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NATIONAL WATER QUALITY INDEX NETWORK OPTIONS TO CONSIDER

Roy E. Kwiatkowski
Water Quality Branch
Place Vincent Massey
Environment Canada
Ottawa, Ontario
K1A 0H3

ABSTRACT

Canada's federal water quality program is aimed at providing information for the management of Canada's water resources to maximize social and economic benefits of these resources for Canadians while ensuring an adequate level of water quality. Adequate being defined as non-impairment of the most sensitive use. The extent of pollution from anthropogenically developed chemicals has become readily apparent over the last decade. As a result in recent years public anxiety about the environment particularly about water quality has increased dramatically. Water pollution issues are no longer solely restricted to the local or regional level. Issues are now discussed at the national, international and global level. As a result, the Water Quality Branch (WQB), Inland Waters Directorate, Department of the Environment, is establishing a National Water Quality Index Network, to provide scientific information and advice to water managers on water quality issues on a national scale. This paper outlines WQB's present activities and the process used to develop the WQB's National Water Quality Index Network.

INTRODUCTION

> In the last two decades, Canadians have become aware, as never before, of the importance of the environment to their own well-being and economic health... If the environment is to be protected in the manner and the degree that Canadians have said - time and again - that they want it protected, then they must have an accurate picture of what has happened, is happening and is likely to happen to their air, soil and water.
>
> Honourable T.M. McMillan
> Minister, Environment Canada
> 1986

Despite the apparent abundance of water in Canada, several authors (Harvey, 1976; Johnson, 1980; Foster and Sewell, 1981) have repeatedly warned of the critical situation with respect to, not only the quantity, but also the quality of freshwater resources in Canada. The overall objective of the Canadian Federal Water Policy (Environment Canada 1987) is to encourage the use of freshwater in an efficient and equitable manner consistent with the social, economic and environmental needs of present and future generations.

Although the management responsibilities for water are shared by the provinces and the federal government, the federal government provides leadership, particularly when addressing water quality on the national level. Within the federal government, the Department of the Environment (DOE) plans and participates with the provinces in national and international water management programs in waters of federal interest.

The Water Quality Branch (WQB), Inland Waters Directorate, Department of the Environment, is the lead agency responsible for the development and operation of monitoring networks to assess the quality of the ambient aquatic environment. This includes the identification of problem areas, gathering of data, promoting research related to inland waters, and the planning, implementation and operation of water programs and policies.

The WQB consists of a headquarters, located in Ottawa, and five regional offices (Moncton - Atlantic Region, Longueuil - Quebec Region, Burlington - Ontario Region, Regina - Western and Northern Region, and Vancouver - Pacific and Yukon Region, Figure 1). Water quality monitoring programs carried out by the regional offices are in direct response to the needs of the region, as well as, providing information for national environmental assessments. The WQB is operational in nature, research and related support services are provided by the research institutes, National Water Research Institute (NWRI) located in Burlington, Ontario and National Hydrology Research Institute (NHRI) located in Saskatoon, Saskatchewan.

The WQB carries out various programs to supply the scientific and technical information and advice on the management of the quality of waters to government, private agencies and the public (WQB 1985). These include :

1) Federal-Provincial Agreements - These agreements will provide long term commitments, compatible data bases, accurate and comprehensive information and improved federal-provincial relations.

2) Development of Canadian Water Quality Guidelines - The guidelines contain recommendations for chemical, physical, radiological and biological parameters necessary to protect and enhance designated uses of water.

3) Monitoring - Monitoring involves the systematic collection of water samples, usually at fixed locations for a specified suite of variables and substrates over an extended period of time for the purpose of providing overviews of water quality and describing the general baseline characteristics at strategically located areas.

4) Surveys - Surveys are usually carried out to achieve a specific objective within a short time frame and are oriented toward either (1) reconnaissance, (2) short-term intensive assessments, or (3) comprehensive assessments (studies).

