2 Water Quality

Water pollution

There are two general sources of water pollution: point and non-point sources. Point sources refer to industrial discharge pipes and municipal sewer outlets that discharge pollutants directly into the aquatic ecosystem. Non-point sources refer to indirect sources of pollution such as run-off from agriculture, forestry, urban and industrial activities as well as landfill leachates and air-borne matter. Water quality also varies naturally to a large degree since some bodies of water are of poor quality due to inherent chemical, physical and biological characteristics. Water pollution from human activities includes nutrients, heavy metals, persistent pesticides, and other toxins.

Nutrients like phosphorus and nitrogen, found in fertilizers, livestock manure, and washing detergents, can cause significant degradation of water quality by accelerating eutrophication,[7] which depletes levels of dissolved oxygen. Government regulation has stipulated reductions in the amount of phosphate in detergents to try to improve water quality. Lower phosphate levels in lakes and streams however, do not always result in higher levels of dissolved oxygen and improved water quality because plants continually recycle phosphorus from sediments.

Heavy metals are found in water as the result of the weathering of rocks. They may also reach the water system directly from industrial and mining activity. Non-point sources such as urban storm-water and agricultural run-off also contribute to metal contamination. High concentrations of heavy metals can affect the quality of drinking water and harm aquatic life as the metals accumulate in organs and tissues (bioaccumulation).[8]

Other substances—pesticides like dichlorodiphenyltrichloroethane (DDT) and toxins like polychlorinated synthetic compounds (PCBs)—can also accumulate in biological organisms. The effects of these compounds on animals such as birds include growth retardation, reduced reproductive capacity, lowered resistance to disease, and birth deformities.

Assessing water quality

To evaluate water quality we need to consider the pollution of surface water as well as the related issue of the quality of our drinking water. There is no national indicator or database for the quality of drinking water: each province has jurisdiction over its own supplies of potable water. Health Canada has published *Guidelines for Canadian Drinking Water Quality* (*GCDWQ*) since 1968, prepared by the Federal-Provincial Subcommittee on Drinking Water. The guidelines include both maximum acceptable concentrations (MACs) based on health criteria as well as aesthetic objectives (AOs), such as colour, iron and pH, factors that do not represent a health concern but contribute to an unfavourable perception of water quality.

As with drinking water, the quality of surface water is also very difficult to summarize on a national basis because there are no nation-wide index or standards. The Canadian Council of Ministers of the Environment (CCME) devised the *Canadian Water Quality Guidelines* (*CWQG*) in 1987 (and the *Canadian Environmental Quality Guidelines* in 1999) as a basis for the provincial and territorial governments to design site-specific water-quality objectives. Although many provinces compare sample results to the *CWQG*—and some provinces have even developed their own objectives and standards based on the *CWQG*—these guidelines are voluntarily adopted and can be ignored by the provincial and territorial governments.

Other obstacles in assessing Canada's water quality are the lack of uniform monitoring and the magnitude and complexity of measuring water quality. The effects of both natural and manufactured contaminants upon water quality fluctuate with water conditions (source, velocity, volume, depth, pH level), photosynthetic activity, and daily and seasonal variations.

To assess the quality of surface water and drinking water in Canada, we shall examine available information for each province and territory individually. In most cases, trend data for these indicators were unavailable. This is unfortunate, as the snapshot data that are available provide no information as to whether water quality is improving or deteriorating. However, some provinces are now trying to create indices of water quality that could be compared over time. In the provincial sections, current regulations are discussed. But, it is important to remember that regulation tells us nothing about environmental quality since regulations may be enforced or ignored.

In addition to the review of information available from provinces, water treatment and the available information of the state of the Great Lakes are also considered in this section.

Use and treatment of water

Domestic, agricultural, and industrial use causes changes to water temperature and chemical content that can cause environmental deterioration when released directly back into rivers, lakes, streams, or oceans. Municipal wastewater effluents, made up of both sanitary sewage and stormwater, can contain debris, suspended solids, disease-causing microorganisms, organic wastes, nutrients, and chemicals. These substances can cause unhealthy increases in nutrient levels, depletion of dissolved oxygen, habitat alteration, and the bioaccumulation of toxics. They can also lead to contamination of drinking water by such bacteria and protozoans such as *Giardia* and *Cryptosporidium*. Through advances in industrial processes and improved wastewater treatment, the amount of pollution being discharged into Canadian waters has decreased dramatically over the last two decades. Wastewater, one of the largest sources of pollution in Canadian waters and estimated in 1999 at 14.4 million cubic metres per day from 1,118 municipalities, is now mostly treated before release to prevent damage to the ecosystem (Environment Canada 2001c).

Primary wastewater treatment removes solid waste mechanically with screens and filters, and finer sediment in settling chambers; secondary treatment employs microorganisms to break down dissolved organic material biologically, and uses settling to remove suspended solids; and tertiary treatment removes additional contaminants, including heavy metals and dissolved solids, through a variety of physical, chemical, and biological treatments. Tertiary treatment is most important for wastewater being discharged into sensitive environments or situations where the water will be reused (Environment Canada 2001c).

Septic systems provide sewage treatment for the 26% of Canada's population living in rural areas (Industry Canada 2001: 3). Of the municipal population, the proportion provided with wastewater treatment increased from 72.7% in 1983 to 96.7% in 1999 (figure 2.1) (Environment Canada 2000). Figures 2.2 through 2.6 show the changes in access to municipal wastewater treatment by region between 1983 and 1999. With a dramatic increase from 11.8% to 97.3% of the proportion of the municipal population served by some form of wastewater treatment, Quebec showed the greatest improvement in general access. The Prairies now provide 59% of the municipal population with tertiary treatment (the highest level), as opposed to 8.8% in 1983. It is also significant to note that British Columbia improved the level of treatment to secondary or tertiary levels by 1999 for 36.3% of the population who had been receiving the minimum primary level in 1983 (Environment Canada 2000).

The next part of this section will include an examination of water quality, with a special emphasis on the quality of drinking water, in each province and territory. Because no national indicators exist, the discussion will focus on the available data and measures that each province collects.

Atlantic Canada

Fishing and maritime recreation continue to be important aspects of the economy and culture of the eastern coast of Canada. The ocean is home to uncounted species and ecosystems and, although it has experienced degradation in the past, restoring and maintaining the quality and purity of its waters is considered vitally important. Water quality on the east coast is monitored in several ways, including by testing levels of toxic contaminants in bird eggs and tracking shellfish closures.

Levels of toxic contaminants have been decreasing over the past 25 years on the east coast. Samples taken from the eggs of double-breasted cormorants in the Bay of Fundy show a decline in levels of dichloro-diphenyl-dichloro-ethylene (DDE) and polychlorinated biphenyls (PCBs) (see figure 2.7).[9] Between 1972 and 1996, the amount of DDE found in the birds' eggs decreased by 91.4% and the amount of PCBs found decreased by 77.8%. Both pollutants are discussed in greater detail in the Great Lakes section of this report.

The eastern coast of Canada is a major shellfish-harvesting area. Shellfish such as oysters, clams and mussels, which feed by filtering water, can become contaminated by bacteriological pollution (such as sewage) and natural biotoxins, which can result in human illness if consumed. The Shellfish Water Quality Protection Program monitors water quality in shellfish-growing areas and classifies areas as approved, conditionally approved, or closed. The percent of surveyed area that is approved for harvesting has remained fairly stable, increasing slightly from 61% in 1989 to 64% in 2000 (table 2.1).

Newfoundland

Newfoundland has an abundance of clean water from its many lakes, rivers and streams, as well as groundwater. A recent report, *Source to Tap: Water Supplies in Newfoundland and Labrador* (Newfoundland Dep't of Environment 2001), gives a detailed picture of the current state of the province's supplies of drinking water.

Approximately 83% of Newfoundlanders receive water from public sources while 17% obtain water from private sources. Eighty-eight percent of public supplies come from surface water whereas 12% relied on groundwater (Newfoundland Dep't of Environment 2001). Newfoundland has adopted a multi-barrier approach to ensure safe and clean drinking water. The main components of this approach include protection of source water, water treatment, monitoring and reporting of water quality, and education and training of waterworks operators.

Under Newfoundland's *Environment Act* (1995), the area surrounding a source of public water can be designated as a Protected Water Supply Area; doing so prohibits activities in that watershed that would impair water quality. All major water-supply areas have been designated, encompassing 350,000 hectares. The majority of the population (70%) receives water from protected areas—the total number of which has grown from five in 1974 to 244 in 2001. Well-head protection is also provided for under the act.

Newfoundland is one of the few provinces in Canada where the responsibility for monitoring and reporting the quality of drinking water is under provincial, rather than municipal, jurisdiction. Monitoring data reveals that drinking water in Newfoundland generally complies with the chemical and physical parameters of the *CDWQG*, which the province uses as an objective. In a few samples, aesthetic objectives were exceeded for copper, iron, manganese, pH, and colour, but these were not significant exceedances from a health point of view (Goebel 2001).

The main concerns for experts monitoring drinking water in Newfoundland are, on the one hand, inadequate levels of chlorination and, on the other, high levels of trihalomethanes (THMs), by-products of chlorination that have been causally linked to bladder and colon cancer in long-term drinkers of water with high levels of THMs. As of March 31, 2001, 59 water supplies (out of 318) had THM levels above the recommended guideline of 100 μg/L (figure 2.8). The two highest exceedances were found in parks where the demand for water is seasonal. These exceedances and others are being examined by water experts and are being addressed on a case-by-case basis (Goebel 2001). According to Martin Goebel, Director of Water Resources Management Division with the Department of the Environment in Newfoundland, the trend for THM levels shows improvement (Goebel 2002).

Assessing trends in the quality of surface water has not been a priority for Newfoundland's Environment Department. Although various pollution parameters are monitored at roughly 60 different sites along major rivers in the province and data go back 15 years, the data are not currently aggregated in a way that would allow for an assessment of pollution trends (Goebel 2002).

The treatment of wastewater is a weak area for Newfoundland. Although many inland communities have their wastewater treated, many coastal communities do not and sewage from these communities is pumped untreated into the ocean (Goebel 2002). In St. John's harbour, the level of fecal coliform density has increased significantly since 1981 and most measured concentrations are substantially higher than guidelines for recreational use (Powell 1998)[10] (table 2.2). However, plans are being developed to build a $93 million waste-treatment plant for St. John's and its surrounding cities, though a time-line and financing arrangements have yet to be established (Goebel 2001).

Nova Scotia

Over the past 25 years, there has been a gradual improvement in Nova Scotia's drinking water due to new municipal treatment facilities and improvements in surface water due to more municipal sewage treatment plants (Wilson 2000). Overall water quality has also been improving through better controls and treatment facilities at pulp and paper mills. Effluents from mills have dramatically decreased since 1995 as a result of improved regulation and investment in pollution control. In 1998, compliance with regulation levels reached 99% (Wilson 2000).

Nova Scotia brought in new drinking water regulations, *Guidelines for Monitoring Public Drinking Water Supplies,* on October 1, 2000. Suppliers of public drinking water are now required to test their water regularly and, if there are problems, to inform their customers and the Department of Environment and to take corrective action.

All water supplies must be disinfected with chlorine and must meet the health-based guidelines in Health Canada's *Guidelines for Canadian Drinking Water Quality* (*GCDWQ*).

Nova Scotia's *Environment Act* includes legislation for the protection of designated water sources; 24 water supplies (out of a total of 77) are currently designated. The number of municipal water supplies designated as protected water areas has been steadily increasing in number since 1965.

One available indicator of the quality of Nova Scotia's drinking water is the number of municipal water samples testing negative for total coliform bacteria. Coliform bacteria are found in the feces of animals and humans and are an important indicator of water quality. The number of negative samples has consistently been over 95% since 1989 and shows improvement over a 25-year period (figure 2.9).

Like Newfoundland, Nova Scotia has some water supplies that exceed guidelines for THMs. In 1993, monitoring data showed that 14% of municipal water supplies had annual averages exceeding THM limits. However, it is important to remember that the risks of not chlorinating water (and potentially suffering outbreaks of water-borne illnesses like cholera) are much greater than risks associated with THMs. Water treatment plants in Nova Scotia are working to reduce the level of THMs without compromising the safety achieved through the disinfection process (Nova Scotia Environment 1998).

