ENVIRONMENTAL MONITORING IN CANADA

prepared for

Fisheries and
Environment Canada

Volume 4
BACKGROUND INFORMATION

August 1977

SEI

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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.

TABLE OF CONTENTS

		Page
1.	INTRODUCTION	
	1.1 History	1-1
	1.2 Terms of Reference	1-2
	1.3 Organization	1-3
	1.4 Study Approach	1-4
	1.5 Presentation of Information Gathered in Interviews	1-6
	1.5.1 Canadian Interviews	1-6
	1.5.2 U.S. and U.K. Interviews	1-6
	1.6 Comments on the Interviews	1-7
	1.6.1 Canadian Interviews	1-7
	1.6.2 U.S. Interviews	1-9
	1.6.3 U.K. Interviews	1-9
2.	COMMENTS ON MONITORING IN CANADA	
	2.1 Introduction	2-1
	2.2 Monitoring Objectives	2-2
	2.3 Monitoring Priorities	2-2
	2.4 Gaps in Current Monitoring Information	2-3
	2.5 Data Collection and Handling	2-7
	2.6 Integration of Monitoring Activities	2-8
	2.7 Priorities for Future Monitoring	2-10
	2.8 Interdepartmental Cooperation	2-12
3.	MONITORING IN THE U.S.A.	
	3.1 Introduction	3-1
	3.2 Radiation	3-2
	3.2.1 General	3-2
	3.2.2 Ambient Radiation Monitoring by the Environmental Protection Agency	3-3
	3.2.3 Radiation Monitoring by the Nuclear Regulatory Commission	3-6

		Page
3.2.4	Interagency Program	3-7
3.2.5	Radiation Studies at Nuclear Facilities	3-8
3.2.6	Summary	3-8
3.3	Toxic Substances	3-9
3.3.1	General	3-9
3.3.2	Identification of Problems Associated with Chemical Activities	3-14
3.3.3	Characterization of the Problems	3-15
3.3.4	Development and Stimulation of Preventive and Corrective Approaches	3-16
3.4	Water	3-17
3.4.1	General	3-17
3.4.2	Drinking Water	3-20
3.4.3	Groundwater	3-22
3.5	Air	3-25
3.5.1	General	3-25
3.5.2	Air Quality Measurement Programs	3-25
3.6	Pesticides	3-29
3.6.1	The National Pesticide Monitoring Program	3-29
3.6.2	The National Pesticide Monitoring Plan	3-30
3.6.3	Summary	3-32
3.7	Noise	3-33
3.7.1	General	3-33
3.7.2	Environmental Trend Monitoring	3-33
3.7.3	Measurement of Stationary Noise Sources	3-34
3.8	Summary	3-35
3.9	References	3-37
4.	MONITORING IN THE U.K.	
4.1	Present Approach	4-1
4.1.1	Objectives	4-1
4.1.2	National Monitoring Framework	4-1
4.1.3	Range of Monitoring Activities	4-3

Page

4.2 Proposed Activities 4-5
4.3 Problems with Current Monitoring Programs 4-8
4.4 Monitoring - related Activities 4-9
4.5 Globally-oriented Activities: MARC 4-13
4.6 References 4-17

5. UNITED NATIONS ENVIRONMENT PROGRAM - GLOBAL ENVIRONMENTAL MONITORING SYSTEM (GEMS)

5.1 Introduction 5-1
5.2 Development of GEMS 5-2
5.3 References 5-7

Appendix 1 - List of Proposed Interview Questions

Appendix 2 - Deputy Minister's Memorandum

Appendix 3 - Persons Interviewed in Canada

Appendix 4 - Persons Interviewed in the U.S.A.

Appendix 5 - Persons Interviewed in the U.K.

LIST OF TABLES

Table 3.1 Parameters Used in the Evaluation of Water Quality 3-19

Table 3.2 Atmospheric Pollutants Currently Being Measured by the EPA 3-28

INTRODUCTION 1

1.1 History

A contract to undertake a study on environmental monitoring in Canada was awarded to a consortium of Canadian companies, led by Philips Electronics Limited (with major participation by James F. MacLaren Limited), as a result of an unsolicited proposal to the Department of Supply and Services. The initial impetus for the proposal came from the Environmental Monitoring Sub-committee of the Air Industries Association of Canada, which is chaired by E.J. DeBeaupre of Philips. A position paper prepared by this sub-committee identified an urgent need for a national environmental monitoring management plan for Canada. Such a plan would ensure that appropriate information is available to persons having to make decisions affecting environmental quality and the management of resources.

The consortium prepared a proposal for a study on this topic and submitted it to an interdepartmental committee of the Federal Government. The committee recognized the merits of the proposal, but asked that it be modified and resubmitted. A modified proposal was submitted and was accepted by the committee. The committee developed terms of reference for the study and this contract was awarded to the consortium based on the terms of reference set out in 1.2.

1.2 Terms of Reference

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

2. Identify the nature, scope and detail of information on the environment which must be obtained or made available on a regular and systematic basis, in order that sound decisions can be made on the management of resources and the quality of the environment; comment on the effectiveness of present systems for gathering such information in the light of present and projected needs. This review should cover socio-economic, biological, physical, chemical parameters relevant to water, air and land, and should indicate the way in which such information might be integrated so as to support management systems.

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

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

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

6. Suggest approaches to an integrated overall environmental monitoring scheme for a mutually agreed upon area highlighting the interaction of the various

monitoring activities for the whole spectrum of air, water and land.

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

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

1.3 Organization

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

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

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

A third group was represented as a Steering Committee on Environmental Monitoring, whose task was to assist and guide the Consortium Group in carrying out the study. This was a

federal interdepartmental committee, chaired by the Scientific Authority, with members from the Departments of Environment, Agriculture, Health and Welfare, and Indian and Northern Affairs, and from the National Research Council.

1.4 Study Approach

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

Work on the study commenced with the preparation of a procedure for interviewing persons involved with environmental monitoring in various federal and provincial departments. The purpose of the interviews was to identify current Federal and Provincial monitoring activities, and to discuss several aspects of these activities, including: objectives, jurisdiction, rationale, and integration. A list of proposed questions for the interviews was developed and forwarded, in draft form, to the Steering Committee for approval. A copy of this list is found in Appendix 1.

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

offices and with Provincial officials. A copy of the Deputy Minister's memorandum is found in Appendix 2.

During September and early October, the project team made presentations to each of the Regional Boards to explain the study further and to seek assistance in arranging interviews.

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

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

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

A complete list of persons interviewed in Canada is given in Appendix 3.

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

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

Lists of persons interviewed are found in Appendix 4 (U.S.A.) and Appendix 5 (U.K).

Throughout the study, relevant literature was reviewed. A bibliography has been prepared and is given in Volume 1.

1.5 Presentation of Information Gathered in Interviews

1.5.1 Canadian Interviews

The information gathered in the Canadian interviews forms the basis for much of this report. Volume 3, "Directory of Canadian Environmental Monitoring Activities", is based entirely on the interviews and written material provided to the project team. The directory was prepared to satisfy Items 3 (partially) and 4 of the terms of reference. The interviews were also responsible for giving considerable direction to the thoughts presented in the main report (Volume 1), which covers items 2, 3 (partially), 5 and 6 of the terms of reference.

Ideas presented in the interviews have been summarized in this volume according to topics that are addressed in the main report.

1.5.2 U.S. and U.K. Interviews

Current and proposed monitoring approaches and activities in both the U.S. and U.K. are described in this volume. These descriptions are based on the interviews and written material provided to the project team. In addition, many ideas gained through these interviews have been woven into the thoughts presented in the main report.

1.6 Comments on the Interviews

Much of the project team's time was devoted to interviewing Canadian and foreign officials, as was required by the nature of the study. Thus the study's success was greatly influenced by the results of these interviews. Several important comments on the interviews have been noted.

1.6.1 Canadian Interviews

1. The draft list of suggested questions, which had been forwarded to the Steering Committee for approval, was sent by the Committee to many of the people who were to be interviewed. Since the list was still in draft form and was not intended to be a questionnaire, the interviewers were often required to spend a considerable amount of time clearing up misconceptions about the study caused by this preliminary list of questions.

2. The broad and vague nature of the study's terms of reference caused substantial difficulty. Many of the people interviewed were convinced that the study was too broad and could not be completed within the time and budget allotted to it. Thus members of the project team had to continually explain, clarify and justify the approach being taken to satisfy the terms of reference.

3. The definition of "monitoring" was a subject of discussion with most people interviewed. The difference between "monitoring", "surveys", "surveillance", and "measurements for research", was often discussed at length. The approach of the project team was to start with a very broad definition of monitoring so that potentially relevant data collection activities were not excluded from consideration.

4. The Regional Boards' general response to the Deputy Minister's request for assistance in carrying out the study was not enthusiastic. Reaction to the project team's presentation at the Regional Board meetings was mixed; with much of it being critical and negative. Some government officials were concerned that the study was duplicating other studies previously undertaken by various government departments. In many cases, the cooperation provided in arranging interviews with regional and provincial representatives was poor. This caused delays in the scheduling of interviews, with the result that interviewing continued until mid-February 1977, whereas the project plan called for completion by November 19, 1976.

5. Particular concern was generated among some of the departmental representatives interviewed, that the project members were attempting to evaluate in detail individual monitoring programs. Thus there was considerable variation in the disclosure of information. The members of the project were concerned that this variability may have resulted in an incomplete understanding and appraisal of current monitoring activities.

6. There did not seem to be much available written material describing current monitoring activities. This is in sharp contrast to the situation in the U.S.A. The best available narrative on environmental monitoring in Canada was "Environmental Monitoring - A Compendium of Data Gathering Activities of Environment Canada", by D. Robert MacKay and D. Glenn MacDonell.

7. In general, the Canadian interviews were not as successful as the project team had hoped they would be. Nevertheless, many of them were very informative and necessary in carrying out the study.

1.6.2 U.S. Interviews

Initial interviews with officials of the Environmental Protection Agency (EPA) and other agencies were arranged through EPA's International Activities Branch.

Subsequent interviews were arranged directly by the project team. In all cases the project team was greeted by enthusiasm and cooperation. A great many reports, many of them preliminary or restricted, were provided and were of great value in carrying out the study.

1.6.3 U.K. Interviews

Only one interview was conducted in the U.K., at the Monitoring and Assessment Research Centre, (MARC), Chelsea College. It was extremely informative and liaison with MARC was maintained throughout the study.

COMMENTS ON MONITORING IN CANADA

2

2.1 Introduction

Information gathered during the interviews conducted in Canada is presented in this report in two ways:

1. Descriptions of current Canadian environmental monitoring activities are given separately in Volume 3 - Directory of Canadian Environmental Monitoring Activities.

2. Comments on several topics related to monitoring are summarized in this chapter. These topics are:

   i. Monitoring objectives.

   ii. Monitoring priorities.

   iii. Gaps in current monitoring information.

   iv. Data collection and handling.

   v. Integration of monitoring activities.

   vi. Priorities for future monitoring.

   vii. Interdepartmental cooperation.

These comments have been taken from notes made during the interviews and are not intended to reflect the views of the study team.

2.2 Monitoring Objectives

- There is no national monitoring policy now and therefore it is not possible to formulate objectives and strategies for monitoring.

- Monitoring systems must be designed to obtain data that meet the needs and requirements of some user.

- The requirement for monitoring develops from:

    1. Program needs (research, baseline data, etc.).
    2. Foresight into future problems.
    3. Establishment of new Acts.

- The main purpose of an integrated monitoring scheme would be to assist Fisheries and Environment Canada in enforcing its regulations. A secondary purpose of monitoring would be to assist in standard setting based on long term acquisition of data.

2.3 Monitoring Priorities

- The Assistant Deputy Minister of the Environmental Protection Service (EPS) has no basis for determining priorities for action based on current data available to him.

- Some regional offices (of EPS) carry out extensive monitoring without reference to headquarters and there

seems to be a lack of direction here.

- The priorities of monitoring are often decided in the social/political sphere, i.e. airport monitoring or monitoring related to oil drilling in the Beaufort Sea.

- A more critical review of Fisheries and Environment Canada's internal program evaluation procedures is warranted.

2.4 Gaps in Current Monitoring Information

Land

- An expansion of the monitoring of land use change is needed. The objective of an expanded program would be to provide an up-to-date national inventory of land use in Canada. The primary user of such information would be the Federal Government. The Federal Government now acts with inadequate information on the use of Canada's land resources.

- A national system for filing data on land ownership would assist in the more effective control of land use.

- More monitoring of toxic substances of land is required.