This special issue of the Water Pollution Research Journal of Canada is devoted to the activities carried out by the WQB. The activities (variables measured, frequency of sampling etc.) under each program and within each Region vary, simply because the informational requirements different between programs and between Regions. Although this approach works well in providing scientific information on a local or regional scale, it often fails to provide information on important issues on a national (coast to coast) basis. Historically, remedial action at the local or regional scale (phosphorus control on the Great Lakes, sulphur emission controls, etc.) has only occurred after the systematic, long term documentation of the resource(s) at risk. The pollution problems of the 80s (pesticides, toxic organics, acid rain, etc.) do not honour local or regional boundaries. As a result, pollution problems and solutions are now multi-regional, national or international in nature. Before any sound management decisions on where and when to implement remedial action can be made regarding Canada's water resources, scientific information gathered nationally in a pragmatic and consistent manner is needed.

> "The existence of a relatively small number of well-placed, representative monitoring stations, providing critical data for a long period of time, can considerably improve the degree of confidence and speed up the management process".
>
> Honourable John Roberts
> Minister, Environment Canada (1982)

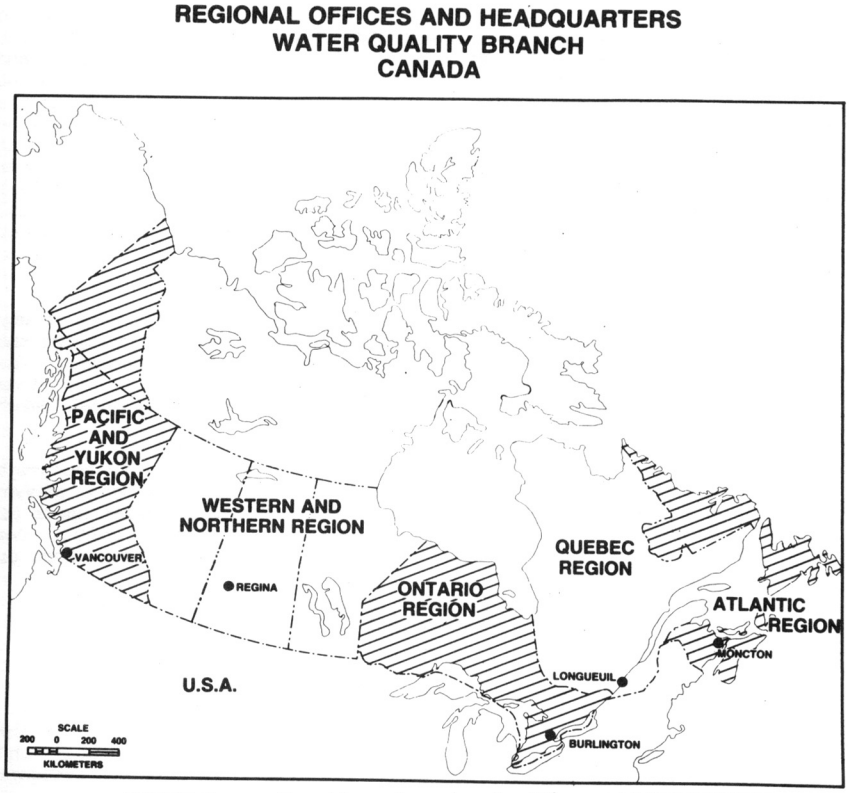


FIGURE 1: Location of regional offices and headquaters, Water Quality Branch, Inland Waters Directorate, Environment Canada.

THE NATIONAL WATER QUALITY INDEX NETWORK (NWQIN)

Presently the only agency capable of assembling environmental data on the aquatic resource on a national scale is the WQB. A national (coast to coast) surface water quality monitoring program is a massive undertaking. Before any efforts to design a national network are made an administrative mechanism must be in place to provide coordination and overall direction of the multi-disciplinary and multi-jurisdictional activities. Terms of reference, targets, goals and accountability are all required to ensure that activities are carried out in a coordinated timely fashion. This paper will describe the decisions (options) which must be made to develop a consistent national strategy. The options flow chart proposed in Figure 2 provides the insight into how the network is to be designed. However, to truly assess the success of the network, to adjust to future priority concerns, or to make use of the latest technological "state-of-the-art" advancements in data aquisition, a clear understanding of all the network components (objectives, design, data acquisition, interpretation,QA/QC, etc.) is required. The first important concept to accept is that in any plan there is a practical level of measurement and a conceptual level of direction which operate together to form the network. Steps 1-4 require a committee capable of developing the conceptual framework needed to resolve the objectives of the plan, to delegate responsibilities and to identify how the information

gathered by the network is to be utilized to meet present and future management needs. Steps 5-8 require a highly technical group familar with field and laboratory procedures, as well as data interpretation, and responsible for implementation of the network. In addition, management requires a vertical structure to respond to both senior management's information needs and to scientific (network) recommendations, whereas, the scientific component requires lateral thinking and operation. The vertical structure, typical of government programs, requires a meshing of these conceptual and practical components of the network to ensure that all components of the environment (water, land, air and biota) and all activities (field, laboratory, research, monitoring) are coordinated to meet the objectives of the network.

