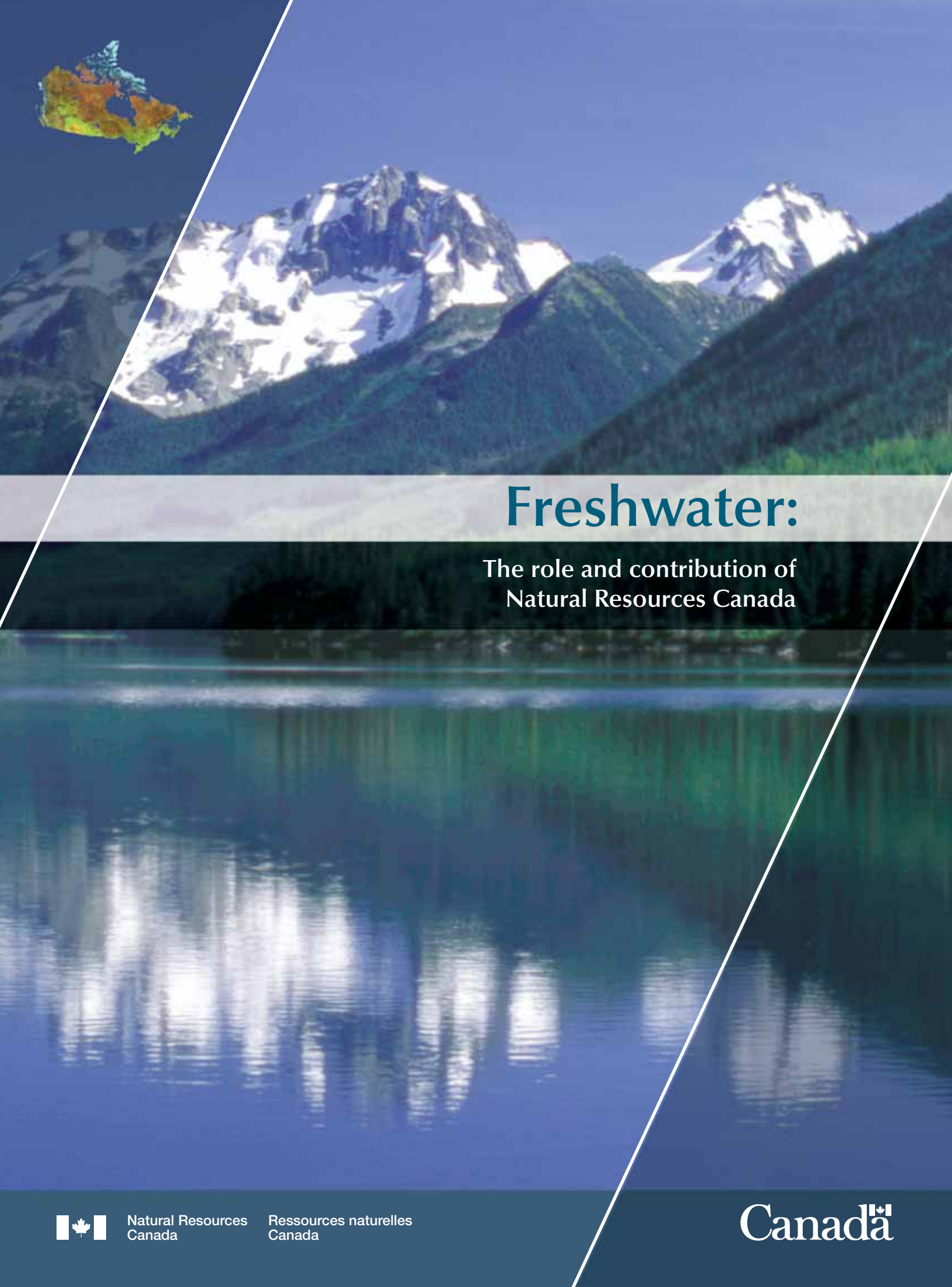

Freshwater:

The role and contribution of Natural Resources Canada

Natural Resources Canada | Ressources naturelles Canada

Canada

Natural Resources Canada (NRCan) is one of over 20 federal government departments and agencies currently involved in addressing freshwater issues. This document is intended to inform interested Canadians, particularly practitioners of water management, about NRCan's unique role and contribution to freshwater issues. The document demonstrates how NRCan activities help Canadians make sound decisions on the sustainable development and stewardship of Canada's freshwater resources. It also illustrates the range of tools and instruments used in delivering enhancements to our knowledge of Canada's freshwater resources.

Further details on NRCan programs and activities can be found on the Department's sustainable development web site at www.nrcan-rncan.gc.ca/sd-dd/

Any questions or comments on the document should be sent to:

Natural Resources Canada
Sustainable Development and International Affairs
Strategic Policy Branch
580 Booth Street, 20th Floor
Ottawa, Canada
K1A 0E4

Phone: (613) 947-4290
Fax: (613) 996-0478
E-mail: sustaindev@nrcan.gc.ca

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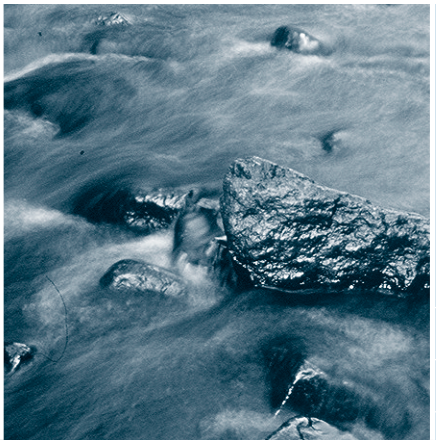

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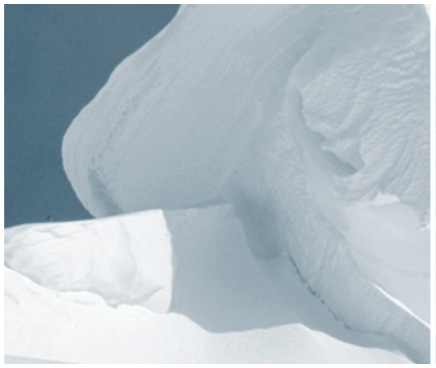



Introduction: 1

Water is an amazing substance – just a simple mix of two fundamental elements found scattered throughout the galaxy.
~ Peter Gleick[1]

The Global Situation

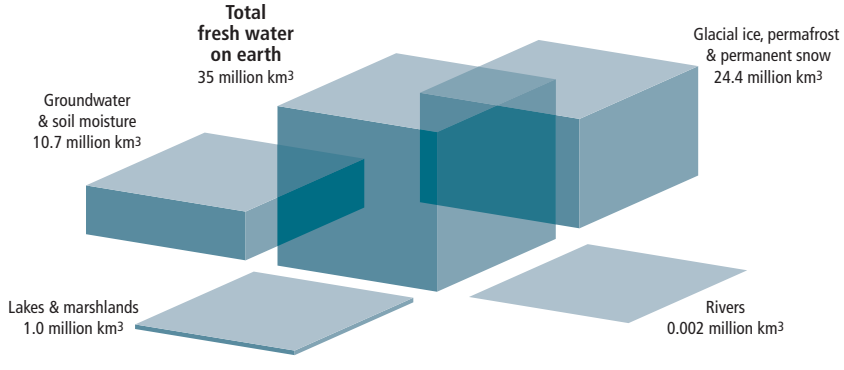
Clean and predictable supplies of freshwater drive the economic and ecological systems on which we depend. This reality makes the sustainable development of freshwater resources among the most pressing of global challenges today. The health and prosperity of future generations depend on it.

In many parts of the world, a limited supply of freshwater combined with inadequate sanitation has created a crisis situation. Over the course of the twentieth century, global population tripled as demand on finite freshwater supplies (illustrated in Figure 1-1) increased sevenfold. Today, over 1.1 billion people do not have access to safe drinking water, and 2.4 billion lack access to adequate sanitation.[2] Since the early 1990s, the international community has been attempting to respond to these disturbing trends.

Figure 1-1:
The world's water supply

There are about 35 million km^3 of fresh water on the Earth. Here's where that water is found.

Source: Environment Canada, 2004



Note: Numbers are approximate

About 70% of the Earth is covered in water.

Integrated water resource management (IWRM) promotes the coordinated development and management of water, land, and related resources in order to maximize the resultant economic and social welfare without compromising the sustainability of ecosystems.

The rationale for the sustainable development and management of the Earth's water resources was clearly articulated in Chapter 18 of Agenda 21, the Program of Action adopted at the Earth Summit in Rio in 1992. As a member of the global community, Canada is committed to achieving international goals for freshwater.

The United Nation's Millennium Development Goal (MDG) 7—"Ensure environmental sustainability"—includes the target to reduce by half the proportion of people without access to safe drinking water, by 2015. The 2002 World Summit on Sustainable Development (WSSD) added a new target to this goal: to reduce by half the proportion of people without access to basic sanitation, also by 2015.[3] The WSSD Johannesburg Plan of Implementation includes the goal to have all countries develop integrated water resource management (IWRM) and water-efficiency plans by 2005.

Integrated water resource management has emerged internationally as the leading governance paradigm for water management. IWRM represents the application of the principles of sustainable development to the management of water resources. Characterized by collaborative, stakeholder-driven processes, IWRM offers an effective approach for reconciling competing demands with existing supplies of freshwater, while protecting water quality. The implementation of IWRM supports the advancement of sustainable development in all countries at all stages of development.

NRCan recently conducted a review of water policy approaches in industrialized countries. The review found that, although first steps are being taken, many countries are struggling to implement integrated water management approaches.[4] Like Canada, most jurisdictions distribute responsibility for water among a range of federal, regional, and local bodies in different sectors. A World Wildlife Fund study of selected European countries suggests that integrating water and land-use objectives is a particular problem.[5] The study did not point to any particular European jurisdictions or policy strategies as models.

Agenda 21

"Water is needed in all aspects of life. The general objective is to make certain that adequate supplies of water of good quality are maintained for the entire population of this planet, while preserving the hydrological, biological and chemical functions of ecosystems, adapting human activities within the capacity limits of nature and combating vectors of water-related diseases. The multi-sectoral nature of water resources development in the context of socio-economic development must be recognized, as well as the multi-interest utilization of water resources."

~ Chapter 18, *Agenda 21*

In addition to work on international policy development, the Government of Canada contributes to the global agenda on water through participation in science-based initiatives on water quality, sharing expertise on issues related to trans-boundary waters and shared coastal areas, and providing access to technology and training in many areas of water-resource management.

Canada and Freshwater

Relative to nations with insufficient or unreliable water supplies, Canada is privileged to enjoy an abundance of freshwater resources. As the steward of seven percent of the world's surface freshwater resources and 25 percent of global wetlands, we boast a wealth of aquatic biodiversity, and the world's longest marine coastline.

Water has played—and will continue to play—a vital role in Canada's economic development. From the first human settlements, through the period of European exploration, waterways have been Canada's corridors for migration, exploration, and trade. Water defines many of our political boundaries, and is an economic cornerstone of the modern, diversified country we know today.

While fortunate to posses significant quantities of high-quality water, Canada is not immune to water-management challenges. Periodic water shortages, conflict over access to the resource, and the rising costs associated with building and maintaining infrastructure, have made it clear that there are management issues related to Canada's water supply.

For example, there are parts of Canada, including much of the southern Prairies, where there are no remaining surface water flows that have not been allocated. In southwestern Ontario, economic development and population growth are placing intense pressure on the groundwater resource. In addition, projected shifts in climate will likely create significant impacts on Canada's freshwater resources.

Supply and demand is one side of the water-management challenge. The other involves protecting the quality of Canada's water—both ensuring that the water we draw from the environment can be safely used, and that the water we return to nature does not harm ecosystem or human health. As most water use involves some degradation of water quality, the two sides are intricately linked.

Being prepared:
Climate change impacts on Canada's water resources

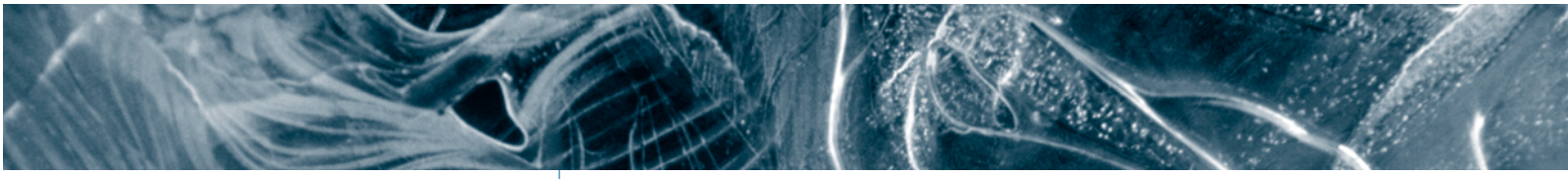
Climate change is expected to impact both the quantity and quality of Canada's water supply. Taking action on climate change includes being prepared to adapt to the impacts on our water resources. But before we can adapt we need to know where we are vulnerable, and what our options for action are.

NRCan is responsible for the Impacts and Adaptation Program, a component of the Government of Canada's action on climate change. The Program aims to reduce Canada's vulnerability to the impacts of future climate conditions by supporting research to improve our understanding of the potential impacts on water resources across Canada, and fostering the development of information that enables adaptation decision-making. Planning ahead can reduce the costs of negative impacts, and may help some communities take advantage of new opportunities.

Between 1998 and 2004, the Impacts and Adaptation Program supported thirty-one projects related to water resources, ranging from addressing questions of future changes, to hydrology and groundwater resources, to the capacity of communities and water-management systems to adapt.

More information on these projects can be found at: www.adaptation.nrcan.gc.ca

Brazil is the country with the most renewable fresh water. Canada is third after Russia.



In 2000, in Walkerton, Ontario, 7 people died and 2,500 became ill due to waterborne pathogens in their drinking water. More than 7,000 people fell ill when the water supply in North Battleford, Saskatchewan, became tainted with the cryptosporidium bacterium.

Water quality in Canada faces a number of threats stemming from sewage, industrial waste, surface runoff, and changing climate patterns. There have been successful actions taken to protect water quality, evidenced, for example, by a substantial reduction in discharges of toxic substances into Canadian waters over the last 15 years. But there have also been tragic failures, most significantly the supply contamination incidents in Walkerton, Ontario, and North Battleford, Saskatchewan.

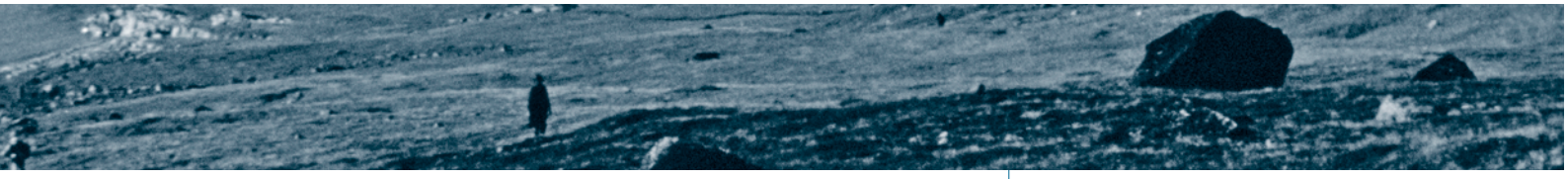
Looking beyond the safety of drinking water, there are also consequential ecosystem impacts resulting from use of water, including the loss of critical wildlife habitat. Many ecosystem effects are directly linked to the quality of life Canadians value, for example, access to safe beaches.

Economic development, population growth, and changes in our climate are combining to intensify the pressures on Canada's freshwater resources. There is a critical need to develop a better understanding of these resources: where and how water is used, how various uses compete and interfere with each other, and how to address this growing competition while protecting the quality of Canada's—and the world's—water supply.

Water Governance in Canada

Jurisdiction over Canada's freshwater, and freshwater-related activities, is a complex matter. Federal or provincial legislation may apply, depending on the water body in question, or the nature of water use. The intent of legislation is realized through a great variety of regulations, public and private-sector policies, and programs. Governance of Canada's freshwater resources presents a challenge, and an opportunity, for the implementation of more precisely structured regulatory mechanisms—an approach that is better known as 'Smart Regulation'.

Canada's provinces are the primary managers of water and are responsible for much of the environmental regulation and policy making that affects water issues. The federal government has jurisdiction related to fisheries, navigation, federal lands, and international relations, including responsibilities related to the management of boundary waters shared with the United States, including relations with the International Joint Commission. It also has significant responsibilities for agriculture, health and the environment, and plays a significant role supporting aquatic research and technology, and ensuring national policies and standards are in place on environmental and health-related issues.



To fully understand the federal government's role in water management in Canada, it is important to first understand the interests and mandates of the departments involved in program delivery. Within the federal government, over 20 departments and agencies have unique responsibilities for freshwater. As all levels of government hold key policy and regulatory levers which apply to water management, a central challenge is to ensure that these levers are developed and used collaboratively.

As the importance of safeguarding our freshwater has risen as a national priority, it has become clear that a better focus and greater degree of coordination at all levels of government is needed. Coordinated and collaborative water governance can result in significant environmental, social and economic benefits for all Canadians.

NRCan is working closely with other federal departments to develop a more strategic approach to addressing nationally significant freshwater issues. The Federal Framework for Water provides a structure for describing the core freshwater programs and activities of the federal government.

The following are the five ultimate outcomes established for the framework:

Human Health: Canadians have access to safe drinking water and human health is protected from water quality-related health threats.

Ecosystem Health: Aquatic ecosystems and biodiversity are conserved and protected.

Sustainable Use and Economy: Economic benefits accrue to Canadians as a result of sustainable and productive use of water resources.

Hazards and Environmental Prediction: Health, safety and socio-economic impacts from floods, droughts and other water-related hazards are minimized through prediction and enhanced coping strategies.

Global Water: Global commitments are met, Canadian assistance is provided, and Canadian water-related interests are protected and promoted globally.

Federal Departments with Freshwater Responsibilities

Agriculture and Agri-Food Canada

Canada Mortgage and Housing Corporation

Canadian Environmental Assessment Agency

Canadian International Development Agency

Environment Canada

Fisheries and Oceans Canada

Foreign Affairs Canada

Health Canada

Indian and Northern Affairs Canada

Industry Canada

Infrastructure Canada

International Trade Canada

National Defence

National Research Council

Natural Resources Canada

Parks Canada

Public Works and Government Services Canada

Statistics Canada

Transport Canada

Treasury Board Secretariat

NRCan's Role and Freshwater: 2

In the context of the Government of Canada's contribution to clean, safe and secure freshwater resources, NRCan has two principle roles to play:

- to provide the information and understanding necessary for informed decision-making through science and policy expertise, and
- to minimize impacts of natural resource sector activities on aquatic ecosystems through science and technology innovation.