Forests

- Forest inventory data gathered by individual provinces are inadequate to give a national picture of forest resources. Efforts are being made to set up a national forest inventory program as part of a National Forest Policy.

Water

- In the Great Lakes Water Quality Program, improved information is required to accurately determine tributary loadings to the Lakes. The current methods for determining loadings were not designed with the Great Lakes program in mind.

- A reporting program on toxic materials does an inadequate job of identification, and there is no monitoring of water quality for some substances on a gross contamination basis. Part of the problem is a lack of detection methods for some contaminants.

- There is a lack of developed water quality instrumentation, and there is a need for this. Instrumentaiton should be able to handle the following: (i) variability, (ii) detectability, and (iii) information translation.

Air

- There is a need for more remote stations to fill gaps in the monitoring grid and to improve climate diagnostic capability.

Biology

- The Great Lakes Water Quality Program should be expanded to include contaminant investigations in biota. More development work is required in the biological field.

- A lack of comprehensive resource survey coverage is the greatest deficiency in the data available for fishery management (Atlantic Coast).

- There is no predictive value in water quality data from a fish biological standpoint. The identification of indicator species and their relation to concentrations of substances in various media would be useful.

- More monitoring should be done on toxic substances. A data bank of existing information should be compiled.

- Most of the monitoring (aquatic) to date has been with chemical parameters and no good biological monitoring parameters have been developed, e.g. in the Qu'Appele Basin study over 100 water quality samples were taken, whereas the analysis of two fish would have yielded the same results.

Agriculture

- An inventory of pesticide use and distribution is desirable. There are estimates based on sales from prairie warehouses, but this information is not available in the rest of Canada. Companies are reluctant to give out this information. Agriculture Canada has requested Statistics Canada to get this information.

Environmental Assessment

- Biologists lack adequate baseline data that can be used to help predict the impact of various activities upon biological species.

- There is generally a lack of adequate baseline data in the north. A standard should be set so that data collected by proponents on new resource development schemes will be assembled on a uniform basis and made available to the public.

- A difficulty exists in selling the Environmental Assessment Review Process (EARP) to others such as Department of Indian and Northern Affiars and Department of Energy, Mines and Resources. There is a lack of legislation requiring the complete and common use of EARP.

- There is generally insufficient data to serve the needs of EARP. The data base should be developed by the service responsible for managing the resource.

General

- There are gaps in information and a mutual lack of understanding of Federal and Provincial programs, which results in overlap and monitoring schemes that are not known amongst the various monitoring agencies.

- There is inadequate feedback from the regional offices to Ottawa on the usefulness of monitoring programs.

- Currently no mechanism exists to insure that adequate information is available to effect control measures. Consequently, decisions on such measures are made in the absence of adequate data. Additionally, economic information should be available to be assessed when control measures are under development. The lack of these items is frustrating.

- Information should be gathered in such a way that it is possible to establish relationships between causes and effects.

2.5 Data Collection and Handling

- There is a strong need for clear documentation of analysis methods and changes in these methods so that data from year to year are comparable. It is also necessary that sampling conditions are clearly documented. Duplicate samples and spiked samples should be used as a quality control check on laboratory analysis.

- There is too much emphasis on analytical techniques and not enough on the manner of obtaining and handling samples.

- Improvement and standardization of analytical techniques are necessary to provide reliable, useful biological data.

- In many Federal and Provincial departments a great deal of the data from monitoring is not interpreted. Also, in many cases the data are published only after a long delay. As a result not many data are used for management decisions.

- The weakness in the present monitoring effort is not a lack of information but is rather a lack of resolve to apply the information. The manner of integrating information and presenting it is inadequate.

- Data gathered by the Inspection Branch, Fisheries and Marine Service are confidential and not available to the Environmental Protection Service, to whom they would be very useful.

- Much of fisheries contaminant data remains classified, which hinders data interchange.

- Socio-economic fisheries data are published in raw form. There should be more interpretation.

- The Ontario Regional Branch of Fisheries and Environment Canada is currently reviewing the accessibility of information. Data generators and user needs have been identified and attempts are being made to improve interaction between the two.

2.6 Integration of Monitoring Activities

- The integrated approach to environmental studies can be improved. Wildlife studies should work through the habitat to animal and to the environment in which the animal lives. The Arctic Islands Pipeline Study and the Streeter Basin Study are good examples of a properly integrative approach.

- The interdepartmental committees within the Federal Government are not effective in promoting integration of monitoring activities.

- There is a lack of integration of Federal and Provincial monitoring. In some instances, this reaches a virtual withholding of information between the two groups.

- Fisheries and Environment Canada's headquarters tends to view the environment as being made up of several distinct compartments, whereas the regional offices look at the environment as a whole. The former approach often leads to duplication of effort; for example, guidelines for air emissions and wastewater effluents may be developed at different times, and this results in industry being approached twice for the same data.

- Fisheries and Environment Canada's present organizational structure is not suited to deal with multi-media environmental problems.

- There is a need for greater coordination of environmental monitoring within and outside of Federal Government.

- The experience of the Atmospheric Environment Service (AES) has not indicated significant duplication of effort, but rather that the efforts are complementary. However, more integration of data is necessary.

- There is no integration of land use data collected by various departments; each department collects data only to meet its own objectives.

- It is difficult for the Environmental Protection Service (EPS) to evaluate the effectiveness of various measures since dependence is placed on others in the feedback loop whose needs and perceptions may differ from those of EPS (control function).

- There have been problems in the past when integrating air and water monitoring programs (especially with data storage).

- A large integrated system (to monitor the Great Lakes) might not adequately meet the needs of individual provinces and states.

- The Department of Agriculture can follow the path of a given pesticide but cannot tell the significance of its effect upon the fauna. The Department has tried to set up liaison with Fisheries and Environment Canada on this matter.

- There is an ad hoc committee of Fisheries and Environment and Agriculture representatives to consider monitoring and observation requirements for new chemicals used by Agriculture and others.

- A mechanism is lacking to provide a check on the environmental consequences of agricultural activities.

- Laboratories should be better integrated in the field to permit greater facility in coping with new types of pollution problems.

- In Quebec, water quality and quantity measurements are undertaken by the Ministry of Natural Resources while Environment Quebec does effluent measurements, and there has been little interaction between the two departments.

2.7 Priorities for Future Monitoring

Early Warning

- There is a need to develop a program to monitor the location and distribution of priority contaminants and to develop an early warning system to disclose "hot spots" that they might be creating. There is a high level of interest in programs that might be able to trace the effect of specific pollutants such as fluorocarbons, Mirex, etc.

- The establishment of national water quality objectives will imply the need to maintain a constant biological survey using birds and fish as the early warning system.

Water

- The Environmental Contaminants Act will force the Water Quality Branch to concentrate more on hazardous chemicals than on the more common chemicals.

- The hydrometric forecast effort will be expanding and this will require new equipment plus the use of satellites to provide the radio link. Satellites provide improved data communication methods to current systems.

- In the future, it may be possible to make better use of field personnel by expanding their responsibilities or also by adding to the measurement capability of monitoring stations (hydrometric), i.e. by the addition of water temperature measurement.

- Water quality and quantity data should, in future, be collected according to a priority ranking of river basin.

Air

- Automate more of the instrumentation.

- AES field personnel have surplus time available and could be used for making other measurements or observations. This program has already been instituted to some extent.

Biology

- The identification and use of indicator species is an important priority.

2.8 Interdepartmental Cooperation

Summary of Comments

- Good interaction between Agriculture Canada and Fisheries and Environment Canada has not yet been established.

- Cooperation between Atmospheric Environment Service and Agriculture Canada also could be improved.

- There is a strong structure between federal and provincial agriculture departments and the Canadian Agricultural Services Coordinating Committee.

- There is little water quality information transferred between Fisheries and Environment Canada and the provinces of Ontario and Quebec.

- In the Atlantic Region, interdepartmental committees such as the Eastern Advisory Committee on Pesticides in the Environment are major sources of contact with other departments.

MONITORING IN THE U.S.A. 3

3.1 Introduction

Environmental monitoring in the United States involves local, regional, State, and Federal agencies in an integrated effort. The local, regional and State agencies are "directed toward enforcement and designed primarily to sample pollutants for which National environmental standards have been promulgated" (1)*. The main goal of the Federal program is to collect and "provide monitoring data not furnished by ...[other]... agencies", (2) and to make "available requisite hydrological, aerometric and related data on a nationwide scale" (1).

Monitoring of environmental quality is carried on for one or more of the following uses:

1. "Establishment of or revisions to standards.

2. Demonstration that adequate progress is being made for the attainment of the standards, in the scheduled time frame.

3. Provide assurance that compliance with standards has been attained.

* Numbers at the end of a sentence (1) refer to references listed at the end of each chapter.

4. Information to show maintenance of the standards.

5. Determine if control of high pollution episodes or spills is adequate and provide guidance on choice of actions.

6. Definition of environmental pollution problems for periodic determination of priorities for resource allocations, and the development of control programs" (3).

The types of monitoring include: (i) Trend Monitoring; (ii) Ambient-source Linked Monitoring; (iii) Exposure Monitoring; and (iv) Biological Monitoring.

In this chapter, present monitoring activities for radiation, toxic substances, water, air, pesticides, and noise are described. Radiation and toxic substances monitoring activities are described in detail since these are areas of rapidly expanding concern. Water and air monitoring programs are by far the largest programs, but they are currently undergoing intensive reviews which may result in a reduction in the resources devoted to them.

A brief discussion of future directions in the design of monitoring systems in the United States is given at the end of the chapter.

3.2 Radiation

3.2.1 General

"Radiation monitoring networks can be arbitrarily divided into two categories: source monitoring networks, established for particular monitoring situations, and nationwide ambient networks" (4).

"Most monitor the more common media including air, water and external gamma fields; however, specialized networks monitor such exotic media as deer thyroids. The results in most cases are used for historical documentation with built-in alert criteria for abnormally high values" (4).

Current nationwide networks are operated by either the Environmental Protection Agency (EPA) or the Nuclear Regulatory Commission (NRC) and Energy Research and Development Agency (ERDA).

3.2.2 Ambient Radiation Monitoring by the Environmental Protection Agency

Local Ambient Near Nuclear Power Facilities

The Surveillance and Inspection Branch of the Office of Radiation Programs (ORP) of EPA has programs which relate sources and levels of environmental radioactivity and the resulting population dose. Radiation Data and Reports, appropriate scientific journals and Divisional technical reports are employed to distribute the findings. The "Environmental Radioactivity Surveillance Guide"* is prepared by the Office of Radiation Programs to guide the surveillance of nuclear facilities. In it, methods "for conducting a minimum level of environmental radiation surveillance outside the boundary of light-water-cooled nuclear power facilities are recommended..." (5) but requirements for any organization conducting such a program are not specified.

"The recommended program consists of two phases: pre-operational and operational. The former provides data which can be used to evaluate increases in local radioactivity after the plant becomes operational. The evaluation must also determine if an increase is due to plant operations or

* Under revision with completion scheduled for September 1978.

to a general increase in environmental radioactivity. Therefore the latter program must include control data from sample sites beyond the measurable influence of the nuclear facility and data from the affected areas. The program must emphasize sampling and measurement of the environmental media which significantly contribute to public radiation exposure." (5)

The program is designed so that the data will be compatible and subject to singular interpretation relative to the estimated population radiation dose. The Guide, which has gained de facto acceptance by State and other Federal agencies involved in radiation protection, suggests that environmental radiation surveillance programs conducted around nuclear facilities should, as a minimum, provide data which may be used for the following purposes:

1. "population dose calculations which can be compared with Federal and State standards;

2. the evaluation of build-up of environmental radioactivity; and

3. public information" (5).

National Ambient

EPA's Environmental Radiation Ambient Monitoring System (ERAMS) was formed in July 1973 from separate networks operated by the U.S. Public Health Service prior to EPA's formation. These previous networks had been oriented primarily to measurements of fallout levels. The new system undertakes surveillance of ambient radioactivity levels. Collection and analysis frequencies and sampling locations of the former system were changed and the analyses for specific

radionuclides were increased. Current emphasis is on identifying trends in the accumulation of long-lived radionuclides in the environment. Specific analyses are made for U-234 and U-238, Pu-238 and Pu-239, C-14, H-3, Sr-90, and Kr-85 (6).