Other exceedances are occasionally recorded from samples of municipal water supplies. In 1996, data from the Nova Scotia Drinking Water Systems Database shows that six of the 78 supplies exceeded criteria for turbidity (cloudiness) and two supplies exceeded the criteria for lead. As a result, 16% of the population received water that did not fully conform to the *GCDWQ* (Wilson 2000). Various actions are taken when compliance is not achieved. For example, if the problem stems from bacteria, an advisory to boil water is issued. If old lead pipes are tainting the water (as is often the case with lead exceedances), the pipes are replaced (Briggins 2001).

In Nova Scotia, 43% of people obtain their drinking water from private wells. In areas of intense agriculture, one concern is that pesticides will seep into the groundwater. However, a random survey in 1989 of farm wells in the intensive agricultural areas of Kings County shows that all wells were within limits for pesticides and about 60% of wells had no detectable levels at all (Nova Scotia Environment 1998).

Prince Edward Island

Prince Edward Island is a province rich in groundwater—a resource that supplies fresh water sufficient for the whole population. The island does not contain large surface water bodies and it is estimated that 60% to 70% of the surface-water flows originate from groundwater discharges (PEI Environment 1999). Because all human needs for fresh water are satisfied from groundwater sources, groundwater has been assessed according to the *GCDWQ*. Surface waters are compared to the *Canadian Water Quality Guidelines* (*CWQG*) with respect to the protection of aquatic life.

Prince Edward Island and Environment Canada co-operatively monitor a network of water-quality stations under the *Canada-PEI Memorandum of Agreement on Water*. A total of 28 stations, including 14 on rivers and streams, five monitoring groundwater wells, and nine in estuaries, are tested six to eight times a year (Raymond 2001). These data have been analyzed and reported on in the *PEI Water Quality Interpretive Report* (1999). Collection of data on water quality in Prince Edward Island began in the mid-1960s. Data collection, however, has been focused on specific, short-term issues rather than trend analyses and long-term records from individual stations are rare (PEI Environment 1999).

The *PEI Water Quality Interpretive Report* describes the quality of the groundwater supplies, fresh surface waters, and estuarine waters as generally high. The province's groundwater is considered "excellent" with only isolated test results exceeding water-quality guidelines. Its waters are considered susceptible to human influence, however, especially in areas of intensive agriculture, and a trend of increasing nitrogen concentrations has been observed at several stations along rivers with longer observation records. Although only 1% to 2% of all wells tested on Prince Edward Island exceed recommended levels for nitrogen, 6% to 7% of wells in some areas of intensive cultivation do not meet the guideline (PEI Environment 1999). Fecal bacteria is another measure that occasionally exceeds guidelines for shellfish and recreation in surface and estuarine waters.

Pesticides leaching into the water table is not a health issue on Prince Edward Island. Numerous studies have examined this issue by testing well water, usually in "high risk" agricultural areas. Although a small percentage of tests have detected pesticides in the groundwater, none of the concentrations exceeded drinking-water guidelines (PEI Environment 1999).

The long-term monitoring data do suggest a subtle decrease in sulphate and marginal increase in pH in surface water, which may be an indicator of an overall decrease in acid rain (PEI Environment 1999).

Protecting drinking water is a priority in Prince Edward Island. A new strategy was announced by the provincial government in June of 2001 that introduces a multi-barrier approach to the protection of drinking water that will be applied to both municipal water systems and private wells. Some of the key components of the new strategy include regulations for water monitoring and public reporting, achieving full accreditation for the provincial water microbiology and chemistry laboratories, and development of well-field protection. The strategy also requires certification of the operators of all municipal water works, though it is important to note that a voluntary certification program has attracted over 95% of operators prior to this regulation (Somers 2001).

New Brunswick

New Brunswick compares its surface water quality monitoring data with the *Canadian Water Quality Guidelines* (*CWQG*) and there is no move at present to develop provincial standards. Data are collected from baseline stations for examining long-term trends, stations providing background information for specific projects in the short term, and downstream stations measuring the effects of point and non-point sources of pollution. A report on trends over 20 years is currently being assembled and will be available in 2002 (Choate 2001).

Major pollution abatement (industrial and municipal) and remedial efforts took place in the 1970s and 1980s and today new developments are more strictly controlled than in the past. This has resulted in significant improvements in water quality in some areas. While efforts are continuing, present effects on water quality are not as obvious as some of the more dramatic improvements of the past (Choate 2002).

Natural waters in many areas of New Brunswick tend to be poor in nutrients (especially phosphorus) and acidic—some natural pH values fall below the *CWQG*'s recommendation of pH 6.5. In some areas, naturally high levels of aluminum and iron often exceed the guidelines (Choate 2000). Generally however, the province's surface waters are considered high in quality, and suitable for recreation and the support of aquatic life (Choate 2002).

One long-term concern in New Brunswick has been the impact of acid rain on surface water. A recent study examined trends in the amount of acid in precipitation and the quality of lakes in southwestern New Brunswick. It found that reduced sulphate emissions have resulted in less acid deposition and that some acidified lakes may be in the early stages of recovery (Pilgrim 2001). Future monitoring is required to determine if recovery is actually in progress (Choate 2002).

About 40% of those living in New Brunswick obtain their water from surface watersheds and the remainder are dependent on groundwater wells. In order to ensure the safety of these sources, New Brunswick has legislation that protects both watersheds for surface water (since 1990) and well-heads (since 2000), the recharge area for groundwater. Thirty-one watersheds servicing 21 municipalities are currently designated under the Watershed Protection Program, which means land uses are restricted within 75 metres of a watercourse. In this setback area, there are strict regulations regarding agriculture, forestry and other forms of development. The government is poised to introduce phase two of the regulations, which will also oversee land use in drainage basins (Vanderlaan 2001).

Municipalities are responsible for regularly testing their own public water supplies according to an approved sampling plan. The testing is conducted either at a government lab or at a provincially recognized facility. Training and instruction on the collection of samples is publicly provided and many treatment-plant operators are certified through a voluntary program. Results of the tests are reported to the Department of Health and Wellness but no comprehensive report of the quality of drinking water across the province is available (Allen 2001). Drinking water in municipalities is normally adequate although bacterial contamination occasionally occurs at some locations, requiring consumers to boil their water while the problem is being corrected (Choate 2002).

Quebec

Quebec is one of the first provinces to carry out an overview of the status and trends of the water quality of its rivers. Over $7 billion has been spent over the last 20 years to restore Quebec's waterways. Two water cleanup programs, the Programme d'Assainissement des Eaux du Québec (PAEQ), and the Programme d'Assainissement des Eaux Municipales du Québec (PADEM), have led to 98% of the municipal population being served with wastewater treatment and to declining levels of contaminants including nitrite-nitrates, phosphorus, turbidity, and fecal coliforms in Quebec rivers since 1979 (Ministère de l'Environnement du Québec and Environment Canada 2001). Improvements in the treatment of mill effluents in the province's pulp and paper industry have also contributed to an improvement in water quality, leading to a 75% decrease in loading by suspended particles from 1980 to 1994 (Painchaud 1997).

The Ministry of the Environment and Wildlife operates 386 monitoring stations located in 40 watersheds to measure nitrogen, phosphorus, fecal coliforms, pH, turbidity, and suspended solids. These readings, as well as biological surveys and measurements of toxic chemicals in fish, artificial substrates and water are conducted on a monthly basis. The province does not set water quality objectives but instead studies point sources to determine the nature of local or regional use of the water body and how it must be preserved or restored. Goals can vary from one site to the next on the same river as the use of that river changes.

Much is made of the environmental degradation of the St. Lawrence River. The Beluga whales of the river were placed on the endangered species list in 1983 and confirmed as endangered in 1997. The river has served as a dumping point for industrial, human, and toxic waste for hundreds of years. It is now showing signs of improvement. Samples taken from the eggs of double-breasted cormorants living in the St. Lawrence estuary indicate that between 1972 and 1996 DDE decreased by 89.8% and PCB levels by 68% (Environment Canada 2001c) (figure 2.10).

In 2001, in response to concerns about water quality, Quebec adopted the *Regulation respecting the quality of drinking water*, which establishes the highest standards of quality and the strictest controls in North America. The standards apply to all municipal and private water distribution systems, including private wells. To increase the protection of public health, the regulation updates 77 quality standards including analysis of 17 inorganic substances and 42 new organic substances at specified intervals. All drinking water that comes in contact with a source affected directly by surface water must be disinfected and filtered, and all operators of distribution systems must be certified to possess the required qualifications (Environnement Quebec 2001). Quebec has also made impressive improvements in its wastewater treatment.

Ontario

The government of Ontario announced new regulations for drinking water in August 2000, just a few months after the Walkerton crisis erupted in the national media. The new regulations replace the *Ontario Drinking Water Objectives* with the *Ontario Drinking Water Standards* and include 84 new, revised, or reaffirmed parameters for assessing drinking water. Under the new regulations, water works in Ontario are responsible for monitoring their drinking water supplies to ensure they satisfy provincial standards and are responsible for notifying both the Ministry of Environment and the local Medical Officer of Health if any health parameters are exceeded.

About 8.9 million people in Ontario—82% of the population—get their drinking water from municipal waterworks; the remainder are served by individual wells or private waterworks. Of some 627 municipal waterworks, 399 rely on ground water, 225 use surface water and three use combined sources. The Ontario Ministry of the Environment runs the Drinking Water Surveillance Program that monitors 175 of these waterworks regularly for 200 chemical and physical parameters (Fleischer 2001).

From 1993 to 1999, the program performed 963,382 tests on source water, treated drinking water and water in the distribution systems. Of almost a million tests, only 192 exceeded parameters: 99.98% of water samples passed all health-related standards. International comparisons have shown that some of the parameters exceeded on those rare occasions—lead, nitrates, THMs and turbidity—are common problems for all jurisdictions. In fact, because of Ontario's stringent standards, more exceedances may have been recorded than if the tests were performed in other jurisdictions. For example, if the American drinking-water standard for fluoride was applied, no violations would have been reported in Ontario (Ontario Ministry of Environment 2000).

Ontario is currently looking at regulations to protect sources of drinking water. The new regulations, which are currently in the development stage, will be designed to safeguard the recharge area for groundwater near wells (Fleischer 2001). Though the need for such regulations had been discussed prior to Walkerton, that calamity reinforced the issue.

Another result of Walkerton was a change in the frequency of waterworks inspections. Previously, they were only inspected every four years; that interval was increased to annual inspections. From June to November 2000, almost 600 water-treatment plants were scrutinized and more than 250 orders were issued resulting from various deficiencies or infractions (Ontario Ministry of Environment 2000b).

Manitoba

Manitoba has over 900 trillion liters of surface water covering 16% of the province. Manitoba Environment has a network of 40 stations for monitoring the quality of surface water across the province. These stations test water for up to 75 substances to ensure it meets the *Manitoba Surface Water Quality Objectives*. These objectives are used as a baseline for developing legally enforceable limits that are specified in licenses issued under the *Environment Act* to control pollution from point sources (Sustainability Manitoba 2001).

Experts in Manitoba are currently studying four areas of concern about surface water. The first is the development of source-water protection regulations. Similarly, riparian zone protection (usually 100 meters from a stream or river) is also being looked at. Riparian zones are natural buffers created by vegetation that filters pollutants and provides habitat for wildlife. Nutrient levels in surface water are also a concern because the Prairies have a naturally high background level of nitrogen and phosphorus and because of agricultural practices. The last area is addressing metal concentrations in water that can occur from acid tailings run-off from mining activity (Williamson 2001).

Almost 80% of Manitobans rely on surface water for their drinking water while 20% use groundwater. Because local authorities value flexibility in assessing drinking water, Health Canada's *Guidelines for Canadian Drinking Water Quality* (*GCDWQ*) are used for comparison only and are not enshrined in law. Chlorination is mandatory for all waterworks along with regular testing for chemical properties and bacteria. New legislation requires mandatory licensing for all operators of waterworks and waste treatment facilities with a five-year phase-in period to allow current operators to undertake training courses (Rocan 2001).

Manitoba has never experienced a deadly outbreak of a water-borne disease though it has had a *Giardia* outbreak that caused minor illness. One improvement to the drinking-water system that will be put into practice shortly is regular testing of the 1,500 semi-public systems in the province (for instance, restaurants that use water from wells) (Williamson 2001). A report on surface-water trends for Manitoba is expected to be published in 2002 but was unavailable at the time of this publication.

