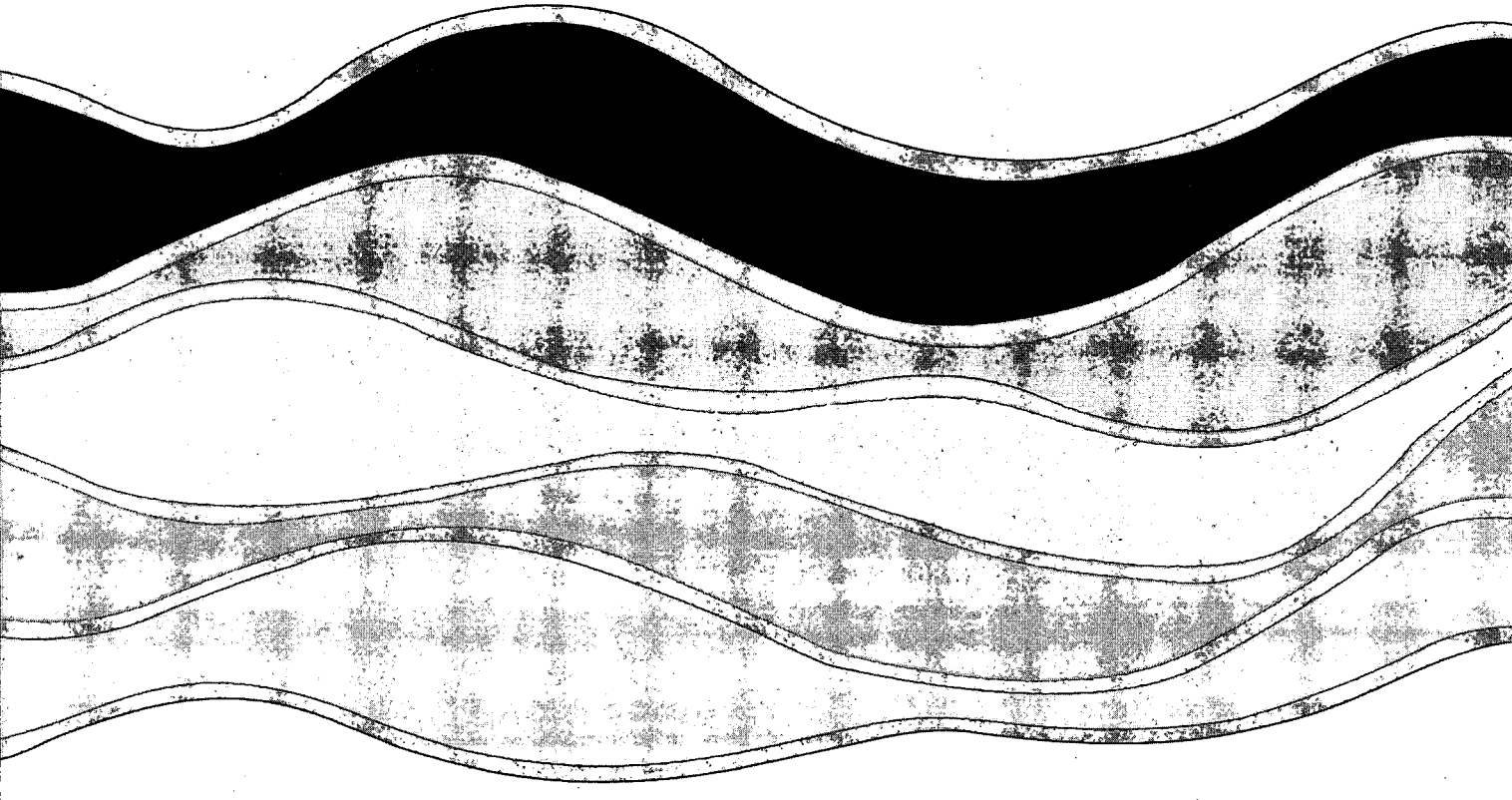
NATIONAL WATER RESEARCH INSTITUTE

INSTITUT NATIONAL de RECHERCHE sur les EAUX



TOWARD AN ECOSYSTEM APPROACH TO RESEARCH ON THE HUDSON BAY BIOREGION

by

R.J. Allan, M. Clamen, R.J. Daley, J. Moenig and B. Sadler

NWRI Contribution No. 92-77

TOWARD AN ECOSYSTEM APPROACH TO RESEARCH ON THE HUDSON BAY BIOREGION

by

R.J. Allan, M. Clamen, R.J. Daley, J. Moenig and B. Sadler

A Report from the DOE Science Scoping Workshop
Held at the Canada Centre for Inland Waters
Burlington, Ontario
July 16 and 17, 1992

National Water Research Institute Contribution No. 92-77

MANAGEMENT PERSPECTIVE

A 1 1/2 day scoping workshop on the status of environmental knowledge of the Hudson Bay Bioregion was attended by approximately 30 participants from several federal agencies. The Bioregion is spatially that area bounded by the height of land to the east and south, by Hudson Strait to the North and to the West by the exposed Canadian Shield.

The Workshop provided an opportunity for scientists and science managers to present and review current knowledge and future directions for research.

Following presentations on current research activities, participants broke into small groups to concentrate on three major issues:

- key environmental issues arising from development activities and proposals;
- knowledge gaps and priorities for further research; and
- approaches for addressing priority needs.

The results of the workshop include:

- preliminary checklists and a matrix for identifying issues and correlating them with development activities and research requirements; and
- a consensus on the need for, and the initial elements of, a strategic research and management framework for the Hudson Bay Bioregion that coordinates activities and responsibilities of federal agencies with each other and those of other stakeholders.

It was agreed that time is of the essence in moving ahead with the process of interdepartmental coordination and consultation on research and information gathering for the Hudson Bay Bioregion. Developments and proposals, such as those for hydropower, are currently undergoing separate environmental reviews and need to be placed in a broader, sustainability context.