Annually, over 7000 individual analyses of air, water, milk, and bone samples from about 150 locations throughout the United States and its territories are undertaken. State and local health agencies collect samples and forward them for analysis to the Eastern Environmental Radiation Facility (of ORP) in Montgomery, Alabama. Radiation Data and Reports (1972-1974), Radiological Health Data and Reports (1966-1971), and Radiological Health Data (1960-1965), published the results. This was suspended in 1974, to be replaced by annual topical reports and quarterly summaries of the ERAMS data.*

Due to the national coverage and consistent sampling and analysis methods, these data have been used for comparison with those from the vicinity of nuclear facilities. Baseline and long-term trend data for major airsheds, watersheds, and milk-producing regions provided by ERAMS complements local programs around specific nuclear facilities, conducted by State agencies and facility operators.

The increase of Kr-85 concentrations in air over the past 13 years is discernible from ERAMS data. The need for continued surveillance and eventual control is indicated by: the clear upward trend, the large worldwide exposed-population group and the increasing use of nuclear energy. Atmospheric nuclear testing and noble-gas releases from spent-fuel-reprocessing plants and nuclear reactors contributed to this accumulation. Increased tritium concentrations in surface water and a decline in the Cs-137 and Sr-90 levels in milk are other discernible trends.

* ERAMS data are currently maintained by Environmental Protection Agency, Eastern Environmental Radiation Facility, P.O. Box 3009, Montgomery, Ala. 36109.

The ERAMS is a dynamic system that is changed and improved as the need for additional information arises. Plans are currently being made to analyse I-129 in milk.

The Pasteurized Milk Network is an example of a nationwide network. It has 65 stations which provide monthly samples. These are analysed for 5 fission products which can occur in milk. Strontium-89, Strontium-90, and Cesium-137 indicate long-term deposition of fission products in the environment and document yearly trends. Iodine-131 and Barium-140 indicate fresh fission products and only occur when new material enters the biosphere. Periodically, samples with known quantities of radionuclides are distributed and then statistically analyzed to maintain network quality control. These samples are also sent to other networks. In this way, compatibility between national, international, and state networks is ensured.

3.2.3 Radiation Monitoring by the Nuclear Regulatory Commission

In 1975, the Nuclear Regulatory Commission (NRC) revised its Regulatory Guide on environmental radiation surveillance entitled "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants" (Regulatory Guide 4.1, Rev. 1). Such programs are essential. They provide additional assurance that the public health and safety and the environment are adequately protected, and their data are used to determine if the plants are operating within the conditions of their licenses.

Each licensee must monitor major and potentially significant pathways of gaseous and liquid radioactive effluents during normal operation. Radiological monitoring and waste systems are checked by NRC inspectors to see if they are built as

designed and operated to keep releases within regulatory limits. The licensee must inform the NRC if a limit is exceeded and take appropriate action.

Moreover, each licensee must monitor major pathways in the environment. Random samples of monitoring records, procedures, and reports are examined during NRC inspections. Confirmatory measurements assess the accuracy and consistency of radioactivity measurements in effluent and environmental samples. Then, these confirmatory measurements are compared with NRC reference data developed in laboratory measurements.

3.2.4 Interagency Program

In 1975, NRC, the National Bureau of Standards, ERDA, EPA, and State health and environmental agencies cooperated to provide corroborative evidence of the environmental and effluent radioactivity measurements submitted by licensees. For example, the National Bureau of Standards and the Health Services Laboratory (HSL) of the ERDA Idaho National Engineering Laboratory developed a system to continuously track the accuracy of radioactivity measurements. HSL is the NRC reference laboratory in such matters. NRC inspectors regularly compare licensee effluent measurements with identical effluent samples by HSL.

Eighteen State agencies help in long-term, repetitive sampling to evaluate licensees' overall environmental programs. NRC provides them with funds, technical support and training to improve their analytical capabilities. Also used in the evaluation of a licensee's analytical capability is the EPA's Environmental Radioactivity Laboratory Intercomparison Studies Program at the Environmental Monitoring and Support Laboratory, Las Vegas, Nevada.

3.2.5 Radiation Studies at Nuclear Facilities

Field studies are done on a case by case basis at operating nuclear facilities by ORP. It is part of its dose assessment program to: (i) develop measurement techniques; (ii) validate dose computational models; (iii) characterize effluents; and (iv) determine the ability of technology for control of nuclear wastes to meet design technical specifications.

Environmental objectives are generally best achieved through controls at the source. Thus effluent monitoring is preferred. Such measurements, when combined with regulatory models for environmental transport, adequately demonstrate conformance with the standards for most situations, based upon existing experience. According to the Environmental Protection Agency, it is often appropriate to supplement effluent monitoring with confirming environmental measurements, as is now the regulatory practice, since varying degrees of conservatism and uncertainty exist in all environmental models. "In the case of light water reactors, models and monitoring requirements for demonstrating conformance with Appendix I of 10 CFR Part 50 are generally adequate for demonstrating conformance with these standards" (7). Similar models and measurements would generally be suited to most other facilities.

3.2.6 Summary

Nationwide EPA networks have changed somewhat in scope and nature in recent years. This is due principally to the decrease in amounts of debris introduced into the biosphere, virtual cessation in most atmospheric testing of weapons and to technological advances in analytical instrumentation. Networks, such as the Institutional Total Diet Surveillance

Network, have been eliminated. Others have reduced either the sampling frequency or the number of stations. In analytical instrumentation, the main change is the use of solid state counting devices in gamma spectroscopy. These aid in identifying trace amounts of radionuclides.

Throughout the country limited radiation surveillance networks have been established for detailed documentation of a specific geographical area (i.e., states, cities, etc.) and for source monitoring. Those monitoring power reactors, fuel production and reprocessing facilities, and AEC research and development installations are examples of source networks. These usually collect and analyse a variety of samples. For example, around the Nevada Test Site are networks for measuring air, water, milk, deer thyroids, cattle, soil, external gamma field, human burdens (measured through whole-body counting) and human urine.

Like nationwide surveillance networks, those employed for source monitoring are constantly changing, depending on new requirements and analytical techniques. More source monitoring networks will be established because of an increased number of sources (namely power reactors).

3.3 Toxic Substances

3.3.1 General

The Toxic Substances Control Act was passed on October 11, 1976. As a result, EPA must develop adequate data on the effect of chemical substances and mixtures on health and the environment. The development of such data should be the responsibility of those who manufacture and those who process chemical substances and mixtures. The law exempts pesticides, nuclear materials, food and non-food items covered by other acts.

With respect to research, development, collection, dissemination and utilization of data, the law states the following:

"Authority - The Administrator shall, in consultation and co-operation with the Secretary of Health, Education, and Welfare and with other heads of appropriate departments and agencies, conduct such research, development, and monitoring as is necessary to carry out the purpose of this Act.

Data Systems - The Administrator shall establish, administer, and be responsible for the continuing activities of an inter-agency committee which shall design, establish, and co-ordinate an efficient and effective system, within the Environmental Protection Agency, for the collection, dissemination to other Federal departments and agencies, and use of data submitted to the Administrator under this Act. The Administrator shall, in consultation and co-operation with the Secretary of Health, Education, and Welfare and other heads of appropriate departments and agencies design, establish, and co-ordinate an efficient and effective system for the retrieval of toxicological and other scientific data which could be useful to the Administrator in carrying out the purposes of this Act. Systematized retrieval shall be developed for use by all Federal and other departments and agencies with responsibilities in the area of regulation or study of chemical substances and mixtures and their effect on health or the environment.

Screening Techniques - The Administrator shall co-ordinate, with the Assistant Secretary for Health of the Department of Health, Education, and Welfare, research undertaken by the Administrator and directed toward the development of rapid, reliable, and economical screening techniques for carcinogenic, mutagenic, teratogenic, and ecological effects of chemical substances and mixtures.

Monitoring - The Administrator shall, in consultation and co-operation with the Secretary of Health, Education, and Welfare, establish and be responsible for research aimed at the development, in co-operation with local, State and Federal agencies, of monitoring techniques and instruments which may be used in the detection of toxic chemical substances and mixtures and which are reliable, economical, and capable of being implemented under a wide variety of conditions.

Basic Research - The Administrator shall, in consultation and co-operation with the Secretary of Health, Education, and Welfare, establish research programs to develop the fundamental scientific basis of the screening and monitoring techniques described in subsections (c) and (d), the bounds of the reliability of such techniques, and the opportunities for their improvement.

Exchange of Research and Development Results - The Administrator shall, in consultation with the Secretary of Health, Education, and Welfare and other heads of appropriate departments and agencies, establish and co-ordinate a system for exchange among Federal, State, and local authorities of research and development results respecting toxic chemical substances and mixtures, including a system to facilitate and promote the development of standard data format and analysis and consistent testing procedures" (8).

The clear trend in the regulation of toxic substances is to shift the burden of proof to industry. Even after only the most minimal demonstration that a substance may represent a health hazard, industry will be required to provide evidence to the contrary before it can use or produce the substance. Fulfilling these requirements will create unprecedented demands, particularly upon the chemical industry, to supply data and information.

Both industry and government are concerned about the lack of available data to determine the health effects of toxic substances. Industry is also concerned about the government's tendency to overregulate before these data are obtained.

Proposed rules have been published in the Federal Register (March 9, 1977) that request information for the preparation of an inventory of chemical substances. Inventory Reporting would prescribe what chemical substances must be reported for inclusion on an inventory of chemical substances required by the Act; procedures for reporting chemical substances for the inventory; exemptions from such reporting requirements and certain prohibitions; and procedures for handling claims of confidentiality.

Shortly after publication of these proposed rules, EPA will publish in the Federal Register a note of availability of a candidate list of approximately 30,000 chemical substances compiled from various government and private sources. This list will simplify reporting by listing these chemical substances with code numbers to be used in reporting them.

There are more than 30,000 industrial chemicals and two million mixtures, formulations, and blends currently in commerce. An estimated 1,000 additional chemicals reach the marketplace annually. Not only must selectivity take into account the potential environmental hazards of the chemicals, the urgency of the problems, and the likelihood that Office efforts will help reduce the problems, but also unnecessary duplication of efforts of other EPA offices, other agencies, and industry must be avoided. There is a need to consider the total impact on society of chemical activities (i.e. cost, risk, benefit) when dealing with a sector of industry that undergirds the American standard of living, accounts for more than 10% of the GNP, and annually contributes $5 billion to the favourable balance of payments.

The program activities of this Office contribute to the much broader Government effort in the following three overlapping areas:

"1. Identification of problems associated with chemical activities as the result of:

Systematic screening of available information;

Monitoring, toxicological, and epidemiological screening programs;

Ad hoc environmental incidents, research findings, and allegations.

2. Characterization of the problems with particular attention to:

Health and ecological effects and environmental behavior;

Current and projected sources, environmental levels, and exposed population;

Substitutes, control technology, and related cost and economic factors;

Action to date and actions underway to clarify and control the problems.

3. Development and stimulation of preventive and corrective approaches including consideration of:

Role of relevant authorities of EPA and other agencies;

Alternative approaches to voluntary or regulatory redress;

Environmental and economic impact of approaches;

Implementation of appropriate approach.

Given the backlog of unattended known chemical problems and the many difficulties usually attendant to remedying problems after they are characterized, the bulk of the Office's in-house efforts will continue to be directed to the development and stimulation of preventive and corrective actions" (9).

3.3.2 Identification of Problems Associated with Chemical Activities

The Early Warning Program sets priorities and characterizes, in a preliminary fashion, chemical problems requiring further attention. Improved techniques for: (i) rapidly screening new chemicals being introduced into commerce; (ii) screening the world of old chemicals to uncover previously neglected problems; and (iii) setting priorities and assessing suspect chemicals, are needed. The development of a model for comparing projected and acceptable environmental loads of chemicals; the testing of the utility of known correlation patterns between chemical structures and biological activity as a means of predicting toxicity; the evaluation of the Delphi approach to problem prediction; and the setting of priorities for some chemicals on the National Institute of Occupational Safety and Health (NIOSH) list of about 1,500 suspected carcinogens, are required immediately (10).

Complementing this program are field screening efforts to identify previously unsuspected chemical problems. EPA field and research offices have traditionally conducted

various ad hoc reconnaissance monitoring efforts to encourage better integrated Agency-wide activities and to fill gap areas. Examples of this are current programs developed jointly with the EPA laboratory in Athens, Georgia, which conducts total chemical cross section analyses on ambient water and effluent pipe samples taken from 15 to 20 selected industrial areas (10).

3.3.3 Characterization of the Problems

Rapid-response capabilities will continue to be strengthened to clarify the multi-media environmental problems associated with "crisis" chemicals of urgent concern. At any given time, efforts will be directed to about ten such chemicals of immediate interest. Moreover, in-depth characterizations of other selected multi-media chemicals of long standing concern are prepared (11).

