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WATER MONITORING NETWORKS IN COLD CLIMATE AREAS*

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ABSTRACT

Public opinion, the scientific community, and special interest groups no longer accept major disruptions in the human environment without sound justification. In view of this social consciousness-level, private, public, and para-public enterprises must evaluate the impacts of their projects on the quality of the human environment, and seriously study possible alternatives. The use of methods for evaluating environmental impacts is only possible through acquiring and understanding basic data on the initial environmental conditions that can be altered by a project at a given site. Original environmental data can be obtained at the beginning of a project starting with the various data acquisition programs underway in several countries. Indeed, to further planning or monitoring efforts, numerous governmental and private organizations systematically generate basic environmental data. Following a brief review of the principle environmental impact evaluation methodologies, this article analyzes the methods for acquiring water quality data in use in three Nordic countries: Canada, Finland, and Sweden. For each country, the groups responsible for the data acquisition network are described by analyzing their objectives, techniques, successes and failures, efficiency, financial backing, personnel, and methods of data treatment.

Technological knowledge has rendered man capable of erecting structures and works of very large scale. According to Bella, this capacity to expand the scale of works, and consequently, their impact on the environment, tends to grow much more rapidly than the aptitude to predict ecological and social repercussions, and to prevent them when they are harmful [1, 2]. Water resources management is but one element of resource planning [3], an activity

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that aspires to assure equilibrium between economic, social, and ecological objectives, and therefore secure the foundations of future well-being [4]. If one really wishes to assure an integrated, global planning effort aimed at achieving economic expansion, environmental protection, and the improvement of social contexts in an area, one must expand the perspectives of the planning effort to take into account the grander aspects of the interdependent management of resources [5, 6].

Evaluation of the environmental impacts of projects is becoming more and more indissociable from the decision process responsible for the intervention on environmental systems [7]. From the very nature of decisional processes, an accounting of the environmental components of an undertaking must be approached in an objective and systematic fashion. In fact, several methods of environmental impact assessment already applied employ a rational approach [8-27]. While it has not yet been demonstrated that the cartesian approach to the environment is the best, it is probably the only approach which is at once acceptable and compatible with the nature of technological projects. These developments in the field of environmental studies are promising and surely constitute an important step in the maturation of technology.

A classification of existing methods invokes the different ways of identifying impacts: *ad hoc*, checklists, cartography, network, statistical methods, Delphi method, scenarios and contextual representation, and creativity methods. Table 1 presents the range of applicability of these broad classes of methods for evaluating environmental impact. In order to be efficient, the application of evaluation methods must rely on an adequate information system. Otherwise an application of the method,would fail at its principal function, which is to furnish a clear and concise description of the important facts justifying the decisions and programs that follow. The absence of such an information system will result in a series of short-term, *ad hoc* judgments lacking orientation and strategic unity.

Official basic data constitute the foundation of this information system. The ease or difficulty with which one obtains data is largely influenced by the practices and procedures of agencies charged with collecting the data. Depending on the nature of data required, the need for it may be continuous or periodical, or in some cases, an isolated event. If the data must be collected and analyzed by consultants and different government agencies, it is necessary to establish certain routing procedures so as to permit eventual comparison between the data. Moreover, if one takes for given that the factors having the same degree of critical importance must be measured with the same precision, the parties responsible for applying environmental impact evaluation could suggest desirable changes in the methods used for data collection.

The initial environmental conditions are characteristics of the state of equilibrium of the aquatic system before the appearance of an alteration in the environment associated with a use that causes direct or indirect changes in

