable.

The contaminant oriented integrated approach must assure compatibility of data from the various types of monitoring systems despite differences that have traditionally developed because of widely dissimilar needs. New techniques and sophisticated instrumentation capable of reliably detecting the very low concentrations that must be measured will be required. On the other hand, accuracy or sensitivity required should only be significant to the level needed to satisfy the specific objectives.

To assure continuity of data over long periods of time, it is necessary to establish adequate reference methods and sample banks. As detection methods and instrumentation improve, the analyst will abandon older methods. Through the use of reference methods and sample banks it will be possible to continually provide the necessary baseline data to relate past, present and future environmental measurements. Additionally, through the use of tissue and serum banks it will be possible to examine past biological samples for presence and quantity of substances heretofore unrecognized as contaminants. Towards this end several such costly banks have been instituted and samples will be gathered for systematic storage nationally in the U.S.A.(49).

Design and development of a quality assurance program is also essential. The program must be legally defensible, and assure comparability and accuracy at all operating phases from sampling methodology through data interpretation and presentation. This is a formidable task when one looks at the historical record.

Despite significant previous effort, most data on environmental contaminants are not directly comparable. Air, water, land or biological samples are most frequently taken and/or evaluated using different techniques and results expressed in non-comparable units; nor is there always a consistent measurement and treatment of data in a single media by different laboratories or from year to year.

> "When one considers the number of different agencies and organizations carrying out environmental monitoring, the variety and the chemical and physical form of pollutants measured, the various media monitored, and the many methods of sampling, analysis, and data reductions used, it is understandable why a uniform quality assurance program on a nationwide basis is needed"(50).

3.2.6 Verification

The final step in the integrated program development is to conduct a pilot study to verify the hypothetical design and, after appropriate modification, to conduct a full-scale field validation program (49).

3.2.7 System Extent

The system size and complexity will depend on the contaminant and the area of influence. Some problems will be related to specific sources and will be of local concern only, requiring a limited variety and number of detectors for a relatively short time. Other systems concerned with a persistent contaminant widely used and distributed by man and nature will be comprehensive. Such systems may need many different types of detectors and may require observation over an extended time interval to satisfy all objectives.

3.2.8 Discussion of Approaches

The logic of the approach of the Las Vegas EPA Laboratory is necessary if we are to develop the overview and knowledge required to examine the total environmental problem. Our existing monitoring systems can only supply part of the necessary information and that is unacceptable, as is evident from the lead controversy in Toronto and similar problems elsewhere.

If we are to obtain a reasonably complete understanding of the existing contaminants problems, 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. Self-regulation of industry as part of a registration or licensing process for individual substances does not ensure that all of the effects and their interactions with other materials in the workplace and the environment have been considered. The existing mix of chemicals in the Great Lakes exemplifies this point. The past performance of self-regulation in the United States suggests that data must be verified by an independent government agency. Furthermore, industry is incapable of considering synergistic effects from numerous chemical combinations, and this must also be a government responsibility.

The Toxic Substances Control Act of the U.S.A. requires that testing be conducted to develop data relative to health and environmental effects of substances or mixtures of substances for which there is an insufficiency of data and experience to determine the risk of injury to health or the environment. The determination is necessary for all stages of substance production and handling including manufacture, distribution, processing, disposal or any combination of these.

This pre-testing provision is absent from the Canadian Environmental Contaminants Act. Potential hazards identification prior to production is frequently inadequate. Furthermore, there is no "provision for regulations governing the safe handling of chemicals in the workplace or during transportation, storage, and use" as in the U.S. legislation cited above(51).

The absence of the self-revealing requirement to identify environmental impacts means simply that we will continue our reactive ways. If nothing more was produced than is already in existence, we would still face the reality that toxic assessments exist "for only a fraction of the enormous number" of chemicals.

Each year we add several thousand new chemicals to the list so that government agencies are becoming overwhelmed under an increasing, awesome burden and need has arisen to determine a manner in which this burden can be carried within current manpower and budget limits.

Several program directors in the U.S. Environmental Protection Agency have considered the same question and, faced with fixed budgets, have indicated that they may undertake to do skeletal monitoring between periods of intensive monitoring. The intensive work will encompass the new demands, albeit at a frequency of once every 4 to 5 years, while the skeletal monitoring (with significantly fewer locations and reduced frequency) will carry on enough of the activities of the past to satisfy the overall monitoring objectives. To implement the foregoing, decisions have and are being made on need, alternatives and cost-effectiveness.