Integral to these are the monitoring and information support programs. These efforts provide essential information. They generate new data to fill significant gaps about production levels and trends, and known and projected exposure levels. Reports by the International Trade Commission, Bureau of Census, Bureau of Mines, Stanford Research Institute (SRI), Dun and Bradstreet, and several other organizations contain production and use data. Monitoring data are drawn from EPA offices (e.g. stack and ambient air, pipe and ambient water, drinking water, adipose tissue, mother's milk, soil, plant residues) and from the files and reports of other agencies. For example, data on food residues comes from the Food and Drug Administration; on ocean levels from the National Oceanic Atmospheric Association; and on work-place levels from Occupational Safety and Health Agency and National Institute for Occupational Safety and Health. At times, data from the States, cities and industry are helpful.

Specialized Office monitoring programs fill the gaps with the newly acquired data tailored to the specific types of regulatory decisions at hand (12).

3.3.4 Development and Stimulation of Preventive and Corrective Approaches

The unanticipated emergence of "crisis" chemicals continues. Thus agency coordination has intensified under the leadership of the Office. These activities alert the Agency to major chemical problems of immediate concern and stimulate preventive and remedial actions. They are closely linked to activities directed to "crisis" chemicals. In the absence of such program support, it would be only an information exchange forum.

The number of potentially harmful industrial chemicals is so vast that the regulatory process will be able to address only a small portion of the potential problems. Thus, an essential complement to the Office's efforts is a major program to reach unregulated chemicals by stimulating industrial stewardship. Initially, efforts were directed to about 30 larger chemical companies and a dozen major trade associations. Efforts are now being broadened to medium and small companies, to special aspects of multi-national companies, and to reach a larger network of specialized trade organizations and professional societies (13).

An area of special expertise is the encouragement of improved industrial testing of chemicals. The Office continues documenting the need for expanded industrial testing of certain characteristics of specific types of chemicals. Of immediate interest is the need to selectively determine the environmental fate of halogenated hydrocarbons and to improve the characterizations of the health effects of suspected

carcinogens. Concurrently, Office contractors are evaluating the reliability and feasibility of several types of test methods for possible adoption by industry. They include: bioaccumulation tests, aquatic teratology assays for organic chemicals, and skin painting approaches for carcinogens. The Office advises industry on testing of several types of detergent builders, dyes, flame retardants, and silicone oils, upon request. Since consistency between the Agency's approach to pesticides and to industrial chemicals is important, the Office will develop and refine pesticide registration guidelines and the quality control program of laboratory test data on pesticides (14).

3.4 Water

3.4.1 General

Many different agencies and groups monitor water quality.

Locally, most municipal water treatment facilities monitor raw water quality daily. About 6,000 such facilities are served by surface water sources. So a great deal of information is gathered on surface water quality by these operators alone. Moreover, many municipal waste water treatment programs and county agencies routinely monitor receiving waters upstream and downstream from treatment plant discharges, and many universities regularly collect water quality data (15).

Most State pollution control agencies have monitoring programs for assessing surface water quality. These vary in scope, ranging from near-minimal to complete systems. Other water-oriented State agencies (e.g. conservation and geology departments) also acquire water data.

The State water quality assessment reports mainly determine water uses relative to the "fishable, swimmable" 1983 water quality goals. They do not generally discuss drinking water problems, except for some descriptions of groundwater contamination. The reports give little information on marine water quality, except for some discussions of shellfish harvesting areas (16).

Over a dozen Federal agencies directly acquire water data. For example, the U.S. Geological Survey (USGS) monitors groundwater quality in every region. All Federal agencies' activities are coordinated by the Office of Water Data Coordination of the USGS. This is consistent with a Bureau of Budget requirement for interagency coordination to avoid duplication of effort. The budget agency (now the Office of Management and Budget) also advocates a National Network to meet the common data needs of two or more Federal agencies. USGS manages this network. Data needs specific to one agency that cannot be met efficiently through the National Network are obtained by that agency through other means (15).

The Accounting Element of this network is significant. It provides an accounting of the quantity and quality of water of 306 hydrologic basins which cover the conterminous U.S. (15).

The list of parameters currently used to evaluate water quality is shown in Table 3.1.

The National Stream Quality Accounting Network (NASQAN) monitors water quality of waterways and provides uniform, national data to determine water quality trends. It has 525 monitoring sites located in "Hydrographic Accounting Units". They are spaced sequentially along the major waterways.

TABLE 3.1

PARAMETERS USED IN THE EVALUATION OF WATER QUALITY (15)

Dissolved Oxygen	Arsenic	Electrical Conductance
pH	Barium	Ammonia
Coliform	Cadmium	Acidity
Temperature	Chromium	Alkalinity
Floating Solids (Oil-Grease)	(hexavalent & trivalent)	Carbon Chloroform Extract
Settleable Solids	Lead	Fluoride
Turbidity and/or Colour	Selenium	Hydrogen Sulphide
Taste-Odour	Silver	Pesticides
Toxic Substances	Suspended Solids	Sodium
Radioactivity	Chloride	Iron
Total Dissolved Solids	Copper	Plankton
Methylene Blue Active Substances	Nitrate	Foaming Substances
Zinc	Phenols	Boron
Salinity	Phosphate	Manganese
Chlorophyll	Sulphate	Hardness
	Cyanide	Biochemical Oxygen Demand

There are about 345 monitoring stations now operating. The Network was expected to be fully operational by July 1976 (17).

The National Water Quality Surveillance System (NWQSS), implemented by EPA, obtains a long-term base to determine trends, establish relationships between land use and water quality, and evaluate the effectiveness of pollution control efforts. Currently, 150 stations report 25 parameters on a biweekly and 5 parameters on a monthly basis (17).

3.4.2 Drinking Water

The goal of EPA's Drinking Water Program is "to ensure that all citizens have safe water to drink". In November, 1976, the Office of Water Supply published a Draft National Safe Drinking Water Strategy. The subtitle of this strategy, "One Step at a Time" epitomizes the EPA's approach to implementing the Safe Drinking Water Act (SDWA).

The Act is basically self-enforcing, so a complicated program structure is not needed. The local utility performs the required monitoring and gives public notice when drinking water is not up to standards. EPA believes that the most effective way to achieve compliance with the National Primary Drinking Water Regulations (NPDWR) is to assure that consumers know about deviations from maximum contaminant levels. In turn, they can make sure that corrective action is taken. Where necessary, a State or EPA may bring legal action. With about 250,000 public water suppliers, the States and EPA rely on public pressure to produce compliance for many public water systems (18).

Several options for different levels of Federal/State partnership are proposed to enforce the NPDWR. They range from

complete certification of the State's program with no extensive Federal involvement (other than the program grant), to non-certification. EPA wants to certify all States for primary enforcement responsibility in accordance with the mandate of the Act. The intention is to establish the groundrules for a true Federal/State/local partnership, based on practical and pragmatic regulations and policies. This will aid cooperation and compliance with the requirements of the Act (18).

Monitoring requirements could present serious problems to small public water systems, so there are less stringent requirements for non-community systems serving primarily transient populations than for those which serve resident populations.

One way to reduce the economic impact of the SDWA regulations is to take advantage of the economies of scale inherent in regional water supply systems and management. Regionalization is not limited to structural, physical integration of impoundment, treatment and distribution systems. It can mean shared laboratory services, training programs, billing systems and a variety of other management services that may be provided more efficiently to a group of water suppliers. There are a variety of factors which may affect the desirability of regionalization. So EPA does not intend to force local communities to regionalize their systems or management. That is a local decision best handled at the local level (19).

State programs vary in complexity. Those with recently implemented programs have limited parameter coverage. Those with more experience have comprehensive procedures, including bioassays. Almost all States measure dissolved oxygen and flow, while coliform bacteria, nitrogen, phosphorus, pH,

oxygen demand, and water temperature are monitored in more than half. The schedule used by most consists of monthly samples taken at fixed stations throughout the year, weather and flow conditions permitting. Almost every State needs increased monitoring to identify specific pollution sources in problem areas; most feel that the existing programs adequately provide a relatively accurate assessment of overall water quality (16).

State reporting procedures follow five basic patterns, of which one or more was employed by each State. The most popular is aggregation of water quality data by river basin. Many States also present river profiles showing variations in water quality parameter values along the length of a stream or stream segment. A third procedure is the identification of the specific water quality problem areas. The classification of streams by current and proposed uses for each segment is used by several Northeastern States to evaluate current water quality. Finally, five States assess water quality by three different indices. Each is based on a weighted average of selected parameters, with the differences between them being the parameters used and the relative weight assigned to each parameter (16).

3.4.3 Groundwater

EPA is now establishing a national groundwater quality monitoring system, in cooperation with the States, to prevent, reduce, and eliminate groundwater pollution (20).

EPA has defined four types of monitoring. "In terms of groundwater quality, these may be interpreted as follows:

Ambient Trent Monitoring

This concerns measurements of groundwater quality and deviations in relation to standards, and involves temporal and spatial trends within a groundwater basin or area.

Source Monitoring

This involves the measurement of effluent quantity and quality for pollution sources which may affect groundwater.

Case Preparation Monitoring

This serves to gather evidence for enforcement actions of past, existing or anticipated groundwater pollution situations; implied are carefully documented measurements within a circumscribed area.

Research Monitoring

This contributes to research investigations on groundwater quality and pollution occurrence and movement" (21).

Of the above types, the methodology is directed largely toward source monitoring. Case preparation and research monitoring are clearly specialized needs which are not suitable for a national program. Ambient trend monitoring provides background quality information on groundwater resources. Thus a national program to protect groundwater quality relative to those human activities which pollute groundwater, focuses primarily on measuring pollution sources and methods of waste disposal contributing to pollution. Because it is infeasible to monitor all sources and causes of pollution, the methodology stresses the identification of the most important sources and methods of disposal. Essentially, the methodology becomes a resource allocation problem. The goal is to develop a cost-effective program to contribute

most to protecting the nation's groundwaters (21).

Needs and Objectives

American groundwaters (like other resources) are becoming excessively polluted. Groundwaters are not being efficiently allocated among their alternative uses. Wastes are an unavoidable byproduct of all human activities and must be disposed of somewhere. The substantive questions of optimum production of wastes and their optimum disposal must be addressed. "Clearly, the nation's aquifers, like every other sector of the environment, must serve as a repository for the disposal of some of society's wastes. The question, then, is not "Can wastes be placed on and in the ground?" but rather, "Where and how much?" (21).

Purpose and Approach

The methodology described serves as guidelines for developing and implementing a groundwater quality monitoring program. Factors such as climate, hydrology, population, pollution sources, and water use vary from place to place; therefore, the design of an appropriate monitoring program will also vary.

No one set of guidelines is all-encompassing; however, with judgement the approach presented can meet most other situations which will be confronted (20).

The physical, chemical, and biological mechanisms govering groundwater pollution are reasonably well understood. Yet, applying this knowledge to the many different situations which can result from superimposing a given groundwater pollution source upon particular hydrogeologic environments is difficult. The methodology described is expressed in a generalized form so that it can be usefully employed by regional, State, and local water pollution control agencies

and is applicable to all types of groundwater aquifers, areas, and basins. Alternatives in the decision-making process leading to the final monitoring program are considered throughout the methodology (20).

3.5 Air

3.5.1 General

The purpose of the EPA's air monitoring program is to:

1. "Determine if national air quality standards are being achieved and maintained;

2. Provide historical analyses of emergency episodes;

3. Determine long-term trends in air quality;

4. Develop control strategies for national or state-level implementation." (22)

Sampled data are collected and stored in the EPA Storage and Retrieval of Aerometric Data (SAROAD) system.

3.5.2 Air Quality Measurement Programs

"SAROAD is a central repository for data for monitoring programs including the Continuous Air Monitoring Program (CAMP), (with six sites located in large cities), the National Air Sampling Network (NASN), (which monitors on a non-continuous basis in rural and city areas), and various individual air monitoring programs established at the state and local levels, which report data to SAROAD quarterly" (22).

This system divides aerometric pollutants and parameters into nine major classes, defined as follows:

1. "Suspended particulates: solid particles or liquid droplets with effective diameters less than approximately 100 microns. Such particles have low settling velocities under average meteorological conditions and therefore tend to remain airborne.

2. Settled particulates: solid particles or liquid droplets of such size and density that gravitational deposition is the principal mechanism for removal from the atmosphere, usually at a relatively short distance from the source. These are also referred to as settleable particulates.

