The Alberta GPI Accounts: Water Resource and Quality

Report # 24

by

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Pembina Institute
for Appropriate Development

About the Pembina Institute

The Pembina Institute is an independent, citizen-based organization involved in environmental education, research, public policy development and corporate environmental management services. Its mandate is to research, develop, and promote policies and programs that lead to environmental protection, resource conservation, and environmentally sound and sustainable resource management. Incorporated in 1985, the Institute's main office is in Drayton Valley, Alberta with additional offices in Calgary and Ottawa, and research associates in Edmonton, Toronto, Saskatoon, Vancouver and other locations across Canada. The Institute's mission is to implement holistic and practical solutions for a sustainable world.

The Green Economics Program is dedicated to designing and implementing practical, street-smart economic tools that would reorient society back to the original meaning of the word "economy"—the care and management of the wealth of the household. By developing new tools for measuring the true wealth or well-being of nations, we can help guide Canadians and Albertans to a sustainable future.

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About this Report

This is one of 28 reports that provide the background for the Genuine Progress Indicators (GPI) System of Sustainable Well-being Accounts. It explains how we derived the water index that was earlier published in *"Sustainability Trends 2000: The Genuine Progress Statement for Alberta, 1961 to 1999."* The research for this report was completed near the end of 2000. The appendices provide further background and explanation of our methodology; additional details can be obtained by contacting the authors. Appendix A includes a list of all GPI background reports.

The water account addresses issues such as trends in the quantity and quality of both surface (rivers, streams) and groundwater. It answers such questions as:

1. What is the quality of water in Alberta's main rivers, how has this changed in recent years, and what differences are there upstream and downstream of the main urban centres?
2. What are the impacts of surface water quality on drinking water and fish?
3. What did the Northern River Basins Study tell us about the rivers in northern Alberta?
4. What effect does agriculture have on surface water quality?
5. What are the impacts of agriculture on groundwater quality?
6. What impacts does the energy industry have on groundwater quality?
7. Is water in Alberta being managed so as to ensure its sustainability for future generations?

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About the Authors

Sara Wilson joined the Pembina Institute in August 2000, as a member of the Green Economics Program. She works on establishing measurements of ecological well-being and community sustainability reflected in genuine progress indicators using time series analysis and valuation methods. Sara aims to promote better physical and economic accounts that will reflect our natural assets, quantitative and qualitative degradation, and the ecological and social costs of losses in ecological integrity. Before joining the Green Economics team, Sara completed the water account and forest account for the Nova Scotia GPI. In addition, she has three years' experience as a forest ecology researcher and three years' experience in environmental education. Sara holds the following degrees: MSc.F. (Mixed Boreal Forest Disturbance Ecology), University of Toronto and B.A. Hon. (International Development Studies and Environmental Geography), University of Toronto.

Mary Griffiths joined the Pembina Institute as an Environmental Policy Analyst in May 2000. She brings strong research and policy analysis skills as well as an extensive background and in-depth understanding of a wide range of environmental issues. Mary works with the Energy Watch team on environmental and energy advocacy issues and with the Institute's Green Economics Program on genuine progress indicators for Alberta. She has long been an advocate for the protection of the environment, both in her previous employment and in her volunteer activities. Mary holds a Ph.D. (Medical Geography), University of Exeter, UK and a B.A. (Geography), University of Exeter, UK.

Mark Anielski is Director of the Green Economics team, and has considerable experience in public policy analysis including natural resource, energy, royalty and fiscal policy issues in both the public (Alberta Government) and private (GPC – Government Policy Consultants) sector. He also serves as Senior Fellow to the U.S. economic policy think-tank Redefining Progress in Oakland, California and authored the 1999 U.S. GPI report with journalist Jonathan Rowe. He currently advises the National Round Table on Economy and the Environment's Sustainable Development Indicator Steering Committee on the development of indicators for measuring sustainability in Canada. Mark teaches business and the environment in the University of Alberta's School of Business. His expertise is varied and broad including accounting for sustainable development, natural resource accounting, public policy analysis, business planning and performance measurement. Mark pioneered the development of natural capital accounts for Alberta's timber, oil, gas, coal and other natural capital as well as having experience in the development of performance measurement systems, land use planning and non-market resource valuation, royalty policy analysis (forestry, oil and gas), and analysis of subsidies for both government and private forestry, energy and financial service industries. He holds a Masters degree in forest economics, plus bachelor degrees in economics and forestry.

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In addition, we thank Kim Sanderson for her editing assistance. Finally, the Pembina Institute appreciates the vision of Western Economic Diversification in supporting this project—the first of its kind for Alberta, if not internationally.

The contents of this report are the responsibility of the Pembina Institute and do not necessarily reflect the views and opinions of those who are acknowledged above or the opinions or positions of Western Economic Diversification who helped fund the research.

We have made every effort to ensure the accuracy of the information contained in this document at the time of writing. However, the authors advise that they cannot guarantee that the information provided is complete or accurate and that any person relying on this publication does so at their own risk. Given the broad scope of the project and time constraints, it has not been possible to submit the entire report for peer review. The material should thus be viewed as preliminary and we welcome suggestions for improvements that can be incorporated in any later edition of the work.

Contents

Figures and Tables

1. Executive Summary

What is the state of Alberta's water quality?

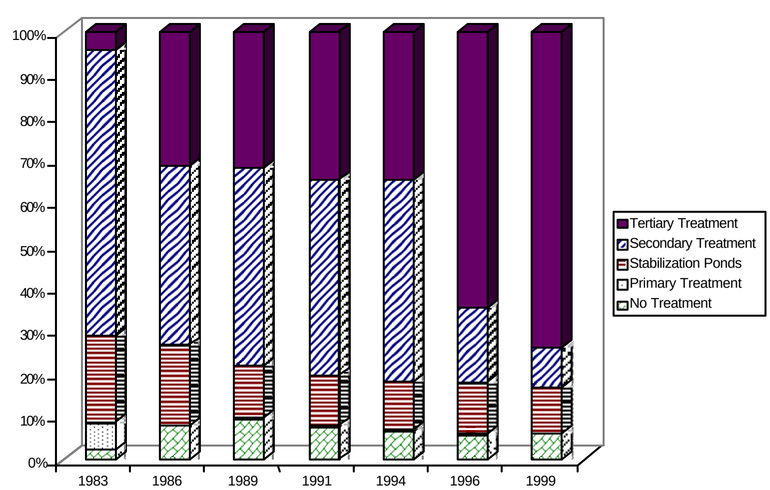
Better sewage treatment has led to a general improvement in bacterial indices downstream of major urban centres. However, urban runoff still contains nutrients, metals and pesticides from commercial, industrial, vehicular and residential sources. There are also concerns about the impact of agriculture and the energy industry on the province's surface and groundwater. A 1998 study under the Canada-Alberta Environmentally Sustainable Agriculture Agreement (CAESA) found that "agricultural practices are contributing to the degradation of water quality, [and that] the risk of ...degradation by agriculture is highest in those areas of the province which use greater amounts of fertilizer and herbicides, and have greater livestock densities." The Farmstead Water Quality Survey found that one-third of samples from 857 wells exceeded the Canadian Drinking Water Quality Guidelines for maximum acceptable concentrations of at least one parameter.[1]