SOMMAIRE À L'INTENTION DE LA DIRECTION

Une trentaine de participants provenant de plusieurs organismes fédéraux ont suivi l'atelier d'une journée et demie sur l'état des connaissances environnementales relatives à la biorégion de la baie d'Hudson. Cette région est délimitée par des hautes-terres à l'est et au sud, par le détroit d'Hudson au nord et par la partie dénudée du Bouclier canadien à l'ouest. L'atelier a permis aux scientifiques et aux gestionnaires dans le domaine scientifique de faire le point sur les connaissances actuelles et les orientations à prendre en matiére de recherche.

Aprés les exposés sur les activités de recherche en cours, les participants se sont divisés en petits groupes pour discuter de trois sujets clés:

- les principales questions environnementales soulevées par les activités et les projets de développement;
- les lacunes du point de vue des connaissances et les priorités quand il s'agit d'effectuer d'autres recherches;
- les méthodes visant à répondre aux besoins prioritaires.

Voici certains résultats de l'atelier:

- des listes préliminaires et un tableau des questions environnementales qui serviront à faire un rapprochement avec les activités de développement et les besoins en recherche;
- un consensus sur le besoin d'un cadre de gestion et de recherche stratégique, ainsi que sur les premiers éléments de ce cadre, pour la biorégion de la baie d'Hudson. Le cadre permettrait de coordonner les activités et les responsabilités des organismes fédéraux et des autres intervenants.

Selon les participants, il est temps d'entreprendre la coordination et la consultation entre ministères en ce qui concerne la recherche et la collecte de reseignements se rapportant à la biorégion de la baie d'Hudson. Les activités et les projets de développement, notamment les aménagements hydro-électriques, sont soumis actuellement à des évaluations environnementales et doivent être analysés dans un contexte plus large de viabilité.

1.0 INTRODUCTION

The Hudson Bay Bioregion is currently an important focus for environmental policy and research. A number of development activities are proposed to exploit the resource potentials of this still largely undisturbed area of Canada. Notably, major hydroelectric projects are undergoing environmental review. It is important to place these initiatives and other economic activities in a broader, proactive, federal context of sustainable development of the Hudson Bay Bioregion.

The purpose of the DOE Science Scoping Workshop was to undertake an initial, preliminary examination of the status of scientific knowledge in support of this approach (see Box 1). More than 30 scientists and science managers from six federal agencies (Box 2) came together on July 16 and 17, 1992 to review research needs and data requirements for ecosystem and resource management in the Hudson Bay Bioregion (Box 3). The goal was to identify and coordinate federal activities in this area. A list of participants can be found at the end of this report.

This report from the workshop is organized into four parts:

- a brief profile of the Hudson Bay Bioregion; (2.0)
- an annotation of background information; (3.0)
- an overview of the main results; (4.0) and
- observations and recommendations on future steps. (5.0)

Box 1

Workshop Objectives:

- to identify key environmental issues and their relationship to development activities and proposals;
- to identify major knowledge gaps and research priorities;
- to identify an integrated approach to address these priorities.

Box2

Workshop Participants from Six Federal Agencies:

- Energy, Mines and Resources Canada (EMR)
- Environment Canada (DOE)
- Fisheries and Oceans Canada (DFO)
- Health and Welfare Canada (NHW)
- Indian Affairs and Northern Development Canada (DIAND)
- Transport Canada (DOT)

Box 3

Three Stage Workshop Process:

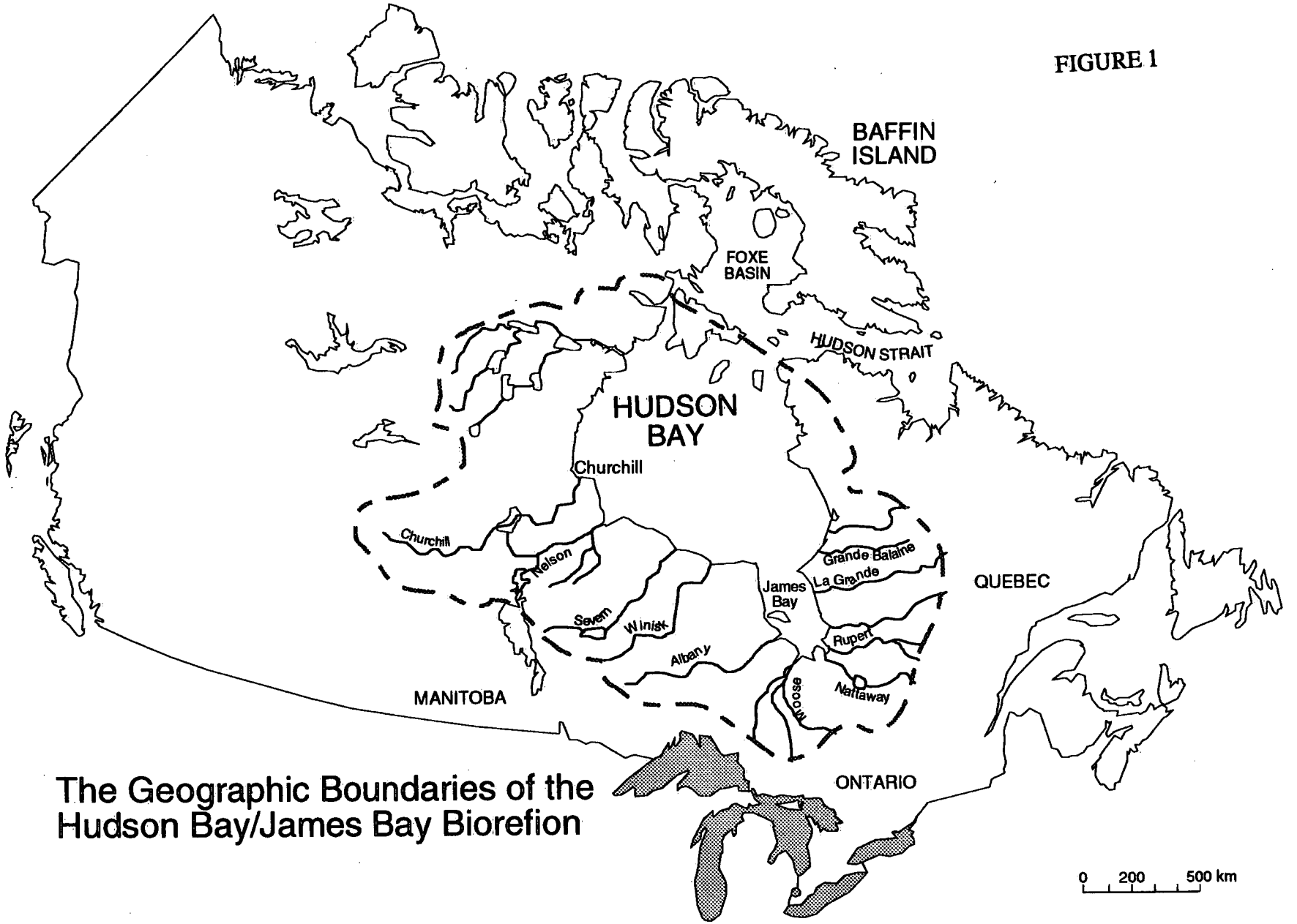
- background perspectives and information exchange on research initiatives currently underway by federal agencies and others;
- group discussion to identify key issues and knowledge gaps;
- plenary review of results and recommendations on an approach.