3. Respirable particulates: particles of size range density, and aerodynamic properties that tend to be inhaled and trapped in the lower respiratory system.

4. Gases and vapours: substances that normally exist in a gaseous state at ambient temperatures and pressures or that evolve from liquids that tend to volatize under these conditions.

5. Biocides, allergens, and pathogens:

   Biocides: commercial chemical preparations for control of selected plant, animal or insect life forms.
   Allergens: airborne substances, frequently of plant origin, that induce allergic reactions.
   Pathogens: viable airborne micro-organisms or infective agents that can cause disease.

6. Atmospheric and related parameters: basic meteorological parameters such as wind speed, wind direction,

and relative humidity. Also ground surface conditions that relate to these parameters.

7. Basic effects: effects of individual pollutants or any combination thereof on human health and safety, animals, vegetation, materials and aesthetic values.

8. Fractional particulates: particle size ranges of suspended particulates and relationships to such parameters as composition, visibility, soiling, and synergistic activity.

9. Miscellaneous: this category will include any data not assignable to other specific categories" (23).

Each major class is divided into nine subclasses, and each subclass is further divided into nine families. Each family may contain up to 99 individual pollutants or parameters.

The program includes over 7,000 sampling stations with 14,000 samplers. They range from simple static sampling devices to continuous sampler-analysers that record the concentrations of numerous gaseous air pollutants. Most sampling stations are in the major metropolitan areas. A list of atmospheric pollutants currently being measured by EPA is shown in Table 3.2.

Local and State agencies' programs monitor those pollutants for which national ambient air quality standards have been promulgated. They include: particulate matter, sulphur dioxide, carbon monoxide, nitrogen dioxide, and photochemical oxidants. These programs are part of the "State Implementation Plan" for controlling air pollution regionally (25). The Plan describes (including control methods, strategy to be used in this control), the manner in which State agencies

TABLE 3.2

ATMOSPHERIC POLLUTANTS CURRENTLY BEING MEASURED BY THE EPA (24)

Elements	Radicals	Gases
Antimony	Ammonium	Carbon monoxide
Arsenic	Fluoride	Methane
Barium	Nitrate	Nitric oxide
Beryllium	Sulphate	Pesticides
Bismuth		Reactive hydrocarbons
Boron		Sulphur dioxide
Cadmium		Total hydrocarbons
Chromium		Total oxidants
Cobalt		Ozone
Copper		
Iron		
Lead	Others	
Manganese		
Mercury	Aeroallergens	
Molybdenum	Asbestos	
Nickel	Radionuclides	
Selenium	Benzene-soluble organic compounds	
Tin		
Titanium	Benzo(a)pyrene	
Vanadium	Pesticides	
Zinc	Respirable particulates	
	Total suspended particulates	

will develop their system to measure air pollution in the future. For each classification of region, the pollutant measurement method and minimum frequency of sampling are presented. The number of air quality monitoring sites (based on the regional population) is also specified. At a more detailed level, the specifications of equipment are given for specific criteria pollutants.

There are 247 Air Quality Control Regions as of 1974. Air quality is monitored within industrial, residential, commercial and mobile sites in city-centre or suburban settings. Also, it is monitored near urban, agricultural, commercial, industrial and other sites within rural settings.

3.6 Pesticides

3.6.1 The National Pesticide Monitoring Program

The National Pesticide Monitoring Program (NPMP) began about 1964 as a cooperative effort of Federal departments belonging to the Federal Committee on Pest Control. The Committee had no direct appropriation to undertake such a venture. So the differing segments of the environment, where determination of pesticide residues appeared desirable, became the responsibility of the Agency most vitally affected. Even at the departmental level the staff and funding were obtained at the expense of other established projects. When extra attention was needed to design statistically sound sampling procedures and devise analytical methods for recovery of diverse parent compounds and their metabolites from biological materials, there was commonly inadequate funding. In 1972, the Federal Environmental Pesticide Control Act was passed, and the NPMP received legislative status (26).

The activities under the program include monitoring in air, soil, water, man, plants and animals.

As of September 1973, EPA took important steps to assure uninterrupted study of environmental residues and to enlarge and upgrade the program. EPA accepted the burden of financing several of the larger projects by contracts with another government agency having a field staff qualified to do the work. EPA broadened the responsibilities of their laboratory on the Mississippi Test Facility at Bay St. Louis, Mississippi, to include pesticide residue analysis on a wide range of biological materials - not just soils (27).

3.6.2 The National Pesticide Monitoring Plan

The amended Federal Insecticide, Fungicide, and Rodentcide Act (FIFRA) mandates the Administrator of the EPA to formulate a national plan for monitoring as is necessary to implement the FIFRA. Accordingly, a National Pesticide Monitoring Plan has been proposed, which calls for the coordinated operation of National Environmental Pesticide Monitoring Methods to include existing Federal networks now comprising the NPMP, as well as other national networks that may be implemented.

The proposed Plan will probably cite the methods described in "Guidelines on Sampling and Statistical Methodologies for Ambient Pesticides Monitoring". The Monitoring Panel of the Federal Working Group on Pest Management, which prepared the guidelines, identified a need for a standard approach to sampling methodologies for the respective environmental components of the Program. A task group was established by the Panel to undertake this effort (28). The guidelines were developed around the following components: "air, soil, water, estuaries, fresh water fish, birds, food and feed,

and human tissue" (28). The Panel recognizes that a precise statement of the sampling program's objectives must be derived. For example, the objective might entail coming to a well founded decision relative to regulatory action, or in another case identifying gross trends in pesticide levels. Sampling results in one situation may not be adequate for the objectives of a different situation (29).

The six on-going component programs are described below.

1. The National Soils Monitoring Program for Pesticides, - part of the overall system - is run by the EPA. Its objectives include: establishing baselines of pesticide residues in soil, estimating trends, evaluating effectiveness of management and regulatory decisions, and providing data toward an early warning system for pesticide-caused environmental problems.

Soil is monitored every fifth year at sites in three basic land use categories: cropland, noncropland and urban areas. All states are scheduled for sampling. In addition to soil samples, data on pesticides applied to each site sampled, on crops grown on those sites and samples of crops that are available, are collected. "Pesticides monitored include varieties of chlorinated hydrocarbons, organophosphates, phenoxy herbicides, triazine herbicides, arsenic and several heavy metals, including mercury, cadmium and lead" (30).

2. The National Water Monitoring Network for Pesticides is a joint program of the EPA and the U.S. Geological Survey (USGS). This program started in 1973 and collects and analyses samples from 161 sites at least four times annually. The pesticides analysed are the same as those in the National Soils Monitoring Network.

3. EPA has the National Estuarine Monitoring Network which collects samples of herbivorous and carnivorous fish in 113 estuaries twice annually. In this way, levels of pesticide residues and any change in these levels through time are determined. Pesticides analysed are the same as those listed for the National Soils Monitoring Network.

4. "The National Pesticide Monitoring Network for Birds and the National Freshwater Fish Monitoring Network are operated by the U.S. Department of Interior. These provide extensive pesticide residue information for starlings and duck wings and for various species of fresh water fish" (30).

5. The National Food and Feed Monitoring Network is the joint responsibility of the U.S. Department of Agriculture and the Food and Drug Administration. The latter network determines pesticide residues in processed and unprocessed consumer food commodities and animal feeds (30).

6. The EPA operates the National Human Tissue Monitoring Network. Levels of chlorinated hydrocarbons in adipose tissues of humans are determined.

3.6.3 Summary

The National Pesticide Monitoring Program has been operating for ten years. It has been a process of learning how to conduct such a program. Sampling collection and analytical techniques have been progressively changed and upgraded. Errors are not difficult to find. Perhaps the most serious fault is an average three-year delay between collecting the samples for analysis and the publication of the resulting data. "The National Pesticides Monitoring Program provides an overview of the first ten years of programs operation as

of 1974, and gives the status of the on-going monitoring projects. Much of the value of the monitoring program is lost by delays in release of information" (30).

"Regardless of its present deficiencies, a well-conducted monitoring program for the detection of environmental contaminants can benefit industry, the regulatory agencies and the general public" (30).

3.7 Noise

3.7.1 General

Present emphasis is on regulation of allowable noise from new products and effective enforcement of these after-sale provisions. "Their enforcement by the Environmental Protection Agency (EPA) would be greatly assisted by an active field enforcement effort on the part of state and local governments" (31).

"EPA has initiated an extensive noise monitoring effort having two primary facets: (i) environmental trend monitoring, and (ii) specific source monitoring. As currently planned, both will be carried out at national and local levels" (32).

3.7.2 Environmental Trend Monitoring

Ambient noise and personal exposure will be examined through physical noise measurements and social surveys. "The Agency anticipates that the trend monitoring effort will:

1. Establish a baseline from which to assess changes in the noise environment.

2. Determine the population at risk.

3. Establish standard methods and procedures for quality assurance and comparability of data.

4. Provide assistance to states and municipalities in assessing the success of their noise control programs (32).

3.7.3 Measurement of Stationary Noise Sources

The Agency recently conducted a study to determine an accurate statistical/manual sampling technique for measuring stationary noise sources. The objective is to recommend measurement methodologies, procedures, and instrumentation suitable for enforcement of various types of ordinance provisions that specify property line sound limits. This study will also be used to support a model code of recommended enforcement practices.

An important feature of the enforcement program is the EPA Noise Enforcement Facility where tests are performed using the regulatory measurement methodology. The Facility allows EPA to do its own emission testing and determine compliance with performance standards (33).

EPA is still faced with selecting a noise monitoring strategy that will measure progress in achieving abatement goals. The variables in ascertaining noise trends have yet to be identified and selected; and the question of who should do the monitoring - local, state, or EPA, has yet to be resolved.

3.8 Summary

In the past environmental monitoring has been established in response to a pre-existing contaminated condition rather than in a planned, systematic way. Regardless of the initial reasons for monitoring, there is considerable reluctance to accommodate any request for change once a large historical backlog of data is acquired. "It is normally argued that the available data base, which has been collected at some expense, will be lost if the existing monitoring sampling sites are moved or if improved analytical methods are substituted for the existing ones" (29).

A.C. Trakowski, EPA's Deputy Assistant Administrator for Monitoring and Technological Support, believes that all existing EPA environmental monitoring should be re-evaluated from a more systematic and analytical point of view and that well defined answers be provided to the following questions:

1. "For what purpose is the monitoring being done?

2. Does it satisfy that purpose as performed?

3. Can alternate means be used?

Until answers to these questions are provided it is not possible to design minimum adequate monitoring networks which optimize cost effectiveness. It is also not possible to evaluate existing monitoring networks to determine gaps in the coverage or redundancies" (34).

"Perhaps the most important conclusion of all relates to the absolute necessity of having adequate quality assurance covering all aspects of environmental monitoring. If EPA have no adequate way of verifying its ability to character-

ize desired environmental quality parameters in space and time from a synthesis of the individual measurements, then the data collected are of questionable value at best" (34).

"More attention to the items discussed above in the future will vastly improve the quality of our environmental monitoring data and insure the collection of a data base which will be responsive to all the needs of an environmental protection program. Any other course of action could lead to the collection, at a great cost, of vast amounts of monitoring data of questionable validity which may, or may not, be applicable to required environmental protection programs" (34).

"Future monitoring systems must be able to detect potential problems and monitor the appropriate parameters before they reach crisis proportion. Some possibilities that might be explored are the use of biological exposure indicators as trend monitors to predict changes, and the development of personal dosimeters, most likely biochemical measurements that integrate the total exposure of an individual to a pollutant or class of pollutants" (35).

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MONITORING IN THE U.K. 4

4.1 Present Approach

4.1.1 Objectives

The major purpose of monitoring in the United Kingdom is guiding policies to protect human health and the quality of life. This, of course, includes monitoring organisms on which human beings are dependent. The focus is on pollution. To this end, two kinds of monitoring are undertaken:

1. Repeated measurement of pollutant concentrations to follow changes over time; and

2. Regular measurements of pollutant concentrations in relation to some standard.

In this way, trends are established as part of an early warning system to avert environmental crises. Also, information on the scale and extent of, and gaps in pollution control, can be used in policy formulation.

4.1.2 National Monitoring Framework

While it is recognized that there are local data needs and that decentralization of measurement is appropriate, the U.K. also needs special programs covering the nation. The national government must remain responsible for overall

strategy, to ensure complete, continuous monitoring.