Noteworthy

- High levels of nutrients, such as nitrogen and phosphorus, encourage algal growth, which in turn depletes oxygen supplies when the algae decompose. Dissolved oxygen levels in the Oldman River below Lethbridge, for example, have often fallen so low that fish populations have been threatened.
- Sewage treatment plant upgrades were undertaken recently by Calgary and Edmonton.
- About 75% of Alberta's municipal population now has tertiary sewage treatment (see figure below).
- The Northern River Basins Study found that effluent from the seven pulp mills in Alberta and from municipal sewage was directly affecting the rivers.
- Higher frequencies of abnormalities occurred in fish caught downstream of the pulp mills: the fish had lower sex hormone levels and a higher proportion were sexually immature, compared with fish taken at sites upstream.
- Changes in pulp mill technology have significantly reduced levels of dioxins and furans, but these compounds are still detected in fish in some parts of the rivers.

In terms of water resources, there is abundant water in the north, but rivers flowing through the dry areas of southern Alberta are being used to capacity. In addition, global climate change is predicted to have an impact on the province's water resources. Much of the water in Alberta's rivers originates in the Rocky Mountains, where increases in average annual temperature are already affecting glaciers: the volume of the Athabasca glacier is declining by over 16 million cubic metres each year.

Percentage of Alberta's Municipal Population with Primary, Secondary and Tertiary Sewage Treatment, 1983 to 1999



Source: Data from Municipal Use Database, 1983,1986, 1989, 1991, 1994, 1996, 1999

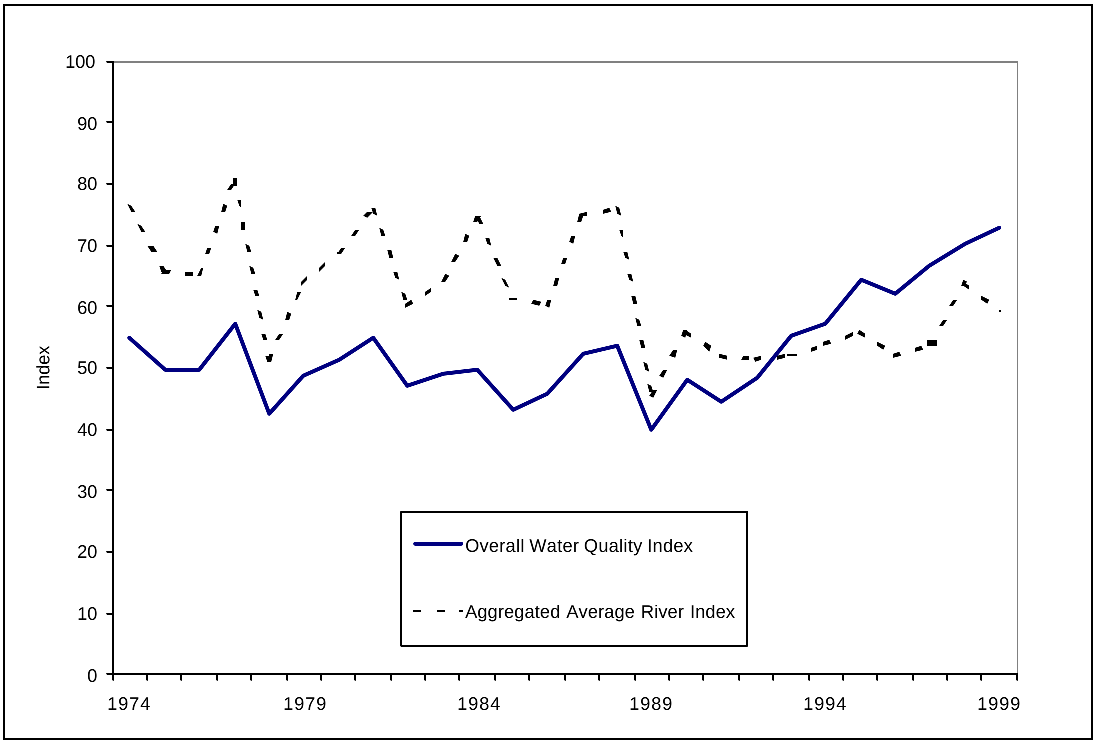
So what?

Although improvements have been made in municipal sewage treatment, source control regulation is vital to curb contaminants entering surface waters from storm sewers. Metals, pesticides and nutrients affect fish populations and freshwater ecosystems. Disease-carrying organisms, nutrients and pesticides found in runoff from livestock operations and arable land can enter nearby surface waters. The potential for water contamination has grown as cattle numbers in Alberta have increased more than 50 percent in the last 25 years, and the number of farm acres on which pesticides and fertilizers are used has tripled.

Contaminants in the food chain are a concern for many people who traditionally rely on local fish and wildlife. Additionally, water contamination affects water supplies, wildlife, tourism and recreational activities. Rural areas across Canada generally have lower water quality than urban areas. There is increasing resistance to the location of intensive livestock operations in Alberta, as many rural residents are concerned that manure will contaminate their wells. Presently, Alberta only has guidelines for the location and operation of intensive livestock operations, and the government has delayed introduction of more stringent legislation. The experience at Walkerton, Ontario shows that not only those using well water, but also those receiving treated water, have genuine reasons for concern. Safeguards for surface and groundwater are imperative and this requires strict regulation. In January 2001, Alberta's drinking water quality was given a grade of 'B' with the comment "with Quebec and Ontario, the best of a bad lot," by the Sierra Legal Defence Fund. Strengths included drinking water requirements and system approvals, but the lack of a mechanism for watershed protection, public reporting and frequency of testing were identified as weaknesses. Ideally, we need to establish watershed accounting systems to track overall conditions in each watershed, similar to what the Northern River Basins Study did for northern rivers. Comprehensive annual monitoring should include depletion rates and recharge rates. This is important for southern Alberta where resources are fully allocated, and for northeastern Alberta where dry conditions occur periodically.

To assess water quality, indices where the best year equals 100, were constructed based on data for: a) pulp effluent; b) percentage of municipal population with tertiary sewage treatment; c) *Giardia* and *Cryptosporidium* cases; and d) long-term monitoring of dissolved oxygen, nitrogen, phosphorus and fecal coliforms along six major rivers. The first three indices were averaged to produce an aggregated index, and a second index was created based on the overall index for each river. The overall water quality index is an average of these two aggregated indices, giving a weighting of 50 percent to each (see figure below). In 1974, the index was 55, and by 1999, the index had increased to 73. Most of the improvement is due to better treatment of effluent from pulp mills and better sewage treatment in municipal areas. At the same time, the average river index indicates a decline in quality, which is a result of additional problems cited in the above summary that are not represented by the other indicators used as indices. This index declined from 76 to 59 over the same time period.