2.0 THE HUDSON BAY/JAMES BAY BIOREGION

The Hudson Bay Bioregion is a large sub-Arctic to Arctic basin. It encompasses an area approximately the size of France, surrounding the 'inland seas' of Hudson and James Bays (760,000 km^2). Spatial boundaries are demarcated by the height of the land in the east and south, by Hudson Strait in the north and by the western edge of the exposed Canadian Shield in the west (Figure 1). Jurisdictional responsibility for the area is shared among the federal government, the provincial governments of Manitoba, Ontario and Quebec, and by the government of the North West Territories.

Hudson Bay forms the core of the Bioregion. It is an almost completely enclosed, and for a marine environment a relatively shallow body of water with a depth of 125m. It is completely frozen in winter except for a pronounced shorelead. Due to the shallowness the marine system is strongly influenced by freshwater run-off, windstress, radiation heat-flux, and annual ice cover, and displays a

FIGURE 1



The Geographic Boundaries of the Hudson Bay/James Bay Biorefion

strong inshore-offshore biological gradient. Offshore waters support a relatively low biomass; nearshore zones and estuaries provide habitat for Arctic fish species. The coastal environment encompasses marine and terrestrial mammals and range for important staging and nesting grounds for Arctic and sub-Arctic birds.

Resource harvesting is primarily for subsistence of native peoples. The Hudson Bay/James Bay Bioregion is a homeland for Cree and Inuit. Much of it remains relatively undisturbed. In several areas, however, major hydroelectric developments have significantly altered the natural systems upon which native subsistence economies depend. Examples are the Churchill-Nelson, La Grande (James Bay Phase I) and Mattagami River complexes. Further developments are proposed for all three basins (see below) and may lead to a wider range of economic activities and options.

The dynamics and interrelationships of the marine, freshwater and terrestrial ecosystems of the Hudson Bay Bioregion are not well understood. Scientific surveys have been infrequent and have focused on particular biophysical and resource components (e.g., water quality, ice conditions). To date, little attempt has been made to apply an ecosystem approach. Other data and information holdings have resulted from environmental assessment and monitoring of development projects (e.g., DOE/DFO Federal Environmental Monitoring Programme in Northern Manitoba; and the Ecological Studies undertaken by Societe d'Energie de Baie James). These data holdings and others are scattered and in some cases are difficult to access. Currently, the Grande Belaine (James Bay II) and Conawapa projects are subject to Environmental Assessment Panel review under a combined federal/provincial process and the Moose River proposal (currently on hold) is undergoing preliminary environmental and socio-economic review by DFO and the Province of Ontario.

3.0 INTRODUCTORY PERSPECTIVES

Opening remarks by Dr. Ralph Daley (NWRI/EC), the workshop Chairman, emphasized that the Hudson Bay Bioregion is of Canadian and international importance. EARP panels are catalysts for a systematic, long term, science-based approach to sustainable resource management and federal agencies must coordinate their activities to common purpose in embarking on an expanded research programme.

This theme was expanded by Dr. Murray Clamen (EHB/EC) in outlining The Hudson Bay/James Bay Information Project. He focused on the challenge of building an information network

to facilitate sound decision-making, and the importance of partnership building -- first putting "the federal house in order, and then linking with other stakeholders" (provincial and territorial governments, native peoples, industry and ENGO's).

Much can be learned, in this regard, from previous experience. Fred McFarland (DIAND) described the adaptive approach taken in the Beaufort Sea/MacKenzie Delta region to assess and monitor the potential impacts of existing and proposed hydrocarbon development during the 1970's and 1980's. In this process, research and management priorities were identified using impact hypotheses -- i.e. predicted changes in "valued ecosystem components" (VEC's) associated with development activities and scenarios. While our reach often exceeds our grasp of the processes involved, the effort at understanding creates the basis for improved knowledge.