Table 1. Classification of the Principal Existing Methods of Evaluation

Categories	*Description*	*Methods*
Ad hoc	These methodologies provide minimal guidance to impact assessment beyond suggesting broad areas of possible impacts (e.g., impacts on flora and fauna, impacts of lakes, forests, etc.), rather than defining specific parameters to be investigated.	
Cartography	These methodologies rely on a set of maps of environmental characteristics (physical, social, ecological, aesthetic) for a project area. These maps are overlaid to produce a composite characterization of the regional environment. Impacts are identified by noting the impacted environmental characteristics lying within the project boundaries.	McHarg, I [10, 11] Krauskopf, M. and D. C. Bunde [20]
Checklists	These methodologies present a specific list of environmental parameters to be investigated for possible impacts but do not require the establishment of direct cause-effect links to project activities. They may or may not include guidelines on how parameter data are to be measured and interpreted.	Smith, W. L. [9] Little, A. D. [12] Atkins, W. C. and D. Burke [13]. Institute of Ecology, University of Georgia [14] Dee, N. [19] Multiagency Task Force [21] Stover, L. V. [22] Tulsa District, U.S. Army Corps of Engineers [23] Dee, N. [24]
Matrices	These methodologies incorporate a list of project activities in addition to a checklist of potentially impacted environmental characteristics. These two lists are related in a matrix which identifies cause-effect relationships between specific activities and impacts. Matrix methodologies may specify which actions impact which environmental characteristics or may simply list the range of possible actions and characteristics in an open matrix to be completed by the analyst.	Leopold, L. B., F. E. Clarke, B. B. Hanshaw, and J. R. Balsley [15] Central New York Regional Planning and Development Board [18] Dee, N. [24]
Networks	These methodologies work from a list of project activities to establish cause-condition-effect networks. They are an attempt to recognize that a series of impacts may be triggered by a project action. These approaches generally define a set of possible networks and allow the user to identify impacts by selecting and tracing out the appropriate project actions.	Sorensen, J. C. [16, 17] Dee, N. [24] Moore, J. L. [25] Couillard, D. [26, 27]

environmental conditions [6]. In the evaluation of initial environmental conditions, the foundation of the data system is original data, reports and other information available at the start of a project. Numerous organizations, particularly in government, sample for biological and physicochemical data in order to evaluate water quality. This evaluation is indispensable to managers who must make decisions concerning the restoration of water quality or the management of aquatic resources for different potential uses. This article analyzes the methods of acquiring water quality data currently used in three Nordic countries: Canada, Finland, and Sweden.

FIRST CASE STUDY: CANADA

In Canada, as in several countries, the responsibilities for the acquisition of water quality data lie with different levels of government. The British North American Act of 1867 and its amendments, which divide legislative powers between the federal and provincial governments, serve as the constitutional basis for natural resources planning in Canada [28]. The federal government has exclusive jurisdiction over fishing and navigation, and it shares jurisdiction with the provinces in aspects related to the use of water for agricultural purposes; there are also legislative responsibilities inherent to interprovincial initiatives.

The federal government also has legislative power over initiatives related to international waters and is responsible for the implementation of the Border Waters Treaty of 1909 concerning the waters along the Canadian-U.S. border [29]. In addition to these legislative powers, the federal government has certain general powers permitting it to legislate certain dispositions that directly or indirectly influence water use [28]. The federal government can also adopt laws concerning the major works located in a province, or in two or more provinces, if the works are of general interest to all of Canada.

The provinces are traditionally considered as owners of the water resources situated in their territory (excepting national parks and federal lands) and they enforce basic laws on water resource management, authorizing development projects, arranging use permits, regulating discharges, and collecting fees. They also have a legislative jurisdiction over water from different titles in the British North American Act which allow them to adopt laws concerning such aspects as domestic and industrial water supply, energy production, irrigation, land reclamation, recreation, and pollution control.

Within the framework imposed by the constitution, the federal and provincial governments are together responsible for the management and regulation of water resources in watersheds across the country. The pertinent federal law, the Water Act of Canada, was adopted in 1970. This law permits the federal government to enter into accords with the provinces to undertake general programs of water management (or, in exceptional cases, to act unilaterally). The law stipulates certain mechanisms to use in water management, notably the continuous joint consultative reviews, plan preparation, and the solicitation of public opinion. The consultations are undertaken within the Federal-provincial consultative committees established with each province. The committees are usually made up of three high officials from each government. These reviews oversee the creation of study committees or planning commissions on the scale of the watershed.