Alberta Water Quality Index: Where are we today?



The total costs of water quality decline and contaminants have not been fully assessed. Further study is needed to adequately assess all costs for the province. A preliminary estimate of the annual environmental cost of Alberta's wastewater pollution in 1999 is $574,000. This cost is based on an extrapolation of the externalized cost per megalitre of wastewater* used in the Australian GPI (Aus 1990$2.20/megalitre; Cdn 1998$2.12). According to the overall water quality index, 1974 scored 55, and 1999 scored 73. However, the average river index declined from 76 to 59 over the same time period.

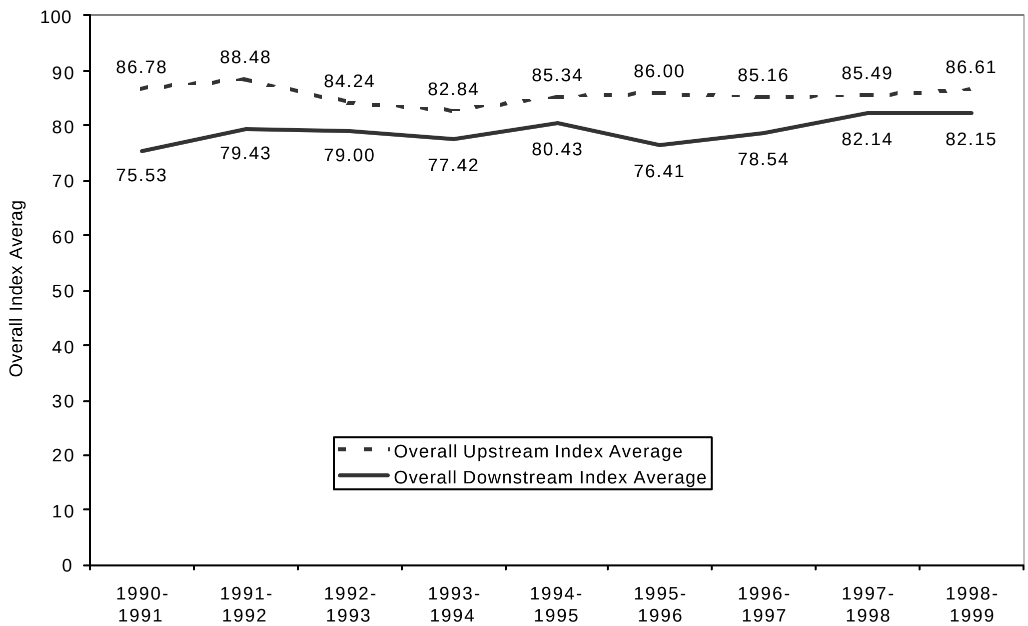
* A megalitre (ML) is one million litres.

2. Surface Water Quality

Alberta Environment has measured the quality of river water upstream and downstream of major towns on six rivers in Alberta in a consistent manner from the mid-1970s, although they started recording additional variables in the 1990s. To provide an overall view of the state of Alberta's rivers, the Department's annual reports indicated whether the water met standards for recreation, agriculture and the protection of aquatic life.

A new reporting system was adopted in 2000, which looks at the overall river quality and at specific index values for metals, nutrients, bacteria and pesticides found in the water. Indices using these parameters can only be estimated back to 1990, given the data available. The average of six major river indices for metals, nutrients, bacteria and pesticides are shown in an overall water quality index in Figure 1.

Figure 1: Average Surface Water Quality Index for Four Major Rivers in Alberta Upstream and Downstream of Urban Areas: Bow River, Red Deer River, Oldman River, and North Saskatchewan River, and at Two Locations on the Athabasca and Smoky/Peace Rivers, 1990 to 1998



Water Quality Category Descriptions for the Alberta Surface Water Quality Index

95 – 100	Excellent - Guidelines almost always met; "Best" Quality
80 - 94	Good - Guidelines occasionally exceeded, but usually by small amounts; threat to quality is minimal
65 - 79	Fair - Guidelines sometimes exceeded by moderate amounts; quality occasionally departs from desirable levels
45 - 64	Marginal - Guidelines often exceeded, sometimes by large amounts; quality is threatened, often departing from desirable levels
0 - 44	Poor - Guidelines almost always exceeded by large amounts; quality is significantly impaired and is well below desirable levels; "Worst" Quality

The overall average index for upstream locations, relative to 1990 (86.8), declined during 1992 and 1993 (82.8), followed by a slow recovery until 1998 when the average overall index was 86.6. Water quality is usually worse downstream of major cities than upstream. The overall average index for downstream locations has improved from a fair quality rating in 1990 (75.5), when guidelines were sometimes exceeded by moderate amounts, to a good quality rating (82.2) in 1998. The improvement is likely due to better sewage wastewater treatment. However, when data are aggregated and averaged, the problem areas are often missed.

The water quality of the Bow River is excellent upstream of Calgary, but the downstream quality is relatively poor, both at Ronalane and Carseland Weir (Figures 2, 3 and 4). The main problems are pesticides and nutrients (both rated marginal in 1998) detected in the water at Ronalane between 1996 and 1998 (Figure 3). At the same time, downstream bacteria counts have improved. These trends are likely due to improved treatment of Calgary's sewage wastewater disposed into the Bow River, but indicate that source controls for metals and pesticides need to be regulated for industrial, commercial and agricultural activity in Calgary and along the river. These trends are evident at the Carseland Weir location, also downstream of Calgary, where the index for bacteria counts has dramatically improved from 10 (poor) to 90 (good), as shown in Figure 4.