A similar approach was also utilized for a 1992 DFO workshop on the potential effects of hydroelectric development on the hydrology and ecology of the Moose River Basin. Sandra George (GLLFAS/DFO) reviewed the "Adaptive Environmental Assessment and Management" (AEAM) methodology used for the workshop, its application on estimating cumulative effects, and the research and information needs that were identified. DFO participants at the workshop underlined the value of AEAM for clarifying what is known about aquatic and riparian ecology and, more importantly, focusing what we need to know in the future. AEAM, however, is only one of a number of methods for conducting an ecosystem approach and environmental assessment.

An area-wide, community-oriented perspective on sustainable development of the Hudson Bay Bioregion is being undertaken by the Canadian Arctic Resources Committee, the Environmental Committee of Sanikiluaq, and the Rawson Academy of Aquatic Science. The orientation, described by Dr. Peter Sly (Rawson), is toward a human ecology framework that relates the potential cumulative effects of development to resource values, use and opportunities for indigenous peoples to maintain a subsistence economy and traditional life-style. Key concerns include "the controlling" processes of ecosystems change, their sensitivity to pertubation and the relationship to circumpolar and global changes.

It appears that polar bears can be used as a significant indicator species of ecosystem health in the Hudson Bay Bioregion, by reason of their location at the top of the food chain. Dr. Ian Stirling (DOE/CWS) summarized the results of recent field research on Polar Bear numbers, range and condition. He noted significant decreases in average weight,

affecting natality and eventually pointing toward a decline in population size. Not enough is known to establish cause and effect relationships, but reasons for these changes may involve a combination of natural fluctuation (e.g.,50 year cycles); fluctuations in food supply (e.g. seal distribution); and increased levels of pollutants (e.g. PCB levels) in Hudson Bay.

A concise summary of the key bio-physical components of Hudson Bay was given by Harold Welch (FWI/DFO). He focused on the relationship of ocean dynamics (the circulation gyre), patterns of stratification, and primary production. Marine food chains are characterised by increasing concentration of organochlorines at higher levels. Long range transport of contaminants are of increasing concern, together with potential effects of climate change on ice conditions, etc.

Dr. Carl Amos (GSC/EMR) reported on an oceanographic survey of Hudson Bay, to be undertaken during the 1992 open water season. Other federal agencies were invited to indicate potential links between their research interests and the EMR survey and invited to participate.

4.0 ISSUE IDENTIFICATION, STATUS OF KNOWLEDGE AND RESEARCH PRIORITIES

The results reported in this section represent a consolidation of the discussions of four working groups. What follows is a first-cut assessment of environmental issues for the Hudson Bay Bioregion and the implications for research. It reflects what could be achieved in a limited period of time with the range of expertise in attendance.

4.1 Issues

- The working groups suggested a number of alternative ways of framing issues. All agreed, however, that hydroelectric development is currently the driving force of ecological and social change in the Hudson Bay Bioregion.

- The hydroelectric complexes located (and proposed) for the area are of direct concern because they alter hydrological regimes and aquatic/terrestrial ecosystems and open the region to other forms of development via supporting infrastructure (roads, settlement, etc.).

- The potential scope of future activities encompass (in no particular order): forestry (harvesting and pulp and paper production), mining, hydrocarbon exploration,

water diversion and transfer, tourism and recreation, and parks and reserves (with the primary objective of heritage protection and conservation of biodiversity)

- Regional population growth is also a concern. Projected rates on increase for the Northern Quebec Cree, for example, point toward possible stresses on the carrying capacity of the local resource base for subsistence activities -- especially when industrial developments are factored into the equation.

4.2 A Focus on Hydroelectric Development

- A second level of issue analysis focused on the potential effects of hydroelectric development. The approaches taken varied, but all groups, explicitly or implicitly, highlighted "Valued Ecosystem Components"(VECs) and incorporated these into a matrix or checklist format (Tables 1-3).

- Table 1 is a preliminary "impact matrix" based on workshop results/discussions that ranks the scope and magnitude of potential effects of hydroelectric development on six (generalised) VECs. In terms of ecosystem components, estuarine, coastal, and river environments are of particular significance. Marine and terrestrial mammals are key ecological indicators.

- A spatial overlay and further exemplification could be added to this matrix. For marine systems, key components and VECs could be organized into i) nearshore (anadromous fish,waterfowl), and ii) offshore marine mammals. Spatially, the geochemical interactions between Hudson Bay and Hudson Strait were also thought to be important (specifically understanding "what is going in and out of the Bay"). For terrestrial systems, important ecological units could be broken out as the Hudson Bay lowlands, Canadian Shield and James Bay basin (as a critical development impact zone).

- Workshop participants repeatedly underlined the difficulties associated with assessing the cumulative effects of hydro projects.

TABLE 1. IMPACT MATRIX FOR HYDROELECTRIC DEVELOPMENTS[1]

RESOURCE/ ECOSYSTEM COMPONENT	VALUED ECOSYSTEM COMPONENTS (VECs)					
	BENTHOS	FISH	WATERFOWL	AQUATIC MARINE MAMMALS	TERRESTRIAL MAMMALS	HUMANS
FORESTS	N/A	N/A	N/A	N/A	L2	L2
UPLANDS	L1	L1	L1	L1	L1	L1
LAKES	L3	L3	L1	L1	L1	R3*
RIVERS	L3	R3	L1	L1	L1*	R3*
ESTUARIES	L3	R3	C3*	C3*	L1	C3*
COASTAL	R2	C2	R2	R3*	L2	R3*
OFFSHORE	?	?	N/A	?	N/A	N/A

1 N/A = Not Available; L = Local; R = Regional; C = Cummulative. Impacts: 1 = High; 2 = Medium; 3 = Low; magnitude of the impacts; ? = unknown/doubt; * = high political visability.