Once a basin has been chosen as having prioritary interest in planning efforts, a planning commission can be created by virtue of an official accord to assure joint surveillance of the study. The Saint John River Commission is a good example of this method of approach [30]. Once created, the Commission oversees the elaboration of a global plan for water management, political concerns, budget controls, and the general orientation of the study. The planning project itself is usually the responsibility of a Director of Planning who reports on his mandate before the Commission. The Commission also forms a committee to oversee the progress of work; this committee is charged with elaborating the general study plan, preparing the budgets, examining the reports of work groups and reciting the progress of works to the Commission by way of the Director of Planning.

The Federal Government

Department of the Environment – The purpose of the Department of the Environment's Inland Waters Directorate is to improve the quality, management, and use of Canada's water resources. This Directorate sees to promoting the establishment and co-ordination of national policies and programs to ensure optimal use of Canada's waters. It establishes programs for pollution control [31] and the conservation of water quality and quantity to meet demand. It works to minimize the undesirable effects of the tapping of water resources and of floods, droughts, erosion and related natural phenomena [32, 33]. Two large-scale programs are not underway to make a detailed study of lakes. The *Fresh Water Institute* program covers lakes in the Canadian Shield [34], while the *Canada Centre for Inland Waters (CCIW)* program is looking at the Great Lakes [35-38].

By virtue of the accord concluded between Canada and the United States on the water quality of the Great Lakes, ultimate responsibility for carrying out the provisions of the accord was entrusted with the International Joint Commission (IJC). This Commission, created under the authority of the Border Waters Treaty of 1909, is usually invited by Canada and the United States to coordinate and negotiate the elaboration of the long-term management programs for the expanse of water shared by two countries. Approximately 3,900 km of the U.S.-Canada border (of a total 8,900 km) is delimited by water courses. The accord on the water quality of the Great Lakes enjoins the IJC to create a special joint U.S.-Canadian commission containing representatives of the governments of the two countries. A consultative commission on research is equally foreseen and the joint commission is authorized to create a regional office and auxiliary organizations to undertake specific tasks [39-42].

The *Fresh Water Institute*, in Winnipeg, has a very well equipped laboratory. About a hundred lakes in the Canadian Shield are now under study (Experimental Lake Area). The program's objectives are:

- to characterize trophic conditions in the lakes and identify means for controlling eutrophication;
- to pursue eutrophication studies by experimentally rendering small lakes eutrophic;
- to study geological, climatic, morphological and human impact on lake eutrophication; and
- to determine the toxicity of certain products through laboratory bioassays.

From a sampling point of view, these studies involve physical and chemical analyses of water at various times of the year. Several highly sensitive techniques have been developed [43] for analyzing various substances in very weak concentrations [44]. At certain times of the year there is also sampling of phytoplankton, zooplankton, periphyton, zoobenthon, fish, etc.

The *Canada Centre for Inland Waters* takes care of Canada's participation in the international Great Lakes study program. Adequately equipped ships visit over 2,500 stations nine times a year sampling water [45] (20,412 samples in 1972), plankton (1,065 samples in 1972), macroinvertebrates [46], and sediment [47-52]. The main parameters measured are pH [53, 54], temperature [53, 55, 56], dissolved oxygen [53, 54], various forms of phosphorus [57-59], and nitrogen [55, 60], the principal ions [54, 61, 62], trace and heavy metals [54, 63-65], conductivity [54], alkalinity [54], hardness, BOD, phenol, pesticides [66-69], chlorophyll [70], and herbicides [71, 72]. These data acquisition activities are part of research programs on the origin, nature, and final destination of a number of substances [50, 51, 55, 73-78].

In addition, the *Water Quality Branch Environmental Management Service (Inland Waters Directorate)* runs a network of 850 stations across the country. Samples are generally taken monthly and additional samples are taken at flood and low water [79]. In particular cases sampling frequency may be increased to two or three times a week. The samples are sent to five laboratories in Regina, Moncton, Calgary, New Westminster, and Burlington. The parameters analyzed are COD, pH, conductivity, color, turbidity, organic carbon, inorganic carbon, various forms of nitrogen, phosphorus, the principal ions, pesticides [80], phenols, NTA (nitrilotriacetic acid), and various trace metals.