Saskatchewan

Saskatchewan is often thought of as an agricultural area, growing endless fields of wheat, but its geography is much more varied than that. The northern half of the province is located in the boreal shield ecozone and has been called a "land of lakes and forests" (SERM 2000). Water—streams, rivers, ponds, lakes and man-made reservoirs—covers 12% of Saskatchewan's surface area.

The province currently employs the *Saskatchewan Surface Water Quality Objectives* (1997) as a guide for assessing water quality. Monitoring stations are currently located on 15 major rivers testing for 70 pollutants. However, these data cannot be considered reflective of overall water quality but give instead a "snap shot" of water quality in the major rivers of southern and central Saskatchewan (Hallard 1997). In general, the quality of surface water varies considerably from region to region. In the north, the water is low in nutrients and can be described as "clean, deep and cold." Waters in southern areas occasionally encounter elevated levels of nitrates and phosphorus (possibly as a result of intense agriculture) but they do not generally exceed standards (Ferris 2001).

The *Municipal Drinking Water Quality Objectives* are used to assess Saskatchewan's drinking water. The objectives are based largely on the *Guidelines for Canadian Drinking Water Quality* (*GCDWQ*). The frequency of testing depends on the population being served by the waterworks and the source of the supply. Shortly after Walkerton, all communities were advised of the importance of conducting regular bacteriological tests. Protocols, called precautionary drinking water advisories, were also established for quicker responses when bacteriological contamination is suspected. Mandatory certification also came into law following Walkerton, decreeing all water treatment operators be trained and certified by 2005.

A recent study of groundwater examined the contamination of well water by pesticides. This is of concern because 45% of Saskatchewan's residents rely on private wells for drinking water. The study determined that although one or more pesticides were detected in all but two of the tested wells, all concentrations were significantly lower than the maximum acceptable under the *GCDWQ* (McKee 1999).

The outbreak of water-borne illness in North Battleford, Saskatchewan during the spring of 2001 was caused by a parasite, *cryptosporidium*, which infected the town's water supply. The cause of the outbreak is believed to have been a malfunctioning filtration device. Tests for *cryptosporidium* are not regularly performed on public water systems in Canada due to technological limits. Generally, the presence of the parasite is only brought to the public's attention after a diagnosis of illness resulting from the organism (Fleischer 2001). However, the situation in North Battleford was complicated by a week-long delay between the time of diagnosis of a case of illness and action taken by the local health authorities. In general, a well-operated and monitored multi-barrier system is critical in preventing and removing these parasites.

Alberta

The majority of Alberta's water is generated in the Peace River system and flows northward through the Slave River. Water quality in Alberta's major rivers is described as "excellent" to "fair" though quality tends to be lower downstream of significant urban, industrial, or agricultural development (Alberta Finance 2001). Water quality is determined by comparing samples to the *Surface Water Quality Guidelines for Use in Alberta*, which replaced previous interim guidelines in 1999.

Water quality is assessed for hundreds of variables at more than 300 locations on lakes and rivers throughout Alberta each year. Data for a sub-set of variables from two stations on each of the six major rivers is used to compute the *Alberta Surface Water Quality Index*. The index was recently revised to employ a new formula that incorporates the number of variables not meeting objectives, the number of times objectives are not met, and the amount by which objectives are not met. The overall index value is based on four sub-indices that are calculated for metals, nutrients, bacteria, and pesticides (Saffran 2001). Because of missing data, the overall index has only been calculated since 1996 (table 2.3) Three of the sub-indices, however, have data going back to 1991 (table 2.4). These data do not go back far enough to establish a trend and it is also important to understand that natural variability causes some of the changes observed. For example, natural variation in flow can cause improvements in nutrients and in a dry year sites may appear cleaner because there is less runoff from storm drains. Some real improvement appears to have occurred downstream of Edmonton and Calgary, where bacteria index values were very low prior to treatment improvements, then became very high after the improvements were made. This fits the stated goal of the government of Alberta to bring water quality downstream of developed areas in line with water quality upstream. Thanks to upgraded municipal wastewater treatment facilities in Calgary (1997), Edmonton (1998), and Lethbridge (1999), water quality downstream of these cities has improved (Alberta Finance 2001).

There are 494 approved waterworks in Alberta serving approximately 2.4 million people (80% Alberta's population). About 44% of these waterworks depend partially or fully upon groundwater, though these systems only serve 150,000 people (or 6% of the publicly served population) (Lang 2001).

Alberta has adopted the *Guidelines for Canadian Drinking Water Quality* (*GCDWQ*) as a standard and, by law, water from treatment facilities must meet the guidelines. Waterworks are required to perform a minimum of one or more tests for bacteria each week and to report test results to Alberta Environment. Legislation also requires the certification of municipal water and wastewater treatment operators. Small private water systems are not regulated and the owners are responsible for testing their own supplies (Samuel 2001).

Alberta does not have any specific regulations for protecting source water. The province ensures the quality of its drinking water through surface water treatment plants, of which it has 210, far more than any other province, though this option is generally more expensive than source water protection regulation (Lang 2001).

British Columbia

The quality of surface water is monitored in British Columbia by the provincial government following the *British Columbia Surface Water Quality Objectives*. About 150 streams, rivers, and lakes have specific objectives set for their quality, depending on the use of the water (drinking, agriculture, recreation, etc.), and depending on the natural state of the water's quality (Swain 2001).

The 1996 *British Columbia Water Quality Status Report* reviewed the quality of 124 bodies of water including rivers, lakes, marine bays or inlets, and ground-water aquifers. The report provides a detailed index developed from objectives and attainment records (including the number, frequency, and magnitude of objectives exceeded), rating water bodies as "poor," "borderline," "fair," "good" or "excellent." The report rated nine of the 124 water bodies as borderline or poor, nine as excellent, 44 as good and 62 as fair (figure 2.11) Unfortunately, data from previous years was not reported in this format, making analysis of trends impossible.

Trends were evident, however, in the new report *Water Quality Trends in Selected British Columbia Waterbodies* (2000). Data from 133 monitoring stations on 49 rivers or creeks, 14 lakes or reservoirs and 5 groundwater aquifers were collected over the last 10 to 20 years. The report revealed that for surface water, 59% of the stations had no observed change, 31% had improving trends and 10% had deteriorating trends (figure 1.12). For groundwater, 53% of the stations had no observed change, 27% had improving trends and 20% had deteriorating trends (figure 1.13). The report makes it clear, however, that these trends are not to be considered representative of the trends in water quality in the province as a whole because monitoring is primarily done in areas where people are active. Thus, "this report gives a view of water quality in developed areas rather than of undeveloped watersheds where water is still in a largely natural state" (BC Ministry of Environment, Lands and Parks 2000: iv).

Levels of toxic contaminants have been decreasing over the past 20 years in British Columbia. Samples taken from the eggs of a Great Blue Heron colony located near the University of British Columbia show a marked decline in levels of PCBs, DDE, dioxins and furans (figure 2.14). Between 1977 and 1998, PCBs decreased by 87.5% and DDE by 87.7% (PCBs and DDE are discussed in greater detail in the Great Lakes section of this section). Dioxins and furans are the chemical by-products of a number of industries including pulp-and-paper production. One of the most toxic of these, 2378-TCDD, showed a 97.7% reduction in 1998 from its highest level in 1989, due to recent changes to processes in the pulp-and-paper industry and to an 82% reduction in contaminated effluent entering the province's waterways (figure 2.15).

Long-term monitoring of groundwater supplies show that the percentage of wells with declining water levels has decreased from a high of 56% of wells in 1980 to 16% in 1996 (figure 2.16). Since 1980, above average precipitation has resulted in the replenishment of water levels in many wells, indicating that climatic factors are the principle agents affecting groundwater levels in the province (BC Ministry of Environment, Lands and Parks 2000).

Drinking water in British Columbia is regulated through the Ministry of Health though monitoring and jurisdiction over drinking water largely rests with the province's 18 health regions. The health regions are responsible for intense monitoring of bacteria levels in drinking supplies. Some regions require the water suppliers to collect their own samples while others collect the samples directly. The *Guidelines for Canadian Drinking Water Quality* (*GCDWQ*) are followed as objectives for all water supplies with the exception of private family wells. The province is preparing to instigate mandatory training and certification for all waterworks operators though some health regions have long required certification as a condition for granting operating approval licenses in their regions.

The major benefit of the drinking water regulatory system British Columbia has adopted is its integration and the resultant rapidity in dealing with water contamination that could produce illness. As one health official put it, "This is the system that all the other provinces wish they had" (Boettger 2001). For example, a viral outbreak in Kelowna in 1997 was quickly discovered and an advisory to boil water was issued in a timely manner because the same people who monitor the water respond to the health emergency (Boettger 2001).

The weakness of British Columbia's current system is the lack of source protection for watersheds that supply drinking water. The type of land from which a region's source water comes greatly influences how much control it can have over it. For instance, a *cryptosporidium* outbreak that occurred in Cranbrook in 1996, which caused thousands of people to become ill, is thought to have been caused by manure entering the water system on the Crown range land from which the community gets its water supplies. Some regions, such as the Greater Vancouver Regional District and the Capital Regional District, are able to protect and regulate their water supplies because they have obtained leases on the land from which the water comes (Swain 2001).

The North

The federal Department of Indian Affairs and Northern Development (DIAND) manages the water resources of the Yukon, the Northwest Territories and Nunavut, often in cooperation with the territorial governments and Environment Canada. The waters of Canada's north generally do not exhibit signs of human pollutants.

Environment Canada is currently analyzing data from the territories and plans to release a trends report with data from the 1960s by 2003 (Haliwell 2001).[11]

Because most water bodies in the Yukon are considered pristine, water quality objectives have not been set in the territory and contamination is prevented through enforcement of water-use licenses. The Northwest Territories employ water-quality objectives that comply with the *Canadian Water Quality Guidelines* (*CWQG*) and some site-specific objectives have been established to track unique natural occurrences and human activity.

One study of water quality in the Slave River, the largest tributary of the Mackenzie River, found that many parameters being tested were present at extremely low levels or were not detected at all, even with state-of-the-art analytical techniques (Indian and Northern Affairs 1998). Of the compounds that were found in low levels, some are the result of natural weathering of rocks, some indicate atmospheric transport, and some could have been flushed downstream from Alberta, British Columbia, and Saskatchewan.

Drinking water in Yukon communities comes mostly from groundwater (17 supplies) though two waterworks, Whitehorse and Carcross, use surface water. There is no territorial requirement for surface water source protection though Whitehorse has a management plan in place for protecting the watershed that provides its water. All waterworks in the Yukon are chlorinated and operators collect regular samples to be tested either at a territorial laboratory or an out-of-territory laboratory, depending on the needed tests. The water is compared to the *GCDWQ* and the territory will direct remediation if the water is found to exceed the limits set by the guidelines (Brooks 2001).

Drinking water in the Northwest Territories is largely obtained from surface water sources (30 of 34 supplies) since groundwater plays a minor role due to the geology of the land and the permafrost that covers it. Some supplies serving major populations, such as Yellowknife, are under source water protection legislation. All other supplies are protected through the territory's land-use permit system or by restrictions placed on individual watersheds by the Chief Medical Health Officer. There have not been any outbreaks of sickness from contaminated water in the NWT and there is regular testing of water samples, which are compared to the *GCDWQ* (Fleming 2001).

Nunavut, Canada's newest territory, relies on surface water to provide all its fresh-water supplies. The hamlets of the territory run the waterworks and provide monthly samples to their regional environmental health officer for testing. Nunavut's guidelines under its *Public Health Act* were based on the *GCDWQ* at the time they were passed, though they are now outdated.[12] Because of the hardness of the ground, residents of Nunavut do not use pipes to transport water but rather truck it from the waterworks to the water tanks in the houses (Trotter 2001).

The Great Lakes

The Great Lakes—Lakes Superior, Michigan, Huron, Erie and Ontario—are the largest system of fresh surface water on earth, containing roughly 23,000 km^3 of water or 18% of the world's supply (GC & USEPA 1995). The lakes provide tremendous economic and ecological benefits to the surrounding area—the Great Lakes basin, which includes the lakes and more than 76,000,000 hectares of land that drains into them. The area contains a large concentration of industrial capacity, housing one-quarter of American industry and almost 70% of American and Canadian steel mills (USEPA 1995: 496). It also supports a large agricultural base with nearly 25% of Canadian and 7% of American agricultural production being located in the basin (GC & USEPA 1995). In addition to economic benefits, the lakes provide drinking water for more than 23 million people and support recreational activities and other uses for one-tenth of the United States' population and one-quarter of Canada'a population who live in the basin (GC & USEPA 1995).