Figure 2: Water Quality Index Average for Bow River Upstream of Calgary and Downstream of Calgary at Ronalane and Carseland Weir, 1990 to 1998

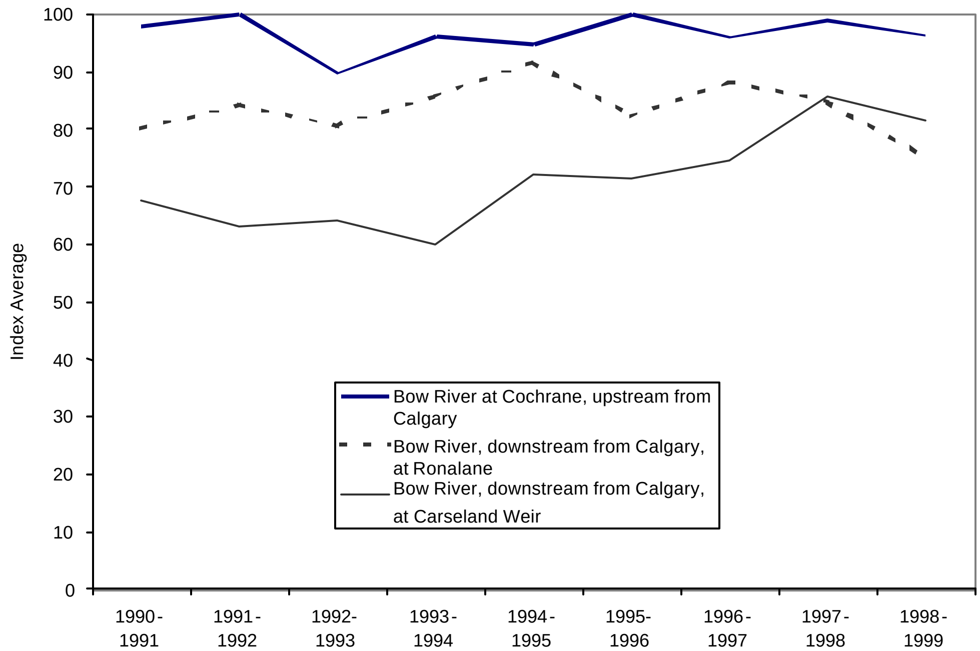


Figure 3: Detailed Water Quality Indices for Bow River at Ronalane, Downstream of Calgary, 1990 to 1998

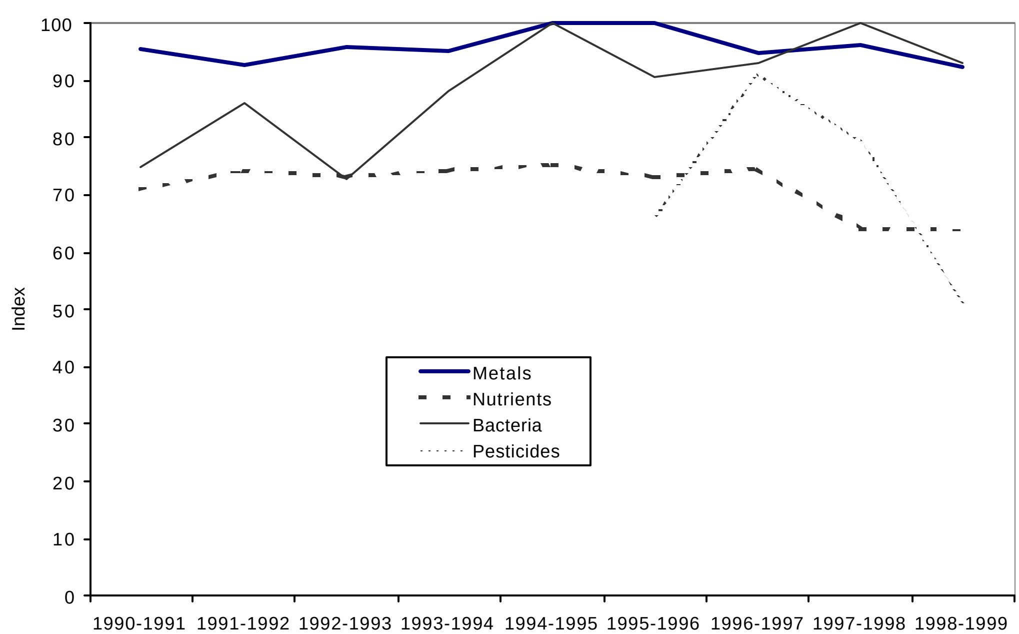
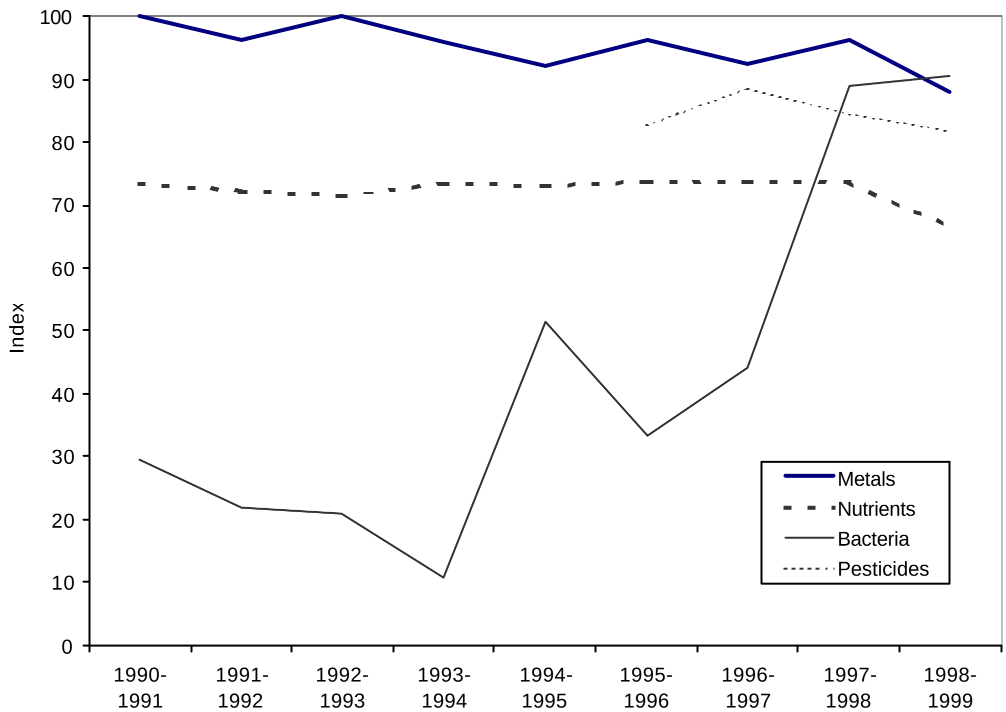


Figure 4: Detailed Water Quality Indices for Bow River below Cars eland Weir, Downstream of Calgary, 1990 to 1998



Water quality in the North Saskatchewan River is rated good to excellent at Devon upstream of Edmonton, except for metals detected in 1994, 1995 and, most recently 1998, indicating that guidelines were sometimes exceeded by moderate amounts (Figures 5 and 6). The average index for water quality downstream of Edmonton at Pakan, is less desirable, ranging from marginal to fair, generally as a result of not meeting the nutrient and bacteria guidelines (Figure 5). However, in 1998 the bacteria index improved dramatically from a marginal rating of 45 to an excellent score of 95 (Figure 6), reflecting the installation of an ultraviolet disinfection system at Edmonton's sewage treatment plant.