These include:

- Selecting scenarios of development and identifying realistic linkages and chains of consequence for proposed activities (e.g., how many secondary projects, when, where, etc.);

- Identifying appropriate time boundaries for projects, e.g., that reflect decommissioning (80-100 years in the case of dams) and climate change;

- Identifying spatial boundaries for tracking downstream effects (e.g., contaminants); and

- Relating environmental changes with socio-economic cultural issues through indicators and the implications of hydroelectric development on indigenous population growth, immigration and the resulting effects on resource harvesting and traditional cultures.

4.3 On Knowledge Gaps and Research Priorities

Table 2 gives an alternative and more detailed breakdown of potential environmental effects of hydroelectric developments, the current status of scientific knowledge and a ranking of research (knowledge gap) needs. Specific concerns listed here that were also identified by other groups are:

- health effects of mercury release in reservoirs;

- alterations in hydrological regime, ice conditions, nutrient flows and stratification; and

- their consequences for fish and wildlife populations.

Other important areas noted were:

- economics of sustainable development, including the full state of benefits and costs of alternative means of energy production;

- establishing a resource management regime for the Bioregion and for impact development zones that reflect the "no net loss" principle for sustainable development; and

- detailed and systematic monitoring so as to adapt quickly to new developments and to learn from this process.

TABLE 2. ESTIMATES OF POTENTIAL EFFECTS OF HYDROELECTRIC DEVELOPMENTS AND PRESENT KNOWLEDGE BASE LEVEL

EFFECTS ON:	STATUS[1] OF KNOWLEDGE LOCAL	STATUS[1] OF KNOWLEDGE REGIONAL	INFORMATION PRIORITIES NO	MID	HIGH
ICE FORMATION AND BREAKUP IN BAYS HYDROLOGICAL RIVER EFFECTS	P-M	P			*
TIMING OF FRESHWATER HYDROLOGIC REGIME, NUTRIENT LOADING, STRATIFICATION	P	N-P		*	
TRANSPORT, FLOOD CONTROL, BRIDGES	M	--		*	
OUTSIDE HUDSON BAY/LAB. SEA	--	N-P		*	
BIO COMPONENTS OF CHANGED ENERGY FLOW SEDIMENT EROSION	M-G	N-P		*	
GROUNDWATER	P	--			*
PERMAFROST	M	--		*	
GREENHOUSE GASES FROM ORGANIC CARBON DEGRADATION=CO2 AND METHANE	--	M		under current study	
WATER QUALITY AND CHEMISTRY (SELENIUM IN MARINE SYSTEM)	M-G	P			*
MERCURY LEVELS	M-G FRESH P MARINE	P FRESH P MARINE			*
ENDANGERED SPECIES AND STOCKS OF FISH	M	P			*
LIVING MARINE FRESHWATER AND TERRESTRIAL RESOURCES	M-H FRESH M MARINE	M FRESH P MARINE			* *
MORPHOMETRY	M-H	--		*	
ESTUARIES	P	--			*
CLIMATE	G	P			*

1 N = None; P = Poor; M = Medium; G = Good.

Generally, local scale, immediate effects, for example in river plumes are much better understood than regional ones, for example the whole of Hudson Bay. Tables 2 and 3 show these differences for both a checklist of issues and problem clusters. Research priorities follow from these classifications. In addition to the research needs noted above, studies of groundwater, the climatic effects of reservoirs, and long range transport of contaminants are considered important.

Table 3 correlates data types and knowledge gaps with information holdings and the responsibilities of federal agencies and other key interests. While incomplete, this table underlines the importance of establishing what information is available, and current research priorities. Further critical issues raised by workshop participants were: how to collaboratively focus research efforts, set coordinated priorities, undertake interdisciplinary research and integrate results into policy making and management.

5.0 FUTURE DIRECTIONS: TOWARD AN INTEGRATED ECOSYSTEM APPROACH

Workshop participants identified the following principles for an integrated ecosystem approach toward research for sustainable development in the Hudson Bay Bioregion.

- involve stakeholders and build consensus among them;
- focus on what is important to people in the Bioregion;
- establish a system of analysis for addressing and linking issues;
- reconcile science-based and management-oriented research; and
- deliver information that is relevant to decision making.

These principles, in effect, point to the importance of drafting a "strategic framework" for the Hudson Bay Bioregion, in which a policy vision for sustainable development gives direction to management and research programmes. With this context, federal agencies can coordinate their efforts consistent with existing mandates. A model or template that schematically expresses this type of approach is already under development for the Great Lakes basin. However, workshop participants stressed the much

TABLE 3. DATA TYPES, KNOWLEDGE GAPS AND POTENTIAL SOURCES OF KNOWLEDGE

DATA TYPES	KNOWLEDGE GAPS	DATA/KNOWLEDGE SOURCES
-LAND USE -LOCAL ECOLOGICAL/ ENVIRONMENT -HARVEST -SOCIO-ECONOMIC	-OFFSHORE -FRESHWATER BENTHOS	ABORIGINAL
-HYDROGRAPHIC -OCEANOGRAPHIC -MARINE MAMMALS -MARINE/FRESHWATER FISH	-HARVEST DATA -OFFSHORE FISHERY -OCEANOGRAPHY -ECOLOGICAL PROCESSES	DFO
-MIGRATORY BIRDS -CLIMATIC -HYDROMETRY -WATER CHEMISTRY -POLAR BEARS	-HARVEST DATA	DOE
-COSTAL PROCESSES -TERRAIN SCIENCES		EMR
-ABORIGINAL POPULATION -SOCIO-ECONOMIC -HYDROMETRIC (N.W.T.) -LAND/WATER USE (N.W.T.) DEVELOPMENT		DIAND
-RESOURCE USE PRESENT -ECONOMIC & DEVELOPMENT POTENTIAL -WILDLIFE -SOCIO-ECONOMIC	-RESOURCE USE -WILDLIFE HARVEST -ECOLOGICAL PROCESSES -FISHERIES	PROVINCES/ TERRITORIES
-BASIN SPECIFIC RESOURCE USE -BASIN SPECIFIC FISH & WILDLIFE -HYDROMETRIC -CLIMATE	-ECONOMIC DEVELOPMENT -CUMULATIVE IMPACTS	HYDRO ELECTRIC COMPANIES
-SPECIES AND SITE SPECIFIC -"EXPERTS"		ACADEMIA
-EXPERTS/CONSULTANTS -RESOURCE DEVELOPMENT POTENTIAL		PRIVATE INDUSTRY