All these data are stored in the NAQUADAT bank; this permits users to retrieve data from various stations according to their needs [81]. Environmental quality control comes under the *Environment Protection Service,* whose officials have the power to require wastewater quality analyses of discharged sewage [44]. For surface water, they rely on the corresponding service in the *Inland Waters Directorate.*

The Provincial Government

Several provincial departments have a role in water quality data acquisition [57, 82-84]. The following deserve mention: Tourism, Fish and Game; Environment Protection Service; Social Affairs; Industry and Commerce; Natural Resources; Agriculture. Also, each of these departments has occasion to commission special studies from industry or the universities.

The Department of Tourism, Fish and Game – The concern of this department in water matters is the promotion of recreational fishing. This leads the department to draw up fish population inventories and to study natural ecosystems, in order to recommend various kinds of development and use. It also takes part in the acquisition of water quality data on lakes in national parks, where conductivity and water temperature are regularly measured [85].

The Department of the Environment – This department is responsible for protecting the environment from the harmful impact of agricultural, domestic, industrial, and urban wastewaters [86, 87]. It sees to the establishment of standards for controlling the various kinds of pollution. Its recommendations are based on quality observations made by the surveys division. Quality data are obtained for certain water-courses, most of the sampling being carried out in summer. The parameters analyzed are temperature, pH, conductivity, hardness, COD, BOD, alkalinity, the various forms of phosphorus and nitrogen, sulfates, the principal ions, certain trace metals, coliform bacteria and fecal streptococci [88-90]. *The Department of the Environment* cooperates with private industry and the universities by entrusting to them certain analyses and some special study projects [91]. In the Province of Québec, most of the latter fall under a federal-provincial agreement on studies of the St. Lawrence River [92-96].

The Department of Social Affairs – One of the purposes of the *Department of Social Affairs* is to protect the population from water unfit for drinking or bathing. In the Province of Québec, two laboratories, one in Montréal and the other in Québec City, carry out the necessary analyses. The Montréal laboratory concentrates on bacterial analysis while the Québec City laboratory is especially well equipped for physicochemical analysis. The following parameters can be measured: pH, turbidity, alkalinity, hardness, conductivity, color, various forms of nitrogen and phosphorus, the principal ions, trace metals, etc. In summer, beach samples are sent to these laboratories, as are drinking water samples from certain municipalities. Special projects are launched and carried out as part of the activities of these laboratories. For instance, last year the potential of gas chromatography for analyzing phenols was studied.

The Department of Industry and Commerce – This department is concerned with fresh water quality as it relates to commercial fishing. The fishing experiments division takes fish from several locations, generally with a view to assessing the biomass, though in some cases they have had occasion to analyze fish flesh for traces of toxic substances. Most of this work has specific goals with respect to particular kinds of commercial fishing: shrimp, eel, etc.

The Department of Natural Resources – In the Province of Québec, this department makes use of two hydrological data acquisition networks. The first is specifically for hydrometric work and the second for acquisition of water quality data on the main lakes and rivers of Québec. The two are well coordinated so that the quality data can be interpreted when the flow is known. More than 150 sampling stations are located throughout Québec [89], most of them in the inhabited areas of the south. The stations in the north are mostly in the James Bay area. For lakes, sampling depends on the season; most of it is done in summer. For rivers, local technicians and observers take weekly water samples at each station [90].

The main parameters measured in rivers are pH, conductivity, hardness, alkalinity, color, turbidity, various forms of phosphorus and nitrogen, the principal ions and trace metals. For lakes, in addition to physicochemical analyses, elaborate biological analyses are carried out on periphyton, macrophytes, invertebrates, fish, fertility, primary productivity, etc. Also in the Province of Québec, the *Department of Natural Resources* cooperates with private industry and the universities on special projects, like a study of the implication of building a water supply reservoir on the Bulstrode River, Victoriaville [97, 98]. The water quality service of this department intends to make studies of biological indicators.

The Department of Agriculture – In the Province of Québec, the *Department of Agriculture* is currently carrying out a special study project on the contamination of groundwater by nitrates. Many samples are being taken from the groundwater layer or in lysimeters, at several locations in the Province of Québec. These samples are sent to a laboratory where the various forms of phosphorus and nitrogen are measured, as is potassium.