Step 1 The Objectives - A clear definition of the objectives of any sampling program is an essential prerequisite to identifying the principles to be applied to a particular sampling problem. The Federal Policy Statement on Inland Waters (1978) provides guidance on the development of objectives of a National Water Quality Index Network.

The overall objective of the Federal Water Policy is to encourage the use of freshwater in an efficient and equitable manner consistent with the social, economic and environmental needs of present and future generations (Environment Canada 1987). Two main goals identified by the federal government, with respect to water are:

- to protect and enhance the quality of the water resource;
- to promote the wise and efficient management and use of water.

More specifically: -

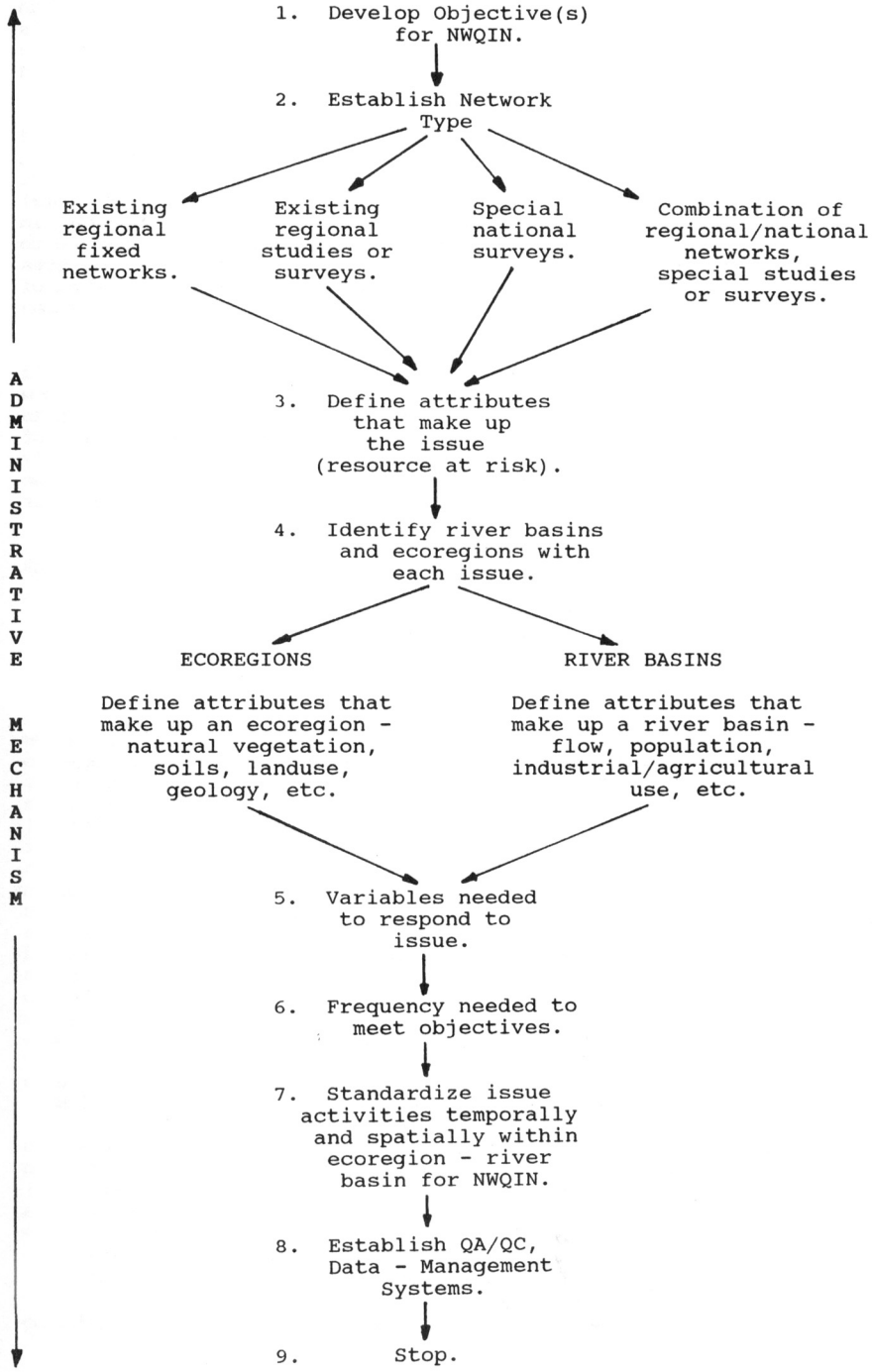
> "Federal monitoring activities are designed to identify pollution problems, establish baseline information and identify water quality trends on a national and regional scale,..."
>
> Federal Policy Statement No. 9
> 1978