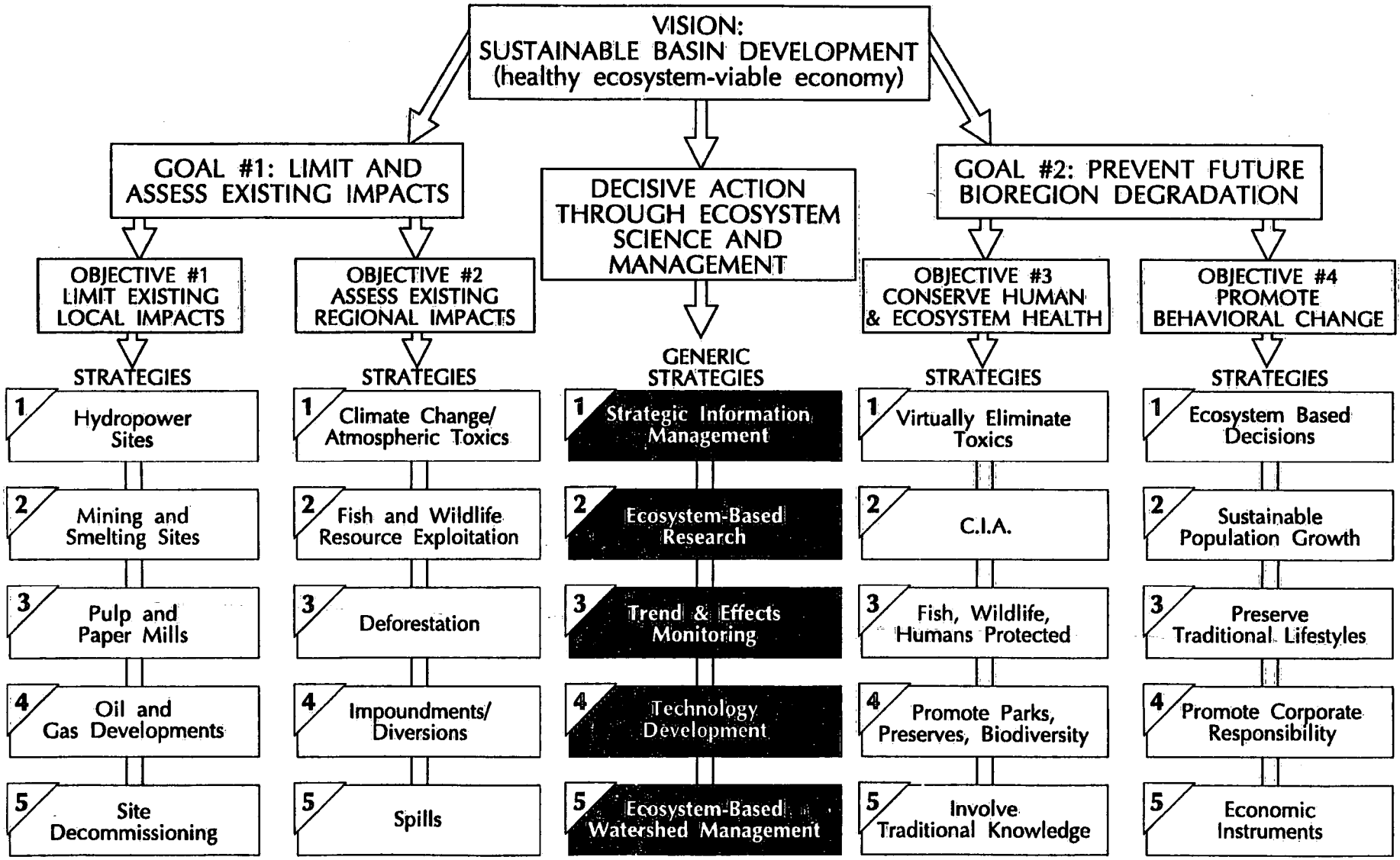
longer history of resource management institutions and programs in the Great Lakes basin compared to the Hudson/James Bay Bioregion.

The workshop concluded that the draft framework outlined in Figure 2 should be both product and cause of collaborative, partnership-building processes. As a first step, key federal agencies should meet informally, map out the next steps, and secure necessary departmental approvals. The workshop Chairman (Dr. Ralph Daley) was asked to convene an informal science working group to explore the possibilities for taking forward this recommendation .

It is important to move quickly on interdepartmental coordination and consultation on research and information assembly in support of sustainable development for the Hudson Bay Bioregion. At a minimum, the reports of various EA Panels in this Bioregion will force governmental responses. Time is of the essence in taking a proactive stance.