To this end, five monitoring management groups (MMG's) were developed:

1. Air Pollution Monitoring Management Group.

2. Freshwater Monitoring Management Group.

3. Marine Pollution Monitoring Management Group.

4. Land Pollution Monitoring Management Group.

5. Environmental Health Monitoring Management Group.

"Consideration is being given to the setting up of a sixth group concerned with biological health later this year"(1).

"Membership of these groups consists of representatives from government departments, local authorities and research organizations among others"(1). Each group has the following responsibilities:

1. Review all monitoring programs.

2. Facilitate the coordination of programs and techniques.

3. Ensure information flow.

4. Ensure that monitoring programs serve the users.

5. Provide data required by international agreements.

6. Ensure the development of new programs where necessary.

"In addition, the MMG chairmen sit on the Steering Committee for Environmental Monitoring and Assessment (SCEMA) with other DOE officials to guide the work of the MMG's. A multi-disciplinary group including scientists, statisticians and operational research specialists has been set up within DOE on an experimental basis. This joint team provides support to SCEMA and the MMG's, as well as other directorates with an interest in monitoring and assessing pollution"(1).

4.1.3 Range of Monitoring Activities

Monitoring is largely decentralized, undertaken by eleven departments and the Agricultural, Medical and Natural Environment Research Councils. The range of activities covered can be grouped into five major categories: air, land, radioactive substances, fresh water and marine pollution (2).

Air

There is one major coordinated program on a national level, a survey of smoke and sulphur dioxide. This is carried out primarily in towns where it is most concentrated and where most of the population resides. Also, there is widespread monitoring at sources by industries, under government supervision. There are a variety of other programs which seek to obtain a picture of conditions for the whole country.

Land

Three kinds of land monitoring are undertaken: land inventories; agricultural inventories; and monitoring of selected pollutants. Land inventories are conducted in specific areas known to be affected by pollutants, by local authorities. Agriculture-related inventories include: the monitoring of pollutant levels in soil and plants, especially crops growing on affected sites; emissions affecting the suitability of land for agriculture; and toxic materials dumped on land. Selected pollutants, particularly pesticide residues and metals, are measured in wildlife, foodstuffs and human beings.

Radioactive Substances

A coordinated committee is responsible for monitoring fallout levels in air, rain, milk and drinking water. Marine foodstuffs are also monitored.

Fresh Waters

Fresh waters are monitored at various points along Great Britain's river system, for discharges from sewers and rivers, withdrawals for supply, and river and estuarine quality. Discharges are monitored by the dischargers, under government supervision.

Marine Pollution

Pollution is measured at source, in water sediments and marine life.

4.2. Proposed Activities

A number of recommendations were made by the Central Unit on Environmental Pollution (CUEP) of the Department of the Environment (DOE) with respect to future needs in each category (2).

Air

It was suggested that the monitoring of sulphur dioxide be improved in terms of continuity and reliability of measurements and adequacy of rural coverage. At least one super site would be established to monitor the full range of pollutants; as well as 20 sites to measure airborne metals and 20 sites to measure acidic particles and aerosols, and relate those levels to sulphur dioxide. At three of the above sites, nitrogen, oxides, ozone and hydrocarbons could be measured, as a pilot scheme to possible monitoring of lead.

Monitoring of grit and dust was recommended. Information on the photochemical reactions leading to the production of oxidants and the results of surveys of motor vehicle emission levels, would assess the scale of this problem. Moreover, surveys and studies were to be undertaken to select and incorporate the monitoring of biological "indicator" organisms. Further exploration of motor vehicle exhaust pollution was warranted, including more systematic surveys of carbon monoxide, oxides of nitrogen, ozone, hydrocarbon and lead, at busy roadside sites in five major cities. Additional proposed areas of measurement are: checks of pollutants on and around airports, continued monitoring of fluoride and heavy metals around factories. Proposed monitoring-related activities include: new methods of assessment of particulate matter deposited from air, as a precursor to national monitoring; and the encouragement of, and advice to, local

monitoring systems.

Land

It was suggested that existing programs be maintained and the adequacy of their coverage reviewed annually. A review of the system for recording the deposit of toxic wastes on land, was in order. It was expected that newly created waste disposal authorities would collect, and make centrally available, data on the most hazardous materials.

Radioactive Wastes

Programs were to be maintained, continually reviewed and adapted to meet changing conditions and new problems. A possible decrease in the intensity of monitoring fallout from nuclear weapons testing, and an increased monitoring of the nuclear industry, was indicated. There was increased concern with the disposal of radioactive substances into the sea.

Fresh Water

Improved coordination and harmony of procedures was expected with new legislation. "It is now proposed that monitoring stations should be established just upstream of the tidal limit on each major river. These will give information about trends within the river basin and on the pollutants passing from that basin to the sea. Further stations should be maintained on tributaries which are important by virtue of their flow or the areas which they drain. Sampling is also appropriate upstream of important users and downstream from major discharges or groups of discharges....Monitoring on unpolluted areas of rivers is important in order to

record 'background' conditions.... All of these requirements will inevitably lead to a substantial increase in the number of sampling points.... To start with, the same substances will be monitored at all stations, but after a time there may be variations in the light of results. The lists include not only substances or factors with a direct ecological effect, but also persuant organic and inorganic materials....Both soluble and insoluble forms of the various substances will be looked for" (3).

Marine Pollution

An important recommendation was the recording of all authorized dumping materials discharged into the sea.

In addition to recommendations specific to one of these categories, the development of epidemiological work was suggested; as well as monitoring the interaction of pollution control and waste disposal.

In summary, much of the data is gathered for local purposes. Because of individuality in data gathering, the sum does not add up to an overall national picture in most cases. On a national level, it is possible to assess smoke and sulphur dioxide, some aspects of river pollution and radioactivity in the aquatic environment, based on current monitoring activities. "Specific problems such as organchlorine pesticides, lead, mercury, oil pollution, have been dealt with by 'one off' assessments....Information to support such national assessments is not readily available on a routine basis"(4).

4.3 Problems with Current Monitoring Programs

The major difficulties with current monitoring activities pertain to: lack of integration of data collection and analysis, and inaccessibility of data.

Presently, data are collected by a variety of groups, each of which monitors specific environmental components, in a specific medium, in a specific region. The result is a piecemeal monitoring effort in which even the monitoring of the same component is accomplished in a variety of ways, many of which are not comparable. Therefore, national direction has been proposed to ensure consistent use of methods and sampling patterns. This does not mean that the same standard techniques must be used across regions. Often different instruments or analysis are used because laboratories differ in size and expertise, and local conditions vary. However, the range of techniques used to analyze a particular substance should be known to yield results of comparable quality, accuracy and data presentation. Thus a central laboratory has been proposed for each of the five main sectors of the environment, to guide the local monitoring stations on equipment and methods. In this way, it is hoped that data can be integrated across media and across regions.

Information is somewhat inaccessible and is not centralized at present. "The intention is to adopt coordinated procedures for data collection and storage" (4). Local monitoring stations would do the first appraisal of the data and then send it to the central body. Even if data from every available source is not used in compiling a national overview, accessibility to the data is stressed. Based on this, summary statements of trends and the significance thereof, could be compiled. It is recommended that the group responsible be CUEP.

In summary, most monitoring activities are local, dealing with specific environmental components and specific jurisdictions. Integration of data gathering has been strongly recommended, because of the costs of manpower and resources for monitoring measurements and the range of expertise required. Moreover, priorities are to be established so that problems and approaches of interest to all concerned are dealt with.

4.4 Monitoring-related Activities

"The DOE report on the monitoring of the environment cites 100 monitoring programs and the DOE library Register of Research for 1975 lists 1,000 research projects in environmental pollution" (4).

Under contract with DOE, the Monitoring and Assessment Research Centre (MARC) "aims to develop information-handling tools to assist CUEP and the monitoring management groups in establishing conformity within and between sectors, in order to service the needs for national overviews" previously mentioned (4).

It is the opinion of MARC that there are three focal points for the design of informational tools:

1. Tracing of one pollutant through the environment.

2. Studying all contaminants for one geographical area, (using environmental impact assessment methodologies).

3. Illustrating ways of anticipating unperceived problems (which requires long-term epidemiological studies) not presently being undertaken.

With limited resources, the government preferred an intensive treatment of one topic, rather than a light treatment of all three. As a result, a background study of the lead cycle was undertaken. However, the focus of this theme is on management, not on long-term study of pollutants.

To this end, an Atlas and Directory of Monitoring was prepared, beginning in July 1975. This was viewed as an indispensable preliminary to rational, optimal deployment of resources for environmental measurement and a key component in future proposals for integrated management of environmental data. Thus the directory was to contain an inventory of monitoring data sources on chemical substances of environmental significance, geographical distribution, methods, the form, reliability and comparability of data, by monitoring site. While it was recognized that the directory would not contain all information necessary for management to determine optimum resource use, it was important.

As work progressed, it became evident that compilation of the directory was an immense task. Hence the need for a simplified monitoring directory or atlas. The atlas was viewed as directory of data sources containing:

1. The nature of the measurment or observation.

2. Its purpose.

3. Its frequency, duration and accuracy.

4. Its location.

5. The name and address of the organization on whose behalf the monitoring was undertaken.

6. The nature of the stored data.

Priority was given to current data sources.

It was hoped that centralization of data would have several benefits: information gaps could be discerned, uniform standards of data quality ensured, duplication avoided, and routine updating made possible.

Ideally, sets of data would be matched such that a synthesis of environmental information, including supportive data would result. It would be presented in a standard format and would provide a coherent, less expensive framework for environmental management. In this way, current monitoring capability would be categorized as well as monitoring management needs. As a result of the directory, priorities would be identified.

A number of problems were encountered in compiling the directory. It was difficult to design a structure for a monitoring data and activity directory that was concise and integrated. This was further complicated by the fact that information was greatly in excess of that envisaged; techniques for screening needed to be developed. Moreover, it was difficult to discern the kinds of peripheral information potentially relevant to pollution management. The sectoral view of the directory was not integrated, making it of doubtful use to those with interests peripheral to monitoring. Also, it was criticized as being too intrusive. The input of industry was not solicited and this was regarded as a shortcoming. It was decided that the task was not generally realizable at the present time. Instead, detailed information of specific areas of interest to DOE were to be compiled. Thus, detail was preferred to scope.

The original approach was to work from the general to specific. Now it is felt that inventories can only be built up successively, adding increasingly comprehensive ones that include a number of media, spatial or time components.

The program is continuing, but is confined to the conceptual stage. "Important aspects of...[this]...stage are the development of classifications for retrieval and the compilation of a thesaurus of environmental pollution terminology" (4).

Other projects complement these activities. These include:

1. U.K. National Referral System (UK/NRS), a general directory of sources of environmental information intended to be compatible with the United Nations Environment Programme International Retrieval System (UNEP/IRS). It is conceived of as a means of integrating environmental information and data, thus categorizing current monitoring capability and promoting information exchange. It is operated by the DOE library.

2. Network of Data on Environmentally Significant Chemicals (DESCNET), a directory of data sources on chemicals of environmental significance, data files on selected chemicals and a "current awareness" system to alert managers to recent developments or concerns (4).

This is currently at the pilot stage. It is being developed by the multi-disciplinary team (previously mentioned) "with the help of contractors such as the United Kingdom Chemical Information Service (UKCIS) and the Stanford Research Institute (SRI)" (1).

4.5 Globally-oriented Activities: MARC

The Monitoring and Assessment Research Centre (MARC) was established by DOE at Chelsea College, University of London. Work commenced on March 1, 1975. It consists primarily of visiting scientists who work on a short-term basis.

Its major purpose is to develop methods to assist in the understanding, definition, evaluation and solution of major environmental problems of global, regional and national concern.

"The members of this team originally held very disparate views of the definition, methodology and role of environmental monitoring. Realization of this only emerged after considerable discussion. These differences, and the lack of perception that they exist, are probably reflective of the situation among the whole range of people concerned with environmental science and management" (5).

"From this starting point, the team:

1. categorized their individual approaches to monitoring;

2. formulated a single conceptual process model for environmental management with special emphasis on the role of monitoring;

3. illustrated the applicability and operation of the model by reference to selected examples drawn from their own specific area of expertise" (5).

"It is the opinion of the above group that...exercises such

as this in constructive collaboration are necessary to make progress in many areas of what is essentially an inter-disciplinary field" (5).

MARC is undertaking research on two sets of work. One is a contract with UK/DOE (previously mentioned) to provide a conceptual design for structuring data bases. The other is a contract with UNEP and the Rockefeller Foundation.

The work for UNEP and the Rockefeller Foundation deals with four themes:

1. The characterization of monitoring data.

2. Regional monitoring needs.

3. Approaches to environmental monitoring via the dynamics of environmental processes, particularly the wider applicability of proven models.