Although for many years it was believed that the Great Lakes were too big to be affected seriously by pollution, modern settlement did cause deterioration in water quality. Agricultural development increased the amount of silt and nutrients in streams and along shorelines, and growing urbanization and industrialization produced large amounts of waste water and toxic contaminants that were discharged directly into the lakes. Consequently, by the 1960s, sewage, fertilizer run-off and chemical wastes had caused serious degradation to Lake Erie and the other lakes showed signs of similar trouble.

As a result of the water degradation, a variety of pollution-abatement initiatives have been formulated at both the regional and international level over the past 30 years. In 1972, the Great Lakes Water Quality Agreement (GLWQA) between the United States and Canada set a management framework for controlling pollution, researching problems, and measuring progress. The initial agreement focused primarily on targeting levels of phosphorus discharged into the waters. Revisions in 1978 and 1987, however, broadened its mandate to include the whole ecosystem, focusing on the impact of both point and non-point pollution on all living organisms. Since 1994, a biennial conference—the State of the Lakes Ecosystem Conference (SOLEC)—has been evaluating trends using a variety of indicators. The findings from these conferences are summarized and made available to the public through the *State of the Great Lakes Reports*.

In addition to the conferences, the GLWQA has developed action plans to restore the Great Lakes. The two main programs are Lakewide Management Plans (LaMPs) and Remedial Action Plans (RAPs). Lakewide Management

Plans were created to address the most critical pollutants that affect whole lakes or large portions of them. Remedial Action Plans are more regionally focused and are designed to rehabilitate the 43 Areas of Concern (AOCs). AOCs are designated geographical areas where several beneficial uses, such as fishing or swimming, are impaired. There are currently 42 AOCs: 11 are located in Canada, 26 in the United States, and five in connecting channels. These programs continue today alongside a variety of local initiatives run by numerous grass-root organizations and special-interest groups.

Through these efforts, water quality has improved. Levels of toxic contaminants released into the basin have steadily decreased and some key contaminants are no longer released at all. There have been note-worthy reductions in levels of organic material, solids, and phosphorus released as well. As a result of its RAP, the harbour in Collingwood, Ontario, which was once identified as an AOC, has been successfully restored. In general, approximately one-third of the beneficial uses in AOCs have been reinstated and more than 60% of the action necessary to restore AOCs fully have been implemented. Plus, all the recommended remedial action at the Spanish Harbour AOC in Ontario has been taken and it is now in a stage of natural recovery (Environment Canada 2000b).

Despite these improvements, most regulatory bodies and environmental groups call for further action to improve water quality in the Great Lakes. The International Joint Commission (IJC), an advisory group of Americans and Canadians, states in its *Tenth Biennial Report on Great Lakes Water Quality* (2000) that decisive action and increased funding is needed to address the issues of sediment contaminated with persistent toxic substances, contaminated sport fish used for human consumption, and alien invasive species. The *State of the Great Lakes Report* also illustrates that many indicators are improving but are not yet at the "good" level.

In this section, we will examine two of the main indicators of water quality in the Great Lakes: toxic contaminants and excess nutrients. We will also briefly discuss another indicator, the Double-breasted Cormorant population, as well as look at the 1999 edition of *State of the Great Lakes*.

Trends for toxic contaminants

The levels of pesticide contamination found in herring gull eggs fell considerably between 1974 and 1999.[13] This measure is a good indicator of water quality because these pollutants are bioaccumulative, so herring gulls, as fish eaters, will have the highest concentration of these pollutants in their systems. Levels of dichloro-diphenyl-dichloro-ethylene (DDE),[14] fell 86% in Lake Ontario, 89% in Lake Erie and 85% in Lake Michigan relative to their levels in the mid-1970s (figure 2.17). And, in Lake Superior and Lake Huron, levels of DDE fell by 91% and 93%, respectively.

Levels of polychlorinated biphenyls (PCBs)[15] and hexachloro-benzenes (HCBs)[16] also showed drastic reductions during the same periods. PCBs fell 89% in Lake Ontario, 82% in Lake Erie and 80% in Lake Michigan relative to their levels in the mid-1970s (figure 2.18). Lake Superior saw decreases of 87% and Lake Huron experienced a 92% reduction in PCBs. HCBs fell 93% in Lake Ontario, 97% in Lake Erie, 86% in Lake Michigan, 92% in Lake Superior and 95% in Lake Huron relative to their levels in the mid-1970s (figure 2.19). Available data also indicate a dramatic decrease in the already low levels of the pesticides Dieldrin and Mirex in herring gull eggs.[17]

Even with these improvements, there are still concerns about the level of toxic contaminants in the Great Lakes. PCB concentrations in fish in various areas of the basin continue to exceed the International Joint Commission's objective of 0.1 μg of PCBs per gram of fish tissue. Restrictions on the consumption of fish also remain and the IJC recommends that advisories on the consumption of sport fish should state plainly that eating Great Lakes sport fish may lead to birth anomalies (IJC 2000). There is also concern about the presence of other toxic contaminants. Including the pollutants already discussed, scientists have detected 362 contaminants in the Great Lakes (32 metals, 68 pesticides, and 262 other chemicals). Eleven chemical pollutants are of special concern because of their toxicity, persistence in the environment, and tendency to bioaccumulate (Statistics Canada 2000). As a result of these concerns, many regulatory agencies recommend further reductions in contaminant concentration and further remediation of contaminated sediment.[18]

Trends for nutrient levels

Annual total phosphorus loadings have shown significant improvements over the past three decades (figure 2.20) Phosphorus loadings decreased in Lake Erie 67% from 1967 to 1995 and 65% in Lake Michigan from 1974 to 1995. Lakes Superior, Huron, and Ontario also saw declines of 43%, 33%, and 5% respectively from 1974 to 1991 (Dolan 2001). Phosphorus loadings in Lakes Michigan, Superior, and Huron have been reduced to levels set to prevent excessive algal growth since 1981, 1985, and 1986, respectively. Loadings in Lake Ontario were reduced to the targeted level in 1988 and 1989 but exceeded it in 1990 and 1991. In Lake Erie, phosphorus loadings fell to the targeted level in 1987, exceeded it in the early 1990s, and again fell to the targeted level in 1994 and 1995.[19]

These reductions have come about to a large degree because of reductions in municipal phosphorus loadings (figure 2.21). Municipal discharges of phosphorus decreased by 80% in Lake Erie between 1974 and 1995, 72% in Lake Michigan between 1976 and 1991, and 42%, 38% and 41% in Lakes Superior, Huron, and Ontario between 1974 and 1991 (Dolan 2001). Limits placed on concentrations of phosphorus in detergents in 1972 were effective in reducing loadings because 70% of total inputs of phosphorus are from detergents from municipal wastes (Environment Canada & USEPA 1995a:3). Other reductions can be attributed to better control practices in industrial processes and agriculture.

Nitrogen levels have been increasing since 1971 (figure 2.22). Between 1971 and 1993, nitrogen levels increased 49.8% in Lake Ontario. Despite these increases, levels remain well below the threshold of 10 milligrams per litre for safe drinking water.

Trends reported in *State of the Lakes 1999*

The report, *State of the Great Lakes 1999*, illustrates the overall improvement in the Great Lakes, including the continued downward trend of contaminants in herring-gull eggs. The report also notes the emergence of the round goby as another invasive species in the lakes that could pose a threat to the integrity of the ecosystem.

In 1996, those involved with SOLEC recognized the need to develop a comprehensive, basin-wide set of indicators that could signify progress under the Great Lakes Water Quality Agreement. The 1998 SOLEC was the first step toward the reporting of 80 indicators grouped within seven environmental compartments: air, water, land, sediments, biota, fish, and humans. *State of the Great Lakes 1999* includes 19 of these indicators. Because some indicators are currently not being monitored, it is expected that it will take 10 years to phase in the reporting of all 80 indicators.

The report arrives at several specific conclusions based on the available indicators and other information. Some of these include:

- Exotic species continue to stress the ecosystem.
- Phosphorus concentrations are mostly at, or below, proposed targets.
- Bird populations are increasing. The peregrine falcon is making a comeback and there are now 120 pairs in the basin. The giant Canada goose, once thought to be extinct, is now considered a nuisance species in the basin. The double-crested cormorant, another species once near extinction, is now at 38,000 pairs.
- Total coastal wetland area is decreasing but there have been some successful wetland restoration efforts.
- The number of farms adopting farming practices that are environmentally sound is increasing.
- Human health is at risk of being negatively affected by the state of the basin's environment, though measurable concentrations of contaminants in human tissue (blood, breast milk, hair, urine, and fatty tissue) have declined over the past few decades.

Table 2.1: Status of shellfish areas on the Atlantic coast, 1989–1997, 2000

	Approved for harvesting (ha)	Conditional approval (ha)	Closed to harvesting (ha)	Total area surveyed (ha)	Percentage of area approved
1989	272,800	4,200	167,600	444,600	61.0%
1990	291,700	7,400	179,500	478,600	60.9%
1991	310,700	8,800	190,800	510,300	60.8%
1992	329,600	7,400	194,700	531,700	61.9%
1993	353,900	8,300	200,900	563,100	62.8%
1994	367,800	8,300	207,600	583,700	63.0%
1995	368,500	7,300	209,200	585,000	62.9%
1996	347,100	6,800	195,800	549,700	63.0%
1997	401,700	5,200	206,200	613,100	65.5%
2000	392,400	8,700	211,300	612,400	64.0%

Sources: Statistics Canada 2000, except for 2000 data from Menon (2001). Note: Total area surveyed varies from year to year.

Table 2.2: Mean fecal coliform densities in the harbour at St. John's, Newfoundland, 1981, 1987/1988, and 1997

Site	1981	1987/1988	1997	Site	1981	1987/1988	1997
1	>1,100	806*	725,000	**7**	175	1,840	3,450
2	>1,100	1,501	7,375	**8**	>920	1,459	1,700
3		13,286	25,650	**9**		1,219	1,135
4		4,359	46,250	**10**	>1,100	5,614	2,525
5	670	3,493	8,750	**11**		1,570	1,668
6		2,417	1,075	**12**		474	1,155

Sources: Powell 1998. * Study attributes low count to combination of high tide and fresh water influx from Waterford River

Table 2.3: Alberta Surface Water Quality Index—overall

	Athabasca River		Smoky/Peace River		North Saskatchewan River		Red Deer River		Bow River		Oldman River	
	Athabasca	Old Fort	Watino	Fort Vermilion	Edmonton Upsteam	Edmonton Downstream	Red Deer Upstream	Red Deer Downstream	Calgary Upstream	Calgary Downstream	Lethbridge Upstream	Lethbridge Downstream
1995/96	94.3		91.5		96.2	69.3	92.9	88.1	100.0	71.4	61.6	67.4
1996/97	90.8	90.0	84.5	85.7	91.1	65.5	75.7	83.7	96.0	75.5	77.7	83.0
1997/98	92.5	90.3	83.3	88.5	97.1	70.7			100.0	86.7	82.9	84.2
1998/99	90.4	95.2	91.1	93.6	93.2	80.3	83.0	80.8	97.5	82.3	89.0	79.6
1999/00	90.9	90.5	90.2	85.9	86.3	81.1	86.7	75.3	97.4	83.9	97.2	86.1

Sources: Alberta Finance 2001. Note that higher index values indicate improvement.