Information on a national scale is required by various data users, including:

- The Canadian Environmental Protection Act (CEPA) has become law. Two requirements identified under the Act are: that the Government of Canada will provide information to the people of Canada on the state of the Canadian environment (air, land and water) and that the Government of Canada will endeavour to establish nationallly consistent levels of environmental quality. Integration of water quantity and water quality information in order to carry out appropriate "assessments" related to environmnental protection, water supply and water demands on a national scale is the way of the future.

- As part of Agriculture Canada's re-evaluation of active ingredients registered under the Pest Control Products Act, information on the benefits and risks to the environment, as well as, to human health on a local, regional and national basis is needed. Information provided by Environment Canada will assist Agriculture Canada in determining optimum conditions for safe and effective use of pesticides, and when warranted, result in suspension or cancellation of registered products because of environmental concerns.

FIGURE 2
NATIONAL WATER QUALITY INDEX NETWORK
(NWQIN) OPTIONS TO CONSIDER



- The Canadian Council of Resource and Environment Ministers requires information on concentrations of various chemicals in the aquatic environment, in all areas of Canada, to assist in the establishment of Canadian Water Quality Guidelines. Water quality guidelines and objectives are used by Canadian provincial, territorial and federal agencies in their efforts to assess water quality problems and to manage competing uses of water resources (CCREM 1987). Guidelines will be updated as new information becomes available.

- Many countries, including Canada, are becoming more concerned with the overall assessment of environmental quality. In several countries, data collection is carried out specifically to provide a national picture of environmental quality. The Stakeholder Group on Environmental Reporting in Canada identified the need for comprehensive information to facilitate the assessment of environmental and resources management policies and to provide a better understanding of environmental problems and their linkages with human activities.

- The Long Range Transport of Airborne Pollutants (LRTAP) is now recognized as a global problem. Water managers must now be concerned with atmospheric loadings to the river basin as well as, direct (effluent) loadings. The concept of "pristine" may well be outdated. Information on historically perceived non-impacted areas, as well as, traditionally known impacted areas, is needed to assist regulators, if our water heritage is to be protected.

To meet these needs the National Quality Index Network will focus on:
- characterization/status of variables of national interest;
- long-term trends for variables of national interest;
- early warning/problem indentification;
- state of the environment reporting.

Step 2 Network Type - The WQB carries out various activities (monitoring, surveys, special studies) under its mandate to supply scientific information and advice to water managers. These activities presently being carried out by WQB regions are a useful approach in that they measure those chemicals and physical properties deemed to be important for regional or local conditions. Study objectives are often issue/variable/location specific. As a result resources at the regional level are often available to do extensive sampling to define minute differences in temporal or spatial scale. Due to financial constraints a national index network must compromise somewhat on temporal and spatial coverage. The difference between the two approaches is in emphasis and scale, not in issues being addressed. The two approaches complement each other. Surveys (variable or issue specific) can be regional or national in scale. A national index network could accommodate regional or national surveys by providing a convenient (already established) network with existing background information on other parameters of interest.