4. Time perspectives of environmental change (5).

Theme 1

The first theme concerns the development of a form and description to structure data bases, and is similar to the work for UK/DOE.

Media-oriented research was considered relevant to this theme (e.g. air quality). Also included is research on criteria for establishing priorities of environmental hazards. Although a list of criteria has been developed (6), it is largely qualitative and requires considerable refinement.

Theme 2

The second theme deals primarily with the needs of developing countries. With respect to this theme, it has been dificult to clearly separate resource management and monitoring from pollution monitoring. Moreover, the need to assign monitoring priorities for resource management, at national and regional levels, has been recognized.

Theme 3

In the first year, "the project...reviewed the role of monitoring in providing information for a number of possible environmental management strategies, including approaches based on social considerations, ...on economics ...and a strategy based upon an understanding of cause and effect relationships in environmental processes... [It was] recommended that resources in the short-term should be concentrated on developing satisfactory arrangements for characterizing physical cause-effect relationships and relevant economic factors" (5).

Much attention has been given to the dose commitment approach. Dose commitment is defined as: "the total exposure integrated over time that is received by a receptor (target - individuals, populations or environmental compartments) from a given practice or event (e.g. from operational releases of a contaminant over a specified period of time or from an accidental release of known magnitude). The dose commitment can provide an overall measure of the total harm to which the receptor is irrevocably committed by a given practice or event" (7). The objectives of MARC were to bring to management the advantages and disadvantages of this approach in terms of understanding the environment, and providing a

model for designing a monitoring system. However, research on other models in addition to this one has been suggested (6).

Moreover, the development of resource models has been suggested (6).

Theme 4

The fourth theme concerns the establishment of environmental norms of trace substances, including variability, by obtaining data describing past conditions.

Future Studies

Munn (6) has recommended the extension of current programs in several ways, including: retrospective analyses of the designs of environmental monitoring systems; a study of monitoring implications of environmental impact assessments; studies of environmental quality indicators (Theme 2); synthesis of existing information of natural emissions of trace substances; monitoring of fluxes (Theme 3); statistical design of monitoring networks (Theme 4); the use of "islands" (e.g. coral reef, city park, biological reserve) for environmental monitoring; and biological monitoring.

He concluded that the MARC program was making a significant contribution to national and international monitoring and assessment activities.

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UNITED NATIONS ENVIRONMENT PROGRAMME - GLOBAL ENVIRONMENTAL MONITORING SYSTEMS (GEMS) (1)

5

5.1 Introduction

In June 1972, as a result of mounting public concern about the environment, the United Nations convened a Conference on the Human Environment, which is now commonly referred to as the Stockholm Conference. Following this Conference, in December 1972, the United Nations General Assembly established the United Nations Environment Programme (UNEP). An important part of UNEP was the development of the concept of Earthwatch - a programme for environmental assessment, which was seen by the Conference as a vital input to the process of environmental management.

Earthwatch consists of four functional components: Evaluation and Review, Research, Monitoring, and Information Exchange. The monitoring component within Earthwatch is the Global Environmental Monitoring System (GEMS).

GEMS is intended to be a coordinated, global effort to gather data essential for effective management of the environment. It encompasses the United Nations family, national governments and any concerned organization that has an input of relevant data. The GEMS Programme Activity Centre (PAC) basically performs a coordinating role between on-going national and international monitoring projects. By providing a small amount of financial support, UNEP also encourages, along with other members of the UN family, the

participation of developing countries in monitoring activities so that a truly global system of data gathering might eventually be established in conformity with the goals of GEMS.

5.2 Development Of GEMS

In preparation for the Stockholm Conference, the UN convened an International Working Group on Monitoring (IWGM) in late 1971 to define the objectives of monitoring, assess how these might be implemented, and assign priorities for their implementation. The IWGM recognized several important principles regarding the implementation of internationally conducted global monitoring:

1. Intergovernmental cooperation in monitoring should build on the basis of existing national and international systems "to the maximum extent possible".

2. UN specialized agencies should be used to the maximum extent possible "as the institutional base for co-ordinating and implementing monitoring programmes".

3. Priority should be given to the development of global and regional (multinational) monitoring.

4. Monitoring systems should be designed to meet clearly defined objectives, and arrangements for the evaluation of the data must be an integral part of the design of the system.

The IWGM defined monitoring as "a system of continued observation, measurement and evaluation for defined purposes". Although this definition makes no distinction between descriptive monitoring and regulatory monitoring, international monitoring has always been discussed in terms of the former.

The meaning of "evaluation" (as used by the IWGM in principle 4 and in the definition of monitoring) in the context of GEMS is not immediately clear, since "Evaluation and Review" is a functional component of Earthwatch separate from "Monitoring". Within Earthwatch the term refers to a two-stage process:

1. Validation of environmental data, i.e. a form of quality control.

2. Interpretation of the data in order to recognize significant trends in individual environmental variables and as an input to environmental management.

Since the role of GEMS is to coordinate among and not within individual monitoring activities, evaluation is taken to mean the identification of trends and the appraisal of the adequacy of the activity. The quality control of data and data interpretation are the responsibility of the operational monitoring group or institution and the implementing UN agency.

The matter of coordinating international monitoring activities was not addressed by either the IWGM or the Stockholm Conference. The initial efforts to address this were made in 1973 by an Inter-Agency Working Group on Monitoring (IAWGM). The IAWGM was the first to report on the existing and planned monitoring activities of UN agencies. The IAWGM also commissioned the Scientific Committee on Problems of the Environment (SCOPE)* to prepare an action plan for Phase 1 implementation of GEMS. This plan examined the priorities

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* A committee of the International Council of Scientific Unions (ICSU).

for monitoring and the bases for selecting certain environmental variables as indicators of possible trends in the environment.

During the same period, various governments also discussed ways in which to best organize international monitoring.

In 1974, the Executive Director of UNEP convened an Intergovernmental Meeting on Monitoring (IMM) in Nairobi. The IMM (a) recommended that the Executive Director be authorized to establish at UNEP headquarters a Director for GEMS with supporting staff; (b) laid down seven programme goals for GEMS; (c) listed the priority pollutants to be considered by GEMS; (d) recognized the need to monitor other (non-pollutant) environmental variables; (e) endorsed the set of objectives and principles laid down by the 1971 IWGM.

The Director for GEMS was appointed at the end of 1974 and the GEMS Programme Activity Centre (PAC) was formally established in 1975 as a section of UNEP responsible for the coordination of all monitoring activities within the United Nations. The role of GEMS PAC is to ensure coordination among individual monitoring activities and does not extend to internal coordination.

The seven goals of GEMS, as laid down by the IMM, are as follows:

1. Expanded warning system of threats to human health.

2. Assessment of global atmospheric pollution and its impact on climate.

3. Assess extent and distribution of contaminants in biological systems, particularly food chains.

4. Assessment of critical problems arising from agricultural and land use practices.

5. Assessment of the response of terrestrial ecosystems to environmental stress.

6. Assessment of the state of ocean pollution and its impact on marine ecosystems.

7. An improved system of international disaster warning.

It is important to note that the goals can be grouped into two broad categories: those relating to pollution monitoring (1, 2, 3, part of 6); and those relating to ecological monitoring, i.e. monitoring stocks of various natural resources (4, 5, part of 6). Depending on the type of natural disaster, Goal 7 could fall into either category (or neither).

These two categories of goals require two different approaches to monitoring. Two different types of output will be produced, although there may be some overlap.

The ultimate aims of global and regional pollution monitoring are:

1. The determination of the levels of selected critical pollutants in particular media, their distribution in space and their trends in time.

2. An understanding of the magnitude and rates of the mass flow of selected pollutants, and their harmful transformation products.

3. The provision of an opportunity for countries, including developing countries, to compare methods of sampling

and analysis, in order to obtain comparable results, and to exchange experience on monitoring systems.

4. The provision, on a global or regional scale, of information essential for management decisions on pollution control.

With regard to ecological monitoring, GEMS has initiated pilot studies to develop methodologies and make large area, small scale global and regional surveys of natural resources (forest, soil, etc.). These small scale surveys will make it possible for individual countries to select, according to the rational criteria embodied in the developed methodologies, areas for monitoring, and to carry out detailed monitoring activities on their own territories.

"As information and data gradually flow into the various components of GEMS, evaluation will usually take place as part of the programs under which the information is collected. The evaluated information will be further reviewed, analysed and published as an input to the State of the Environment Report of UNEP, but this is unlikely before 1977." (2)

"It is evident that much background-level monitoring will yield meaningful trends only gradually and that the interpretation of these trends must proceed with caution and thoroughness. The role of UNEP in this procedure is one of co-ordinator and synthesizer, whereas the operational responsibility will rest, in most cases, with the international organization concerned. UNEP's annual State of the Environment Report to which GEMS will soon be making major contributions should eventually become a definitive document to which national environmental management authorities may look to for guidance and advice." (2)

5.3 References

1. B. Martin and F. Sella. "The development and implementation of the global environmental monitoring system. Draft." presented at the Rockefeller Symposium on Environmental Monitoring, Belagio, Italy. February 11, 1977.

2. B. Martin and F. Sella. "Earthwatching on a macroscale. GEMS: The global environmental monitoring system of the United Nations aims to assess conditions on planet Earth." Environmental Science and Technology 10, #3 (March 1976): 230-233, p. 233.

APPENDICES

APPENDIX 1

LIST OF PROPOSED INTERVIEW QUESTIONS

A. Monitoring Information

M1 What is your involvement with environmental monitoring?

M2 Who is responsible for monitoring information in your areas of jurisdiction?

M3 What monitoring schemes currently exist in your area of responsibility?

M4 What is the historical development of these monitoring schemes?

M5 What is the purpose of these monitoring schemes?

M6 In your opinion, should these monitoring programs be expanded, reduced, revised or left as is? Please explain.

M7 Identify any studies that have been carried out to evaluate these monitoring programs.

M8 Do you know what the results of these studies were? If possible, please elaborate.

A. Monitoring Information (Cont'd.)

M9 Is information on monitoring in other related areas known to you?

M10 If so, is this information accessible and useful to your programs in its present form? If not, is it adaptable?

B. Parameters

P1 What types of parameters are being monitored in your jurisdiction?

P2 In your opinion what parameters should be added or deleted to this list? Explain.

P3 Who evaluates the adequacy of these sampling programs and how is the adequacy evaluated?

P4 Do you feel that the methods of sampling and analysis are adequate? Explain.

P5 How is the collected information made available?

P6 What are the parameter measurements used for?

P7 How should the parameter measurements be used?

C. Objectives

O1 What were the original objectives of the monitoring systems set up to measure parameters in your jurisdiction?

O2 Which of these objectives is being achieved?

O3 Have the objectives been altered during the course of the program? If so, by whom?

O4 In your opinion, what should the objectives be for a) future short term; b) future long term

D. Jurisdiction

J1 What mandates exist for initiating and conducting monitoring programs in your discipline?

J2 Are these mandates properly utilized?

J3 Do you feel these jurisdictions should be altered?

E. Rationale of Monitoring

R1 What is the current management strategy with respect to environmental monitoring?

R2 What rationale is used to expand or change monitoring programs?

R3 What is a desirable current and future management strategy?

R4 How far in the future should our management strategies project?

F. Integration

I(1) Indicate programs you feel are good examples of integrated monitoring schemes.

I(2) What are the drawbacks and advantages of integrated monitoring schemes?

I(3) How easy is it to get information from other monitoring schemes at present?

I(4) Can federal-provincial co-operation on monitoring schemes be improved?

G. Further Information

F1 Who would you recommend talking to in order to gain more information on monitoring schemes in Canada, the United States and elsewhere?

F2 Can you recommend any published information on monitoring that would help supplement this study?

F3 Do you feel there are any other pertinent questions that should be asked when talking to others?