Figure 5: Average Water Quality Index for the North Saskatchewan River, Upstream and Downstream of Edmonton, 1990 to 1998

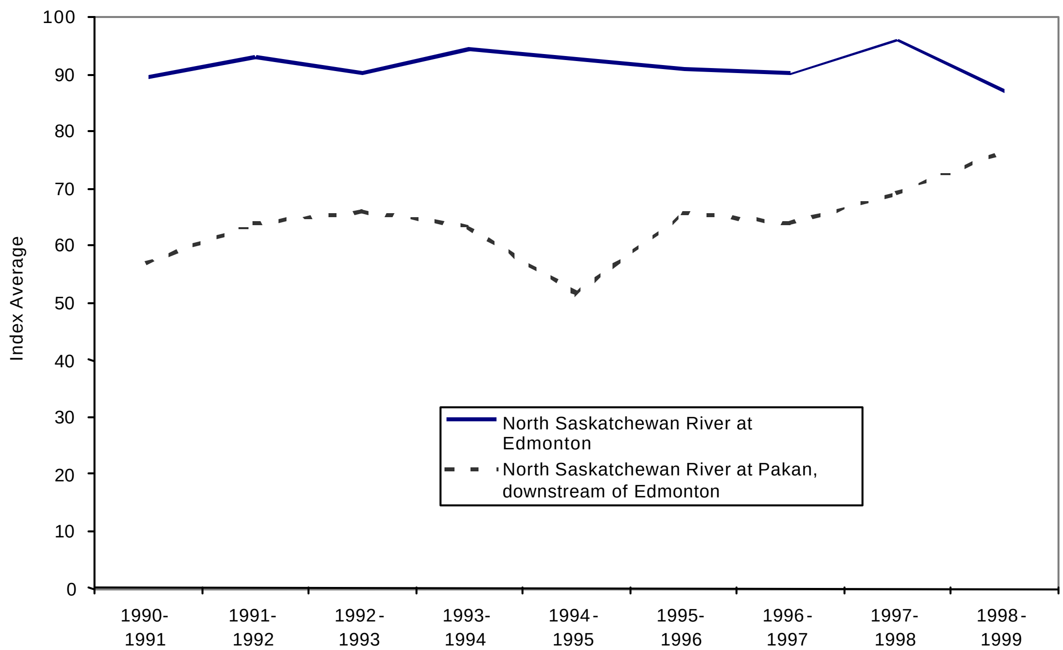
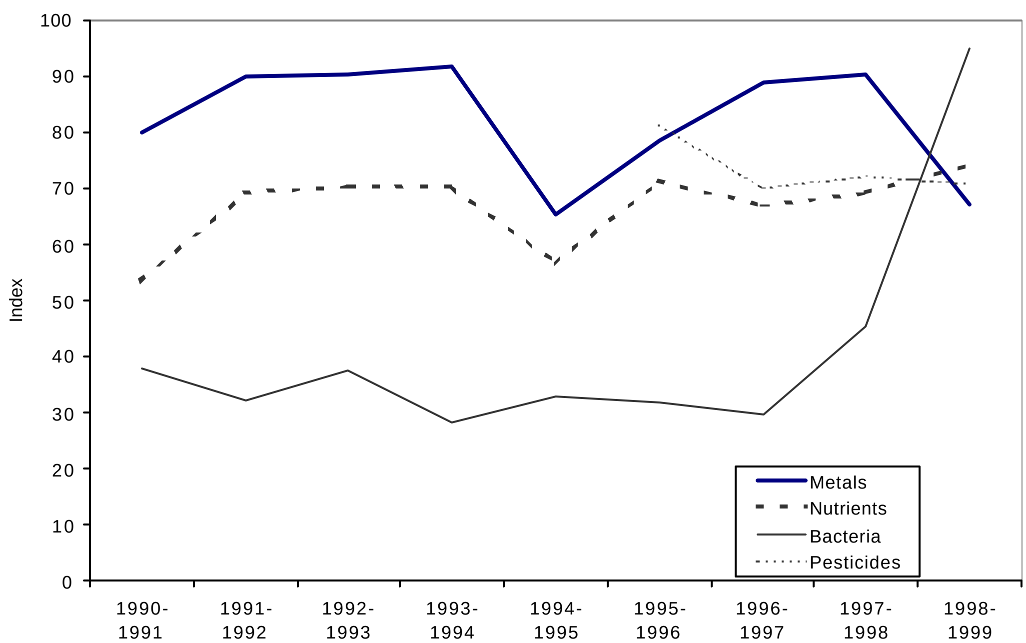
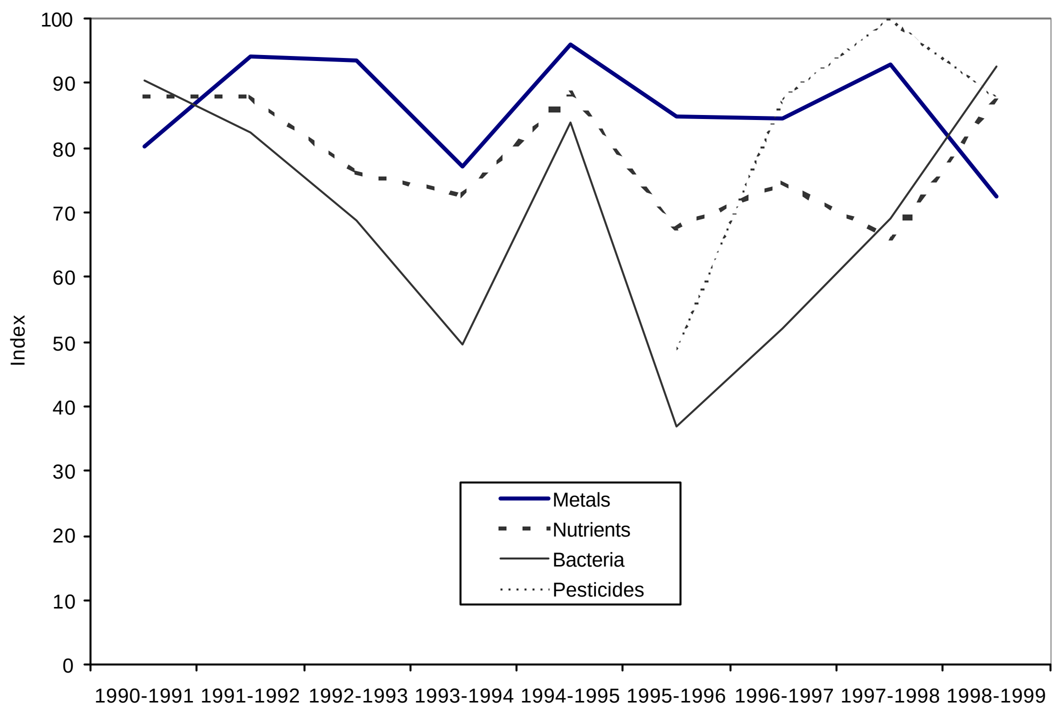