Step 2 is a major turning point in the Decision Tree. Decisions now go from the objective/policy setting stage to implementation (resource commitment) stage. Within all WQB regions (Figure 1) fixed networks, special studies and surveys exist. Therefore a number of options are open to the NWQIN including: 1) the amalgamation of existing regional fixed networks; 2) amalgamation of regional surveys or studies; 3) carrying out special national surveys, or 4) some combination of regional/national fixed networks, special studies or surveys. Options 1 and 2 require no

future resource commitment, however, due to the fact that each network/survey/study is designed (station location, variables measured, frequency of sampling, etc.) to meet their own objectives, development of a consistant approach to a national program would be difficult. Options 3 and 4 would allow for the development of a network specially to meet national needs, however, new resources or re-alinement of present resources (at the expense of other valuable programs) are required.

Step 3 Issues - The development of any network needs a unifying approach to provide a purpose to station location, variable selection and sample frequency. Historically it is research/monitoring activities which identify issues. Management must assess the magnitude of the issue (eg. is it a national issue?) and clearly identify the need for long term monitoring. With most water quality issues (eutrophication, metals, toxic organics, pesticides) loadings to the environment are direct (end-of-pipe) or diffuse (atmospheric, runoff). Establishment of stations within various ecoregions provides information on baseline conditions (reference sites), atmospheric loadings, as well as response to diffuse loadings by the various ecoregions within Canada. River Basin monitoring provides information on point source(s), impacts and the response of the river basin as it flows between various ecoregions.

Identification of water quality issues is a major component to step 3. In this document, an issue is defined as an environmental problem created by the impairment of a given water use. The nine major water quality issues identified by the Canadian Council of Resource and Environment Ministers (1985) are given in Table 1. Of course a complete assessment of the aquatic environment for all issues is a very complex and expensive task. Decisions must be made on the type of information needed to meet the objective(s) established in Step 1 for each issue. No one network can be designed to respond to all questions or supply the same quality of information on all issues. The advantage of establishing a well defined focus to the National Water Quality Index Network is to simplify network design and implementation and augment the chances of meeting the Network objectives scientifically.

Step 4 Approaches - Two approaches are possible under step 4. Each has positive and negative components.

i) Ecoregion Approach - Division of Canada into naturally occurring ecoregions based on soil type, geology, natural vegetation, etc. is possible. Canada is presently divided into 6,000 ecodistricts; combination of ecodistrict attributes to form a specified number of ecoregions is possible.
Advantages - Development of large ecoregions (say 10-20) would cross administrative regional boundaries. Comparisons (with proper planning) of stations (trends) within ecoregions would be possible.
Disadvantages - Difficult to develop a workable number of ecoregions. An excessive number would add complexity - too few reduces scientific credibility. Unless only headwater stations are selected under the ecoregion approach (an undersireable design), the effects of upstream activities on the monitored variables would be impossible to assess.

ii) River Basin Approach - River basins are considered as unique management units. Sampling is done at headwaters and mouth stations, as well as at key locations (major inputs) along the river.

Advantages - Issue(s) are identified for each basin and station location(s) within the basin are established to provide information on the issue(s) identified. Comparisons (with proper planning) between stations (trends) within a basin are possible.

Disadvantages - Issues become river basin or regional specific (too narrowly focused for national reporting). This is a result of the fact that within Canada most river basins are within the political regions described in Figure 1 (there are some exceptions - i.e. - St. Lawrence, MacKenzie, etc.). Comparison of results with other river basin(s) within the same ecoregion or in other ecoregions is rarely done.

A combination of the two approaches would require greater pre-planning and coordination, but not necessarily greater resources. For example, a headwater station within the river basin approach can also be a baseline reference site for a given ecoregion. Similarly a station located within an ecoregion to assess the effects of a given issue within the ecoregion can be used to provide information at a key location within a river basin.

TABLE 1

Canadian Water Quality Issues*
as identified by the Task Force of the
Canadian Council of Resource and Environment Ministers
(1985)

1. Pollution of waters used for recreational purposes.
2. Contamination of water supplies for drinking purposes.
3. Impact of land use practices on water quality.
4. Impact of toxic and other contaminants on the aquatic environment.
5. Impact of water-related development projects on the aquatic system.
6. Impact of LRTAP (Long Range Transport of Airborne Pollutants) on water quality.
7. Chemical contamination of fish.
8. Public perceptions of water quality.
9. Conflicts over water quality uses.

* This list does not indicate any order or priority.