APPENDIX 2

DEPUTY MINISTER'S MEMORANDUM

Government of Canada / Gouvernement du Canada

MEMORANDUM **NOTE DE SERVICE**

OSA-BCS/MCB HOTZ/7-2347/sj

SECURITY - CLASSIFICATION – *DE SÉCURITÉ*

OUR FILE - *N/RÉFÉRENCE*

YOUR FILE – *V/RÉFÉRENCE*

DATE AUG AOU 6 1976

TO / *À* Chairmen of Regional Boards
Présidents des conseils régionaux

FROM / *DE* Deputy Minister
Sous-ministre

SUBJECT / *OBJET* ENVIRONMENTAL MONITORING PLAN FOR CANADA
PHILIPS ELECTRONICS INDUSTRIES LIMITED & JAMES F. MACLAREN LIMITED
PLAN DE CONTROLE ENVIRONNEMENTAL POUR LE CANADA
PHILIPS ELECTRONICS INDUSTRIES LIMITED & JAMES F. MACLAREN LIMITED

We have recently entered into a contract to examine the monitoring requirements for organizations that have to make decisions that affect environmental quality and resource management. This contract arose from an unsolicited proposal submitted to the Department of Supply and Services by a consortium of companies led by James F. MacLaren Ltd. and Philips Electronics Industries. The objectives of the study were identified in inter-service and interdepartmental discussions, and have been included in the contract. Dr. M. Hotz, Director of the Integrated Programs Branch (997-2347) has been identified as the scientific authority responsible for the technical content of the work under the contract.

While much of the area covered by the contract obviously lies outside the area of purely federal jurisdiction, we believe that a national review is timely, and that it would be of help to all concerned with environmental and resource problems, whether the decision makers are at federal, provincial or industrial levels.

Nous avons récemment passé un contrat visant à examiner les besoins, en matière de contrôle en ce qui concerne les organismes qui ont à prendre des décisions dont les effets se font sentir sur la qualité de l'environnement et la gestion des ressources. Ce contrat tire son origine d'un projet spontané présenté au ministère des Approvisionnements et Services par un consortium ayant à sa tête les sociétés James F. MacLaren Ltd. et Philips Electronics Industries. Les objectifs de l'étude ont été déterminés lors d'entretiens interservices et interministériels et ont été spécifiés dans le contrat. C'est M. M. Hotz, directeur des programmes intégrés (997-2347) qui agira comme autorité scientifique responsable du contenu technique du travail effectué en vertu du contrat.

Bien qu'une grande partie de la sphère d'application du contrat déborde de façon évidente les limites de la compétence purement du fédéral, nous croyons qu'il est opportun de faire une révision à l'échelle nationale et qu'elle sera utile à tous ceux qui sont confrontés avec des problèmes d'environnement ou de gestion des ressources, que ce soit au niveau national, provincial ou industriel.

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This contract only covers a first phase, which is essentially a fact-finding one, looking at the types of information basis and systems in use in Canada, how they are currently being used, what use decision makers might like to make of them, and whether or not users feel that modifications would be useful. Before proceeding with any subsequent phase, it is our intention to consult our regions, and through them, the interested provincial agencies, to get their opinions on the study to date and how it might proceed in the future.

Ce contrat ne s'applique qu'à une première phase qui se résume essentiellement à l'établissement de faits; il s'agit d'examiner tous les types de bases et de systèmes d'information utilisés au Canada, la façon dont on s'en sert actuellement, l'usage que les décisionnaires aimeraient en faire et de déterminer si les usagers jugent utile de les modifier. Avant de s'engager dans une autre phase, nous avons l'intention de consulter nos régions et, par leur intermédiaire, les organismes provinciaux intéressés afin de connaître leur opinion sur l'étude jusqu'ici et sur la façon dont elle pourrait se poursuivre dans l'avenir.

The consortium as part of their program wish to visit our regional offices and interested provincial officials. The consultants have identified Doctors F. Snape, D.B. Chambers, and D.A. Gorbel as their project officers. As such, all or any one of them may be making the visit. Please contact Dr. D.E. Koczkur in Toronto (499-0880) to arrange times for a visit to your region and to work out a suitable program of interviews with appropriate members of our regional offices and provincial officials.

Dans le cadre de son programme, le consortium se propose de se rendre dans les bureaux régionaux et de rencontrer les hauts fonctionnaires provinciaux intéressés. Les experts-conseils ont choisi comme agents de projet MM. F. Snape, D.R. Chamers et D.A. Gorbel. A ce titre, tous ou n'importe lequel d'entre eux peuvent faire cette visite. Veuillez donc communiquer avec M. D.E. Koczkur à Toronto (499-0880) pour fixer la date d'une visite dans votre région et préparer un programme convenable d'entrevues avec des membres appropriés de vos bureaux régionaux et des hauts fonctionnaires de la province.

While a number of federal departments will be contacted for needed data, a good deal of information will be sought from provincial sources; hence, the desire on the part of the consultants to meet with and to seek assistance from provincial officials. It is therefore important that you outline to the provincial organizations the merits of a nationwide environmental information management plan when making arrangements for the consultants to meet with these officials.

Les données nécessaires, seront obtenues d'un certain nombre de ministères fédéraux mais une bonne partie des renseignements proviendront néanmoins de sources provinciales; c'est pourquoi les experts-conseils désirent rencontrer les hauts fonctionnaires de la province et chercher à obtenir leur aide. Il importe, par conséquent, lorsque vous prendrez des disposition en vue de la rencontre des experts-conseils avec ces hauts fonctionnaires, que vous souligniez aux organismes provinciaux les mérites d'un plan de gestion de l'information environnementale à l'échelle nationale.

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The program, as I see it, should assist the provinces in recording and maintaining base data, in the timely identification of environmental problem areas, in expanding their knowledge and understanding of the environment, in the development of environmental policies and plans and in controlling the environment to obtain optimum use of the natural resources. Undoubtedly there are other benefits to the plan which you have identified and which should be brought to the provinces' attention.

Your expertise in the field of environmental management coupled with that of provincial officials can contribute significantly to this study and program and, as such, I ask that you give it full support.

A mon avis, le programme devrait aider les provinces à relever et à conserver des données de base, à identifier les sujets de préoccupation environnementaux en temps opportun, à accroître leur connaissance et leur compréhension de l'environnement, à élaborer des politiques et des plans concernant l'environnement, à élaborer des politiques et des plans concernant l'environnement et à le contrôler pour en arriver à une utilisation maximale des ressources naturelles. Le plan comporte sans doute d'autres avantages que vous aurez relevés et qui devraient être portés à l'attention des provinces.

Ajoutées à celles des hauts fonctionnaires provinciaux, vos connaissances spécialisées dans le domaine de la gestion de l'environnement peuvent contribuer grandement à cette étude et à ce programme, et c'est pourquoi je vous invite à les appuyer pleinement.

SIGNED BY
SIGNÉ PAR K. C. LUCAS

for J.B. Seaborn

APPENDIX 3

PERSONS INTERVIEWED IN CANADA

APPENDIX 3

LIST OF ABBREVIATIONS

Fisheries and Environment Canada

EMS	-	Environmental Management Service
EPS	-	Environmental Protection Service
O&AS	-	Ocean and Aquatic Sciences
F&MS	-	Fisheries and Marine Service
AES	-	Atmospheric Environment Service

Provinces

DOE	-	Department of Environment
DTRR	-	Department of Transportation and Renewable Resources
DRRTS	-	Department of Renewable Resources and Transportation Services
DMREM	-	Department of Mines, Resources, and Environmental Management
MNR	-	Ministry of Natural Resources
MOE	-	Ministry of Environment

FISHERIES AND ENVIRONMENT CANADA

Ottawa-Hull

C.S. Alexander, Attorney, Legal Advisor

J.P. Bruce, Director General, Inland Waters Directorate, EMS

Dr. J. Brydon, Director, Contaminants Control Branch, EPS

A. Coulson, Chief, Water Management Division, Water Planning and Management Branch, EMS

Dr. A.R. Davis, Monitoring and Surveys Division, Water Quality Branch, EMS

R.M. Gale, Chief, Monitoring and Surveys Division, Water Quality Branch, EMS

M. Gilbertson, Protocol Ecologist, Environmental Contaminants Control Branch, EPS

R.A. Halliday, Special Services and Survey Division, Water Quality Branch, EMS

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P. M. Higgins, Director General, Water Pollution Control Directorate, EPS

F. G. Hurtubise, Environmental Assessment Panel

Dr. H. Inhaber, Advanced Concept Center, P & FS

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Dr. C.J. Kerswill, Director, Fisheries and Research Branch, Resource Services Directorate F & MS

Dr. J. Kruus, Coordinator, Satellite & Airborne Sensing, Office of the Science Advisor

Dr. M.F. Millson, Chief, Protocol Assessment and Ecological Protocols Division, Environmental Contaminants Control Branch, EPS

H. Mooij, Solid Waste Management Branch, EPS

L. Munn, Director, Land Use Planning Branch, EMS

V. Niemela, Chief, Program Studies Division, EPS

Dr. N.S. Novakowski, Coordinator, Research and Conservation, Canadian Wildlife Directorate, EMS

J. Payne, Solid Waste Management Branch, EPS

R.M. Prentice, Director, Forest Protection, Branch, EMS

I. Price, Toxic Chemicals Division, CWS, EMS

R.M. Robinson, Director, Federal Provincial and U.S. Relations Branch, F & PS

J.B. Seaborn, Deputy Minister

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Dr. R.A. Stacey, Ocean Technology Division O & AS

Dr. A.D. Stanley, Office of Program Evaluation and Liaison Inland Waters Directorate, EMS

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C. Wachman, Coordinator, Environmental Impact Surveillance and Monitoring Section, EPS

Canada Centre for Inland Waters

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Dr. K. Rodgers, Chief, Applied Research Division

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S. Gardy, Executive Secretary, Regional Board

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J.F. Herity, Coordinator, Environmental Assessment, EMS

B. Kelso, Project Biologist, Freshwater Study, EPS

W. Kreuder, Water Survey of Canada, EMS

O.E. Langer, EPS

M.R.C. Massie, Economics and Environmental Forestry, CFS, EMS

R.E. McLaren, Regional Director, EPS

M. Nassichuk, F & MS

S. Nikleva, Scientific Service Meteorologist, AES

S. Pond, Chief, Ecological Protection, EPS

D.G. Schaeffer, Scientific Service Meteorologist, AES

D. Wilson, Biologist, Pesticides EPS

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J.R. Marshall, Environment & Land Use Committee Secretariat

R.L. Morley, Fish and Wildlife Branch

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G. Nelson, DRRTS

C.K. Smith, Regional Director, DRRTS

M.M. Ward, Director, Program Development and Review, DMREM

L.G. Yarn, DMREM

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D. Terry, Water Resources Branch, MOE

PROVINCE OF QUEBEC

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PROVINCE OF NEW BRUNSWICK

Dr. O. Washburn, Environment New Brunswick

PROVINCE OF NOVA SCOTIA

A.J. Crouse, Director, Inspection and Monitoring, DOE

APPENDIX 4

PERSONS INTERVIEWED IN THE U.S.A.

U.S. ENVIRONMENTAL PROTECTION AGENCY

Washington

T.D. Bath, Executive Secretary, Science Advisory Board, Office of Research and Development

M. Bills, Associate Deputy Assistant Administrator, Monitoring and Technological Support

W.A. Cawley, Director, Technical Support Division, Office of Research and Development

V. DeCarlo, Monitoring and Information Systems, Office of Water and Hazardous Materials

K. Harper, Deputy Associate Administrator, International Activities

R. Heath, Ecological Monitoring Branch, Office of Water and Hazardous Materials

R. Johnson, Environmental Analysis Division, Office of Radiation Programs

C. Klevano, Bilateral Programs Division

A. Konheim, Office of Noise Abatement and Control
B. Manns, Office of Noise Abatement and Control

T. Murray, Monitoring and Data Support Division, Office of Water Planning and Standards

Dr. D. Oakley, Director, International Technology Division

Las Vegas

Dr. J. Behar, Environmental Monitoring and Support Laboratory, Office of Research and Development

D.W. Hendricks, Director, Office of Radiation Programs, Las Vegas Facility

Dr. P. Lem, National Environmental Research Centre

L.G. McMillion, Senior Hydrogeologist, National Environmental Research Centre

G. Morgan, Acting Director, Environmental Monitoring and Support Laboratory, Office of Research and Development

E.A. Schuck, Chief, Monitoring Systems Analysis Staff, National Environmental Research Centre

Research Triangle Park, North Carolina

R. Neligan, Monitoring and Data Analysis Division, Office of Air and Waste Management

Ada, Oklahoma

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Athens, Georgia

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DEPARTMENT OF INTERIOR

Washington

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CENTER FOR SHORT LIVED PHENOMENA, CAMBRIDGE, MASS.

R. Golob, Director

APPENDIX 5

PERSONS INTERVIEWED IN THE U.K.

MONITORING & ASSESSMENT RESEARCH CENTER, CHELSEA COLLEGE, LONDON, ENGLAND

J. Michael Buchanan

Dr. G.T. Goodman, Director

Dr. P.C. Robbins

S. Staynes

Dr. B.K. Wyatt