The Municipal Governments

Municipalities are authorized by the provinces to supply drinking water and to treat sanitary wastewaters. Initiatives to regroup municipalities and solve problems on a regional scale are increasing at an accelerated pace. Moreover, in certain provinces there are agencies with powers for planning and project implementation, notably dam and water conservation administrations. The municipal governments also take part in surface water quality sampling and analysis. At filtration plants, two samples are generally taken every day and analyzed for the following parameters: turbidity, pH, temperature, color, and conductivity.

SECOND CASE STUDY: FINLAND

The *National Board of Waters* is responsible for water management in Finland. The board is a central agency with six administrative divisions, themselves divided into a number of separate offices (Figure 1). Particular attention is given to legal questions related to compliance with pollution laws, to the issuing of various kinds of operating permits, and since 1970, to overall water uses planning in the areas of conservation, supply, sewage treatment, resource tapping, flood control, and research [99].

There is a special research division: the *Water Research Institute* [100]. Its task is to develop water resource knowledge, to monitor water pollution, and to design and implement special research projects on various problems in this field. The *Water Research Office*, one of the *Water Research Institute*, operates several permanent and temporary networks. In principle, the purpose of the permanent networks is to supply information on a continuing basis while the temporary networks exist for specific purposes. There are five permanent networks now in operation.

Permanent Networks

The flowing water network – In this program, water is sampled at 160 stations four times a year (March, May, August, and October). The samples are taken at a depth of one meter; the parameters analyzed are given in Table 2 [101].

The lake network – Water is sampled at 155 stations once a year in the second half of March. Samples are taken at one meter, five meters, the mean depth, and one meter above the bottom. The parameters analyzed are given in Table 2. Temperature, dissolved oxygen, conductivity, pH, and color are studied more intensively, in their relation to stratification.

The frontier waters network – Flow is measured and water sampled at fourteen stations along the border with the USSR.

The marine network – Samples are taken at thirty-three ordinary and fifty to sixty-five special stations off coastal towns, in July, August, February, and March. The parameters measured are given in Table 2.

The brookwater network – Samples are taken from thirty-four stations located throughout the country. The aim is to determine the quality and quantity of inputs to surface water from ground sources and to study the factors contributing to these inputs [102].

Temporary Networks

Several networks were set up for definite periods of time to satisfy needs for specific knowledge. Their objectives and sampling programs are described below.