Figure 6: Detailed Water Quality Indices for the North Saskatchewan River at Pakan, Downstream of Edmonton, 1990 to 1998



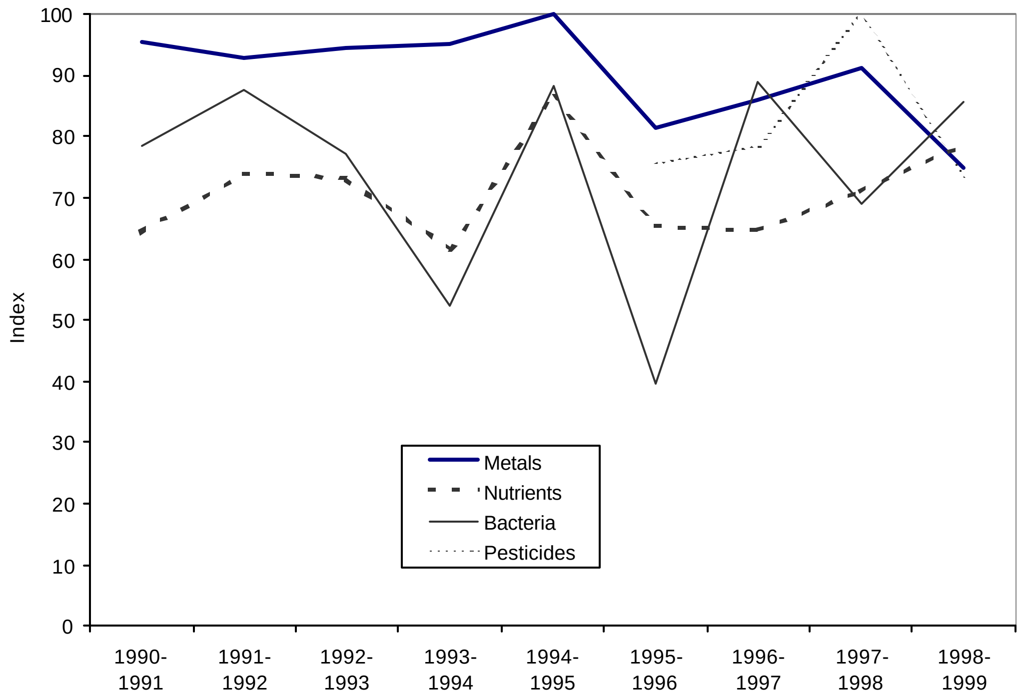
The overall water quality index for the Oldman River upstream and downstream of Lethbridge ranges from fair to good. In both 1990 and 1998, the average index rated upstream water quality as good, and downstream water quality as fair. Between these years, the water quality changed often at both locations with upstream water quality dramatically declining in 1995 to marginal as a result of a poor index rating for bacteria counts, a marginal index rating for pesticides detected, and a fair rating for nutrients detected (Figure 7). However, since then bacteria counts and nutrient detections have improved, bringing the indices back up to ratings similar to 1990. Pesticide detections also improved but there was some decline (similar to the metals index) again in 1998, the latest year reported. It should be noted that, as a result of urban growth, the effects of some urban runoff can now be monitored at the upstream monitoring location in Lethbridge.

Figure 7: Detailed Water Quality Indices for the Oldman River, Upstream of Lethbridge, 1990 to 1998



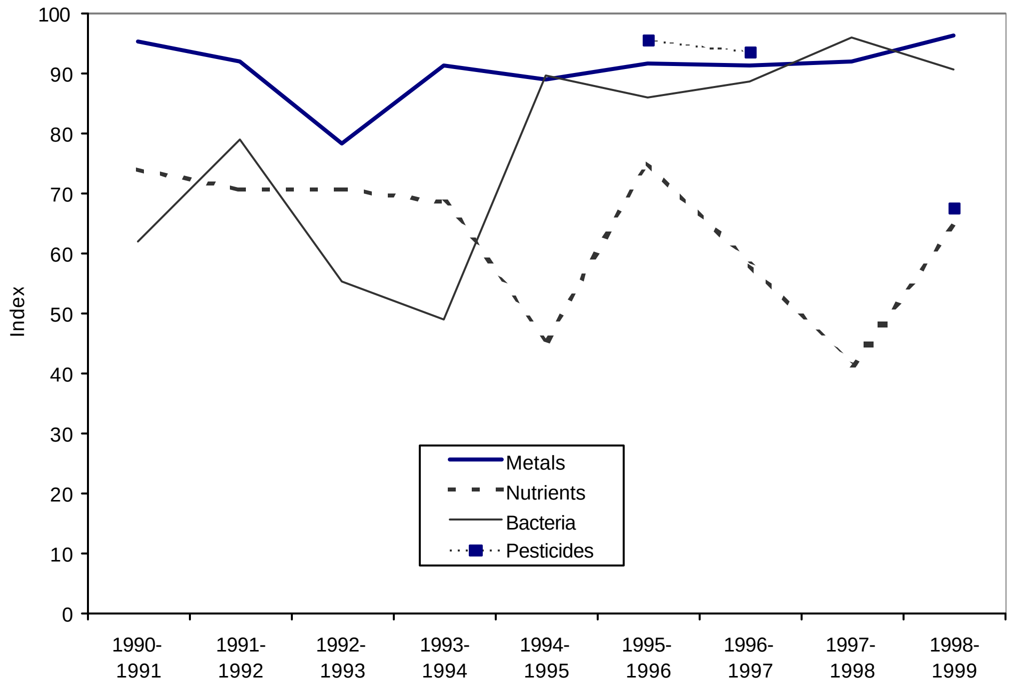
Downstream of Lethbridge (Figure 8), the average index remained fair in 1998 after many fluctuations over the past decade. The nutrients and bacteria indices declined between 1990 and 1998, but improved to approximately 1990 levels by 1998. Conversely, the metals index decreased after 1994. Similar to the situation upstream of Lethbridge, pesticide detections improved between 1995 and 1997, but declined by 1998. These water quality problems are probably due to intensive agricultural operations.

Figure 8: Detailed Water Quality Indices for the Oldman River, Downstream of Lethbridge, 1990 to 1998



On average, water quality in the Red Deer River upstream from Red Deer, rates as good except for nutrients, for which the rating is only fair. Downstream of Red Deer, the Red Deer River has a fair to good index on average, but detailed indices indicate ongoing problems with nutrient levels, and the limited data show that there was a serious problem with pesticides in 1998/99, not seen in 1995 to 1997 (Figure 9). This could be from urban runoff and/or an agricultural source along the river. At the same time, the bacteria index shows improvement.