Table 2.4: Alberta Surface Water Quality Index—sub-indices, 1991–2000

	Athabasca River		Smoky/Peace River		North Saskatchewan River		Red Deer River		Bow River		Oldman River	
	Athabasca	Old Fort	Watino	Fort Vermilion	Edmonton Upstream	Edmonton Downstream	Red Deer Upstream	Red Deer Downstream	Calgary Upstream	Calgary Downstream	Lethbridge Upstream	Lethbridge Downstream
Nutrients												
1990/91	74.6	74.0	68.4	55.8	84.0	53.4	76.4	74.0	100.0	73.4	87.9	64.2
1991/92	75.7	85.2	70.9	68.4	87.4	69.2	75.1	70.8	100.0	72.1	88	73.9
1992/93	88.3	80.1	73.5	73.2	87.2	70.2	76.3	70.8	75.5	71.3	76.1	73.0
1993/94	76.2	89.3	72.5	68.3	88.4	70.3	75.7	68.7	88.4	73.3	72.6	61.6
1994/95	77.5	73.4	54.0	54.2	100.0	56.5	76.3	45.6	88.4	72.9	88.4	86.3
1995/96	86.3	84.4	70.3	60.1	88.3	71.4	76.1	75.2	100.0	73.5	67.6	65.3
1996/97	75.4	72.6	71.7	64.4	87.5	66.8	75.6	58.2	88.4	73.7	74.6	64.6
1997/98	73.6	68.0	63.5	65.7	88.2	69.1	88.3	41.4	100.0	73.4	65.9	71.1
1998/99	79.5	87.7	76.1	88.3	80.4	74.2	76.7	64.6	100.0	66.4	87.4	78.7
1999/00	80.2	77.2	75.3	78.8	76.5	72.8	79.8	75.9	89.6	68.6	100.0	90.2
Bacteria												
1990/91	85.4	100.0	100.0	90.1	100.0	37.8	81.4	62.1	93.8	29.4	90.4	78.3
1991/92	92.7	100.0	100.0	100.0	100.0	32.2	93.0	78.9	100.0	21.8	82.3	87.6
1992/93	100.0	100.0	100.0	100.0	100.0	37.6	92.9	55.4	94.0	20.7	68.6	77.0
1993/94	100.0	100.0	100.0	100.0	100.0	28.1	100.0	49.0	100.0	10.6	49.6	52.3
1994/95	100.0	100.0	78.4	100.0	100.0	32.7	96.5	89.5	100.0	51.4	83.9	88.4
1995/96	100.0	100.0	100.0	87.7	100.0	31.7	100.0	86.1	100.0	33.4	37.0	39.7
1996/97	100.0	100.0	91.3	100.0	95.9	29.6	85.6	88.6	100.0	44.0	51.9	89.0
1997/98	100.0	100.0	93.7	100.0	100.0	45.4	74.3	95.9	100.0	88.9	69.1	69.1
1998/99	93.2	100.0	100.0	93.7	100.0	94.9	89.5	90.7	100.0	90.4	92.5	85.6
1999/00	100.0	100.0	100.0	100.0	93.6	89.2	90.7	78.1	100.0	88.5	100.0	82.6
Metals												
1990/91	92.4	100.0	81.9	69.0	100.0	84.5	100.0	100.0	100.0	100.0	96.3	100.0
1991/92	100.0	96.4	100.0	80.3	96.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1992/93	100.0	96.5	100.0	86.2	100.0	100.0	100.0	92.3	100.0	100.0	96.2	100.0
1993/94	92.9	95.9	100.0	84.1	100.0	100.0	100.0	96.3	100.0	100.0	100.0	100.0
1994/95	96.7	93.2	96.1	89.9	86.9	85.6	96.2	92.2	95.7	95.7	100.0	100.0
1995/96	91.0	95.7	95.8	86.4	96.5	93.0	95.7	95.4	100.0	96.0	93.0	89.1
1996/97	87.6	87.3	74.9	78.5	95.7	95.8	93.2	95.7	95.7	96.0	96.4	100.0
1997/98	100.0	93.3	79.6	92.0	100.0	96.5	92.1	96.0	100.0	100.0	96.5	96.5
1998/99	96.7	96.5	88.3	92.5	96.1	81.3	86.1	100.0	90.0	90.6	88.4	80.9
1999/00	83.5	84.8	89.0	88.0	82.4	76.8	91.5	76.6	100.0	97.3	97.2	93.9

Sources: Alberta Finance 2001. Note that higher index values indicate improvement.

Figures 2.1–2.6 Percentage of Canadian municipal populations served by wastewater treatment

Figure 2.1: Canada

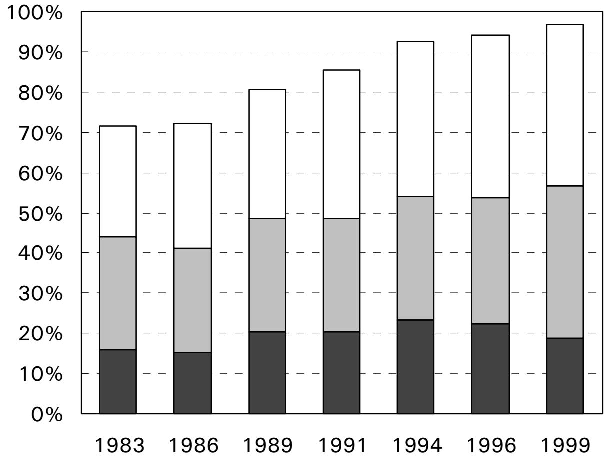


Figure 2.2: Atlantic Provinces

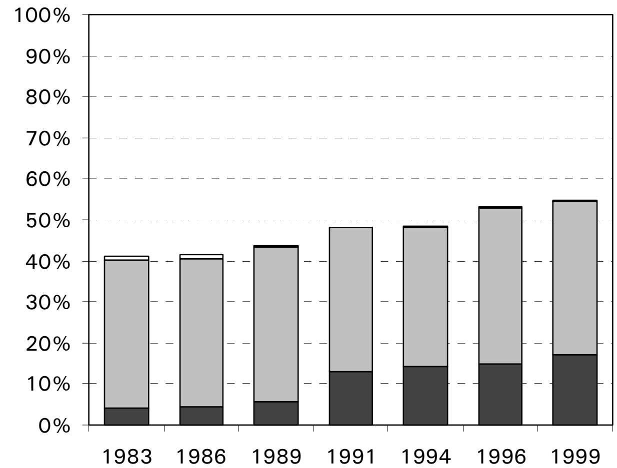


Figure 2.3: Quebec

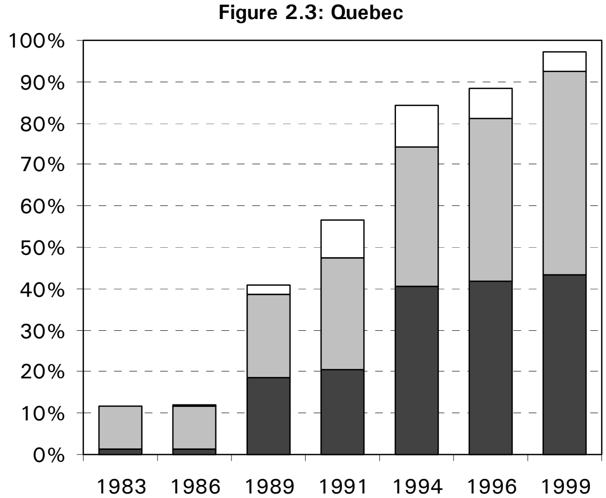


Figure 2.4: Ontario

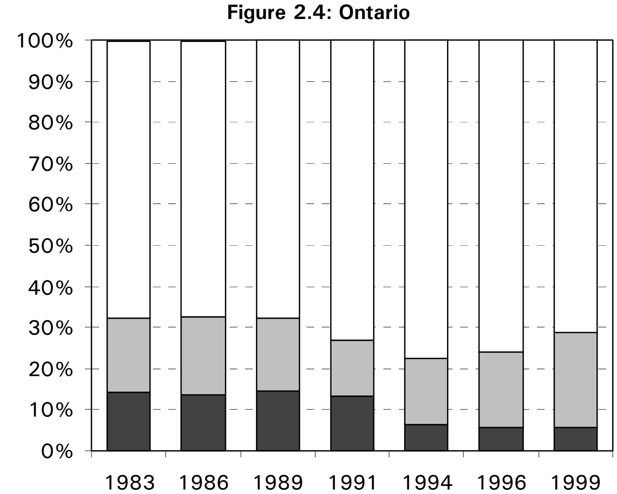


Figure 2.5: Prairie Provinces

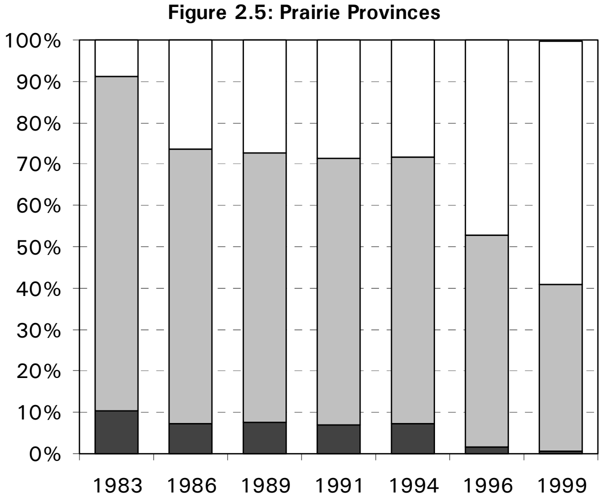
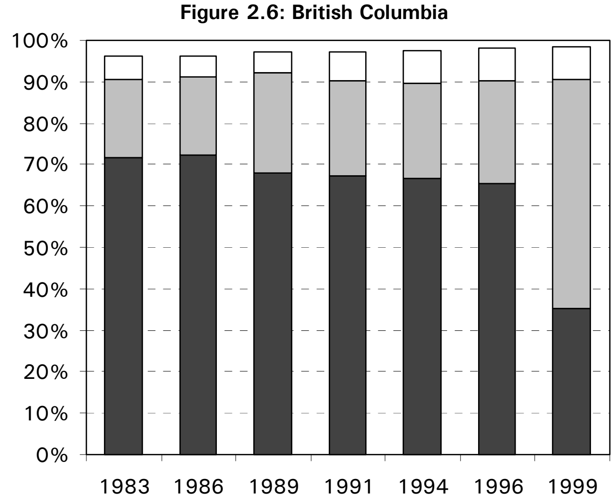