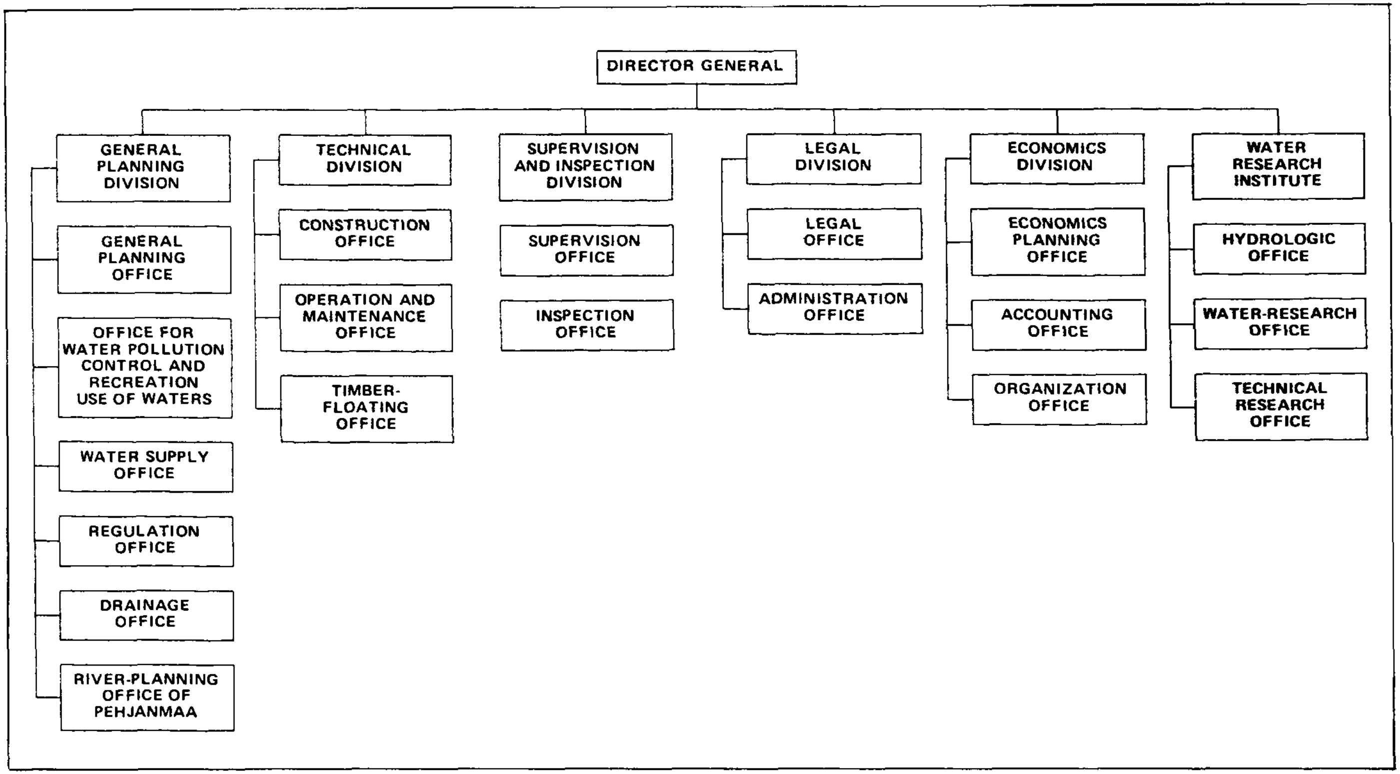

Figure 1. Organization chart for the National Board of Waters, Finland.

Table 2. List of Measured Parameters

Parameters	*Unit*	*Range*
Water		
Water Level	cm	0-999
Temperature	°C	0.1-10.0
Oxygen	percent saturated	0-110
Carbonates	mg/l	0-99
Suspended Solids	mg/l	0-99.0
Conductivity	μ S	10-500
Alcalinity	meg/l	0-2.50
pH		3.0-9.0
Color	mg/l Pt	1-800
$KMnO_4$	mg/l $KMnO_4$	5-700
Total Nitrogen	mg/l N	0.1-9.9
Total Phosphorus	mg/l P	0.001-0.990
Total Sulfur	mg/l S	0.0-50.0
Potassium	mg/l	0.1-10.0
Calcium	mg/l	0.1-50.0
Sodium	mg/l	0.1-50.0
Magnesium	mg/l	0.1-20.0
Chlorine	mg/l	0.1-50.0
Iron	mg/l	0.1-50.0
Silica	mg/l SiO_2	0.1-50.0
Sediments		
Fixed Residue	percent	1-99
Ignition Losses	percent	1-99
$K_2Cr_2O_7$	mg/g O_2	5-500
Total Nitrogen	mg/g N	0.5-20.0
Total Phosphorus	mg/g P	0.1-30.0
Iron	mg/g	5-400
Manganese	mg/g	0.1-20.0
Zinc	mg/g	0.02-2.00

The biomass network – The program lasted two years, with sampling at 700 stations. The main goal was to study eutrophication through biological indicators.

The biomass growth period variation network – Samples were taken in special tubes at 370 stations on two occasions during the summer of 1971. The purpose of this network was to study changes in the algal biomass during the summer [103].

The Gulf of Bothnia network – The purpose of this network was to study the effectiveness of aerial photography in monitoring water quality off the coasts. The false-color and infrared photographs were taken at an altitude of 2,000 meters.

The water quality network south of Lake Saimaa – The purpose was to study the effectiveness of aerial photography in water quality studies. False-color and infrared photographs were taken of a 10,440 km area from a height of 2,000 meters. These were compared with the results of chemical analyses of water at eighty-three stations.

The special river network – The purpose was to establish the relationship between river water quality and the nature of the drainage basins. Fifteen stations were sampled twelve times a year.