Figure 9: Detailed Water Quality Indices for Red Deer River at Morrin Bridge, Downstream of Red Deer, 1990 to 1998



Better sewage treatment has reduced bacteria levels downstream of major urban centres, but several locations still have problems with metals, nutrients and pesticides. Metals and pesticides from commercial, industrial, vehicular and residential sources are often found in storm sewer runoff from urban areas. Nutrients and pesticides are also found in runoff from other non-point sources, namely agricultural areas. Source control regulation is vital to curb these contaminants. In urban areas, source control can be promoted through education, recycling programs (which will also save money for businesses) and regulations backed with fines for improper disposal of contaminants. In rural areas, educational programs for farmers can be enhanced to promote agricultural practices that will reduce nutrients and pesticides in runoff.

In northern Alberta, monitoring data reveal some problems with the Smoky/Wapiti and Peace Rivers, although in this case we are not comparing the situation upstream and downstream of major towns. The measurements on the Smoky/Wapiti are taken downstream of Grande Prairie.

Water quality problems in the Smoky River, upstream of the Peace River, are related to nutrients and metals (Figure 10). The respective indices were rated as fair in 1998 (meaning guidelines are sometimes not met), but in some years prior to 1998, the index fell to marginal indicating that guidelines were often not met. While the index for metals fell over the nine-year period, the nutrient index improved from 68 to 76. Downstream at Fort Vermilion, the Peace River has the same water quality problems, and showed a similar improvement in the nutrient index (Figure 11).

Figure 10: Detailed Water Quality Indices for Smoky River at Watino, Upstream of the Peace River, 1990 to 1998

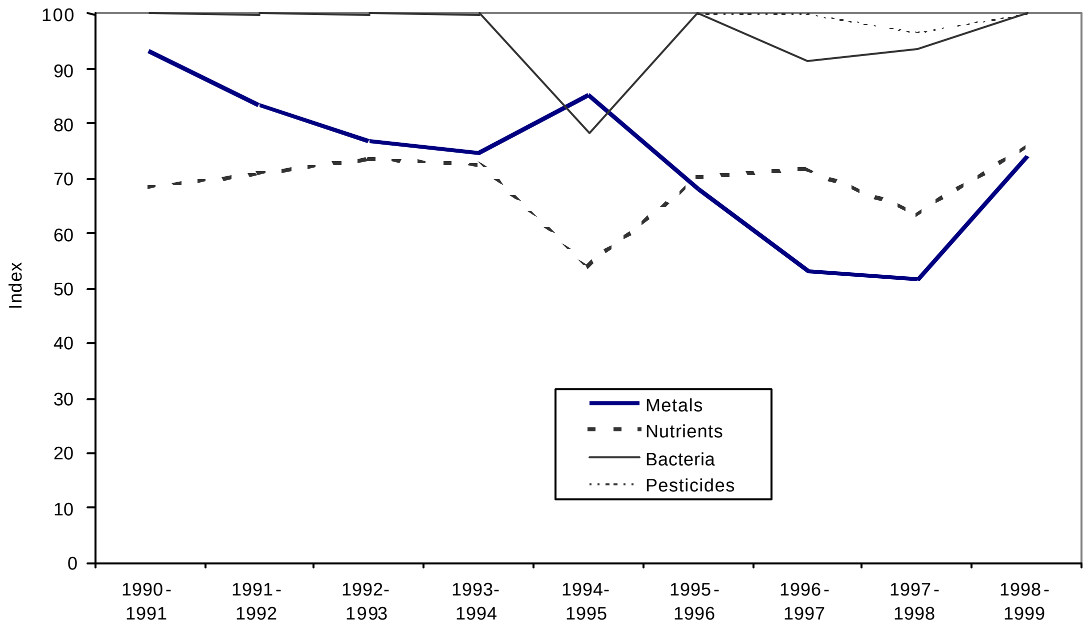
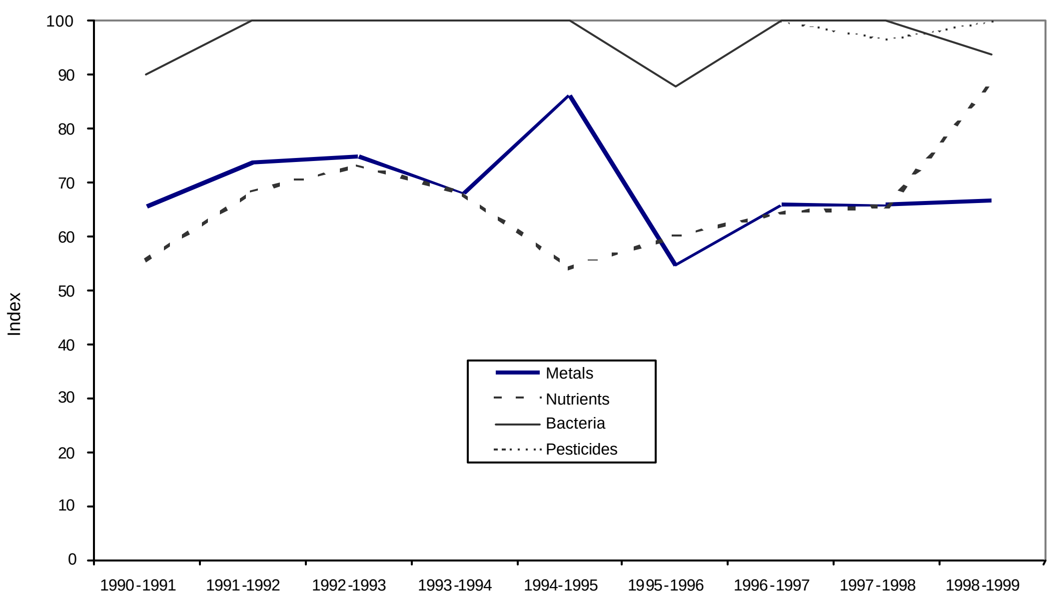
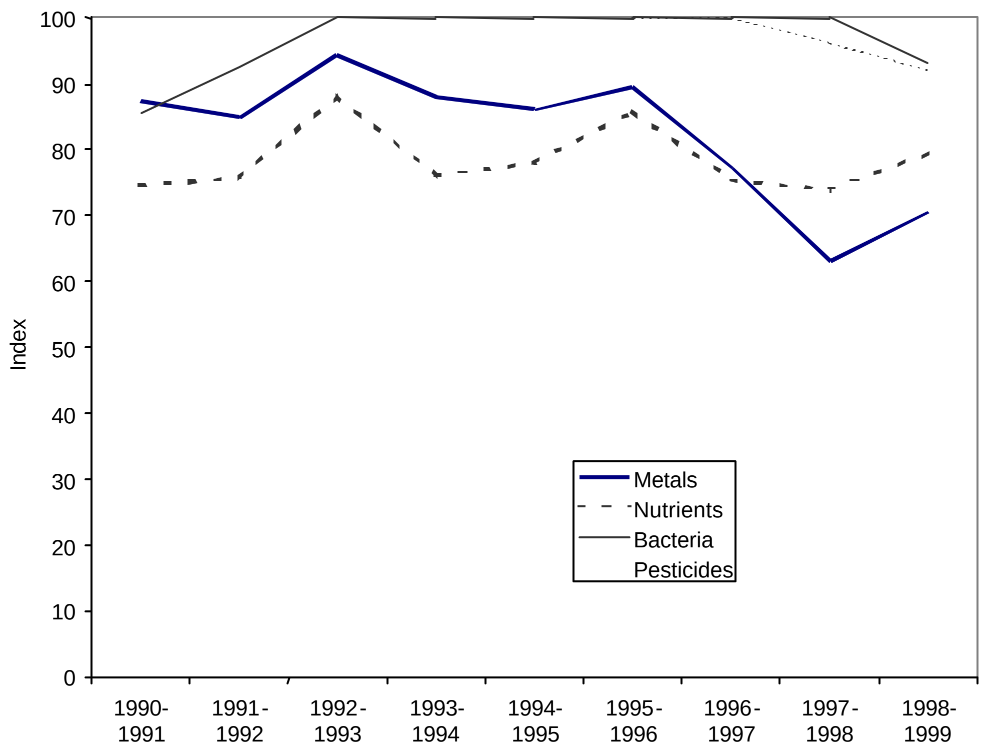