Steps 5-8 Network Activities - Details on which variables to measure, where and at what frequency have been addressed by numerous authors on sampling and measurement techniques (Hellawell, 1978; Lind, 1979; Dodge et al., 1981; Sanders et al., 1983 and APHA et al., 1985. The question of the most appropriate media to sample (water vs sediment vs biota) within the aquatic environment is discussed by Chapman et al. (1982). For the 126 United States - Environmental Protection Agency's priority pollutants, water was suggested as a suitable medium to measure for 44 priority pollutants; however, the preferred media for measurement were identified as biota (64 priority pollutants) and/or sediment (86 priority pollutants).

Two valued components to any large scale monitoring network often under estimated in the planning stages are Quality Assurance/Quality Control and Data Management. Even when environmental data displays a large annual variation; if the data has been gathered under a well documented procedure containing the proper QA/QC protocols, the data can be accepted as baseline information from which management decisions can be made. However, without QA/QC; without an estimate of the realiability of the data gathered, the use to which the data set can be put is severly restricted. QA/QC procedures to measure the accuracy, precision and compatability of the data generated under the NWQIN will be documented prior to any data collection. Procedural documents on field measurement methodologies, sample preservation protocols and inter- and intra-lab QA/QC procedures are presently being prepared.

The handling of thousands of data points annually by laboratories and data users requires an integrated computer network. All data collected under the NWQIN will be stored in a central data bank, NAQUADAT, to ensure that all agencies interested in obtaining information from the program will have quick and easy access to the data (Whitlow and Lamb 1983).

CONCLUSIONS

If Canadians, industry, consumers and governments alike, are to begin thinking environmentally, they will need a better understanding of the environmental consequences of their decisions. The quality of water affects its suitability for a variety of uses (e.g. drinking water supplies, recreation, aquatic life, agricultural and industrial water supplies). When uses are impaired, conflicts/issues arise. Water quality monitoring data supplies the water managers with the fundamental information needed to resolve the conflicts and to make knowledgeable decisions with respect to the issues. A national water quality index network like, the local and regional fixed networks, must have clearly defined objectives, a stated strategy and a well developed plan for implementation. As a result, coordination and cooperation are the cornerstones on which a successful national network is built. Not only must approved protocols be developed for field and laboratory procedures (QA/QC), an effective, user friendly data storage and retrieval system must be in place. As well, lines of communication and decision making must be clearly established. All participants actively involved in the process must not only know what their responsibilities are, but must also be in full agreement with the overall goals and objectives of the national network.

A major difficulty associated with any undertaking as massive as a national network, is response time. Changes cannot be instanteously put into place, as they often can in local or regional networks. The requested change must be transmitted nationally, and often requires approval by all participants prior to implementation. As a result, national networks are appropriate vehicles for long term trend assessments. Crises-of-the-day

issues cannot, and should not, be addressed by national networks. Similarly, national networks cannot provide information on all aspects of the environment (e.g. short term (daily, weekly) cycling, short term temporal variability, microlocation variability, definitive cause-effect modelling efforts, etc), nor is it necessary for all stations to monitor all the same parameters. If evidence exists that a parameter of national interest is non detectable in any given ecoregion/river basin, then only one or two reference sites within the ecoregion/river basin are needed to ensure the non detectable status. This prevents the filling of data files with expensive non-detectable measurements. It must be recognized that the national network is not the only source of information available to the water manager. Regional networks, surveys and special studies are all tools available to augment the water managers information needs or fill knowledge gaps. Water managers must not only accept the ecosystem approach (water, sediment and biota) to monitoring but they must also accept the integrated management approach. No network (like no single medium) can supply all the informational requirements. Integration is needed. However, a national network will give the regional manager a national scope to their regional activities, thus allowing the regional manager to assess priorities, develop and exchange information on integrated (with other regions) approaches to remedial action and an opportunity to request from headquarters more resources (to respond to national concerns).

With the ever expanding list of chemicals being introduced into the environment annually, a manditory, future need for water quality assessment in Canada is the close cooperation among the various agencies responsible for water. Whether operational or research, federal or provincial, fisheries, health or environment, all agencies must recognize that although each has its own mandate, resulting in a patchwork (prochial) approach, we all share the same environment and we all must respond to common environmental issues. The Water Quality Branch's National Water Quality Index Network will offer environmental information to all agencies. How the information will be translated into a "better" environment will depend on the creative managerial capabilities of federal and provincial water managers.

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