NRCan is responsible for federal resource policies, and science and technology (S&T) that support the sustainable development and competitiveness of the energy, earth sciences, forest, minerals and metals sectors, and their allied industries. The Department enables the Government of Canada to address resource issues in a comprehensive manner, from a national perspective.

In doing so, NRCan works with communities both within Canada and around the world to improve their capacity to better manage their natural resources, including freshwater.

NRCan has a unique responsibility for improving our knowledge of Canada's freshwater resources. Resource development through

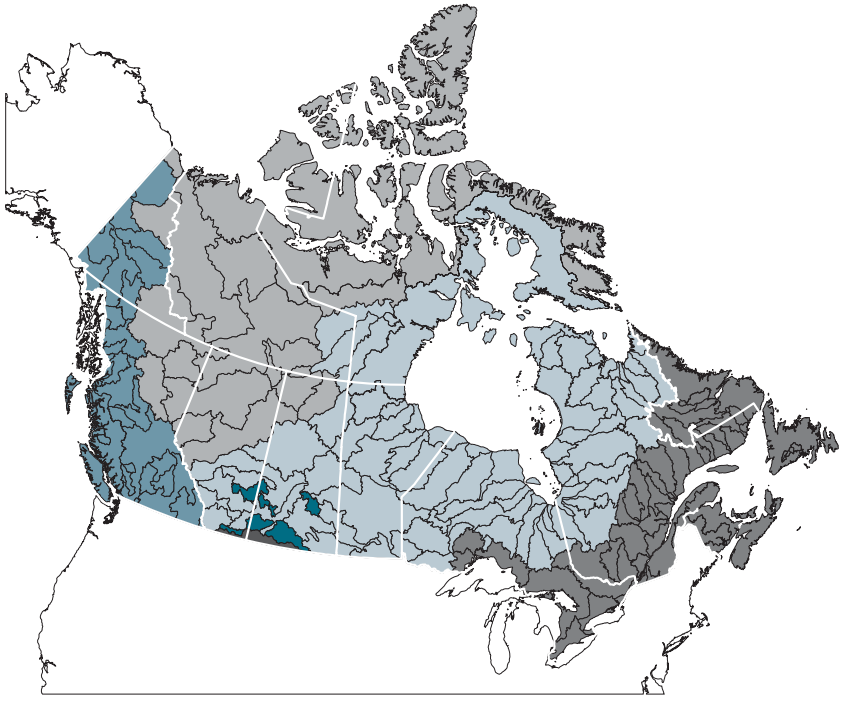
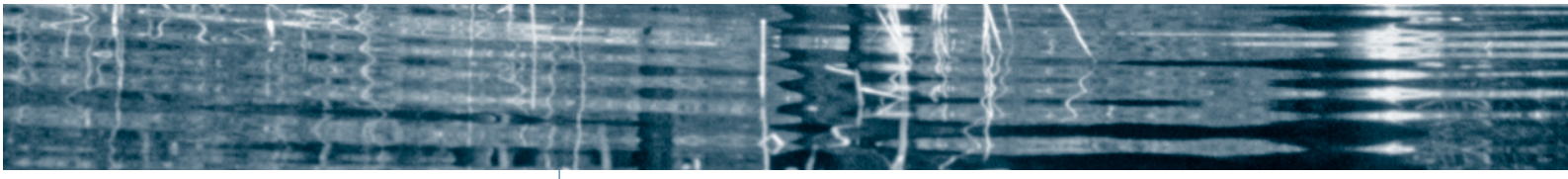


Figure 2-1:
Ocean drainage map

Source: Atlas of Canada

In 1993, Ontario became the first province to introduce plumbing codes that require all toilets, showerheads, and faucets in new buildings to be water conserving.



When viewed alongside the contributions of other departments, NRCan expenditures on freshwater-related activities represent less than five percent of total federal government spending on freshwater activities.

Key NRCan water-related activities

Understanding water resources and hazards:

- Mapping groundwater capacity and vulnerability
- Surface water mapping
- Source water composition and protection
- Climate change impacts
- Riparian zone and forest ecology and hydrology
- Development of small hydro technologies
- Hazards:
  - » monitoring floods and analyzing flood risk
  - » shoreline erosion
  - » drought history

Minimizing resource sector impacts:

- Improving treatment of mining effluent and metals in aquatic ecosystems
- Sustainable forestry practices
- Pesticides and herbicides in the environment
- Enhancing water-use efficiency in industrial processes
- Reducing contaminated water discharge from oil sand and heavy oil processing

the energy, forestry, and mining and minerals sectors can have significant impacts on Canada's freshwater resources. Energy production is a major user of water, and resource extraction/harvesting activities can result in negative impacts on water quality and aquatic ecosystems. Each of these sectors use large quantities of freshwater in their operations, and both water use and wastewater management are ongoing challenges. Increasing our understanding of freshwater issues and developing the tools to help meet the resource-sector industries' water-management challenges are important aspects of the work done at NRCan.

NRCan's program contributions related to freshwater are very modest in proportion to total federal expenditures on freshwater-related activities (i.e., less than five percent), but they are quite varied and very diverse—a function of the Department's considerable expertise and experiences in earth sciences, energy, forestry, and mining. Throughout each of the natural resource sectors, NRCan works in partnership with industry, universities and local communities to develop and deploy innovative S&T-based solutions to water-related challenges.

In the context of groundwater, the *Resources and Technical Surveys Act* (RATS Act) provides NRCan with the mandate to describe the geological structure of Canada, which includes the delineation of aquifers. Consequently, NRCan has a role in supporting other government departments for whose mandate geological structures are relevant and important. NRCan has signed a Memorandum of Understanding with Environment Canada under which NRCan will study groundwater quantity and Environment Canada will study groundwater quality.

Canada has about 25% of the world's wetlands – the most of any country in the world.

NRCan and Sustainable Development

Sustainable development is central to the mandate of NRCan. In some respects sustainable development is a challenge, but it also brings opportunities for Canadians—helping us to maintain the benefits of resource development, fuelling innovation to create new benefits, and ensuring that future generations will also be able to enjoy a high quality of life, supported in part by our great wealth of natural resources. NRCan was the first federal department to enshrine sustainable development in its mandate and legislation.

The 1995 amendments to the *Auditor General Act* established the requirement for federal departments and agencies to table a sustainable development strategy in Parliament every three years. The purpose of the strategy is to outline how the department will systematically integrate the principles of sustainable development into their policies, programs, legislation and operations. Through these strategies, the federal government is accountable to Canadians for their decisions and actions.

NRCan's sustainable development strategy, *Moving Forward* (2004), established four key results to advance sustainable development.

Within these key results, there are two specific action items pertaining to water:

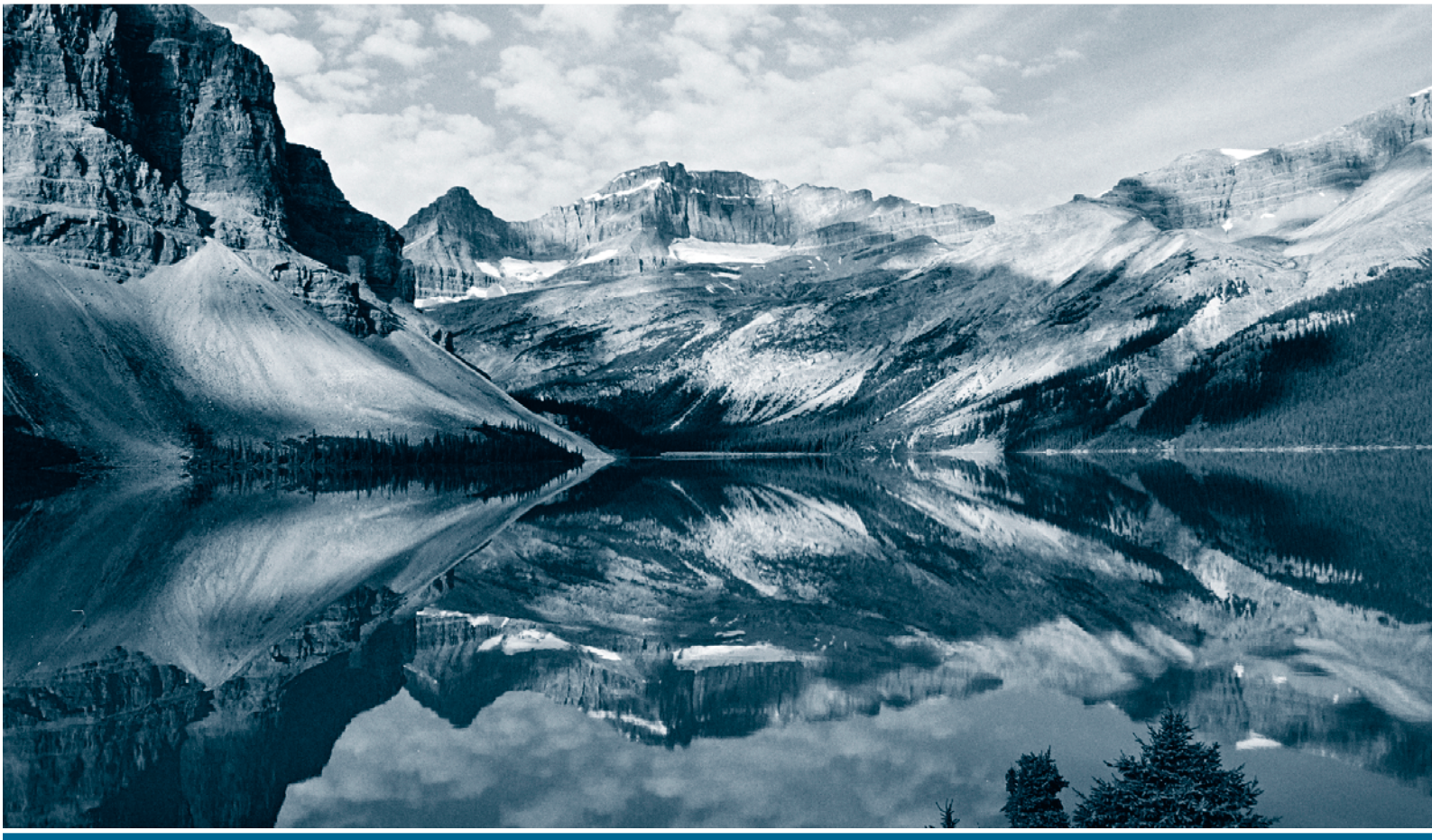
- Increasing our understanding of Canada's water resource supply and minimizing the impacts of natural resource sector activities on aquatic ecosystems, and
- Improving NRCan operations through sound environmental management.

A complete list of activities and targets relating to water from *Moving Forward* can be found in Appendix 2.

"Corporations throughout the world have a unique and crucial role to play in the sustainable management of water. In economic terms, the business case for sustainable water management is, at its simplest, based on the fact that reduced water quality and availability lead to higher costs and business interruption losses."

Travis Engen, President and Chief Executive Officer, Alcan Inc.

Wetlands totalling 147.9 million hectares (1.479 million km^2) cover about 14% of the land area of Canada.



Water Issues and NRCan Activities: 3

Groundwater is an "invisible" resource, making its use difficult to monitor and manage. ~ Marcus Moench[6]

What is Geomatics?

Geomatics is the science and technology of gathering, analyzing, interpreting, distributing and using geographic information. Geomatics encompasses a broad range of disciplines that can be brought together to create a detailed but understandable picture of the physical world and our place in it. These disciplines include:

- surveying
- mapping
- remote sensing
- geographic information systems (GIS)
- global positioning system (GPS)

Canada's geomatics community is a recognized world leader in providing the software, hardware and value-added services that can help clients address problems and opportunities in such areas as:

- the environment
- land management and reform
- development planning
- infrastructure management
- natural resource monitoring
- sustainable development
- coastal zone management and mapping

~ Geomatics Canada, NRCan

This section of the report provides an overview of water issues of relevance to NRCan's four principal sectors (earth sciences, energy, forestry, and minerals and metals) as well as departmental operations. Information on the Department's organization is included in Appendix 1.

Earth Sciences

Water Issues and Earth Sciences

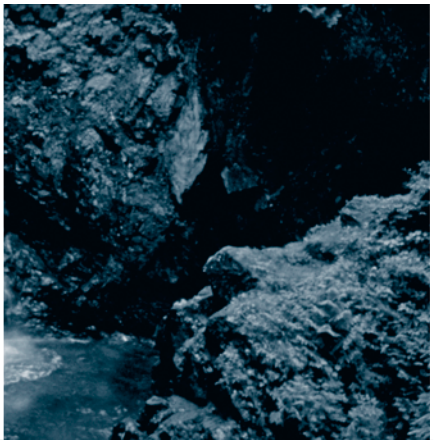
NRCan's Earth Sciences Sector (ESS) provides essential knowledge and geomatics data, tools and solutions to support informed decision-making on water-related issues with domestic and international implications.

Earth science knowledge is essential for the evaluation of water resources, both surface water and groundwater. With an increasing number of Canadians relying on groundwater to meet household needs, burgeoning industrial demand (e.g., for oil sands development), and the likely impacts of climate change on water supply, it will be increasingly important to understand the factors influencing water quantity and quality.

The generation and dissemination of new knowledge to contribute to the well-being of Canadian citizens is at the forefront of all ESS activities. Through geomatics and geoscience, this sector provides the infrastructure for efficient and effective discovery, access and management of Canada's geoscience data, information and knowledge for decision support within government, industry and the public.

Groundwater availability and quality

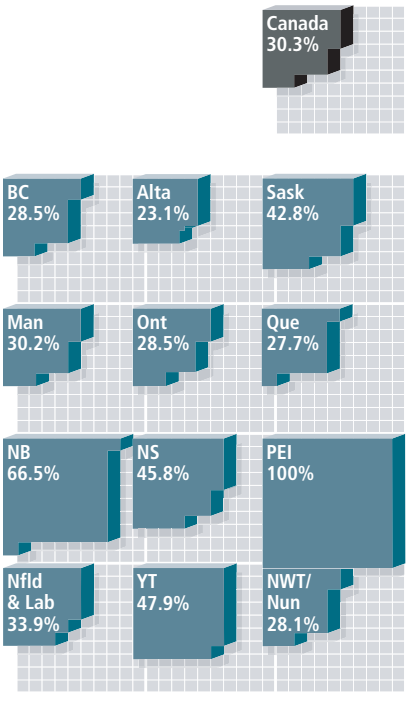
The key knowledge gaps with respect to the amount of available groundwater include the number, size and characteristics of major aquifers (the geological units in which groundwater resides), their vulnerability and sustainability. NRCan has taken a federal leadership role in hydrogeology, particularly with respect to understanding the



In 1996, over 40% of Canada's municipal water systems were reliant on groundwater.

Groundwater use in Canada per province

Percentage of population that relies on groundwater
Municipal, domestic and rural only. Figures shown are provincial averages and may vary regionally.



Source: Environment Canada, 2004

magnitude of Canada's groundwater resources. Much progress has been made to protect both the quality and quantity of our water resources through partnership programs (e.g., programs with the provinces and other government departments, and the Canada-U.S. Great Lakes Water Quality Agreement); however, more needs to be done, particularly in the area of trans-boundary aquifer issues such as key groundwater aquifer delineation and recharge zones across the country.

Climate change

Our world's climate is changing. Global temperatures rose by 0.6°C during the 20th century and are projected to increase between 1.4–5.8°C over this century. Climatic variables, such as temperature and precipitation, greatly influence the hydrological cycle, and changes in these variables will affect, runoff and evaporation patterns as well as the amount of water stored in glaciers, snowpacks, lakes, wetlands, soil moisture and groundwater. Specific impacts will vary across the country; regional projections include declining water levels for the Great Lakes, decreasing soils moisture in the southern Canada and a reduction of wetlands in the Prairies.[7] These changes are expected to advance as average temperatures rise.

The impacts of climate change will continue to be felt for many decades and in many economic and social sectors. Key anticipated effects of climate change on Canada's water include:

- decreases in water quality from lower summer streamflows, saltwater intrusion into coastal aquifers (resulting from sea-level rise), and increases in the intensity and frequency of flooding;
- decreases in water availability resulting from increased intensity and frequency of drought, declining snowpack and glacier dimunition; and
- increasing conflict between competing water users.

While Canada is working to reduce its greenhouse gas emissions, it is essential that Canadians understand the potential impacts of climate change on water in order to adapt to changing conditions.

Glaciers

As a Nordic country, much of Canada's freshwater is derived from seasonal and perennial snow and ice, which exerts important controls on the timing and magnitude of water fluxes. The presence of snow and ice concerns all manner of water-related resource and hazards issues. When conditions are warm and dry, glaciers act to regulate surface water flows. Glaciers also play a role in recharging ground-

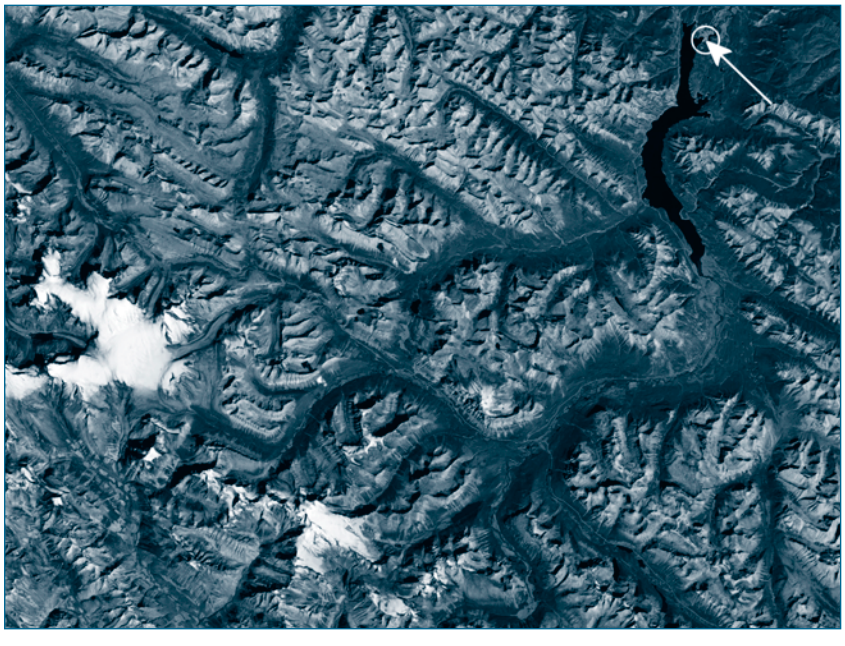
water aquifers. This aspect of our hydrology is critical to understanding the variability of water supply under a changing climate and developing water-management strategies, particularly for western Canada.