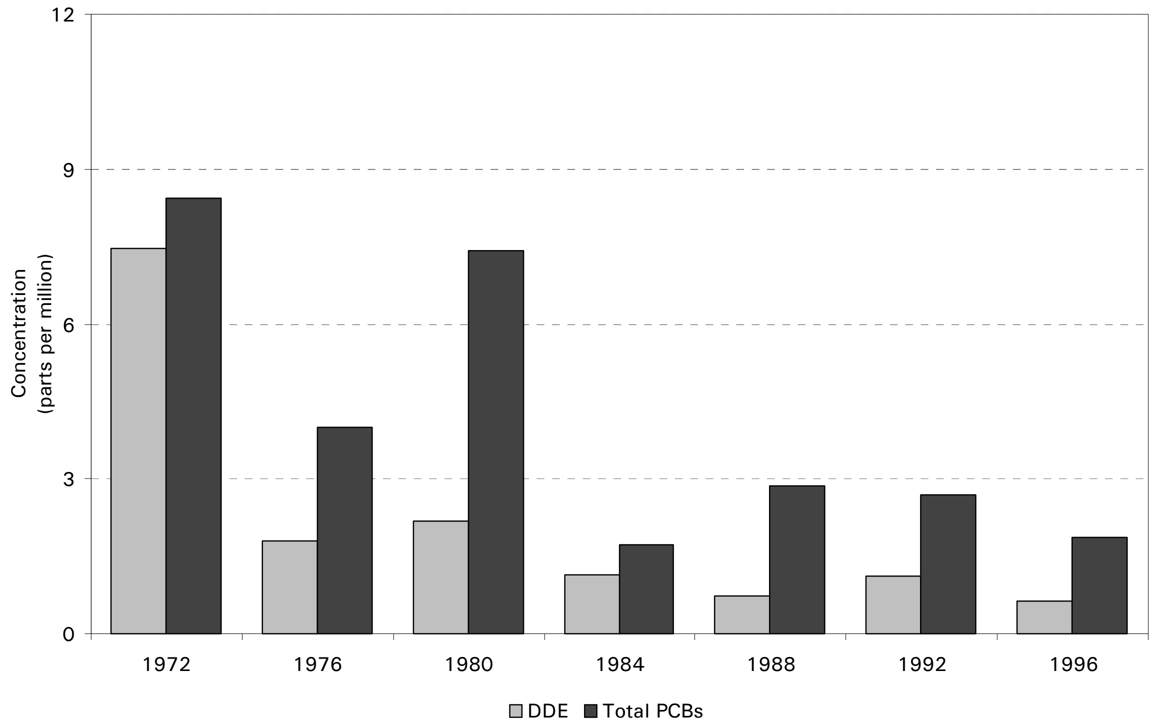
Figure 2.6: British Columbia



Primary treatment | Secondary treatment | Tertiary treatment

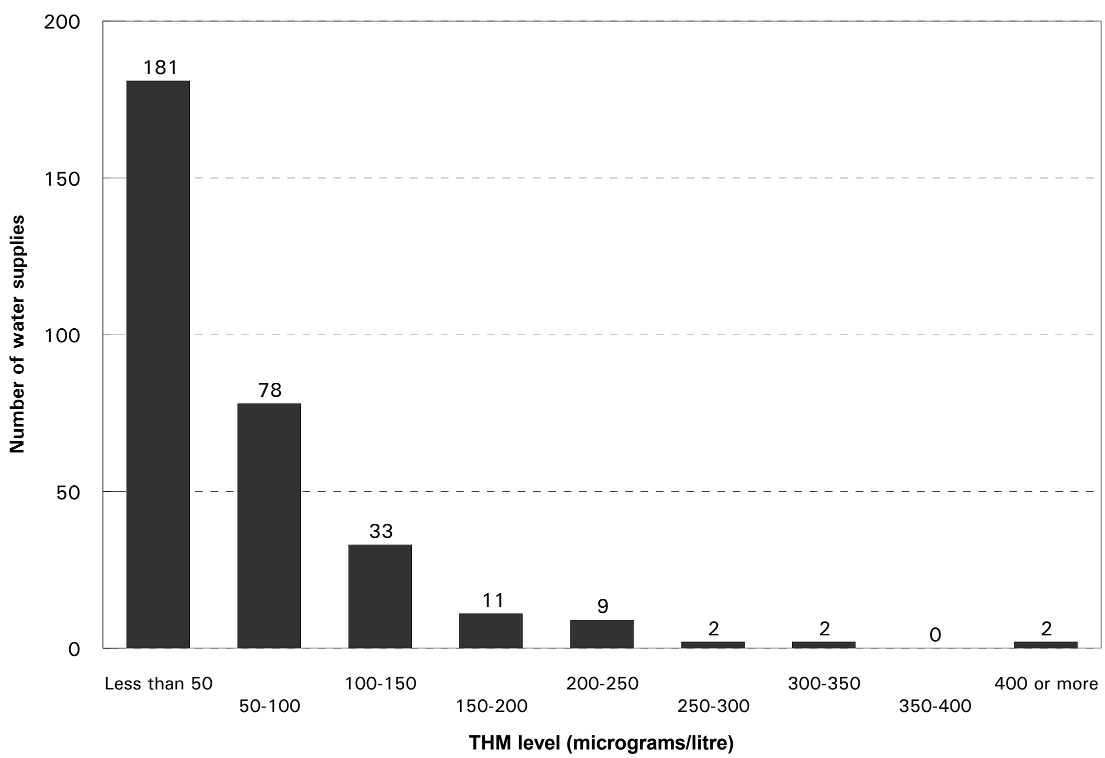
Source: Environment Canada 2001c.

Figure 2.7: Levels of dichloro-diphenyl-dichloro-ethylene (DDE) and polychlorinated Biphenyls (PCBs) in the eggs of double-breasted cormorants in the Bay of Fundy



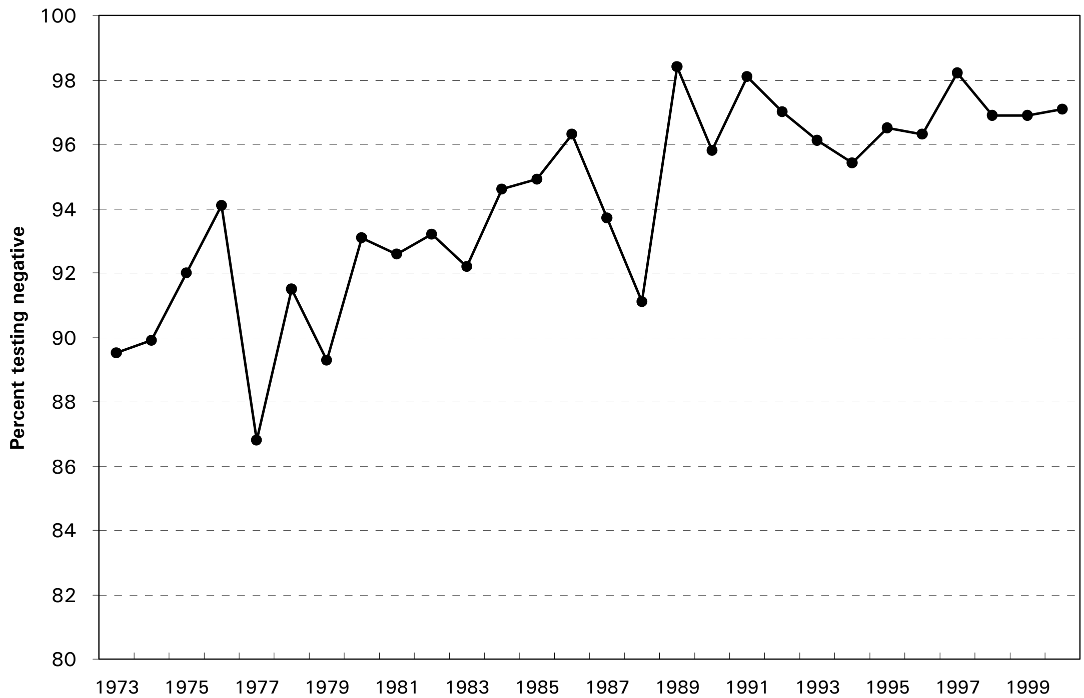
Source: Environment Canada 2001d.

Figure 2.8: Levels of trihalomethanes (THMs) in water supplies in Newfoundland



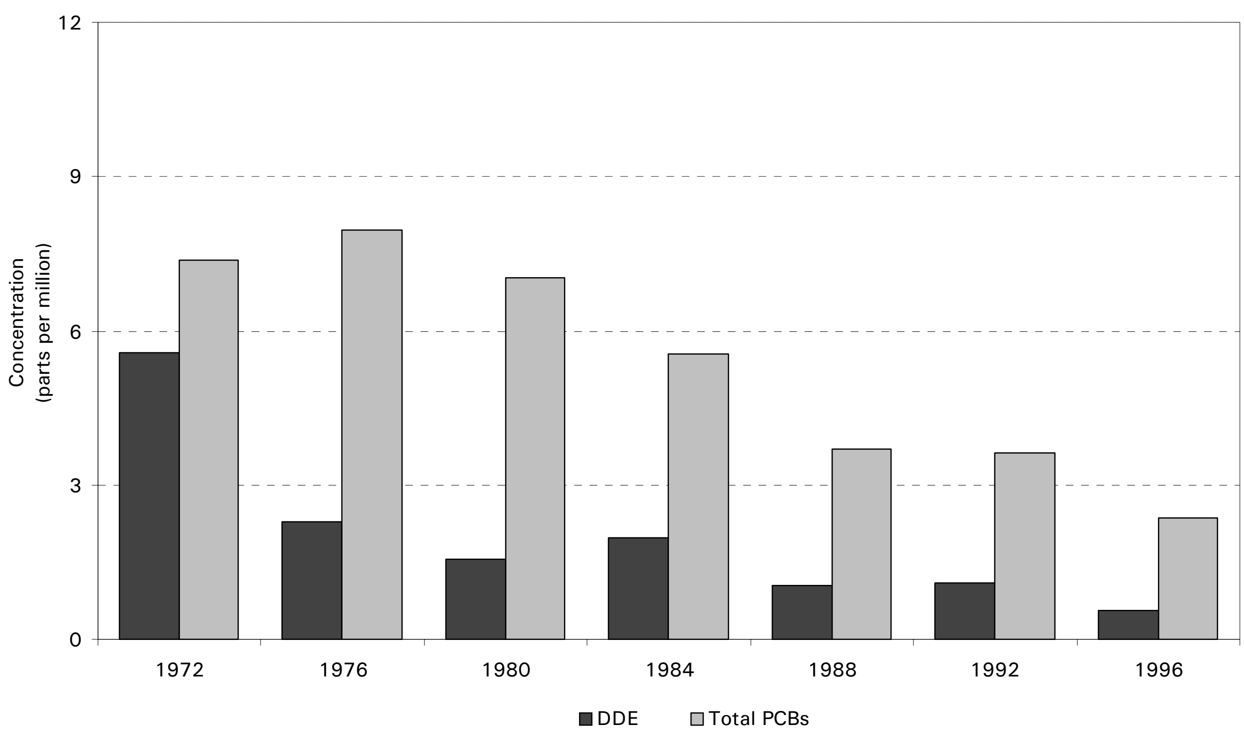
Source: Goebel 2001; data as of March 31, 2001. Note: The guideline for THMs is 100 micrograms per litre.

Figure 2.9: Municipal water samples in nova scotia testing negative for coliform bacteria, 1973–2000



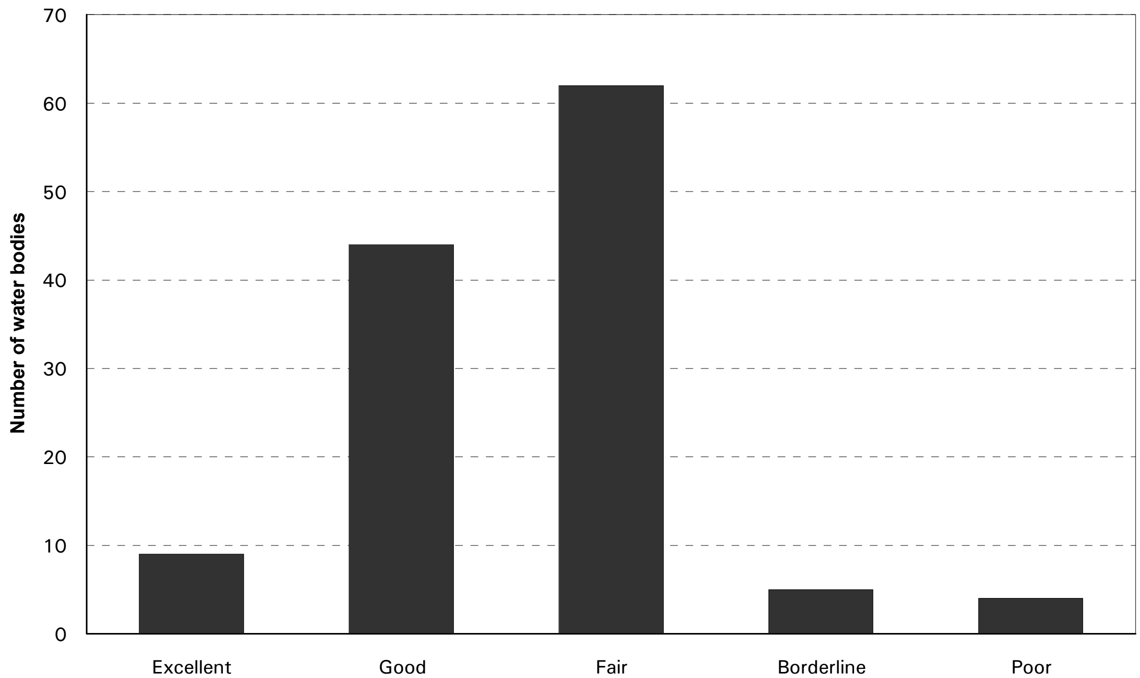
Source: Mosher 2002.