Figure 2

HUDSON\JAMES BAY BIOREGION STRATEGIC FRAMEWORK



LIST OF PARTICIPANTS

Organizing Committee

Dr. R.J. Daley (Chairman)
Executive Director
National Water Research Institute
Environment Canada
867 Lakeshore Road
P.O. Box 5050
Burlington, Ontario
L7R 4A6

Telephone: (416) 336-4625
Fax: (416) 336-6444

Dr. M. Clamen
Environmental Assessment Branch
Ecosystems Sciences & Evaluation
Environment Canada
351 St. Joseph Boulevard
Place Vincent Massey
Hull, Quebec
K1A 0H3

Telephone: (819) 953-1523
Fax: (819) 953-4093

Dr. R.J. Allan
Director
Lakes Research Branch
Environment Canada
867 Lakeshore Road
P.O. Box 5050
Burlington, Ontario
L7R 4A6

Telephone: (416) 336-4678
Fax: (416) 336-6430

Mr. J. Moenig
Environmental Assessment Branch
Ecosystems Sciences & Evaluation
Environment Canada
351 St. Joseph Boulevard
Place Vincent Massey
Hull, Quebec
K1A 0H3

Telephone: (819) 953-1524
Fax: (819) 953-4093

Facilitator

Dr. B. Sadler
Institute of the North American West
1631 Barksdale
Victoria, B.C.
V8N 5A8

Telephone: (604) 477-0119
Fax: (604) 477-8752

Attendees

Dr. C.L. Amos
Geological Survey of Canada
Atlantic Geoscience Centre
Bedford Institute of Oceanography
Department of Energy, Mines & Resources
P.O. Box 1006
Dartmouth, Nova Scotia
B2Y 4A2

Telephone.: (902) 426-7730
Fax: (902) 426-4104

Mr. H. Bain
Biological Sciences
Fisheries and Oceans
200 Kent Street
Ottawa, Ontario
K1A 0E6

Telephone: (613) 990-0283
Fax: (613) 995-0807

Mr. J. Bunch
Physical and Chemical Sciences
Fisheries and Oceans
200 Kent Street
Ottawa, Ontario
K1A 0E6

Telephone: (613) 990-7284
Fax: (613) 990-5510

Dr. D. Bodaly
Fish Habitat Research
Fisheries and Oceans
Freshwater Institute
501 University Crescent
Winnipeg, Manitoba
R3T 2N6

Telephone: (204) 983-5218
Fax: (204) 984-2404

Dr. J.H. Carey
Lakes Research Branch
Environment Canada
867 Lakeshore Road
P.O. Box 5050
Burlington, Ontario
L7R 4A6

Telephone: (416) 336-4693
Fax: (416) 336-4972

Dr. J.P. Coakley
Lakes Research Branch
Environment Canada
867 Lakeshore Road
P.O. Box 5050
Burlington, Ontario
L7R 4A6

Telephone: (416) 336-4881
Fax: (416) 336-6430

Mr. L. Desilets
Champlain Harbour Station
Fisheries and Oceans
901 Cap Diamant
P.O. Box 15500
Quebec City, Quebec
G1K 7Y7

Telephone: (418) 648-7777
Fax: (418) 648-4470

Ms. S. George
Fisheries and Habitat Management
Fisheries and Oceans
Bayfield Institute
867 Lakeshore Road
P.O. Box 5050
Burlington, Ontario
L7R 4A6

Telephone: (416) 336-4870
Fax: (416) 336-6437

Dr. D. Gregor
Lakes Research Branch
National Water Research
Environment Canada
867 Lakeshore Road
P.O. Box 5050
Burlington, Ontario
L7R 4A6

Telephone: (416) 336-4611
Fax: (416) 336-6430

Dr.P.F. Hamblin
Lakes Research Branch
National Water Research
Environment Canada
867 Lakeshore Road
P.O. Box 5050
Burlington, Ontario
L7R 4A6

Telephone: (416) 336-4611
Fax: (416) 336-6430

Dr. F. Hopper
Air Quality Branch
Atmospheric Environment Service
4905 Dufferin Street
Downsview, Ontario
M3H 5T4

Telephone: (416) 739-4872
Fax: (416) 739-5704

Dr. C. Hudon
Benthic Fisheries and Aquaculture
Fisheries and Oceans
Halifax Fisheries Laboratory
1707 Lower Water Street
Halifax, Nova Scotia
B3J 2S7

Telephone: (902) 426-5379
Fax: (902) 426-2698

Dr. T.A. Jackson
Lakes Reseach Branch
National Water Research Institute
Environment Canada
867 Lakeshore Road
P.O. Box 5050
Burlington, Ontario
L7R 4A6

Telephone: (416) 336-4795
Fax: (416) 336-6430

Dr. L. Johnston
Environmental Protection
NWT District Office
P.O. Box 307
Yellowknife, NWT
X1A 2N3

Telephone: (403) 873-3456
Fax: (403) 873-8185

Mr. K. Mancuso
Environmetal Health
Monitoring and Criteria
Health and Welfare
Environmental Health Centre
Tunney's Pasture
Ottawa, Ontario
K1A 0L2

Telephone: (613) 941-5749
Fax: (613) 954-0692

Ms. D. McClymont-Peace
Marine Navigation Services
Canadian Coast Guard
Transport Canada
Canada Building
344 Slater Street
Ottawa, Ontario
K1A 0N7

Telephone: (613) 998-1418
Fax: (613) 991-4982

Mr. R. McCrea
Inland Waters Directorate
Ontario Region
Environment Canada
867 Lakeshore Road
P.O. Box 5050
Burlington, Ontario
L7R 4A6

Telephone: (416) 336-4642
Fax: (416) 336-4609

Mr. F. McFarland
Biological Resources
Claims and Northern Affairs Program
Indian and Northern Affairs
Terrasses de la Chaudiere
10 Wellington Street
Hull, Quebec
K1A 0H4

Telephone: (819) 997-9621
Fax: (819) 953-2590

Dr. C.R. Murthy
Lakes Reseach Branch
National Water Research Institute
Environment Canada
867 Lakeshore Road
P.O. Box 5050
Burlington, Ontario
L7R 4A6

Telephone: (416) 336-4920
Fax: (416) 336-6430

Dr. W. Nicholaichuk
Hydrometeorological Research Division
National Hydrology Research Centre
Environment Canada
11 Innovation Boulevard
Saskatoon, Saskatchewan
S7N 3H5