As an example of NRCan's diverse freshwater geoscience activities, NRCan has signed a Memorandum of Agreement with Environment Canada under which the two departments will cooperatively monitor and study glacier fluctuations and their hydro-ecological impacts.

Drought

As a direct threat to water quantity in Canada, drought impacts a wide range of water-sensitive sectors including agriculture, industry, municipalities, recreation, and aquatic ecosystems.[8] The ability to predict drought onset, intensity, and termination more accurately requires improvements in modelling and monitoring of current drought conditions, as well as better short-term (seasonal) climate forecasts.[9]

Canada's glaciers hold water resources equivalent to all of the water contained by our lakes and rivers.



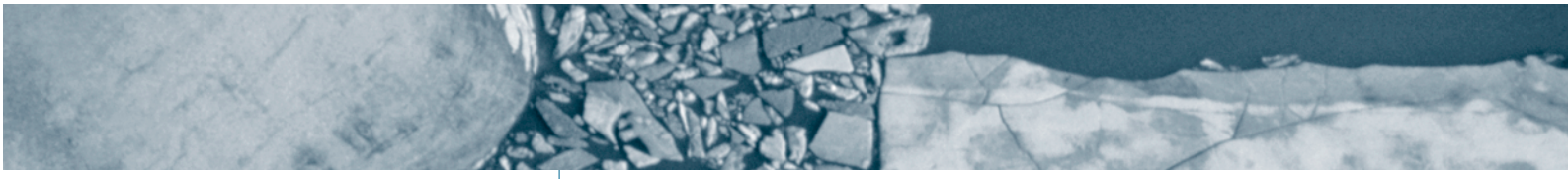
1998 Landsat image of the North Saskatchewan River Basin headwaters showing the concentration of glacier cover, in white, in proximity to Trans Alta Utilities' Abraham Lake Bighorn power generating station (station identified by arrow).

Drought in Canada

The following are activities where NRCan contributes to improving our capability to monitor, model, and predict droughts in Canada.

- Development of a total water supply database including, for example, improved data of streamflow records, wetland numbers, glacier volume, and groundwater supplies.
- Better understanding of the amount and distribution of groundwater resources, including linkages to climate and surface water supply.
- Development of better methodologies to incorporate remote sensing and in-situ techniques for drought and water-resource monitoring and management (to augment information provided by the climate station network). The geospatial and temporal capacity of satellite imagery offers many opportunities for advanced monitoring capabilities.
- Incorporation of existing Geographical Information System (GIS) techniques to provide better spatial representations of drought; for example, the migration patterns of drought and its associated synoptic circulation patterns could be tracked on a variety of temporal scales.

Source: NRCan Terrain Science Division, http://sts.gsc.nrcan.gc.ca/sanddune/drought.asp



Groundwater Program

The Groundwater Program is delivered through four projects:

1. National Groundwater Database, Outreach and Monitoring
2. Assessment of Regional Aquifers: Towards a National Inventory
3. Thematic Groundwater Research
4. Remote sensing in support of groundwater monitoring and vulnerability assessment

Outcomes

The GWP will produce the following outcomes.

- By the end of the three-year program, NRCan will have mapped and fully assessed 12 regional aquifers systems, but this would only be a modest start, far from a full inventory of the groundwater resources of Canada.
- The hydrogeological information produced will be used by governments at all levels to assess the sustainability and quality of some key Canadian aquifers.
- Information on aquifers at high risk will assist governments and municipalities to make informed decisions related to water and waste management issues.
- NRCan will provide training sessions on how to effectively use groundwater databases and models, and vulnerability studies.

Water-Related Earth Sciences Sector Activities

Groundwater Program[10]

The growing importance and recognition of the Canada's groundwater resources is demonstrated through NRCan's Groundwater Program (GWP), which is working towards creating an inventory of groundwater resources and regional aquifer assessments, including sustainable yield and vulnerability. NRCan is building partnerships with other government departments, provincial governments, universities, and the private sector for the purpose of carrying out the full assessments of regional aquifers. The GWP operates with a very high degree of cooperation and transparency, which is enhancing the Program's impact across Canada and beyond our borders, as well as contributing to the recognition of NRCan's leadership on the sustainable development of Canada's freshwater resources.

Although the inventory is far from complete, the GWP has already yielded very good knowledge of trends and indicators for the water resources of Canada as a whole. Thirty key regional aquifers have been identified, six of which will be fully mapped and assessed by 2006. The focus will be on determining the extent and characteristics of the most strategic groundwater resources.

The data and information from these aquifers are being populated into NRCan's National Groundwater database. The database and supporting tools such as maps, publications and models, will enable water management agencies and well owners to make decisions that will support a reliable groundwater supply.

NRCan is also involved in international groundwater activities. In cooperation with the Canadian International Development Agency, NRCan managed PROASNE, a Northern Brazil–Canada technology transfer program designed to help develop the region's groundwater resources as a means of augmenting the long-term water supply for the rural communities. Results of the program include reducing the hardship caused by drought and improving living conditions in general.

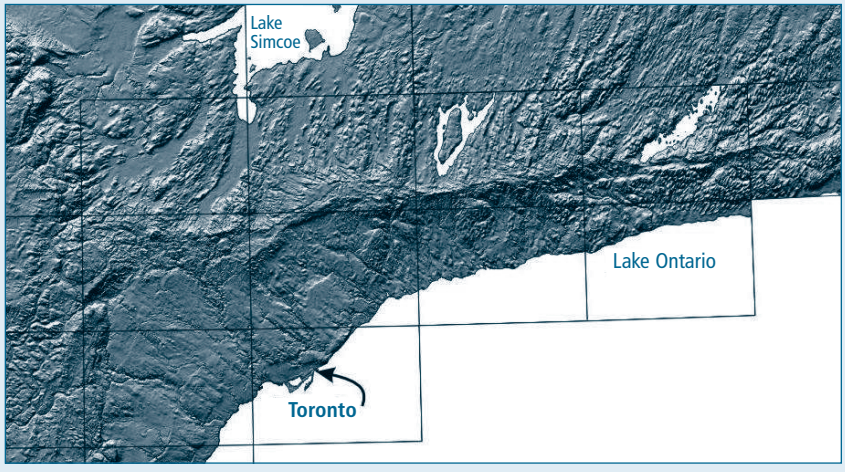
Program highlights:

Oak Ridges Moraine research contributes to Ontario water-resource management and land-use policy

The Geological Survey of Canada's (GSC) recently completed work on Oak Ridges Moraine (ORM) groundwater systems continues to impact land-use planning and water-resource policy implementation in Ontario. The Oak Ridges Moraine is provincially significant as it supplies groundwater to ~200,000 residents, contributes up to 50 percent of yearly flow in 30 streams and sustains a vibrant habitat and cold-water fishery across regional watersheds. The GSC research team assisted Ontario agencies, private-public sectors and academia by providing critical data, approaches and results so that recent water-resource knowledge supports official plans and zoning bylaws linked to a new ORM planning policy.[11]

GSC efforts have contributed new mapping and 3-D models, for example (Fig. 3-1), to regional watershed planning and sustainable water-resource management in ORM aquifers. The basin analysis study approach (Fig. 3-2) demonstrated the value of investment in both high-quality 3-D data collection and in a regional watershed focus.

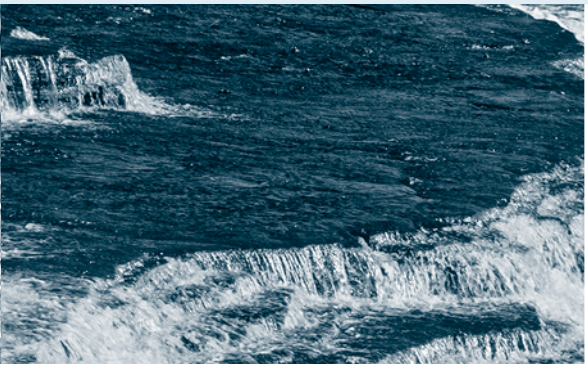
Figure 3-1:
The ORM is an east-west ridge and drainage divide north of Lake Ontario.



Moreover, the ORM study continues to show positive outcomes from ongoing collaboration with provincial, municipal and other agencies as part of a national framework to address water-resource priorities.

The provincial Ministry of Housing and Municipal Affair's Director of Planning praised GSC research for assisting provincial efforts to protect and manage ORM water resources. Particular praise was extended for high-quality scientific evidence and professional conduct at Ontario Municipal Board hearings to urbanize sensitive ORM groundwater recharge areas.

The scientific credibility that the GSC contributed to the hearing's central water-resource issues helped this landmark case lead to the Oak Ridges Moraine Conservation Act.[12] The Province is using the ORM research methods and models in practical ways to help all stakeholders improve their understanding and management of the area's water resources. GSC efforts have also been instrumental in both imparting knowledge and raising awareness of groundwater science by communicating[13] to many, including provincial agencies, municipalities, and, public and educational communities.



The Great Lakes Basin (shared with the United States) is the world's largest freshwater lake system.

Figure 3-2:
Basin analysis uses three-dimensional geological models of subsurface sedimentary strata (centre) to explain how water moves through a complex reservoir, or plumbing system, such as the glacial landscape of the Oak Ridges Moraine.

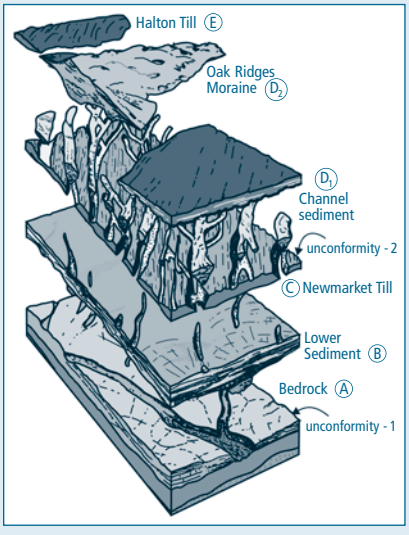
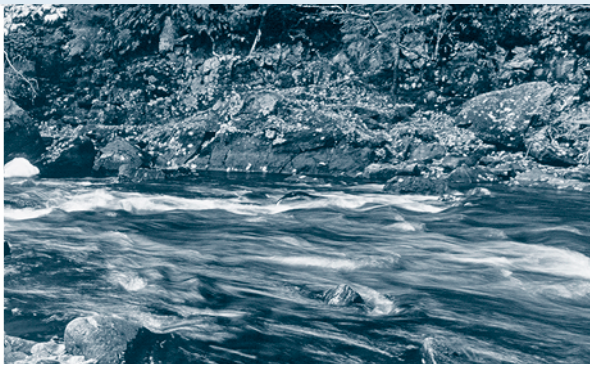
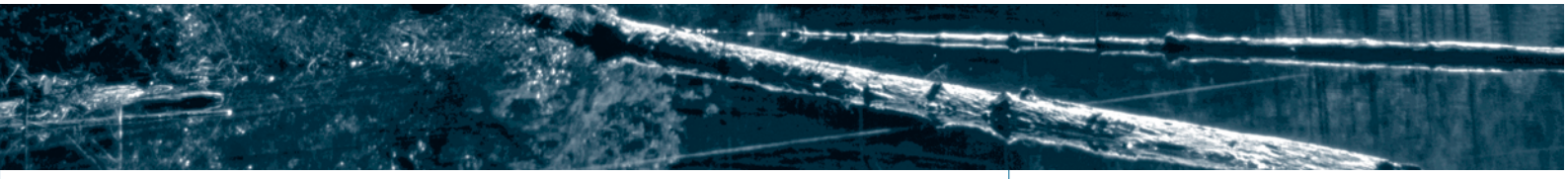


Figure 3-3:
An aerial view of a small 'kettle'. Phillips Lake is on the crest of the ORM: the public considers such lakes to be the 'rainbarrels' of the ORM groundwater system.

Current impact of the GSC work on the ORM for Ontario users:

- ORM mapping protocols are being used in a $10 million municipal groundwater-protection program across southern Ontario.
- A coalition of nine ORM conservation authorities and three regional municipalities contracted GSC to produce 3-D models (Fig. 3-2) to support groundwater/surface-water management.
- *Canadian Geographic* and the *Toronto Star* editorial page highlighted GSC expertise to national/area audiences with articles and photo essay on the Oak Ridges Moraine studies.
- Ontario agencies continue to engage GSC as partners in regionally based groundwater science that supports water-resource policy and management issues across Ontario.
- ORM experience is being used by GSC study team to provide technical advice regarding Ontario's ground-breaking initiatives on Source Water Protection.[14]





Reducing Canada's Vulnerability to Climate Change Program

The goal of the Reducing Canada's Vulnerability to Climate Change (RCVCC) Program is to reduce the vulnerability of Canadians, their communities, and the country's infrastructure to climate change. This goal will be achieved through conducting and publicizing research aimed at an improved understanding of the sensitivity of Canada's landmass and coastal areas, and through the incorporation of new knowledge in planning and resource management. The Program's six projects are linked by common themes, including landscape and ecosystem vulnerability. Of these projects, five have a specific interest in water-related issues. The project study areas overlap geographically and share common socio-economic aspects.[15]

Geomatics for Sustainable Development of Natural Resources Program

Effective natural-resource management requires geospatial data and information to support actions and decisions. The Geomatics for Sustainable Development of Natural Resources (GSDNR) Program provides consistent, reliable, high-quality, accurate geospatial information to ensure that clients and stakeholders have the capacity to make responsible decisions. Consistent improvements are being made to the reliability and use of this information by incorporating new sources of data, where applicable, and moving towards integration with other reference sources within NRCan.

As part of the GSDNR Program, a national-scale watershed framework has been developed in partnership with the Water Survey of Canada (Environment Canada). This framework is being utilized for environmental indicator reporting by Agriculture Canada, Statistics Canada and Environment Canada. Work has also been completed to harmonize a water mapping framework for North America in partnership with the U.S. and Mexico, as a base for continental environmental reporting.

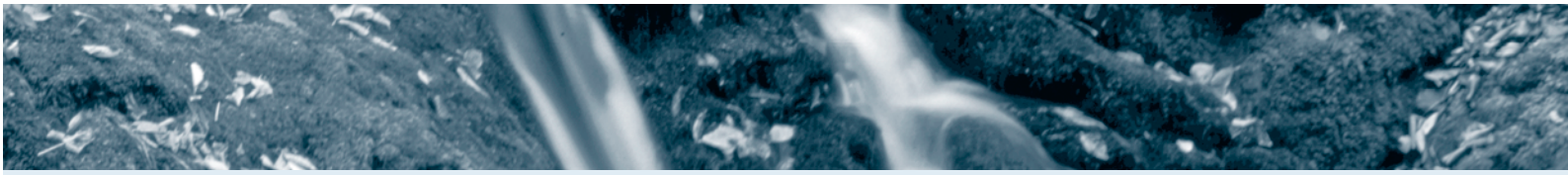
In addition to these generalized frameworks, production has started on the National Hydro Network—a federal-provincial partnership to build a detailed digital hydrological database for the nation.

GSDNR Projects

- Communications, Outreach and Assessment
- Image Processing Standards for Earth Observation Data
- Geomatics Services for National Parks and Ocean Spaces
- National Imagery Coverage – Landsat 7
- GeoNames Applications
- Geographical Names Board of Canada Secretariat
- National Atlas Frameworks
- National Elevation Data
- National Hydro Network
- National Transportation Networks

Source: http://gsdnr.nrcan.gc.ca/project_e.cfm

Almost 9%, or 891 163 km^2, of Canada's total area is covered by freshwater.



Program highlights:
Reducing the Vulnerability of Canada's Water – RCVCC Program Projects

The **Earth Science for National Action on Climate Change** project generates new knowledge in key areas where gaps were identified by the Canadian Climate Change Program and the Intergovernmental Panel on Climate Change (IPCC). Relating to water, research activities tackle 'Cryosphere Changes: Glaciers and Permafrost'; 'Coastal Zone Changes'; 'Ecosystem Impacts'; 'Surface Water Availability'; and 'Canada's Landmass Response to Climate Change from Satellite Records'.

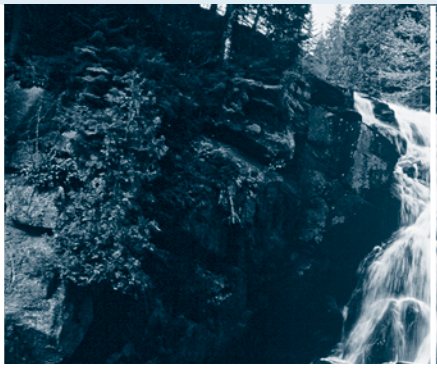
The **Regional Climate Change Impacts: Geoscience Information for Other Government Departments** project emphasizes the development of information-sharing relationships with key clients, including federal, provincial and territorial transportation agencies, territorial governments, and environment and water resource agencies. A particular activity that relates to water is the 'Impact of Climate Change on Regional Snow/Ice - Dependent Water Supply'.

The **Municipal Case Studies: The Planning Process and Climate Change** project has undertaken a limited number of case studies that will address a representative cross-section of the major climate change issues facing Canada (water resource depletion, coastal attack due to higher sea levels, and permafrost melting). The project relies on the involvement of municipal planners and stakeholders in the individual case studies, and will communicate results through collaboration with the Canadian Institute of Planning, provincial planning institutes and the Federation of Canadian Municipalities. One such study that relates to water is the 'City of Calgary Case Study: Municipal Water Supply'.

The **Paleo-environmental Records of Climate Change** project goal is to provide paleo-climatic, paleo-environmental and, paleo-geographic data required by scientists and policy makers in developing or using realistic scenarios for assessing potential future impacts caused by climate change. As well, clients for these data are scientists developing numerical models of past climate change (ice sheet evolution, hydrology, crustal motion and paleo-biome shifts) who require paleo-data for verification and development of these models. Outputs from this project will provide paleo-scenarios for evaluating the potential response of specific regions or environments to climatic change, and will help to constrain or validate simulations of past climatic changes. Three activities relate particularly to water: 'National Paleo-environmental Records of Climate Change'; 'Regional Scale High-Resolution Reconstructions of Paleo-Climatic Variability'; and 'Critical Process Thresholds from Past Climate Changes'.

Finally, the **Socio-Economic Vulnerability and Integrated Assessment** project goal is to address the cost issue by linking scientific assessments of climate change vulnerability with socio-economic dynamics for improved understanding of socio-economic costs and vulnerability. From case studies, regional and local cost estimates will be generated, including impacts of coastal erosion and extreme events on selected eastern and western coastal communities; costs of permafrost degradation to northern communities; and costs of declining water resources to communities in the Prairie region.