The special Lake Pääjärve network – The long-range goal is to study changes in fertilizing substances and identify the mechanisms of these changes. Samples were taken seventeen times a year at eight stations on rivers and four times a year at two stations on the lake [103, 104].

The lake eutrophication-sedimentation network – The purpose was to establish the relation between lake eutrophication and the nature of sediments [103, 105].

The nutrient leaching network – The aim was similar to that of the permanent brookwater network. Five small streams were sampled from one to seven times a week. All factors that could have an impact on soil leaching were looked at thoroughly.

The drainage and fertility network – The aim was to determine the influence of the fertilizing season, of fertilization methods and of drainage on the leaching of fertilizers. Samples were taken monthly and fifteen parameters measured.

The rain network – The purpose was to determine rainwater quality and to assess the quantity of nutrients carried to surface waters by rain. Forty-two stations were sampled four times a year and fifteen parameters measured [106].

The mercury network – The aim was to determine surface water mercury content in sufficient detail for mercury analyses not to be needed again. Water, sediments, fish, and fish organs were analyzed for mercury.

The estuary sediments mercury network – The aim was to determine the stratification of mercury in the estuaries of polluted rivers. It was hoped thereby to characterize mercury mobility in sediments.

The network studying pesticides and toxic materials in industrial effluents – The aim was to characterize the use of pesticides, and of other toxic substances in industry. Water, sediments, and fish were analyzed.

The man-made drainage basin network – The aim was to determine water quality in thirty-seven man-made drainage basins and identify the influencing factors. Data already obtained were used and in some basins new samples were taken. For basins under construction, soils were analyzed before flooding. Basins recently flooded were sampled four times a year while old ones were sampled only once, in April.

The network studying water from fish farms – The aim was to determine changes in surface water downstream from fish farms. Three such farms were being studied.

The Lapland man-made basins network – The aim was to determine water quality and identify changes in the Lokka and Porttiphata basins.

In addition to performing routine analyses for each network, the laboratories carry out research on methods of taking, preserving and transporting samples. Methods are also being developed for analyzing various chemical products such as nitrogen compounds, resinous acids, pesticides, and hydrophobic compounds.

THIRD CASE STUDY: SWEDEN

Responsibility for environment protection falls mainly to the ministry of agriculture. Within the ministry, an advisory committee on environmental problems has been formed. This committee advises and is consulted by the government on all aspects of the environment: management, development and planning, and, consequently, environmental studies, and research.

Responsibility for resource management is divided among several agencies. One of these, the *Environmental Protection Agency*, is responsible for everything having to do with environmental protection, while the others are concerned with the development of the various resources. Its mandate is to conduct and promote environmental research, to advise on and establish directives regarding use of the environment and to direct the preparation of lists of areas to be protected for conservation or tourist purposes. The agency's organization is described in Figure 2.

The *Environmental Protection Agency*'s research program focuses on the study of lake pollution resulting from wastewater discharge [107, 108]. To elucidate the impact of urban effluents, the plan is to analyze trends in various kinds of lakes over several years. These studies will also look at reclamation of several polluted lakes whose tributaries have been completely diverted [109]. At the same time, the effectiveness of treatment plants will be assessed and the pollutant loads discharged into the lakes will be monitored.

The basic program has been drawn up so that obvious changes in surface water quality can be measured [102]. Observations and results are generally based on weekly averages. Some lakes are being looked at in greater detail through specialized studies. The provincial governments are responsible for daily sampling of the lakes. The following parameters are measured in situ: turbidity, pH, temperature. Water samples are taken vertically from zero to