The data from an integrated monitoring network can provide answers to the monitoring objectives described in Section 2.1, because of its holistic approach to the contaminants cycle. Furthermore the holistic approach quantifies total exposure to the sensitive population at risk. The necessary predictive models used to design the monitoring system are in place to evaluate changes due to usage, remedial measures or control strategies that are part of larger environmental management decisions.

To what extent and to which materials can an integrated contaminant-oriented monitoring system be applied? The metallic substances such as mercury, lead, zinc, arsenic nickel, cadmium, copper, vanadium, and manganese qualify. In addition, other substances such as radionuclides, pesticides, asbestos, PCB's, and a wide range of organic substances should also be investigated. In short, almost all the man made substances, which by inadvertent or planned release become environmental burdens, are candidates for integrated environmental monitoring(52).

3.3 Environmental Assessment

3.3.1 General

Environmental assessment is designed to identify, predict, interpret and communicate information about the impact on human health and well-being (including the well-being of ecosystems on which man's survival depends), of proposed human actions such as the construction of large physical works, land reform, legislative policy and program proposals(53). Monitoring plays an important role in providing information upon which an assessment is based.

3.3.2 The Role of Monitoring

In designing a monitoring program for environmental assessment, the issues described in Chapter 2 should be addressed. With respect to objectives, monitoring should be dependent on the nature and scope of the proposed action. Since aspects potentially sensitive to the proposed action are studied in detail, the following types of monitoring may be required:

1. Monitoring for background.

2. Monitoring for trends.

3. Monitoring for non-compliance.

A second issue is to determine monitoring priorities. For example, monitoring for background must be undertaken after aspects of environment have been identified and their meaning (significance) in terms of the particular project, evaluated. The careful selection of parameters has been stressed in Chapter 2, for it is impossible to monitor everything.

A third issue involves coordination of monitoring data from various sources. As an example with respect to monitoring for trends, long-term variation may be discerned from previous records, but this is often difficult because of a lack of accessible, coordinated data banks.

Data are often stored in different places because a particular environmental component may be studied by many individuals. Only an expert in the subject area would know where to find all of them, and the perspective from which they should be interpreted. Thus expertise is important in providing the context within which various kinds of trend data can be evaluated. If data were stored in raw form with sufficient referencing parameters, and made accessible, as suggested in Chapter 2, it would be more useful for environmental assessment documentation.

Moreover, data from monitoring of a particular site could be optimally used if reported in aggregated form to regional and/or national data banks. Hopefully, such data would be compatible with the monitoring needs on regional and national levels, while being responsive to the needs of a particular site.

A fourth issue concerns integration of monitoring data. An environmental assessment report usually contains recommendations for ongoing compliance monitoring to ensure that environmental quality standards are met. For example, in terms of oil and gas exploration, environmental assessment statements must specify "how oil, gas or other substances that may be toxic, which have escaped into the environment, would be detected"(54).

Thus 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. It is extremely important that careful consideration 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 (e.g., the location of a major discharge pipe is changed) there will be adequate data upon which to base standards.

A final issue to be considered here, is the relationship of monitoring in environmental assessment to long-term environmental management. As has already been stated, environmental impact focuses on a specific project; whereas environmental management is regionally and nationally oriented.

At present, environmental assessment cannot be placed within a framework of long-term environmental management. This condition arises in two ways. First, despite the gathering of background data, an environmental evaluation has no real past, as has been described already in terms of difficulties in obtaining and using long-term background data. Second, it is possible that two projects undertaken in the same region, several years apart, may affect one another. At present, there is normally no way of taking into account this effect before either project is proposed, because a regional environmental management plan usually is lacking.

If such plans were available, the effort spent in documenting an environmental issue could be eased by relying, at least in part, on a compendium of historical data available in an accessible regional data bank. Moreover, an environmental assessment could be made in terms of long-term regional needs and plans. A regional management plan would provide that context.

All of the foregoing statements are made with respect to monitoring for the assessment of the physical aspects of the environment, although they are not necessarily limited to them. Social and economic conditions are receiving increasing emphasis in environmental evaluation and could be incorporated into this context.

CONCLUSIONS AND RECOMMENDATIONS 4

4.1 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.

4.2 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.

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