Telephone: (306) 975-5748
Fax: (306) 975-5143

Mr. G. Packman
Habitat Management & Sustainable Dev.
Fisheries and Oceans
200 Kent Street
Ottawa, Ontario
K1A 0E6

Telephone: (613) 990-0207
Fax: (613) 993-7493

Dr. P. Sly
Rawson Academy
Suite 404
1 Nicholas Street
Ottawa, Ontario
K1N 7B7

Telephone: (613) 563-2636
Fax: (613) 563-4758

Dr. I. Sterling
Wildlife Conservation Research
Canadian Wildlife Services
Twin Atria No. 2
210-4999-98th Avenue
Edmonton, Alberta
T6B 2X3

Telephone: (403) 435-7349
Fax: (403) 435-7359

Dr. L.H. Thorliefson
Terrain Services
Geophysics, Sedimentary & Marine
Geoscience Branch
Energy, Mines and Resources
1 Observatory Crescent
Ottawa, Ontario
K1A 0Y3

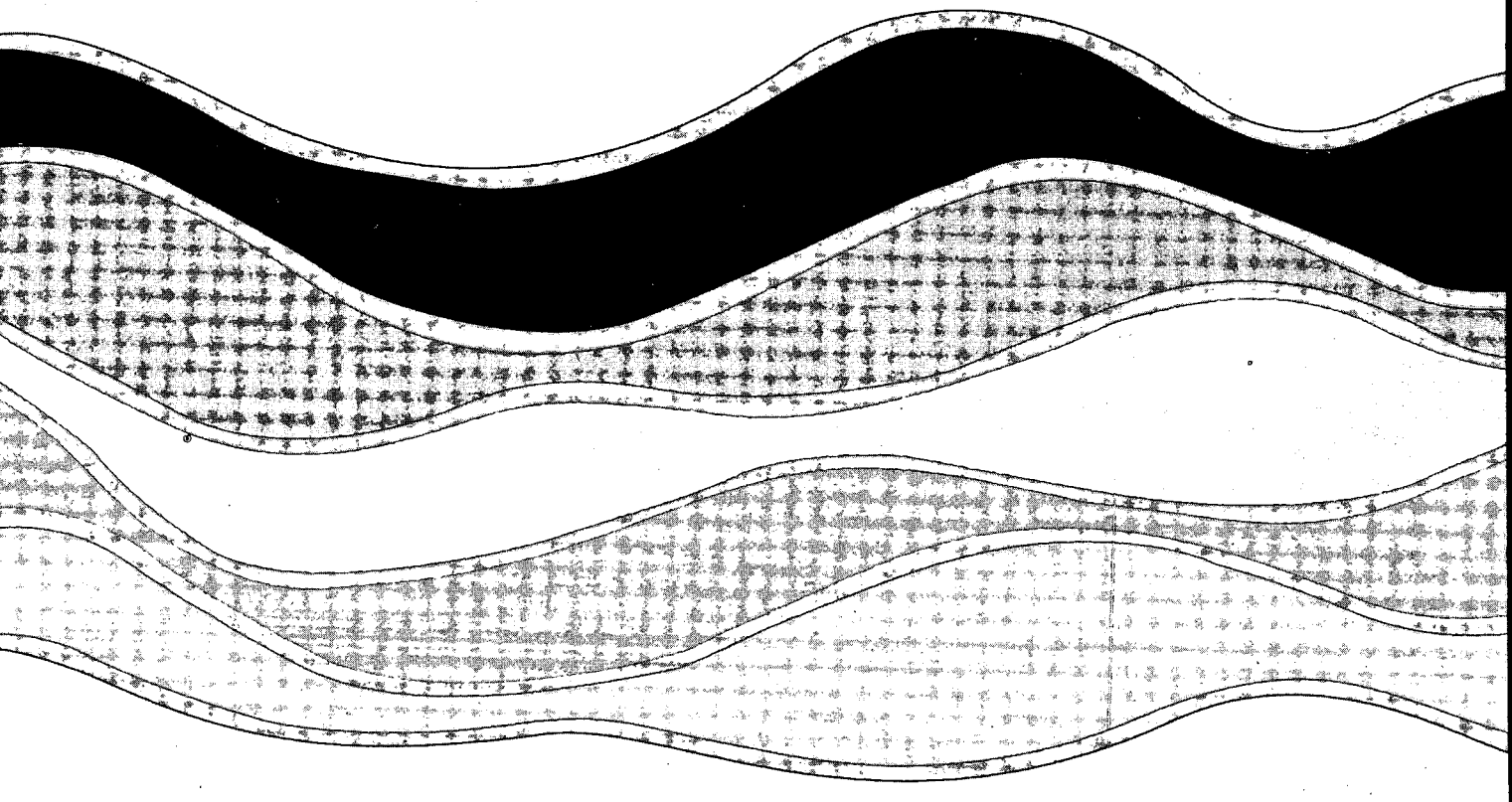
Telephone: (613) 992-3643
Fax: (613) 992-2468

Dr. G. Walsh
Institut Maurice-Lamontagne
Fisheries and Oceans
850, rue de la Mer
C.P. 1000
Mont Joli, Quebec
G5H 3Z4

Telephone: (416) 775-0577
Fax: (416) 775-0542
984-2404

Dr. G.H. Welch
Fish Habitat Research
Fisheries and Oceans
Freshwater Institute
501 University Crescent
Winnipeg, Manitoba
R3T 2N6

Telephone: (204) 983-5132
Fax: (204)



NATIONAL WATER RESEARCH INSTITUTE
P.O. BOX 5050, BURLINGTON, ONTARIO L7R 4A6

Environment Canada Environnement Canada

Canada

INSTITUT NATIONAL DE RECHERCHE SUR LES EAUX
C.P. 5050, BURLINGTON (ONTARIO) L7R 4A6