Figure 2.10: Levels of toxic contaminants in the eggs of double-breasted cormorants in the St. Lawrence Estuary



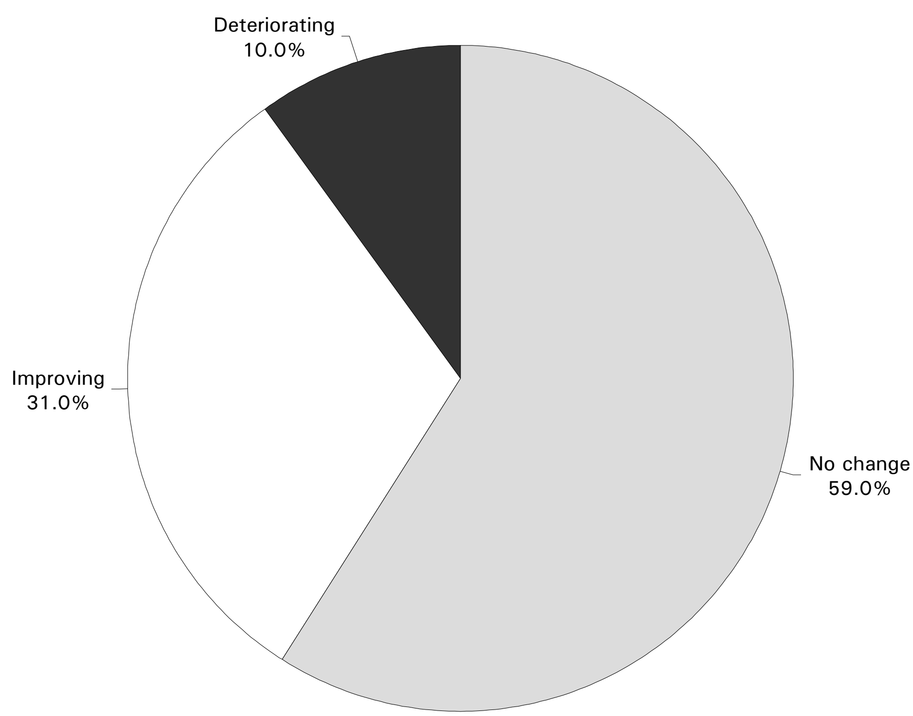
Source: Environment Canada 2001d.

Figure 2.11: Summary of water quality in selected bodies of water in British Columbia



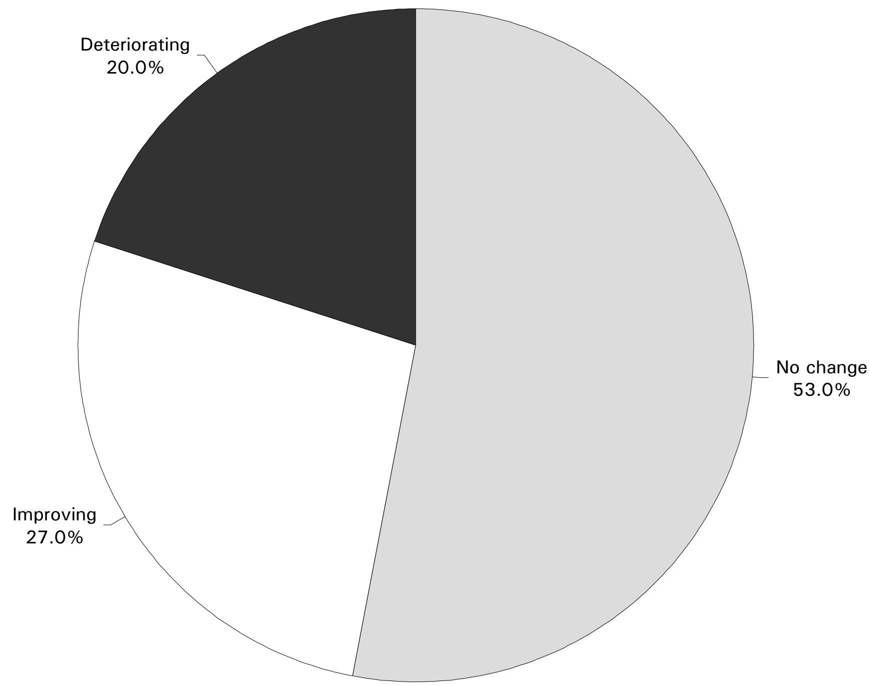
Source: British Columbia Ministry of Environment, Lands, and Parks 1996.

Figure 2.12: Trends in water quality, ground water, British Columbia



Source: British Columbia Ministry of Environment, Lands and Parks 2000: iv.

Figure 2.13: Trends in water quality, surface water, British Columbia

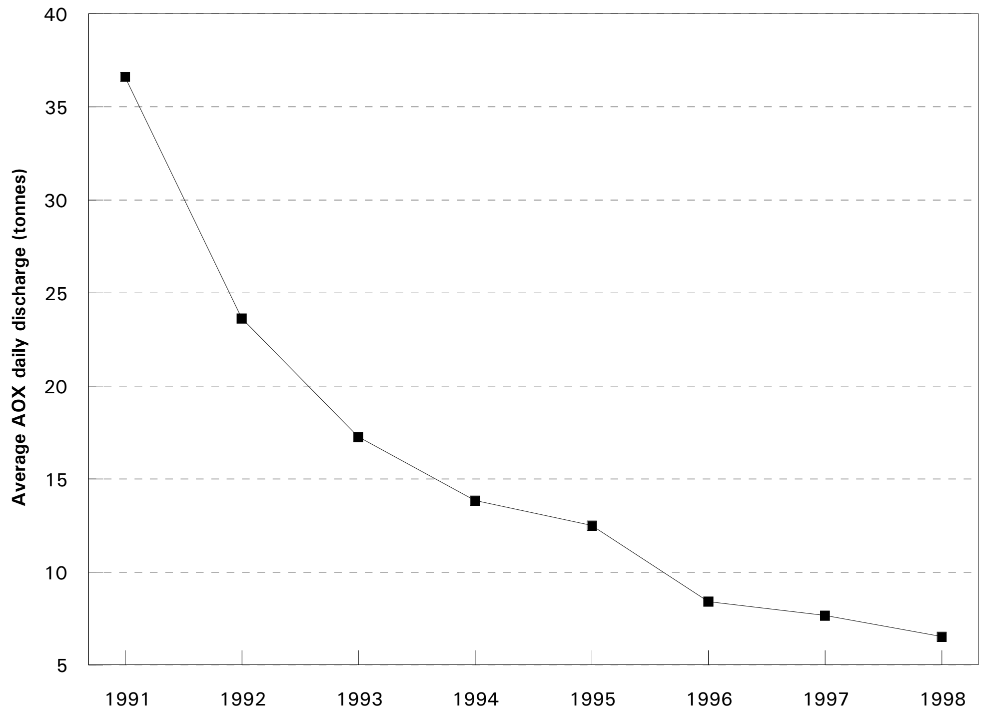


Source: British Columbia Ministry of Environment, Lands and Parks 2000: iv.

Figure 2.14:Trend in contaminants in the eggs of great blue herons from a colony at the University of British Columbia

Source: British Columbia Ministry of Environment, Lands and Parks 2000. Note: Dioxins and furans were measured using one of the most toxic forms, 2378-tetracholordibenso-p-dioxin.

Figure 2.15: AOX levels in pulp and paper effluent discharges (tonnes/day)

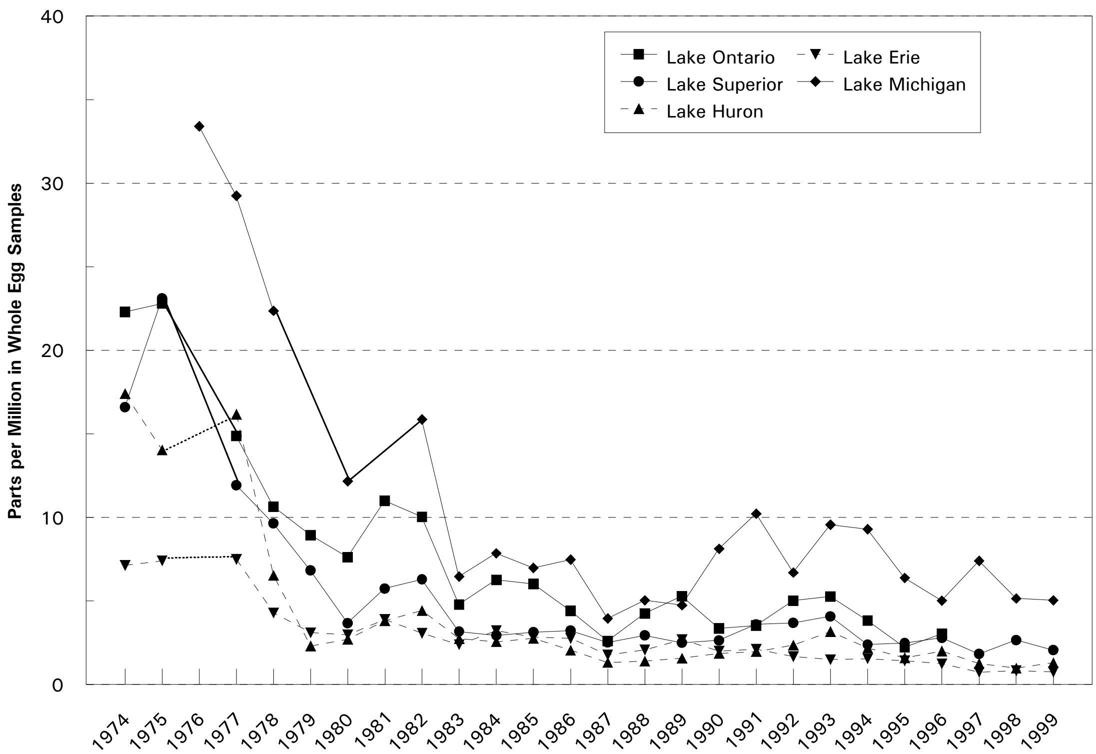


Source: British Columbia Ministry of Environment, Lands and Parks 1999. Note: Dioxins and furans are components of AOX (adsorbable organic halogen), the term used to describe a family of chemicals resulting from natural sources and the actions of humans. AOX is used as a surrogate measure of the amount of chlorinated organic compounds in effluents discharged by the pulp-and-paper industry.

Figure 2.16: Percentage of wells in British Columbia with declining water levels

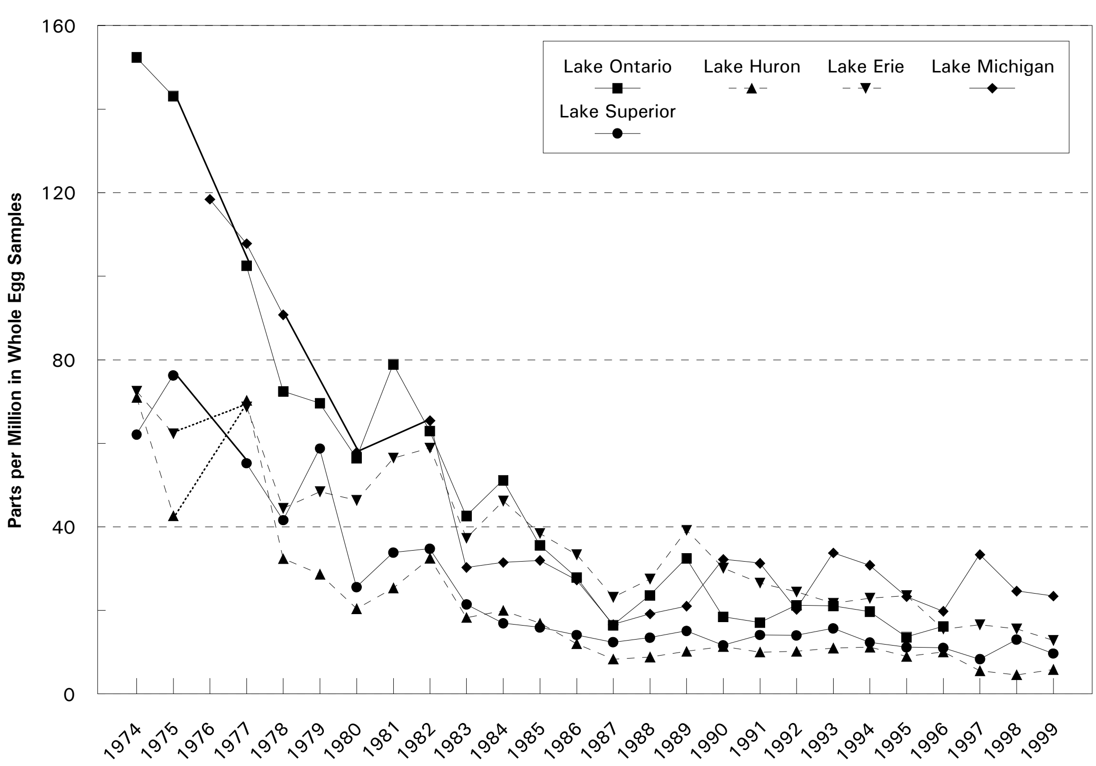
Source: British Columbia Ministry of Environment, Lands and Parks 1999