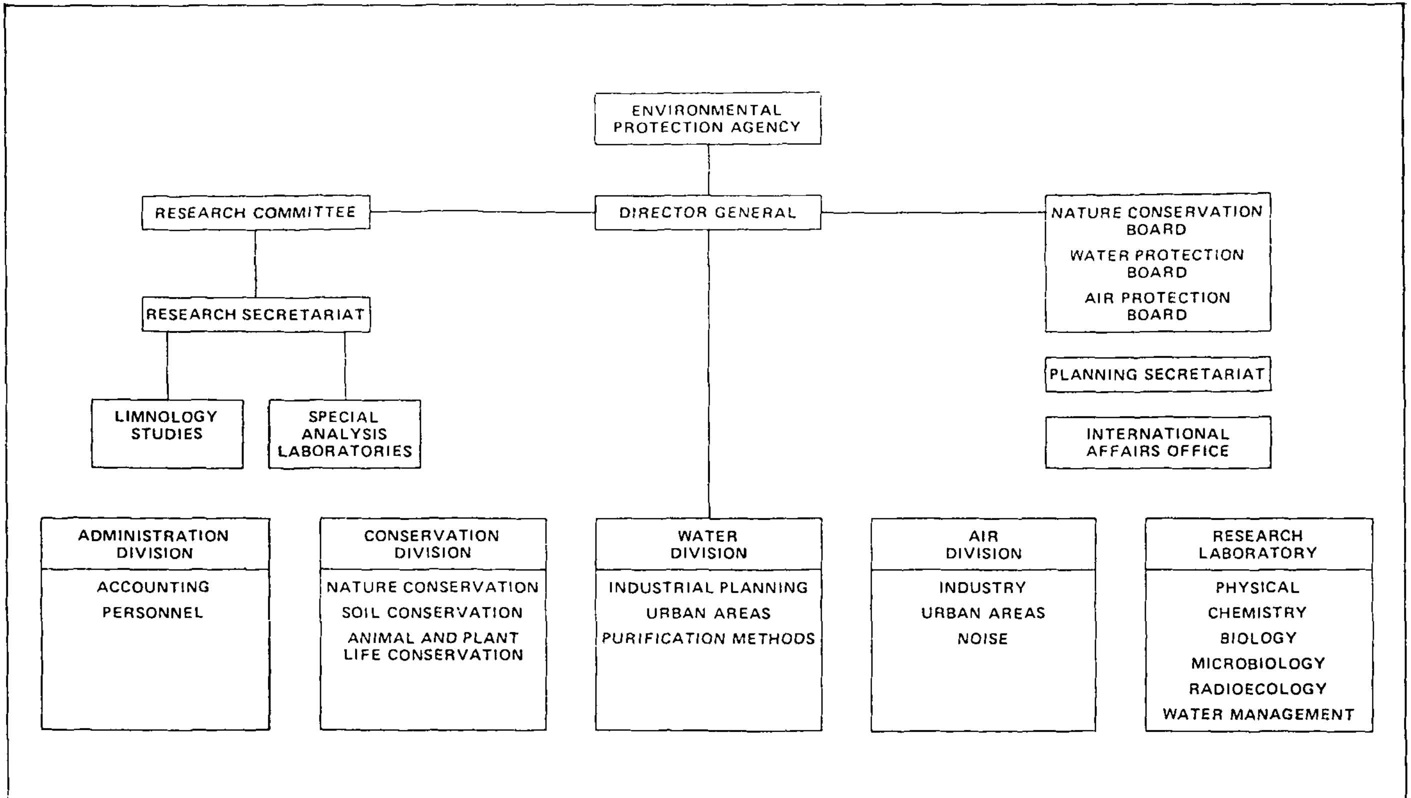

Figure 2. Organization chart for the Environmental Protection Agency, Sweden.

two meters with a special sampling tube. The 250 milliliter samples are frozen for chemical analysis in the laboratory of suspended solids, COD, total nitrogen, and total phosphorus. Biological tests (on algae) to determine the factor limiting primary production are also made with these samples. Water samples are preserved by iodine injection for analysis of plankton; these are kept in a samples bank for later reference [110].

Sanitary sewage is sampled daily and a fertility test [108] and chemical analyses are made. The samples are preserved in the manner mentioned above. Weekly samples are made up proportional to flow and analyzed for the following parameters: suspended solids, total nitrogen, total phosphorus, COD, and BOD; a fertility test is also made [108]. In addition, continuous measurements of phosphorus, COD, and suspended solids can be made from time to time using a mobile laboratory. Special surveys are also being done for lakes and effluents: for lakes, a detailed inventory of inputs and an analysis of seasonal changes in stratification, and for treatment plants, in most cases, detailed studies of the effectiveness of the various processes used.

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