Annually, Canada's rivers discharge 105 000 m^3/s, 7% of the world's renewable water supply.



Climate Change Impacts and Adaptation Program

The Government of Canada is committed to improving our knowledge of the impacts of climate change and identifying appropriate adaptation measures.

The Climate Change Impacts and Adaptation Program, delivered through Natural Resources Canada, helps meet this commitment by providing funding for research and activities to improve our knowledge of Canada's vulnerability to climate change. This will enable Canadians to better assess the risks and benefits posed by climate change, and to build the foundation upon which appropriate decisions on adaptation can be made.[16] The Program also facilitates interaction between stakeholders and researchers through support of the Canadian Climate Impacts and Adaptation Research Network (C-CIARN) and defines research priorities. There are 13 regionally and sectorally based C-CIARN offices, one focussing on water resources[17] and another on landscape hazards including flooding and drought.

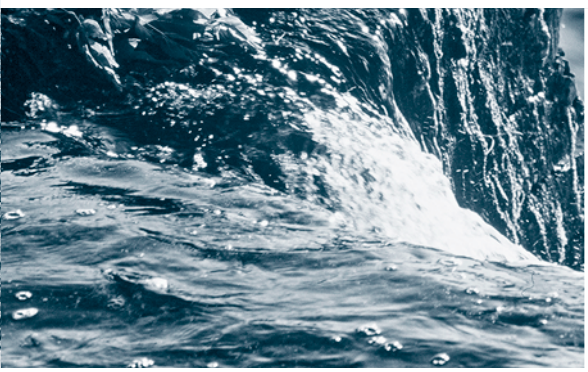
Natural Hazards and Emergency Response Preparedness Program[18]

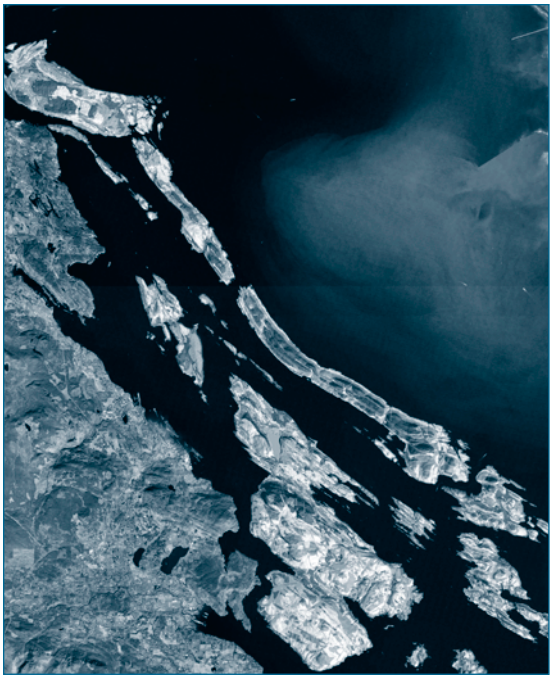
This Program assists in the mitigation of natural hazards and is intended to reduce the loss of life and economic costs of all natural disasters in Canada. To reduce losses from natural hazards, the Program works with national and international partners and clients to produce: a modern robust analysis of seismic risk, suitable for developing a modern building code; effective forecasts of magnetic storms and mitigation strategies against damage to electrical grids, satellite communication and pipelines; and landslide, tsunami, tidal wave, flood- and volcano-hazard inventories and assessments, used to build effective response scenarios and disaster mitigation for populated centres at risk.

Emergency-response programs are enhanced through the provision of comprehensive digital and custom maps for emergencies, integrated hazard and infrastructure information, and the capacity to measure radiation contamination from accidental dispersal or potential terrorist acts.

NRCan responds to natural hazard emergencies

During and immediately following the flooding of the Saguenay River in 1996, and the Red River and in 1997, NRCan took action to assist. The Department contributed satellite imagery to monitor flood development and maps to assist in rescue and recovery operations. Immediate reconnaissance was undertaken to assess the of the impacts and significance of flood sedimentation—information critical for health considerations. In the case of the Red River flood, NRCan initiated an assessment of long-term flood hazards, influencing the International Joint Commission recommendations for major revisions to flood protection works in Winnipeg and southern Manitoba.





Pathways output: An intrinsic aquifer susceptibility map provides an assessment of water quality in fractured bedrock aquifers in the Gulf Islands, B.C.

Sustainable Development through Knowledge Integration – The Pathways Project[19]

The Pathways Project is part of the Sustainable Development through Knowledge Integration Program (SDKI). SDKI aims to move selected portions of the Earth Sciences Sector's information and knowledge assets into the decision-support environments of government, industry and the public. The Pathways Project specifically aims to bridge the gap between science knowledge and policy decision-making for issues related to resource scarcity and public safety in selected local and regional areas in southern B.C.. Pathways activities focus on adding value to traditional ESS information through the development of vulnerability, risk and land-use assessments related to groundwater and natural hazards. The Project is also integrating a suite of methods and web-based tools. Pathways provides decision support for current land-use decisions and the assessment of future growth strategies that may impact groundwater quantity and quality. In addition, the Project is developing and refining a sustainable water yield model for surface and groundwater availability in the study areas.

Legislated Environmental and Resource Assessments (LERA)

The LERA Program provides resource assessments so that the mineral and energy resource potential is duly considered when establishing protected areas. These assessments will apply to lands under federal jurisdiction and under consideration as National Parks, Marine Protected Areas or other special designations that restrict mineral or energy development, including those in the territories (Yukon, Northwest Territories, Nunavut) and Canada Lands off-shore. In response to federal government agencies' requests and as required by the *Canadian Environmental Assessment Act* (CEAA), the Program will also provide expert geoscience reviews of projects undergoing environmental assessment ensuring the identification, consideration and minimizing of adverse environmental impacts.[20]

Through NRCan's LERA Program, the expertise of Geological Survey of Canada (GSC) is constantly sought to review environmental impact statements (EIS) for projects of various sizes throughout Canada; these may include mines, pipeline developments, waste-disposal facilities, etc. GSC's hydrogeologists are often asked to comment on water quantity and quality issues in their review of EISs. GSC permafrost scientists, in their review of EISs for northern mining projects, are often asked to comment on the

design and impacts associated with tailing containment facilities that rely on permafrost for dam foundations or encapsulation of waste (which is directly applicable to water quality). Through LERA, NRCan plays an important role in ensuring that water quality and quantity issues are adequately considered in environmental assessments, and that related environmental impacts are minimized and/or mitigated.

Metals in the Environment Program[21]

This program supports the assessment and management of ecosystem and human-health risks posed by metals in the environment. This is achieved by informing regulations and risk-management decisions with improved understanding of the presence of metals in the environment.

Water is a conduit for metals to be transported and is an important entry point for metals into the food system. The Metals in the Environment Program characterizes the surficial environment, including water, with respect to concentrations of metals and thereby identifies areas at potential risk of toxicity. Additionally, activities within the Program investigate geochemical processes which affect the level and bioavailability of metals. Overall this information is passed to other departments for developing risk-management policies.

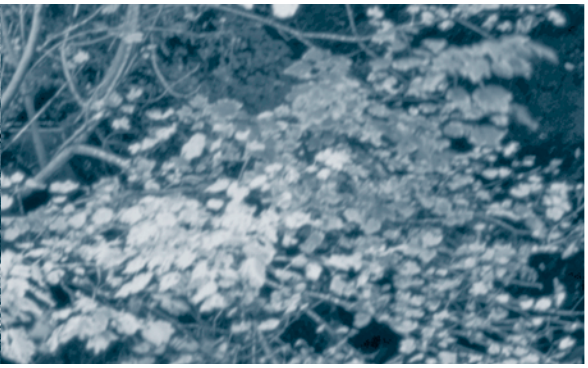
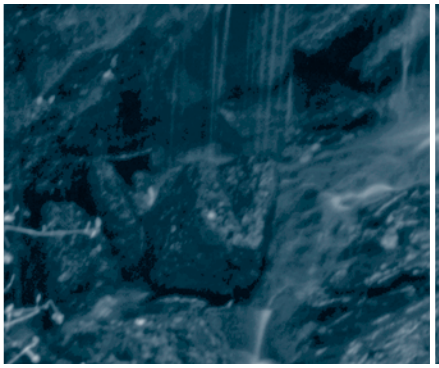
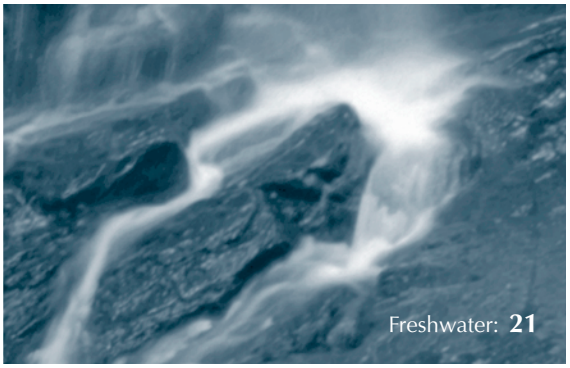
Energy

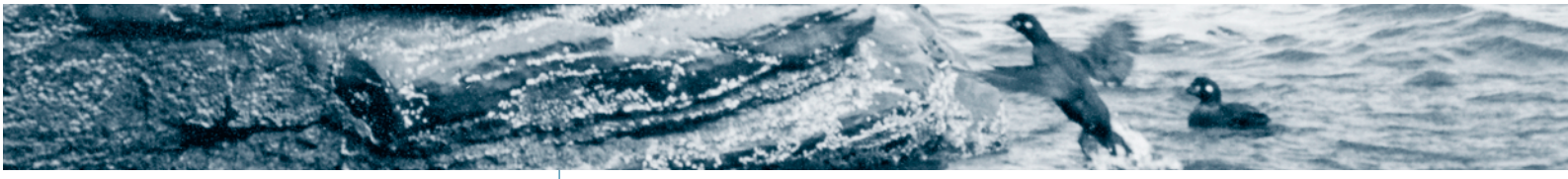
Water Issues and Energy

Water and energy have numerous commonalities: both are essential to human well-being, limited in supply, and subject to a growing demand. As world population grows and living standards rise in developing nations, there will be increased pressure on these resources. Water and energy issues are also interconnected; for example, the delivery of water depends on energy for pumping, and many forms of energy production require a dependable water supply. A combined approach to water and energy issues makes sense, for both developed and developing nations.[22]

In Canada, oil and gas development and the generation of hydroelectricity require significant water supplies. In fact, the energy industry withdrew 63 percent of all surface water used in Canada in 1996, making it the single largest user of water. At least 40 percent of this water is recirculated, and 98 percent is discharged.[23] The three main water users within the energy sector are the oil and gas industries, thermal electric generators, and hydroelectric power plants.

Significant potential exists in Canada for conflict between competing users of water. This conflict is already emerging in the western provinces where increasing and competing demands for water by both existing agricultural operations and oil and gas development have escalated into a significant and sometimes heated public-policy issue.



Public Concern

In addition to water-quality issues, some of the public concerns raised in Alberta have included:

- The volume of water being used for enhanced oil recovery;
- Opportunity costs of using surface water for enhanced oil recovery instead of irrigation;
- The risk of wells drying up due to the energy industry's use of groundwater; and
- Perceived limits on agricultural expansion resulting from the energy sector's water use.

Oil and gas industry

The petroleum sector is a large user of water, although a much smaller user than irrigation, commercial cooling and municipal users. This sector, including water injection for oil recovery purposes, was allocated slightly over 4.6 per cent (2.7 billion barrels) (Fig. 3-4) of the total 60 billion barrels of water that were allocated in Alberta in 2002.[24]

The quantity and use of water in Alberta has become a high-profile issue due to many factors. The consecutive years of drought, dwindling water supplies and the rapid growth and expansion of industries and population in Alberta have all played a role in increasing the demand on Alberta's water supply, thereby raising stakeholder concern about the supply of water for the future.[25] As part of its *Water for Life – Alberta's Strategy for Sustainability*, the Alberta government is currently assessing water demands and at the watershed level.[26] The Senate Committee on Environment and Natural Resources expressed particular interested in these issues during a recent hearing with the Honourable John Efford, Minister of Natural Resources Canada.

Water use in conventional oil recovery

In conventional recovery, oil is extracted using a well that either allows the oil to flow naturally to the surface or pumps the oil to the surface using artificial lift. Once primary production is complete, secondary or tertiary oil recovery techniques can be used to recover more of the oil resource. In secondary recovery, water or gas is injected into the reservoir to maintain pressure, and water flooding is used to drive the oil through the reservoir to the producing wells. Tertiary recovery techniques include thermal, gas, solvent and chemical recovery processes. A large amount of water is recycled during the water-flooding process. However, water ultimately replaces the oil that is removed from the reservoir and cannot be recovered, and is therefore removed from the hydrological cycle. It is this loss of water from the cycle that is the greatest concern among stakeholders, especially when freshwater is used.[27]

Use of water in oil sands development

Water is an integral part of the oil sands industry for both surface mining and in situ projects. Mining occurs where bitumen deposits are located near the surface and can be recovered by open-pit mining techniques. In situ projects, in which the bitumen is extracted in-place, occur where bitumen deposits are buried too deeply (more than about 75 metres) for mining to be practical. Water from rivers and/or groundwater is used in oil sands projects. Projects located close to a river, as is the case for the existing surface-mining operations, will draw some river water. In situ projects typically use fresh or saline groundwater as their source. In either case, it should be noted that recycling of water to reduce overall requirements is common and that brackish or saline groundwater is used wherever possible.

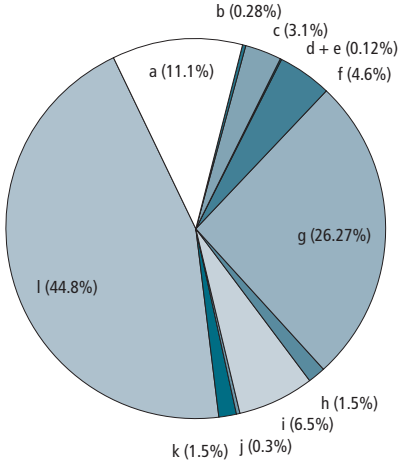
In mining projects, water is used create a slurry of the oil sand ore that is then transported by pipeline to the extraction plant where more water is added and the bitumen is separated the from the sand. Water is also used in integrated operations to upgrade the bitumen to synthetic crude oil. About 70 percent of water is recycled, leaving a balance of two to three barrels of water being used to produce one barrel of synthetic crude oil.[28]

In addition to the above noted uses of water, mining operations affect the natural water flows in the area. To keep the mine area from flooding, water flow from nearby aquifers is diverted, overburden and adjacent formation is dewatered, and muskeg is drained. Overburden, the layer of material (muskeg, shale) between the surface and the underlying bitumen ore, is stripped before the oil sands can be mined. Mining projects route tailings to the tailings-management area where clay and sand separate out of the water. Sand separates rapidly leaving suspended clay and fine sand particles in the tailing pond. As the tailings solids settle, all water released is recycled back to the plant. The long-term objective is to return lands to their pre-mining condition (or as close as possible) within a 10- to 50-year timeframe. This involves topography and watershed reconstruction, as well as vegetation and wildlife repopulation.

In the case of in situ projects, water is used to produce the steam that is injected into the reservoirs to heat up the bitumen and reduce its viscosity in order to bring it to the surface. Because water for steam generation is largely recovered with bitumen produced, and is continuously treated and recycled, net water consumption for in situ production is considerably smaller than for the mining operations. The industry has increased the amount

Figure 3-4:
Water allocation in Alberta by specified purpose

(surface plus groundwater, based on existing licences as of 2001)



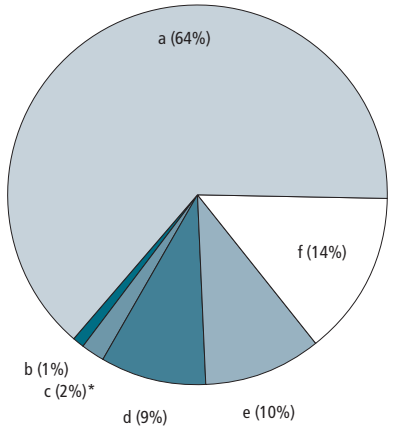
a Municipal
b Recreation
c Water Management
d Other Purpose Specified by the Director
e Wildlife Management
f Oil & gas
g Commercial (Cooling)
h Agricultural
i Commercial
j Fish Management
k Habitat Enhancement
l Irrigation

Total Licensed Volumes = 9,443,795,000 m^3
(9,259,492,000 m^3 surface water;
184,303,000 m^3 groundwater)

Source: *Water and Oil: An overview of the use of water for enhanced oil recovery in Alberta*. Government of Alberta, March 2004.

How Canada uses its water

In Canada, almost two out of every three litres of water are withdrawn for thermal power generation. Here's how Canada's 44.7 billion cubic metres of annual freshwater withdrawals are put to use.



a Thermal power generation
b Mining
c Rural
d Agriculture
e Municipal
f Manufacturing

*Municipal and rural percentages include: residential, commercial/institutional and other non-industrial uses.

Source: Environment Canada, 2004

of water that is recycled, typically more than 90 percent, for a net loss of less than 0.2 to 0.3 units per unit volume of bitumen.[29]

The recent oil sands expansion announcements have led to concerns regarding water availability for these new and expanded commercial operations. Questions have been raised regarding the ability of some watersheds to meet the projected demand for water by oil sands developments. Although groundwater is used in most oil sands projects rather than river or lake water, the choice is dependant on where the project is located with respect to water supplies. A project with no river or lake water source close by has no choice but to use groundwater as its source.[30]

With knowledge gaps concerning the actual supply of freshwater and a forecasted increase in oil sands development, it is anticipated that this issue will continue to be a priority among concerned stakeholders. More data collection and research is required to create a sound knowledge base to support decision making on the oil sands industry's use of freshwater sources in its extraction processes.