Figure 2.17: Levels of dichloro-diphenyl-dichloro-ethylene (DDE) in the eggs of herring gulls in the Great Lakes



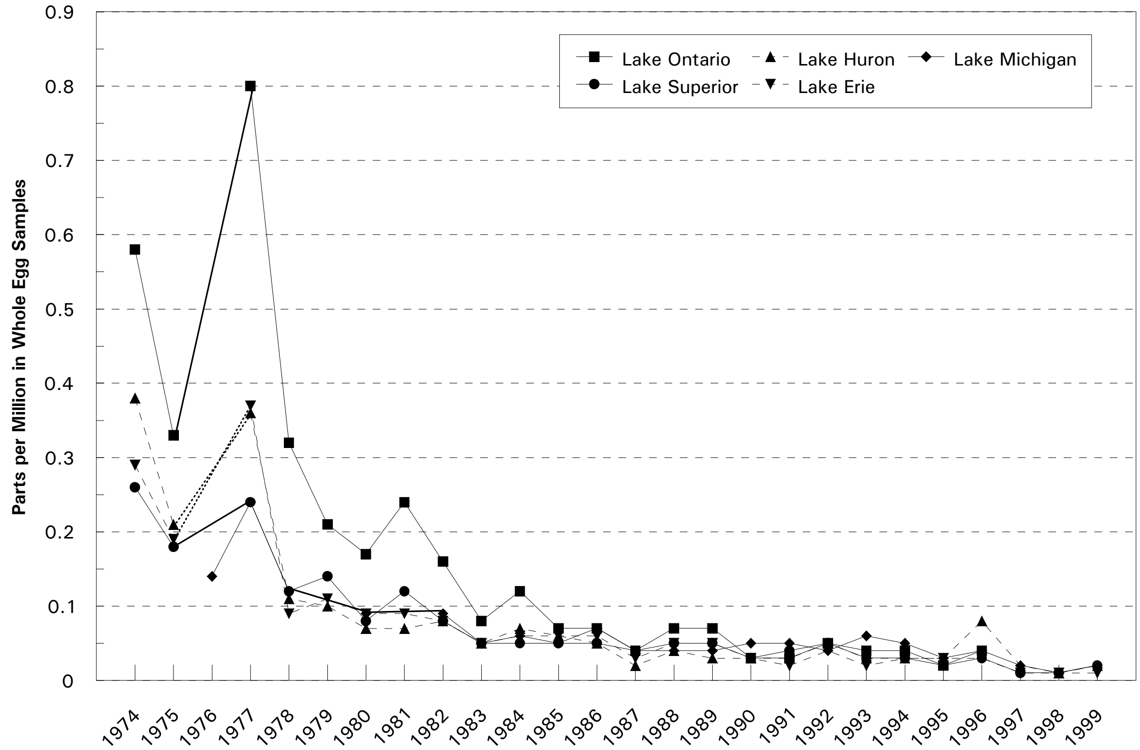
Source: Council on Environmental Quality 2001

Figure 2.18: Levels of polychlorinated biphenyls (PCBs) in the eggs of herring gulls in the Great Lakes



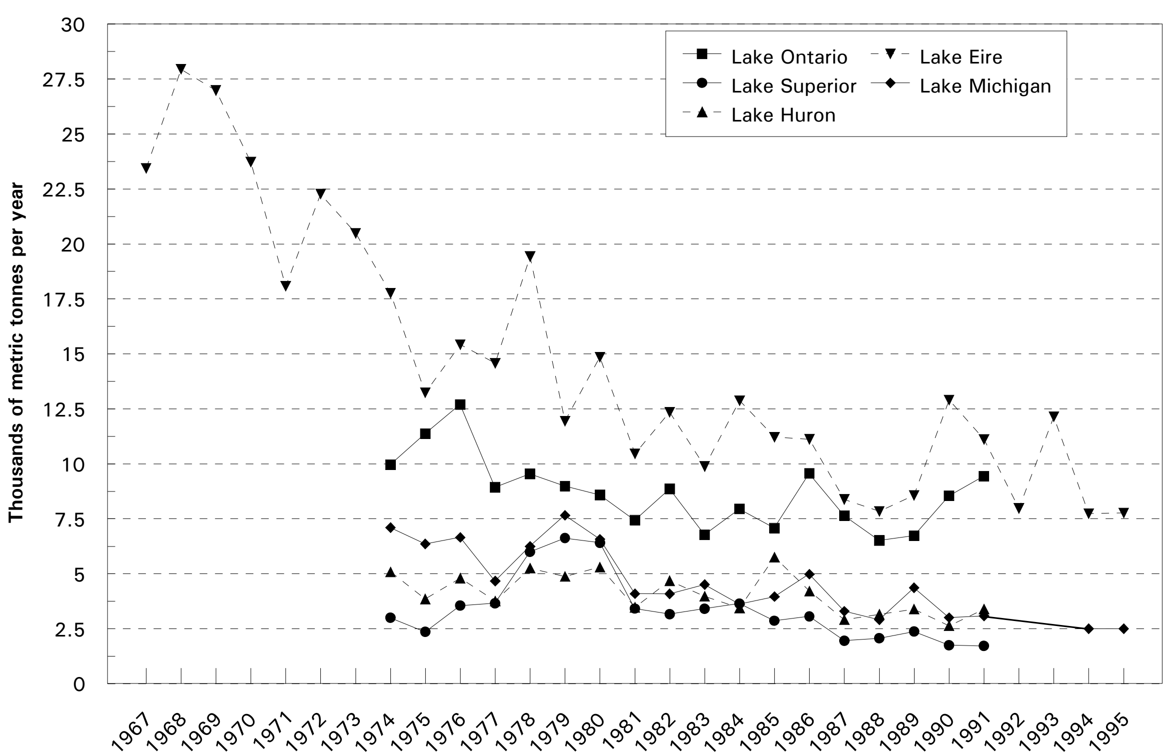
Source: Council on Environmental Quality 2001

Figure 2.19: Levels of hexachloro-benzenes (HCBs) in the eggs of herring gulls in the Great Lakes



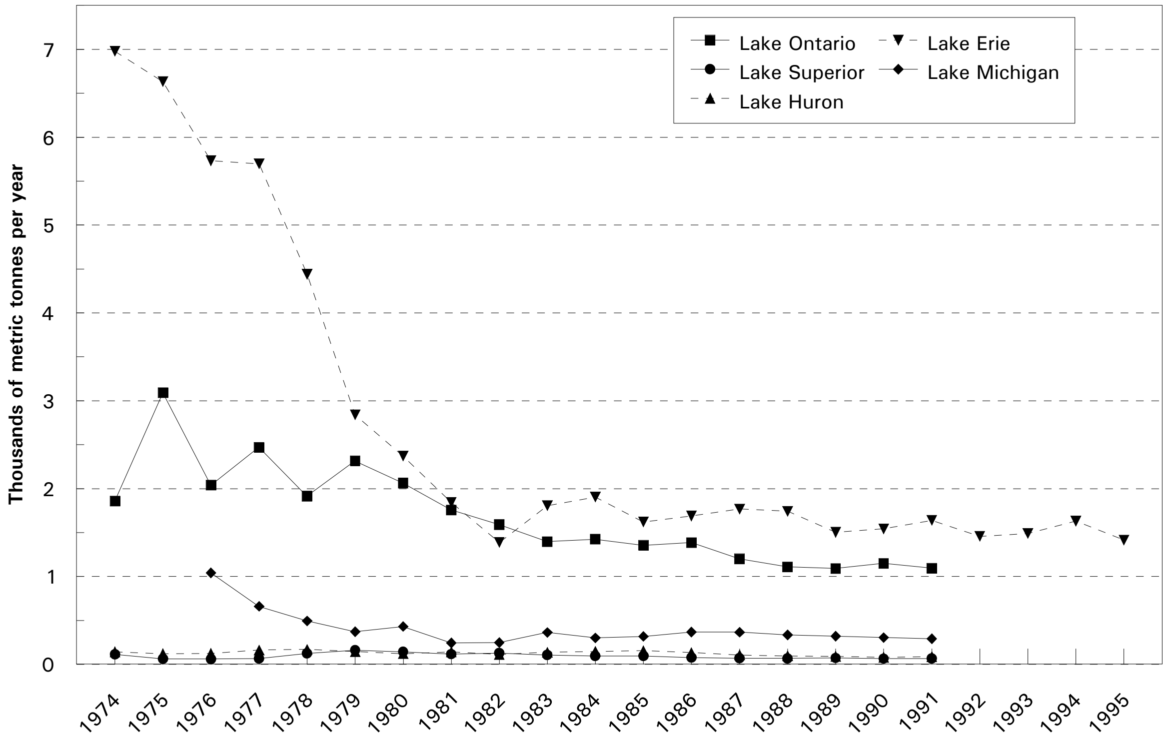
Source: Council on Environmental Quality 2001

Figure 2.20: Total phosphorous loadings for the Great Lakes, 1976–1995



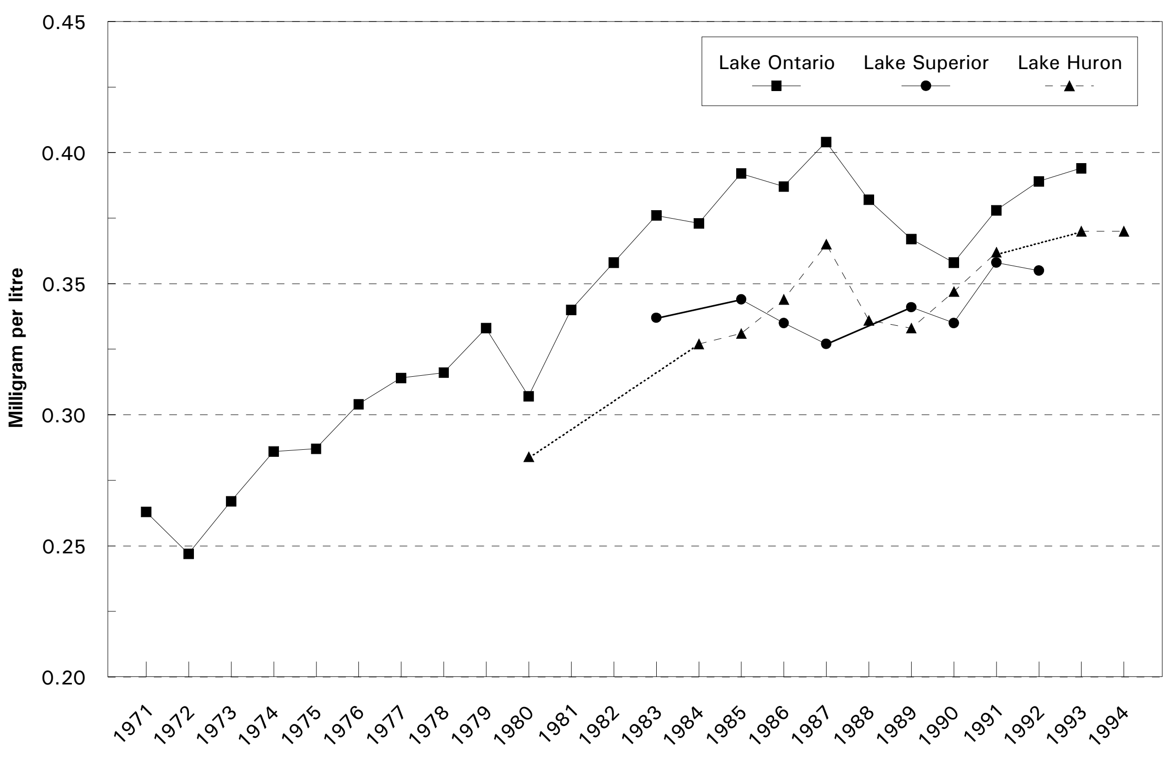
Source: Dolan 2001.

Figure 2.21: Phosphorous loadings for the Great Lakes from municipal sources, 1976–1995



Source: Dolan 2001.

Figure 2.22: Concentrations of nitrates and nitrites in the Great Lakes



Source: Richardson 1999.