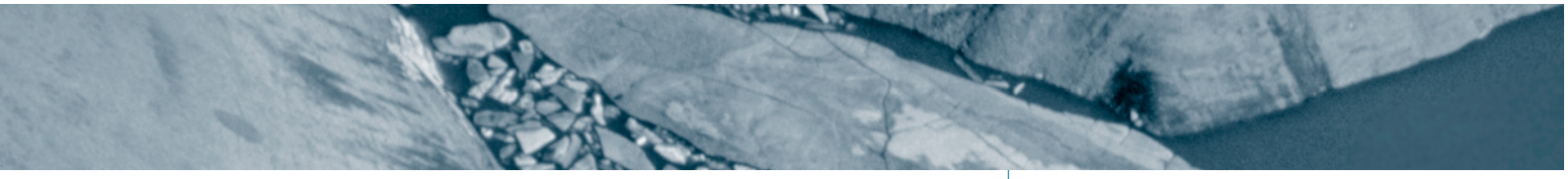
Thermal and nuclear power plants

Thermal and nuclear power plants generate electricity by converting water into high-pressure steam, which then drives turbines. Water is also used as a coolant to condense the steam back into water. The main issues arising from thermal and nuclear generating plants' water use include the impacts of withdrawing large volumes from aquatic ecosystems, the effects of temperature change caused by thermal plant water discharge, and the potential release of impurities into the environment.[31]

Hydroelectric power generation

The amount of electricity a hydro power installation can produce depends on the quantity of water passing through a turbine (the volume of water flow) and on the height from which the water falls (the amount of head). The greater the flow and the head, the more electricity produced. There are different types and sizes of hydro power installations in Canada, ranging from micro hydro plants that provide electricity to only a few homes to mega-installations, such as Churchill Falls in Labrador which produces enough power to light three cities the size of Montreal.

In 1999, the total electric power generated from hydro sources was 340 464 GWh, representing 60.4% of the total generated electricity in Canada. Over 45% of that electricity was produced in Quebec.



Hydro power provides an opportunity to meet Canada's increasing energy needs, provide recreational uses, steady sources of water for drinking, forestry operations, and irrigation without substantially increasing greenhouse gas emissions, or increasing air emissions, smog or acid precipitation. However, there are impacts of building dams that must be considered.

In Canada, there are over 600 large dams, and 54 inter-basin diversions created mainly for the purpose of hydroelectric power generation.[32] An inter-basin diversion is the withdrawal of water from its basin of origin for use in another drainage basin. Dams can alter the natural habitat of fish, and result in changes in plant life and nutrient levels which can impact the food chain.[33] Other potential impacts of reservoirs and inter-basin diversions include effects on water quality in terms of temperature, nutrient loading, mobilization of mercury from soils, and changes to sediments and the amount of silt in the water. Reservoirs can also alter the timing and distribution of streamflow, which in turn, disrupts ecosystems upstream as well as downstream.[34]

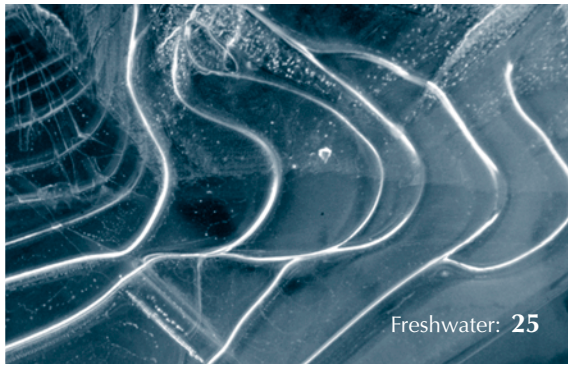
Today, more emphasis is being placed on small hydroelectric developments and run-of-river facilities. A recently completed inventory of Canadian small hydro sites generating between 20 and 25 megawatts (MW) identified over 5,500 sites with a technically feasible potential of about 11,000 MW.[35] Small hydro stations particularly in New Brunswick, Nova Scotia, Ontario, and Alberta produce about 2,000 MW. This capacity is only a small contribution to the total Canadian installed hydroelectric capacity of 70,000 MW.[36]

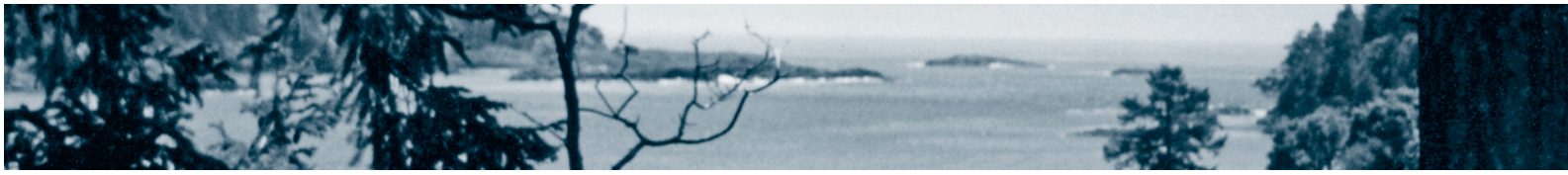
Responding to Stakeholder Challenges

For the past decade hydroelectric companies have been facing challenges from many stakeholders, including Aboriginal communities, fisheries agencies, environmental groups, and recreational users, about the allocation of water resources. Companies have been developing water planning processes involving extensive stakeholder consultations to ensure their continued 'licence to operate' while balancing stakeholder needs and other resource values.

World Water Council
First International Summit on
Sustainable Use of Water for Energy

Columbia Power Corporation's Brilliant Dam on the Kootenay River, near Castlegar, B.C.





Water-Related NRCan Energy Sector Activities

NRCan's Energy Technology and Programs Sector enhances the economic and environmental well-being of Canada by fostering the sustainable development and use of the nation's energy resources through technology innovation, development and demonstration. Activities include: the enhancement of water management in the energy industry, reduction of contaminated water discharge from the recovery and processing of oil sand bitumen and heavy oil, supporting the development of CO_2 sequestration technologies using depleted oil reservoirs and aquifers, improved oil sands processing technologies for greater water recycling, and improved hydrocarbon-water separation technologies that reduce the discharge of oily water from various hydrocarbon processes and sites. These projects contribute to reducing the demand for freshwater and also decrease the negative environmental impacts of energy development.

Managing Cumulative Effects

NRCan is an associate member in the Cumulative Environmental Management Association (CEMA), a multi-stakeholder group that has been set-up to look at issues related to the cumulative environmental effects of Athabasca oil sands development—including water management—especially in the Wood Buffalo Area.

Water use in oil and gas production

NRCan is involved in issues related to the cumulative effects of development, particularly as it relates to the oil sands, and has a number of science and technology initiatives dealing with water use in oil and gas production.

CANMET Energy Technology Centre tailings research

NRCan scientists at CANMET Energy Technology Centre (CETC – Devon, Alberta), have developed a comprehensive understanding of the implications of water chemistry on surface mined bitumen extraction performance and tailings behaviour. These researchers have also built a water chemistry model capable of simulating process water chemistry changes associated with recycled water use decades into the future.

NRCan researchers were directly involved in the development of composite or consolidated tailing (CT), and paste tailing technologies for oil sands tailings. These technologies result in rapid water release from tailings and reduce make-up water demand by providing more recycle water for the process. Paste has the added advantage of recovering heat from the waste water. The tailings activity at CETC–Devon also includes research and development and/or evaluation of more aggressive tailings treatments that can return even more water to the extraction process than CT or past technologies.

The Oil Sands Tailings Research Facility (OSTRF) was opened in 2004 at the Devon Research Centre to develop long-term technology options for oil sands tailings management. The OSTRF is a joint partnership between CETC-Devon, University of Alberta, Alberta Research Council and the oil sands industry with start-up funds provided by Canada Foundation for Innovation.

Science and technology development

NRCan researchers are evaluating and researching new extraction technologies that would use less water per barrel of bitumen extracted at both mining-based and in situ oil sands operations, and/or tolerate the use of poorer-quality water streams rather than draw from the Athabasca River.

Through the Petroleum Technology Research Centre (PTRC) in Regina, Saskatchewan, NRCan is financially supporting research on 21st-century water flooding. That work is expected to help improve our understanding of water injection on reservoir processes and reduce the need for potable water use in water flooding (i.e. increased saline groundwater and recycle fractions).

NRCan was a major sponsor of the four-year International Energy Agency Greenhouse Gas Weyburn CO_2 Monitoring and Storage Project, led by PTRC. Funding was provided during 2000-2004 towards the study of CO_2 sequestration through tertiary recovery at the EnCana Weyburn CO_2-EOR (enhanced oil recovery) operation in southeastern Saskatchewan, which was previously operated solely as a water-flood oil recovery field. More than one-quarter of the oil production at Weyburn is now attributed to CO_2-EOR. A further phase of the project is expected to begin in April 2005 to further improve the understanding and operation of CO_2 sequestration in partially depleted oil reservoirs.

Small hydroelectric power technology

There is considerable scope for the development and optimization of this renewable, non-polluting energy source. Small-scale hydroelectric facilities have a valuable role to play in meeting Canada's energy requirements, particularly those of rural regions, in a sustainable and environmentally friendly manner. Natural Resources Canada supports the development of small hydroelectric facilities in Canada through the programs described below. More information is available on the program web sites referenced in the notes.

Renewable Energy Technologies R&D Program[37]

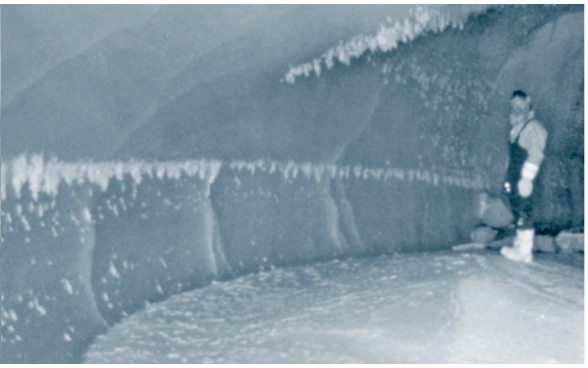
The Small Hydro Technology Development Program is part of NRCan's Renewable Energy Technologies (RET) Program. Its objective is to promote the development of appropriate technology to make it more economical to develop a greater range of small-scale and low-head hydroelectric resources. This Program responds to the needs of the Canadian small hydroelectric industry, and brings together the expertise in industry, universities and other relevant government programs. The Program is now concentrating on tools and techniques for reducing equipment and construction costs.

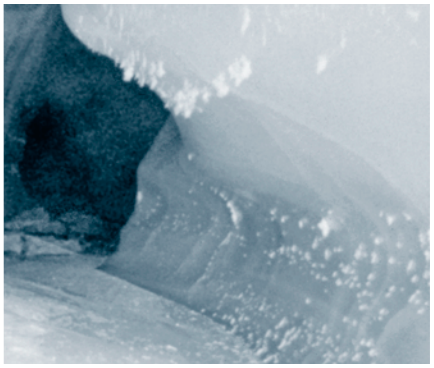
Renewable Energy Policy and Market Development[38]

NRCan's Renewable and Electrical Energy Division promotes the development of a sustainable renewable energy industry in Canada, including small hydro. The Division promotes investments in renewable energy systems for heating and cooling and provides information on renewable energy technologies. It also provides analysis and advice to the Minister on electricity issues in Canada. By strengthening markets for the renewable energy industry, the Division's programs will contribute to the reduction of greenhouse gas emissions and reduce traditional water needs in the energy sector, as well as fostering job creation and export sales.

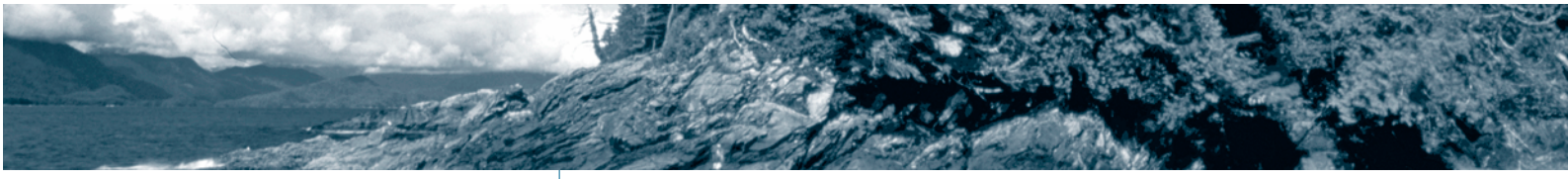
The Canadian Renewable Energy Network[39]

The Canadian Renewable Energy Network (CanREN) was created to increase understanding of renewable energy to accelerate the development and commercialization of renewable energy technologies. CanREN promotes what NRCan and its partners are doing to advance the role of renewable energy, including small hydro, in Canadian society. It offers general information on renewable energy sources, highlights the technologies and applications being developed to harness these sources, and presents Canadians with the knowledge and support they need to make renewable energy part of their everyday lives.



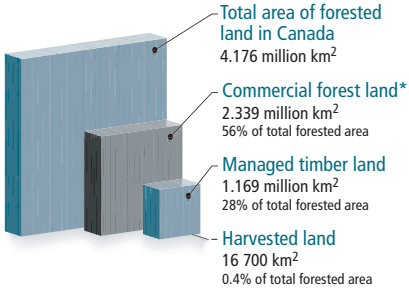


In the developed world, roughly 70% of hydroelectric power generation potential has already been developed; in the developing world, only about 10%.



Canada's forest story

Although forests cover more than two-fifths of Canada's total land area, only a small sliver of that is harvested each year. The chart below shows how Canada's forest land is used.



Slabs are shown in relative proportion to total area of forested land.

*Commercial forest land is capable of producing timber and non-timber products such as maple products and Christmas trees.

Source: Environment Canada, 2004

Forests play a key role in moderating climate, regulating water systems, preventing erosion, alleviating air pollution and providing wildlife habitat.

Forestry

Water Issues and Forests

There are approximately 418 million ha of forests in Canada, accounting for about 10 percent of the world's forests. Our forests contribute $34 billion to Canada's GDP and provide 376,000 direct jobs for Canadians. Canada is the world's largest exporter of forest products ($40 billion in 2003).

Canada's forests are not only vital to our economy, but also to our nation's water supply. Forests are an integral part of the hydrological cycle; they recycle water to the atmosphere, which decreases water transport into ground and surface water. In addition, they filter air and water, moderate climate, provide habitat for wildlife, stabilize soil, and form a dominant feature of Canada's economy, culture, traditions and history.

Forest hydrology research[40]

Forest hydrology research in Canada was strongly supported by government in the late 1960s and early 1970s, a period known as the International Hydrological Decade. Gauges were set up and monitored in many watersheds, and a variety of studies examined the most immediate impacts of clear-cut harvesting practices on stream flow and erosion. The results of these studies were used in developing current forest management practices, which protect Canada's soils and freshwater resources. Although most harvesting operations still involve a one-pass removal system (clear-cutting), significantly smaller cut-blocks, protection of residual stands and gradual removal approaches, including selection cutting, shelterwood felling, and seed tree method, are increasingly used in Canada. The overall size of clear-cuts generally has been reduced, and the number of unharvested strips (leave strips) within cutblocks has increased.

Timber harvesting impacts on watersheds

A number of major urban centres derive all or some of their water supplies from forested watersheds. Because of these attributes, forested watersheds provide a range of important services to humans including provision of clean stream water and support of healthy aquatic ecosystems.[41] Research has demonstrated that the most significant impacts to forested watersheds following timber harvest are changes in water table levels, stream flow, water quality, erosion, and sedimentation. It is likely that similar changes occur after fire. Notably, watershed impacts differ between forestry practices and other land uses, including agriculture and mining.[42] As a general rule, harvesting impacts on stream flow regime and water quality are usually short-lived and less severe

than those brought about by land-use changes, provided that forest soils are protected and vegetation recovery is rapid.[43]

The increase of sediment in water streams is linked to the building and use of forestry roads, and to direct disturbances of the stream bank by machinery.[44] Changes in forestry practices have been implemented across Canada to minimize these impacts. When regulations are respected, inputs of sediments into streams because of forest operations are short-lived and often small.[45]

Forest products manufacturing

There are about 155 pulp and paper companies in Canada, with over 500 more in related industries such as converted paper products, asphalt roofing paper, paper box, and bag industries. In 2002, shipments of pulp and paper totalled 30.5 million tonnes, for a value of approximately $26 billion. In 2001, Canada was the world's leading newsprint producer, with approximately 92 percent of newsprint production destined for export markets. The majority of the pulp and paper producers are world-scale operations located in remote communities close to the forest resource. The pulp and paper industry throughout Canada, particularly in the west, fulfills most of its fibre needs from chips produced in sawmills as a by-product of lumber making.[46] Although the pulp and paper sector has significantly reduced bark and wood waste production through process recycling, the management of water and wastewater residuals continues to be a major issue at most mills.[47]

Water use and wastewater in mills

The pulp and paper industry, because of its diverse nature, can release a wide range of compounds into the aquatic environment. Research done on pulp and paper effluents has implicated fibre and suspended solids, colour and turbidity, and organic and nutrient enrichment loads as the three conventional pollutant factors with adverse environmental impacts.[48] The pulp and paper industry is also the third largest industrial polluter to air, water, and land in both Canada and the United States, and releases well over a hundred million kg of toxic pollution each year.[49] Over the last ten years the pulp and paper industry worked closely with the federal government, environmental non-governmental organizations, the provinces and other key stakeholders to ensure compliance with regulations under the *Canadian Environmental Protection Act* and the *Fisheries Act*.

The Canadian pulp and paper industry has invested billions of dollars towards research and technology aimed at reducing its emissions and improving the quality of their effluent. These investments in processes and technological changes have allowed the industry to achieve the following results:

- reduced releases into water of chlorinated dioxins and furans by 99%;
- decreased its carbon dioxide emissions (CO_2), a key greenhouse gas, by 26% from 1990 levels;
- reduced the use of products containing the toxic substance nonylphenol and its ethoxylates (NPE) by 99.8%; and
- led to a 94% reduction in Biochemical Oxygen Demand (BOD) discharges and a 70% decrease in discharges of total suspended solids (TSS).[50]

Although mills have been successful in dramatically reducing the toxicity of their effluents, environmental effects monitoring data show that impacts continue in the aquatic environment.[51]

Pulp and paper mills are big users of water. There are four essential functions of water in pulp and paper mills:

- Process chemicals (e.g., adding water to sodium chlorate),
- Conveying/controlling material through manufacturing unit processes,
- Separating and purging contaminants from the product, and
- Cooling: a significant water activity in mills to remove heat from different plant processes.

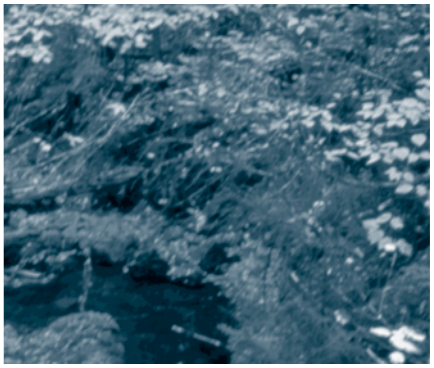
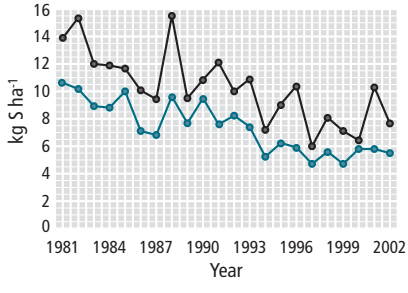


Figure 3-5:
Effects of pollution on watersheds

The deposition of sulphate has decreased at Turkey Lakes Watershed since the project began in 1980. There has been a parallel decrease in the amount of sulfate being released from small forested watersheds. These results demonstrate the effectiveness of pollution abatement strategies on ecosystem recovery.



Water-Related Canadian Forest Service Activities

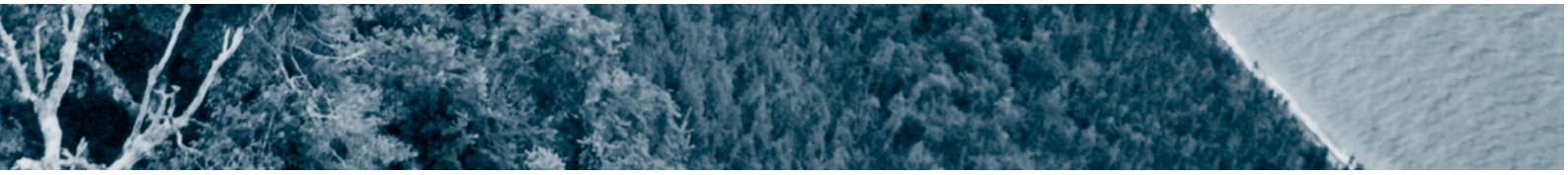
NRCan's Canadian Forest Service (CFS) has long recognized the need to better understand the linkages between forests, forestry practices and freshwater quantity and quality. NRCan science and policy activities regarding sustainable forestry and water-resource management cover a wide range of issues including: natural and forest management disturbances (including forestry practices) on water quality, quantity and forest hydrologic systems; innovative water resource conservation activities; best practices and knowledge transfer to policy making; and understanding how changes in climate affect the relationship between water and forestry practices.

Effects of forest practices on water quantity and quality

Timber harvesting has either positive or negative impacts on surface and ground water depending on the nature of the site and disturbance. To further understand the effects of human activities and other disturbances on forests and the environment, CFS conducts research on water and air quality, in collaboration with colleges and universities, other federal and provincial agencies, and private industries. This type of research provides a basis for the improvement of the harvesting regulations implemented by the provinces. These regulations minimize the negative impacts of harvesting by requiring, for example, stream-side buffer strips, road-building methods that control the discharge of surface water, and improved design of culverts and bridges.

Effects of pollution on watersheds

While some environmental concerns related to the forestry sector have been successfully addressed, there remains a need to better understand the role of forests in the global water cycle, and the cumulative environmental impacts of anthropogenic pollutants, sulfates, and nitrates on forests (Fig. 3-5). To address some of these concerns, CFS, in collaboration with partners, is monitoring water quality at a study site near Sault Ste. Marie, Ontario. The Turkey Lakes Watershed Study, is a multi-agency endeavour initiated in 1979 to evaluate the effects of human disturbance on Canadian Shield ecosystems. Participants in the study include both the federal and provincial governments and several universities. Originally focussing on the effects of acid rain alone, the study has evolved to include research on the effects of other pollutants and ecological disturbances such as forest harvesting and climate change.



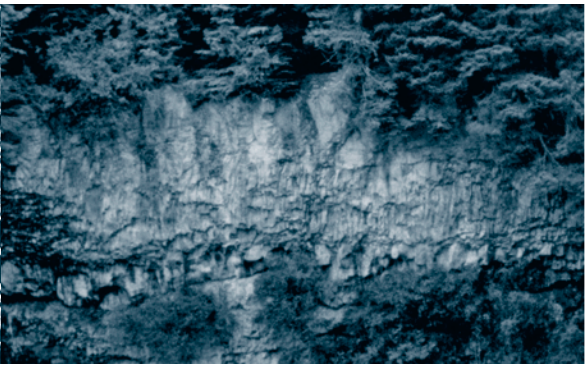
Measuring stream flow in a small river near Turkey Lakes Watershed. Long-term records of stream flow and other physical and chemical parameters allow researchers to measure how forested ecosystems are responding to human impacts, such as forest harvesting, changes in pollution levels and longer-term climate fluctuations.

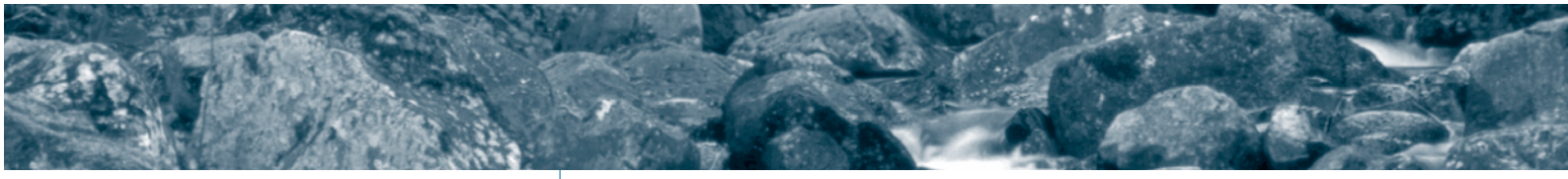
Effects of pesticides on water quality

As part of its forest protection program, CFS investigates the fate and persistence of forest pesticides in water bottom sediments and aquatic systems, including fish, amphibians, aquatic insects, zooplankton, phytoplankton and microbial communities. Studies not only measure individual, population, and community-level effects, but include biotic interaction and ecosystem processes, and try to comprehend multiple stressor effects.

Effects of forest product manufacturing

NRCan supports research in the area of forest products manufacturing through institutes such as the Pulp and Paper Research Institute of Canada (Paprican). Paprican is a market-driven, applied research and technology institute whose mission is to enhance the technical competitiveness of the pulp and paper industries. From forest product research to technology dissemination, Paprican is integral to minimizing the pulp and paper industry's negative impacts on the environment. The three major environmental issues regarding the discharge of pulp and paper mill effluents are regulatory toxicity compliance, potential effects on fish reproduction, and fulfilling the regulatory environmental effects monitoring program correctly.[52]





Minerals and Metals

Water Issues and Minerals and Metals

Today, Canada is one of the world's largest exporters of minerals and mineral products. In 2003, minerals and mineral products provided 13.3 percent of Canada's total exports and contributed to the Canadian trade surplus. Some 80 percent of Canada's mineral and metal production is exported.[54]

Mining in Canada has a rich history going back almost 9000 years—that is the estimated age of evidence of mining discovered by archeologists in a quartzite quarry near Manitoulin Island, Ontario. During the 1600s, mining became a substantial economic driver for some communities in the Maritimes. Over the years, the number and size of mines have increased substantially, especially since the 1940s.[53]

The growth in mining activity has increased the volume of water required for mine site management and increased the total volume of mine wastes, resulting in the potential contamination of our environment and water resources.[54]

Peak concentrations of contaminants discharged from mine sites may occur many years after the peak of mining activity, and even after a mine closure. This delay of contaminant release can occur because of natural mine flooding, temporary acid neutralization and contaminant attenuation, and long groundwater transport times.[55]

Water use in mining

Through land use associated with mining, impacts on water can arise from a multitude of sources.

To gain access to minerals, metal and non-metal mines are dewatered using pumping wells, diversion techniques and near-horizontal drainage passages. In mining operations water is mainly used to extract and process ore at the mine site.[56] This water is often recirculated, and as a result many mines are able to minimize water discharge during operation; however the concentration of contaminants increases. Waters are then primarily (78 percent) discharged to freshwater bodies and undergo little beyond primary treatment.[57] After ore recovery is complete, previously drained underground mines and open pits refill with water, further diverting ground and surface water flows. Precise estimates of water intake and discharge associated with mining activities are difficult to obtain due to uncertainties associated with evaporative losses, and gains and losses through subsurface flow during both the active and inactive stages of mining.[58]

Water quality

Very large volumes of waste are produced by the mineral extraction industry. Water used in the mining process and the precipitation infiltrating mine tailings can become highly contaminated with metals, process reagents and other undesirable constituents that result in concerns about discharge waters and require the implementation of treatment technologies.

There are numerous examples throughout the world where elevated concentrations of metals in mine drainage have had adverse effects on aquatic resources and created severe impediments to the reclamation of mined land. Metal leaching (ML) problems can occur over the entire range of pH conditions, but are most commonly associated with acid rock drainage (ARD). Once initiated, metal leaching may persist for hundreds of years. In North America, metal leaching and ARD (ML/ARD) have led to significant ecological damage, contaminated rivers, loss of aquatic life and multi-million dollar clean-up costs for industry and government.[59]

Degradation of water quality continues for decades or centuries after resource recovery is complete. At this time, there is no accepted methodology for estimating the value of the lost use of water due to these long-term adverse changes in water quality.[60]

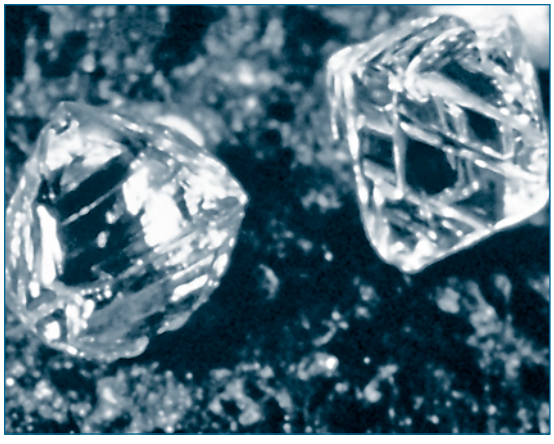
Preventing future degradation of water quality often requires mitigation facilities capable of functioning across both normal climatic ranges, but also after extreme climatic events. Assignment of design flood magnitudes is hampered in most mining districts due to a lack of long-term temperature, snow course, precipitation and hydrological data from which predictive calculations can be made.[61]

The development of treatment technologies for the mining sector presents special challenges. Removing toxic substances in effluents can be difficult and the regulatory framework is shifting the focus from concentration-based criteria, to acute toxicity and, increasingly, to the potential for long-term chronic impacts on ecosystems. Given that many mines are located in remote regions, including ones that may be sensitive to disturbances, it is critically important to understand the potential for impacts and develop the treatment and mitigation systems to ensure environmental protection.[62]

MMS played a central role in the revision of the Metal Mining Effluent Regulations (MMERs), which directly regulate the quality of water and waste water emitted from mining operations." Since the announcement of the revised MMER scientists have continued to play a vital role, developing data and approaches

Tailings pond converted to lily pond

It takes 39 090 gallons (about 148 000 litres) of water to manufacture a new car, including new tires.



towards applying and interpreting the regulatory context, assisting industry in working out solutions to problem discharges and continuing to build the understanding on the potential impact of mine effluents and how this should be assessed.

Through innovative research, development and technology transfer, the Mine Environment Neutral Drainage (MEND) Program has reduced the risk and liability associated with acid mine drainage by nearly half a billion dollars since its inception. This, in turn, has had positive implications for mineral investment, employment, regional development, human health and environmental quality throughout Canada and in other countries.

Water use in aggregate operations

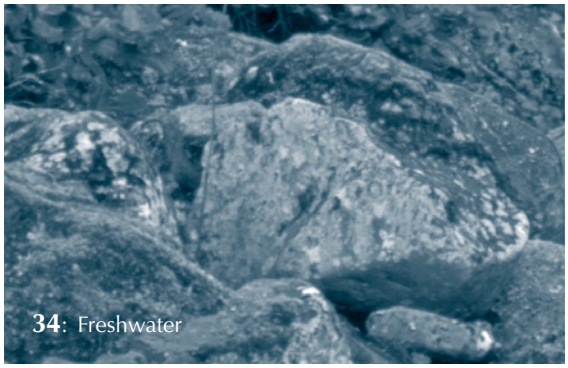
The volume of aggregate removed from pits and quarries is large. At any given time, there are many thousands of aggregate operations in Canada. Small aggregate operations are numerous and often follow construction activities. Near urban centres, aggregate operations are usually larger and can last for several decades or longer. Where water tables are high, extensive dewatering is required to gain access to rock and gravel. This dewatering can affect local water supplies and water levels of adjoining surface water bodies. Washing activities can result in increased suspended solids.

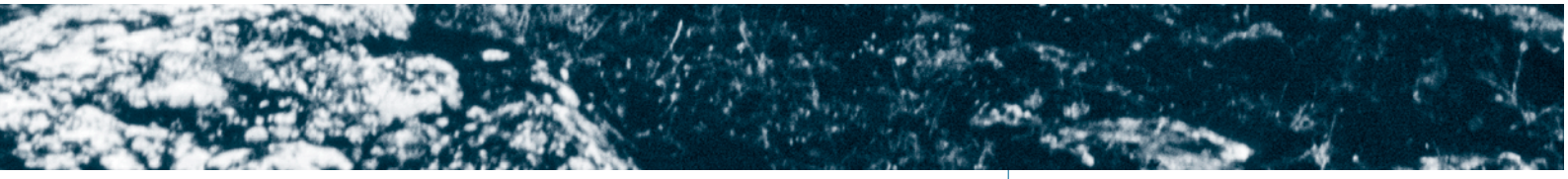
Impacts do not usually persist long after aggregate removal is complete. In urban areas, as shallow aggregate sources diminish, deeper operations become viable, and dewatering activities intensify.

There are numerous examples in urban areas of Canada, such as Calgary and Toronto, where water intake for aggregate production conflicts with other demands such as municipal, industrial and recreational uses. With increased urbanization, these conflicts are expected to increase in frequency.[63]

Water use in diamond mines

The initiation of diamond mining in Canada has introduced some new issues regarding water use. Despite the presence of apparently extensive surface water in the North, much of the terrain is actually semi-arid by most climatic classifications. As a result, there may be limited water available for dilution of mine effluent. These new mines have also resulted in increased interest in the use of permafrost both for dams and as a means of limiting sulphide oxidation. Greater information is needed on the long-term impacts of permafrost development on water consumption and water-quality management.[64]





Water-Related Minerals and Metals Sector Activities

The water issues addressed by NRCan's Minerals and Metals Sector (MMS) arise from use and disposal of metals and metal substances, as well as orphaned or abandoned sites that are contaminated. Understanding and mitigating the impacts on water resources are key factors for ensuring water quality, for maintaining markets for Canadian metal products, and for sustaining communities in Canada.

Assessment tools

Assessment tools are required to understand the potential for aquatic impacts on both a site-specific and an aquatic ecosystem basis. NRCan is actively engaged in developing the scientific and technological methodologies that improve the understanding of how to assess and mitigate against impacts in aquatic systems. For example, MMS is working on the development of physiologically based, bio-geo-chemical modelling approaches that can be used to predict the impacts of metals in aquatic systems on a site-specific basis. These developments have application in understanding the potential for impacts, setting effluent discharge objectives, identifying sources of toxicity and setting water quality guidelines and criteria. The development and application of these approaches is focussed on reducing regulatory uncertainty.

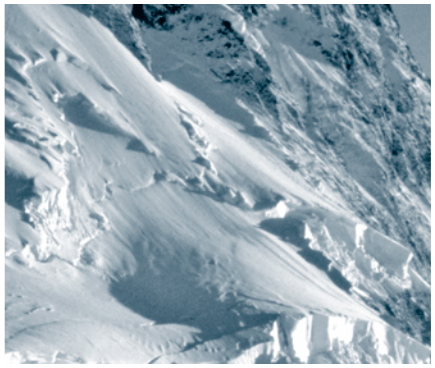
Treatment technologies

Affiliated with improved assessment tools and regulatory approaches is the need for innovative solutions with respect to the water-treatment technologies and water-use strategies within the mining and metals industry. These technologies will be essential to meet discharge targets and to maintain Canadian industry at the forefront of productivity, efficiency and environmental protection. These S&T activities help to ensure that Canadians are likewise able to benefit from the most innovative approaches in these areas.

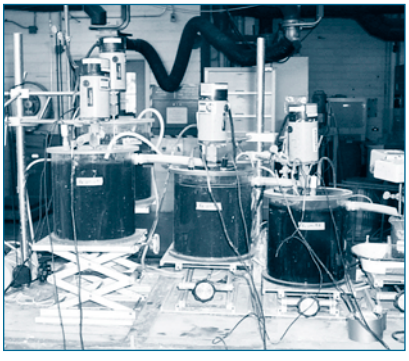
Stewardship and safe use

MMS leads Canadian involvement with a Life Cycle Initiative sponsored by the United Nations Environment Program and the Society for Environmental Toxicology and Chemistry. MMS also works through the Organization for Economic Cooperation and Development to ensure that the potential environmental hazards and risks of metals products are assessed in the appropriate and correct manner.

Water as a cover to stabilize mine tailings



Sampling of mine waste sludge



Pilot-scale Sludge Treatment Plant

Development of safe use and good stewardship principles to ensure minimal negative impacts on aquatic resources over the full life cycle of a metal substance is also a key issue for MMS. While the previous two activity areas deal primarily with the potential for aquatic impacts during the production process, this deals with the metal product itself. Ensuring the proper tools are in place to correctly and efficiently assess and manage metal products over the course of their life cycle (including recycling and/or final disposal) is an integral part of maintaining and sustaining aquatic resources. This issue is also a key factor in maintaining markets for Canadian products, for example with respect to non-tariff trade barriers. NRCan's activities include the life-cycle considerations of substances currently in use, as well as the development of innovative manufacturing and design processes directed a minimizing potentially toxic releases.

MMS is also involved in the design of novel metal alloys and other materials for plumbing fixtures, pipes and other water delivery infrastructure which are safer and better performing; and the development of protocols for determining the hazards and bioavailability of metals, metal compounds, alloys and other inorganic substances in the aquatic environment.

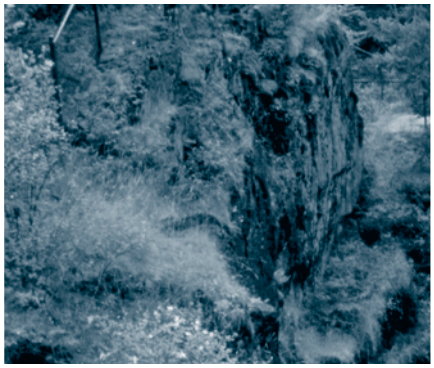
Suppression of acid mine drainage and toxic releases

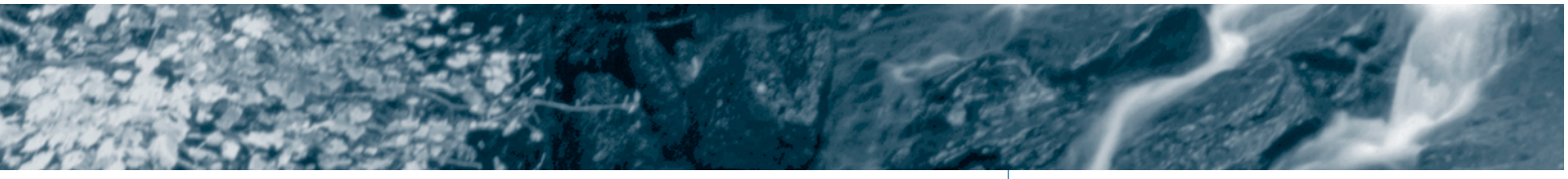
An example of an MMS program activity that incorporates the above is the suppression of acid mine drainage and toxic releases. The progress achieved in this area has been made through the following activities:

- Development and application of novel tools and predictive models for assessing the long-term risks of mine and smelter emissions in aquatic ecosystems.
- Design and long-term stability of mine waste sludges directed at minimizing release of metals into the aquatic receiving environment.
- Development of novel and improved treatment technologies and water recycling methods to reduce the impact of mine and smelter waste discharges.
- International programs to enhance water management in the mining industry through capacity building, training and mine-rehabilitation projects directed at water management.
- Increased understanding of processes, fate, and chronic toxicity of mine and smelter emissions in relation to long-term impacts and sustainable ecosystems.

Participation in multi-stakeholder consortia such as the Mine Environment Neutral Drainage (MEND), Toxicological Investigations of Mine Effluents (TIME) and the Thiosalts Consortium.

It takes 62 600 gallons of water to produce one ton of steel. That's about 215 000 litres of water to produce one metric ton of steel.





Water Issues and Activities in NRCan Operations

With regard to freshwater, the role of the Strategic Policy Branch (SPB) at NRCan is to advise the Minister and senior management on water policy issues of relevance to the department. In doing so, SPB undertakes strategic analysis and coordination among the sectors to position the department on freshwater policy issues of significance. SPB also represents the department in international, intergovernmental and interdepartmental water policy fora and events as necessary.

The role of SPB's Environmental Management Team is to assist in improving the environmental performance of NRCan operations. The Team is responsible for the development of environmental performance measures (indicators) for sustainable departmental operations, and the use of these to report progress where possible. Complementing our internal objectives is the government-wide goal for environmental excellence in federal operations.

The mechanism by which the environmental aspects of NRCan's operations are managed is the departmental Environmental Management System (EMS).

- The Resource Use aspect of the EMS includes the management of water consumption in NRCan operations. One of our Departmental Environmental Policy objectives is to seek cost-effective ways of reducing the input of raw materials, toxic substances, energy, water and other resources, and reducing the generation of greenhouse gases, waste and noise associated with day-to-day operations.
- The Land Use Management aspect of NRCan operations includes the management of NRCan wastewater.

As of early 2005, NRCan occupies more than 312 leased and custodial buildings across Canada and uses them for a variety of purposes, for example, office space, research and laboratories, field stations, and storage space.

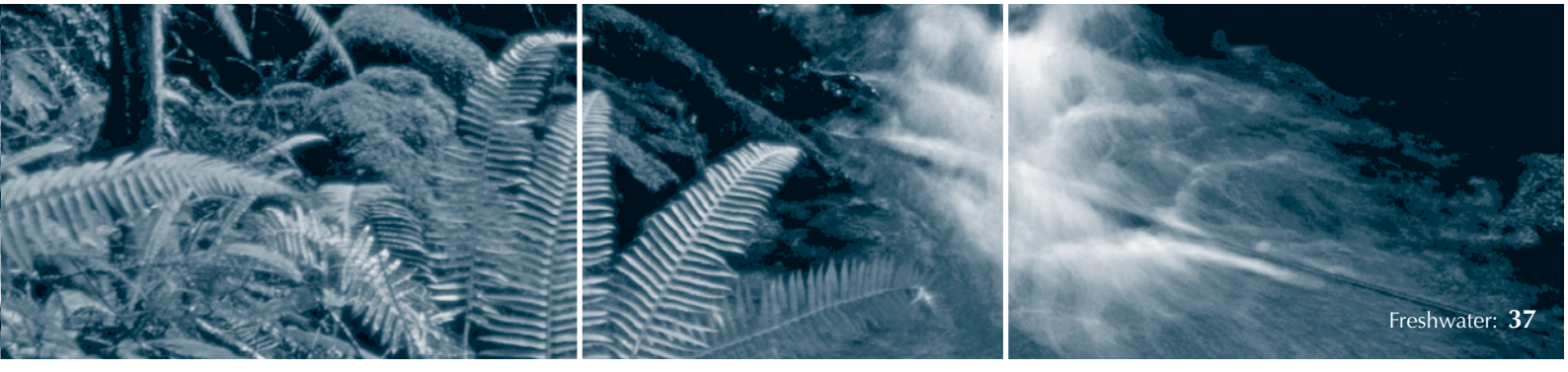
Water Use in Operations

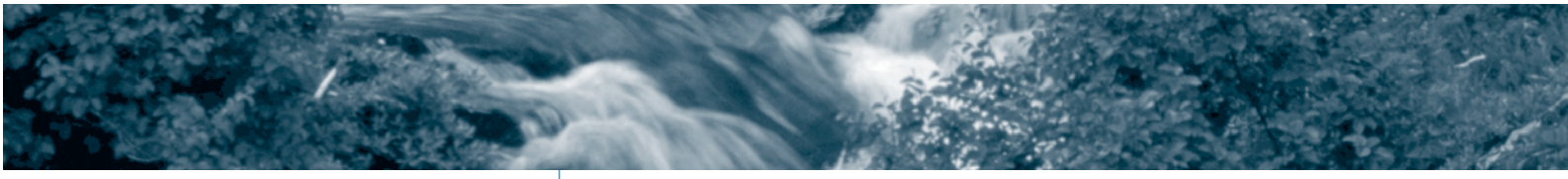
NRCan possesses baseline data on water consumption (volume and cost) for some custodial facilities dating back to 1997. Internal data and data trend analyses indicate that efforts to meet the Department's objective to reduce water use are proving successful.

In 1994-95, water consumption audits were conducted at four major NRCan facilities (Bells Corners Complex, leased by NRCan from PWGSC; H.J. Flemming Forestry Centre; Great Lakes Forestry Centre; and the Pacific Forestry Centre). Funding was provided by the

Sustainable Development in Government Operations

The Sustainable Development in Government Operations (SDGO) initiative is led by NRCan, Environment Canada, and Public Works and Government Services Canada. Water Conservation is one of the six aspect areas of federal operations for which the initiative is concerned (others are Energy Efficiency/Buildings, Vehicle Fleet Management, Land Use Management, Solid Non-hazardous Waste Management, Wastewater Management and Green Procurement). SDGO targets the 28 departments and agencies (including NRCan) that produce Sustainable Development Strategies (SDSs). The role of SDGO is to assist federal departments and agencies in the integration of sustainable approaches and actions in their day-to-day activities, coordinate their efforts (more precisely, the targets related to sustainability of operations set in their respective SDSs), and facilitate/undertake uniform measuring and collective reporting against progress on greening government operations.





Water Conservation at Federal Facilities

Using its experience in reducing operational use of water, NRCan actively participates on the Interdepartmental Advisory Group on Water Conservation at Federal Facilities (WCFF), which was formed in 1990. The WCFF serves as a forum for sharing experiences and developing joint tools, including The Water Conservation Plan for Federal Government Facilities and the accompanying Manual for Conducting Water Audits as well as Developing Water Efficiency Programs for Federal Facilities. The Advisory Group also serves an information-sharing function for federal facilities striving for excellence in water conservation .

NRCan Federal Buildings Initiative (established to conserve energy and reduce emissions resulting from lighting, heating and air conditioning) and was used to implement water-conservation strategies at the facilities (e.g. water-cooled air conditioning units have been replaced with air-cooled units at Bells Corners). Water savings at these facilities averaged 23.5 percent (total of 62,000 cubic metres) compared to 1994-95 levels.

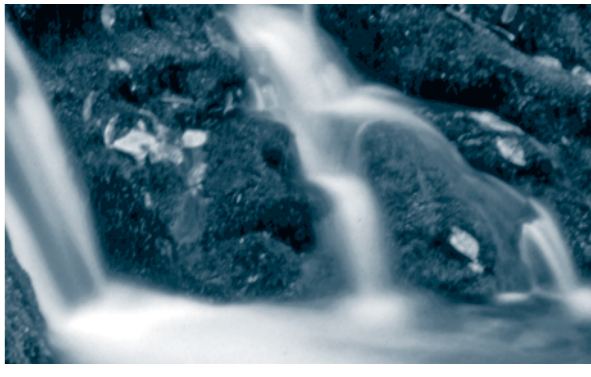
Through this initiative and via other actions, including the implementation of water-conservation measures (reduce, repair and retrofit) on a project-by-project basis where and when practicable, the Department has lowered its total water consumption over 40 percent since 1998. Drawing upon this positive trend, NRCan has developed and formalized a *Natural Resources Canada Water Conservation Strategy* to facilitate better tracking of water-efficiency measures and water consumption at NRCan facilities. Completion of the Strategy fulfills one of our sustainable development commitments.

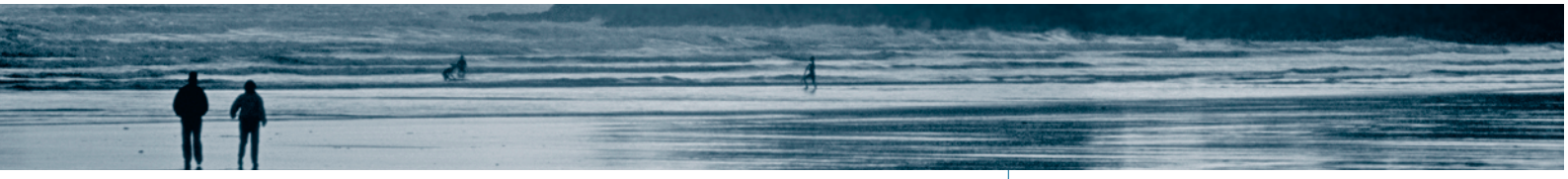
Wastewater Management

The Departmental Environmental Policy requires NRCan to meet or exceed federal environmental laws, regulations and policies, and where appropriate to be compatible with provincial, national and international standards. NRCan protocols for wastewater sampling follow ISO guidance methods (i.e. ISO 5667). Compliance verification and monitoring of wastewater discharge from NRCan facilities is a component of the overall environmental program. Internal guidance documents such as the Wastewater Compliance Program Methodological Framework (2001) and Approach for Assessing and Managing Wastewater Effluent Quality for Federal Facilities (2000) facilitate assessment.

Wastewater studies have been conducted by the Environmental Management Team at selected facilities within NRCan, starting in 1996. The facilities selected are those which have the greater risk of having compliance issues, those with large laboratories and which use many types of chemicals in large quantities, or those where an Environmental Compliance Audit has produced negative findings relating to wastewater discharge.

Municipal waste water – largely human waste – is the largest point source of nutrient (nitrogen and phosphorus) releases to the Canadian environment. In 1999, about 82 750 tonnes of total nitrogen and 4 950 tonnes of total phosphorus were released to lakes, rivers, and coastal waters from municipal sewage.





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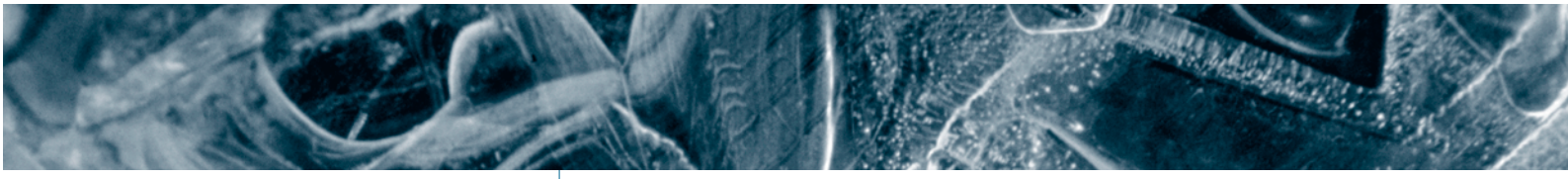

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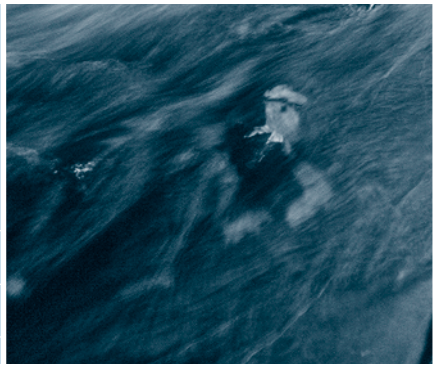

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All "Quick Facts" were provided by Environment Canada's Freshwater Website: http://www.ec.gc.ca/water/

Photo credits

Cover: Duffey Lake, B.C.; from the Forests of Canada collection (Natural Resources Canada, Canadian Forest Service, 2003).

Page 25 – Dam: Columbia Power Corporation.

Page 34 – Diamonds: BHP Billton.

Appendix 1: Departmental Mandate and Organization

Natural Resources Canada is an economic, science-based department with a mandate to:

- promote the sustainable development and responsible use of Canada's mineral, energy, and forestry resources;
- develop an understanding of Canada's landmass; and,
- collect and disseminate knowledge on sustainable resource development.

The Department conducts research and technical surveys to assess Canada's resources, including the geological structure and legal boundaries. NRCan is also authorized to provide the national framework of reference for spatial positioning; prepare and publish maps; conduct scientific and economic research related to the energy, forestry, mining and metallurgical industries; and to establish and operate scientific laboratories for these purposes.

Departmental Mandate

NRCan is responsible for federal resource policies, and science and technology that support the sustainable development and competitiveness of the energy, forest, minerals and metals sectors, and their allied industries. The Department enables the Government of Canada to address resource issues in a comprehensive manner, from a national perspective.

By legislation, the Minister of Natural Resources is responsible for:

- coordinating, promoting, recommending and implementing policies, programs and practices pertaining to the mandate of NRCan;
- fostering the integrated management of, and having regard for, the sustainable development of Canada's natural resources;
- helping in the development and promotion of Canadian scientific and technological capabilities;

- gathering, compiling, analyzing, coordinating and disseminating information respecting scientific, technological, economic, industrial, managerial, marketing, and related activities and developments affecting Canada's natural resources;
- participating in the development and application of codes and standards for spatial positioning and natural resource products, and for the management and use of natural resources;
- improving remote-sensing technology and promoting the development of the Canadian remote-sensing industry;
- encouraging the responsible development and use of Canada's natural resources, and the competitiveness of Canada's natural resource products;
- working to widen and promote markets for Canada's natural resource products and geomatics industries, both at home and abroad; and,
- working in partnership with provincial/territorial governments and non-governmental organizations in Canada, and promoting cooperation among nations and international organizations.

Other Agencies

NRCan maintains a special relationship with agencies which report to Parliament through the Minister of Natural Resources. These agencies include the National Energy Board, the Canadian Nuclear Safety Commission (formerly Atomic Energy Control Board), Atomic Energy of Canada Limited, the Energy Supplies Allocation Board, Canada-Newfoundland Offshore Petroleum Board, Canada-Nova Scotia Offshore Petroleum Board and the Cape Breton Development Corporation.

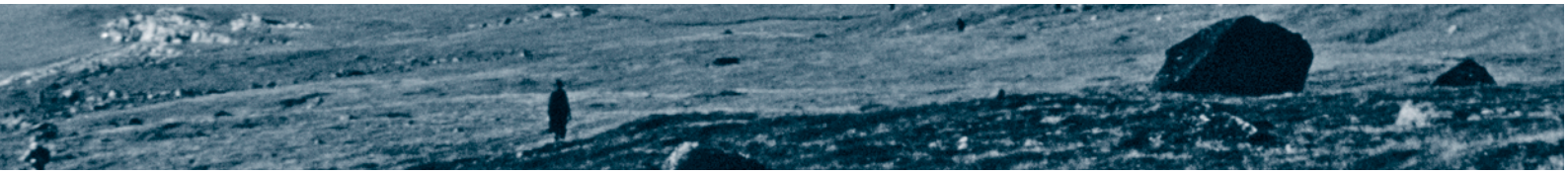
Organization

NRCan is organized into six operational sectors, three branches, and the Office of the Chief Scientist.

The **Strategic Policy Branch** is NRCan's centre for strategic policy leadership, expertise and advice for departmental and portfolio priorities, horizontal policy issues and initiatives (e.g. freshwater policy), and sustainable development in Canada and internationally. It leads the development and implementation of the Sustainable Development Strategy, as well as providing functional direction to the Department in the area of environmental affairs.

The **Communications** and **Audit and Evaluation** branches contribute to improved accountability as well





as an increased understanding of NRCan's mandate and programs among Canadians, clients and employees.

The **Earth Sciences Sector** is the Government of Canada's principal agency for earth science knowledge and information. Geomatics Canada provides a reliable system of surveys, remotely sensed data as well as geographically referenced information describing the Canadian landmass; the Geological Survey of Canada is a principal contributor to a comprehensive geoscience knowledge base of Canada; and, the Polar Continental Shelf project contributes to scientific research in our Arctic regions by providing comprehensive logistics support.

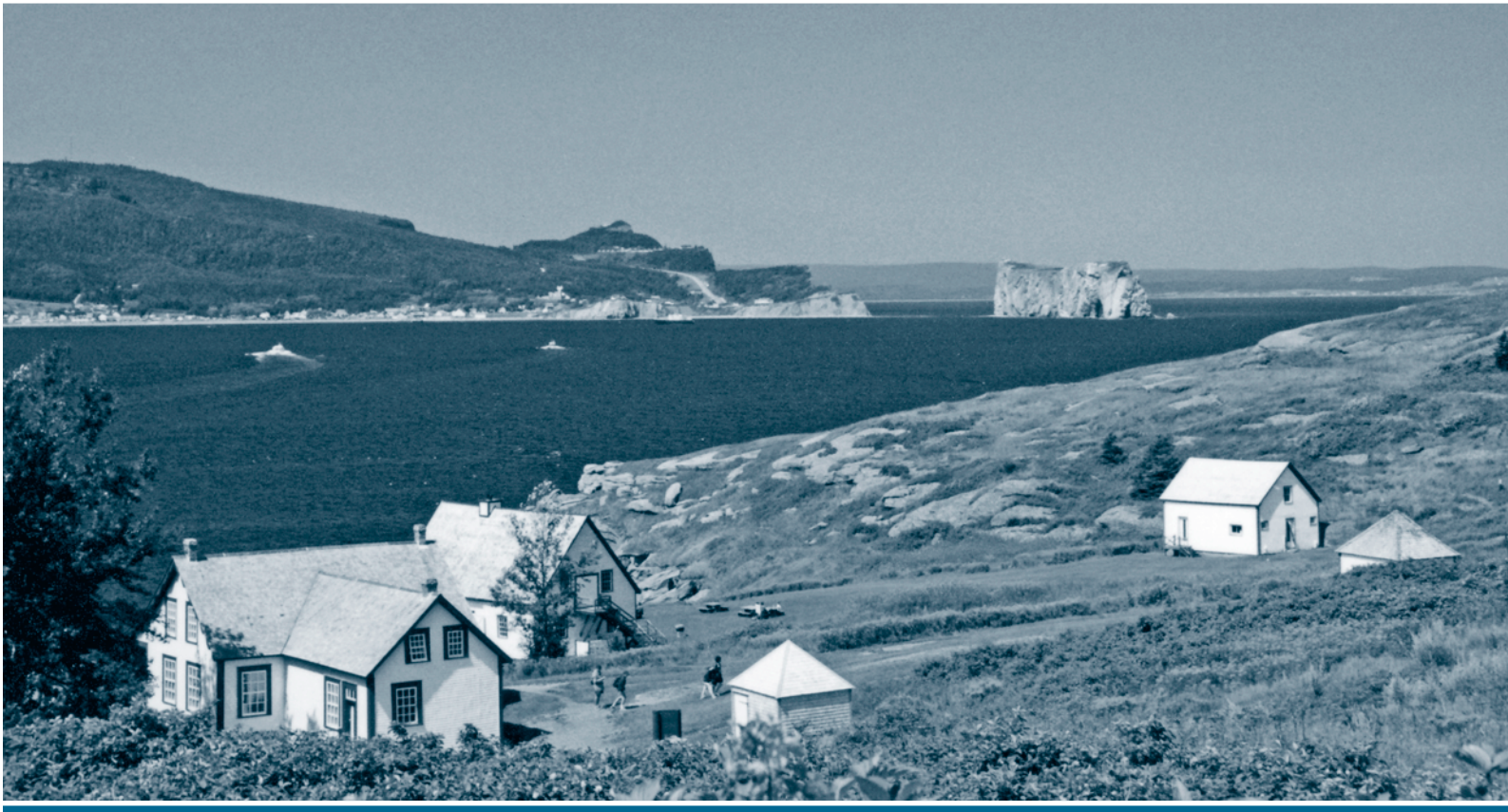
The **Canadian Forest Service** promotes the sustainable development of Canada's forests and the competitiveness of the Canadian forest sector for the well-being of present and future generations of Canadians. As the premier forestry S&T research and national policy coordination agency in Canada, the Canadian Forest Service plays a pivotal role in building consensus on key forest issues, in shaping the national and international forest agenda, and in generating and transferring knowledge through its Canada-wide world-class forestry research centres.

The **Minerals and Metals Sector** promotes the sustainable development of Canada's minerals and metals resources industry by integrating economic, social and environmental objectives. It provides policy advice, S&T, as well as commodity and statistical information in support of decision making. It is also the federal government's primary source of expertise on explosives regulations and technology.

The Electricity Resources Branch, the Energy Policy Branch, the Large Final Emitters Group, the Office of Energy Research and Development, and the Petroleum Resources Branch together comprise NRCan's **Energy Policy Sector**. It assesses the potential economic, regional, international and environmental implications of Canada's energy production and use. It also provides technical knowledge and advice to the energy industry and to government. Its knowledge base helps the Government of Canada to formulate policies, implement regulations, enhance job and wealth creation, and meet its international commitments. The **Energy Technology and Programs Sector** includes the CANMET Energy Technology Centre and the Office of Energy Efficiency. Together these sectors promote the sustainable development and safe and efficient use of Canada's energy resources through their policies, programs, and science and technology.

The **Corporate Services Sector** provides functional direction to the Department in the effective and efficient management of resources in the areas of finance, administration, human resources, information management/information technology, real property, and safety and security.

Created in 2003, the **Office of the Chief Scientist** is responsible for positioning Natural Resources Canada as a leader in the performance of science and technology. The Office works closely with the departmental science sectors as well as other science-based departments and agencies, both nationally and internationally, to ensure the excellence and relevance of our laboratories and science programs. The Office of the Chief Scientist also oversees the NRCan On-Line Secretariat, which is enabling NRCan to deliver its programs and services to Canadians through the Internet.



Appendix 2: Sustainable Development Strategy

2004-2006 Water Commitments

This appendix presents the water-related commitments from *Moving Forward*, NRCan's third sustainable development strategy (SDS), tabled in Parliament in February 2004. There are water-related activities found under two of the Strategy's 'Key Results' which form the document's structure. Some of the descriptive text for each of the key results has also been reproduced here.

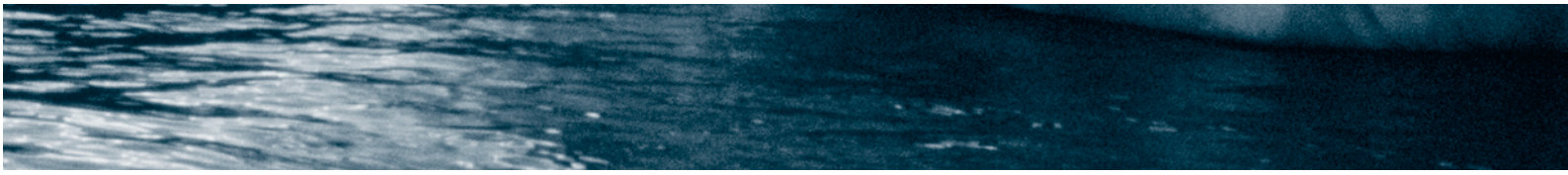
Each of the actions the Department plans to take during the period of the SDS (April 2004–March 2006) is described in one line from the Strategy's action tables. The action tables follow a consistent format, with the action listed across the top and the individual items described in the body of the table. Reading the columns across from left to right shows a progression from a description of the specific issue, to NRCan's approach to addressing the issue, to the specific, measurable target that will be achieved within the timeframe of this SDS, to the anticipated outcome of the activity. In some cases, related items have been presented as one action item, in other words, as a single row in the action table.

Key Result 1:

Canadians make better decisions that advance sustainable development

Turning NRCan's vision into reality depends on improving decision making at all levels of Canadian society, so that social, economic and environmental considerations are thoroughly integrated in decision-making processes. Building capacity is about creating the conditions for advancing sustainable development by improving our ability to make better decisions.

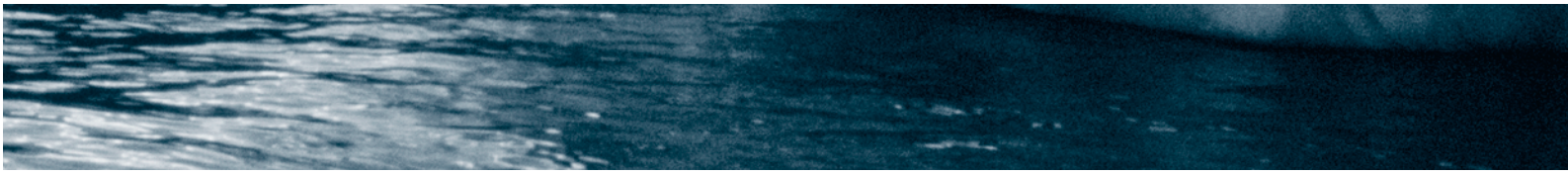
Close to 10 million Canadians rely on groundwater for domestic use. Approximately two-thirds, or 5 million, of these users live in rural areas.



Action 1.3:
Increase understanding of water resource supply and minimize impacts of natural resource sector activities on aquatic ecosystems

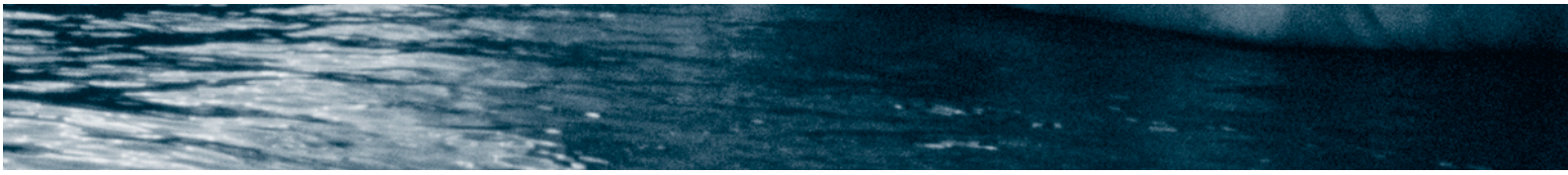
Issue	Approach	Target	Anticipated outcome
Close to 10 million Canadians rely on groundwater. This number is constantly growing, yet our understanding of how much groundwater is available for use in Canada, is limited. There is a need for governments (municipal, provincial and federal) to better understand the quality and quantity of existing groundwater resources and the dynamics and vulnerability of key regional sources.	NRCan will focus on determining the extent of the most strategic regional groundwater resources. NRCan will also develop methods for assessing the vulnerability of groundwater resources to land use and climate change. The emphasis of this initiative will be on the synthesis of existing data, as well as resource characterization of aquifers with critical dependencies for human use, agriculture and/or industry.	By 2006, map 20% of key regional aquifers. By 2006, complete current regional projects, to standards proposed by the Canadian Framework for Collaboration on Groundwater. By 2006, produce maps of natural quality of the groundwater of regional aquifers. By 2006, establish national database on groundwater. By 2006, establish and implement approaches for assessing the impact of land cover and climate change on groundwater.	Improved knowledge of key regional groundwater resources in Canada. Identify aquifers at risk and aid municipal government to plan related to water and waste management issues.
Canada has the third largest resource of fresh water globally. Yet the majority of Canada's water use is found in areas away from the major population centres. At issue is the impact of climate change on the balance of water supply and demand at regional and national scales.	NRCan will assess Canada wide land surface water budget through a combination of earth observation data, numerical simulation models and observed and modelled climate data. Earth observation will also be applied to provide Canada wide maps of snow cover on a daily basis by processing archival and current satellite imagery. By 2006, complete the Canada Water Accounts of annual sub-sub-basin water budgets under current and projected conditions.	By 2006, a record of current and historical snow cover trends over Canada from 1985 onwards.	Canadians have information that helps them to better plan adaptation responses. Governments make use of snow cover trends to assess fire danger levels and impacts of snow cover changes on water availability for in-stream and consumptive use.

Issue	Approach	Target	Anticipated outcome
According to climate change scenarios, the Prairie region will become even drier than now. The ability of biophysical systems to adapt to change, the human capacity of adaptation, the need for additional water resources as an option for adaptation are under question – as well as the policy and program options to address these issues.	NRCan will use an integrated assessment and modelling approach to address these issues, in collaboration with other government departments and the University of Saskatchewan, using NRCan's capacity in glacier monitoring, biophysical systems monitoring and modelling, and spatially-explicit modelling and simulation, and using an integrated assessment and modelling approach.	By 2006, produce an assessment of costs of climate change and water resource impacts to Prairie agriculture and economy; By 2006, develop an integrated assessment framework that can be used to test scenarios of the costs under different climate change and socio-economic assumptions.	Prairie provinces have information to assist them with adaptation decision-making.
The production of oil and gas can be a highly consumptive use of fresh potable water. Conventional oil water flooding and water withdrawal from the Athabasca river for oil sands development are two examples. Recent oil sands announcements have led some to question the ability of the Athabasca River to meet the projected increasing demand for water. Prolonged and more periodic drought conditions can further exacerbate the challenges which lead to a very difficult allocation of potable surface and near-surface water rights between the conventional oil water flooding industry, other industrial groups, agriculture and community/residential users.	NRCan has developed a number of science and technology initiatives dealing with water use in oil and gas production. At its research lab in Devon, Alberta, NRCan is active in surface mined oil sands extraction and tailings research focussed on increasing recycled water use to reduce fresh water demand. NRCan is also actively encouraging other government departments as well as provincial, academic and private-sector interests to pursue less water-intensive oil and gas technology developments.	By 2004, establish the Oil Sands Tailings Research facility, with a focus on tailings and water management. By 2004, establish a multi-year research program on 21st century conventional oil water flooding technology development.	Enhanced stewardship, and reduced intensity of fresh potable water use in oil and gas production, particularly oil sands development and conventional oil production by water flooding.
There is a need to better understand the linkages between forests, forestry practices, and freshwater stewardship, in a Canadian context.	NRCan will finalize a synthesis report on the role of forests and impact of forest management on Canada's water by assembling and reviewing scientific information and knowledge. This product will be developed in partnership with the University of Alberta. The publication will target members of the Canadian forest community.	By 2004, publish a synthesis report on the role of forests and impacts of forest management on Canada's water.	A better understanding of the linkages between water and forest ecosystems, and related federal government science activities. Better informed policy and operational decisions, leading to improved sustainable development practices over time.



Issue	Approach	Target	Anticipated outcome
The Canadian mining industry faces the ongoing challenge of complying with the regulatory requirements for effluents under the *Fisheries Act* in a cost-effective manner. Mine effluents are the largest environmental liability facing the Canadian industry. Low-impact chemical technologies and innovative biotechnologies have the potential to offer cost-effective and efficient tools for effluent treatment.	NRCan works with industry on the development of treatment strategies for mine, mill and metallurgical effluents. NRCan is developing chemical and biological treatment technologies for mine effluents by researching passive treatment systems; metal absorption using biosorbent from seaweed; and biotechnology for oxidization of thiosalts. Research partners include universities, consultants and the mining industry.	By 2004, test technologies that employ bacteria to naturally treat contaminants in mine effluents. By 2005, provide scientific report and conference presentation outlining biological and chemical processes occurring within passive treatment systems in order that they could be more widely utilized at mine sites in Canada. By 2006, develop scientific report and conference presentation on the use of alginate and paper mill sludge as metal adsorbents in mine effluent treatment Treatment systems that can be applied at mine sites and engineered to respond to the specific conditions at the site.	Leadership in the design and development of sustainable treatment systems for mining operations.
Mining and related processing of ores produces wastes that are typically deposited in the natural environment. Understanding how metals behave in the environment is key to developing appropriate policies and strategies to manage them. Improved understanding of the potential toxicity of mine wastes in the receiving environment is essential for a valid characterization of mine effluents.	NRCan is conducting research to characterize mine effluents by evaluating the persistence of bioavailable forms of metals; characterizing hazards of metals and alloys; developing prediction models for chronic metal toxicity; and developing microcosm/macrocosm facilities. Research partners for this initiative include universities, consultants and the mining industry.	By 2004, complete study on geochemical behaviour of copper, zinc and cadmium in receiving waters. By 2005, complete study on hazard identification of stainless steel. By 2005, complete study of the effect of copper on the invertebrate indicator Ceriodaphnia. By 2006, conduct ecosystem column set-up.	Changes to the regulatory approach for environmental protection that are based on sound science Development of prediction models that offer simple but accurate assessment of effluent toxicity and their acceptance by the regulatory community.

Issue	Approach	Target	Anticipated outcome
There are opportunities in Canada to develop more small- and medium-sized stations to generate hydro-electricity, as renewable energy source, often with little or no storage; but there are environmental concerns related to aquatic ecosystems. NRCan develops methods and technologies to mitigate impacts of hydroelectric development on aquatic ecosystems to help industry stakeholders meet regulatory requirements.	NRCan is involved in streamflow modelling and development of a management framework based on biological criteria, instream flow assessments, habitat requirements of fish species and studies on the effects of hydro-peaking on aquatic resources. NRCan will be also conducting a gap analysis on innovative impact-reduction technologies. One identified priority is the need for low-cost, reliable and efficient fish-friendly equipment for small and medium hydro sites.	By 2005, collect and report on innovative impact-reduction technologies and approaches at selected hydro facilities in Canada. Conduct a gap analysis to identify further R&D needs related to habitat management, fish bypass and water management operations. By 2006, develop three new modelling tools for stream flow assessments for use by utilities, federal and provincial regulatory agencies. By 2006, develop concept for specially designed fish-friendly turbines and advanced speed generators, conduct computational fluid dynamics analysis, develop model and conduct testing and field trials.	Streamflow management tools applicable to individual hydro sites to ensure compliance with the *Fisheries Act* and provide adequate protection of aquatic ecosystems. Canadian-designed leading-edge fish-friendly hydro equipment for small- and medium-sized hydropower.
The small hydro industry requires data and tools to assess potential changes in streamflow regimes resulting from climate change. As most small hydro sites have little or no storage, they are especially vulnerable to climate change which may affect energy outputs and/or increase risks of extreme events such as flooding.	NRCan develops and adapts tools and methods for resource assessment and extremes analysis of small hydro sites. New research to address the impacts of climate change on small hydro is in the planning stages. Climate data will be obtained from the Department of Fisheries and Oceans and Environment Canada (EC) and a partnership may be forged with EC.	By 2006, complete hydrological model calibration and validation for small hydro resource assessment across Canada. By 2007, complete extremes model calibration and validation across Canada. By 2008, complete comparison of present-day and future climate scenarios in small-scale watersheds representing various hydrological regimes in Canada.	Information on hydrologically vulnerable areas in Canada, specifically related to small watersheds where small hydro development is prominent. Climate change data and calibrated parameters that can be used in adapted resource assessment and extremes models for site-specific analysis of climate change impacts.



Key Result 4:

NRCan demonstrates its commitment to sustainable development in its operations

As a federal government organization, NRCan has a responsibility to provide Canadians with a department that is efficiently and effectively managed in all respects. However, to achieve progress towards our vision it will be imperative to go beyond normal business practice.

As a champion of the sustainable development of Canada's natural resources, the Department must demonstrate its commitment to the principles of sustainable development in its own operations in order to be able to lead with authority and credibility.

Action 4.2:
Develop and implement further strategies to improve resource use efficiency and reduce greenhouse gas emissions in NRCan facilities

Issue	Approach	Target	Anticipated outcome
Like the reduction of energy consumption and greenhouse gas emissions, the reduction of water consumption is essential to achieving sustainable NRCan operations.	Water conservation activities aim to achieve the following: the reduction of the absolute amounts of water (less water per person or given product or service) and/or the reduction of the rate (using water only when it is needed) at which water is used on a daily basis (sustainable use).	By 2004, consultation on NRCan's Draft Water Conservation Strategy completed, Strategy finalized and approved. By 2004, provide input into the feasibility study for the development of a national Sustainable Buildings Policy. By 2005, establish baseline data of water consumption. By 2006, establish a target to reduce water consumption at NRCan facilities.	The sustainable use of water, which contributes to overall sustainable NRCan operations.