Figure 11: Detailed Water Quality Indices for Peace River at Fort Vermilion, 1990 to 1998



On average, water quality of the Athabasca River at Athabasca and further downstream at Old Fort is rated as good (83 to 94) on the index. However, when the individual indices for metals, nutrients, bacteria and pesticides are examined, there were six years when the index for nutrients was only rated fair (74 to 76; Figure 12). More importantly, the index for metals in the water has declined. In 1997, the index rating was marginal, meaning that metals detected often exceeded guidelines, sometimes by large amounts that threatened water quality. In 1998, the metals index increased by eight points, improving to a fair rating of 71.

Figure 12: Athabasca River at Athabasca, 1990 to 1998



3. Long Term Monitoring of Surface Water Quality – Impacts on Fish Habitat and Drinking Water Quality

A study of the specific parameters for the 12 monitoring sites from the 1960s or 1970s (depending on the time series available) to the present time provides more detail than a general index. It is not easy to discern clear trends in the monthly data available, but the differences between locations upstream and downstream of major urban areas are evident.

Water must contain oxygen if it is to support fish. The current standard for dissolved oxygen varies from 5.0 mg/L to 9.5 mg/L.[†] Annual average dissolved oxygen levels indicate a declining trend upstream of Athabasca since 1961, but they remain above the CCME guideline of 9.5 mg/L. Dissolved oxygen in the Oldman River below Lethbridge fell below 6 mg/L several times between 1975 and 1985, when it reached a record low of almost zero. Since then, values have often been around 8 mg/L, which is still lower than the CCME objective. Such low levels are threatening fish populations in the Oldman River.

High levels of nutrients such as nitrogen and phosphorus encourage algal growth, which depletes oxygen supplies as it decomposes. Upstream of Athabasca, annual average nitrogen levels are increasing slightly, while phosphorus levels have decreased slightly. It appears that peak nitrogen levels increased in the 1990s, at least on the Oldman, Bow, North Saskatchewan and Smoky Rivers. Only the Smoky and Peace Rivers in Northern Alberta had higher levels of phosphorus in the 1990s.

A parameter of great concern is fecal coliform bacteria. Bacterial content in water is indicated by the presence of coliform bacteria. Annual average monthly data recordings of fecal coliforms present in upstream locations have shown an increasing trend on the Athabasca, North Saskatchewan, Oldman and Red Deer Rivers since the 1970s (Figures 13 to 16. Note that these figures use different scales due to the wide range in data values for different rivers). However, the numbers vary greatly from year to year and month to month. The annual averages are relatively high at the upstream location on the Oldman River, reaching up to 952 coliforms per 100 ml in 1995 (Figure 13).

[†] The lower level of 5.0 mg/L is the Alberta Surface Water Quality Objective, one-day minimum; the level of 9.5 mg/L is the Canadian Council of Ministers of Environment (CCME) Objective for the early life stages of cold water organisms.

Figure 13: Annual Average of Monthly Fecal Coliform Counts for the Athabasca River, Upstream of Athabasca, 1978 to 1999

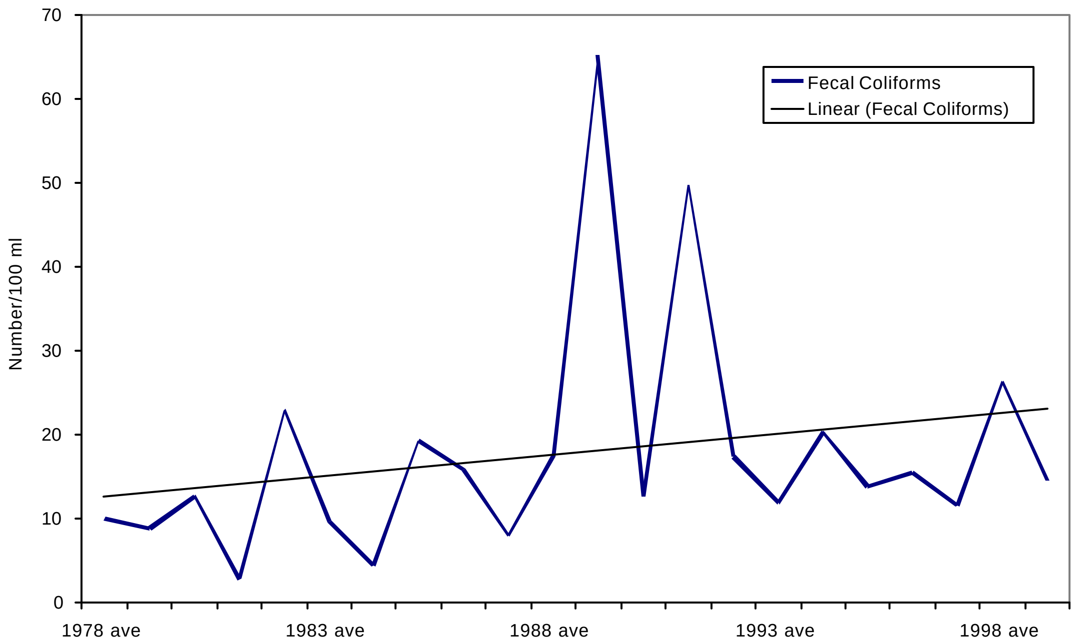


Figure 14: Annual Average of Monthly Fecal Coliform Counts for the North Saskatchewan River, Upstream of Edmonton, 1977 to 1999

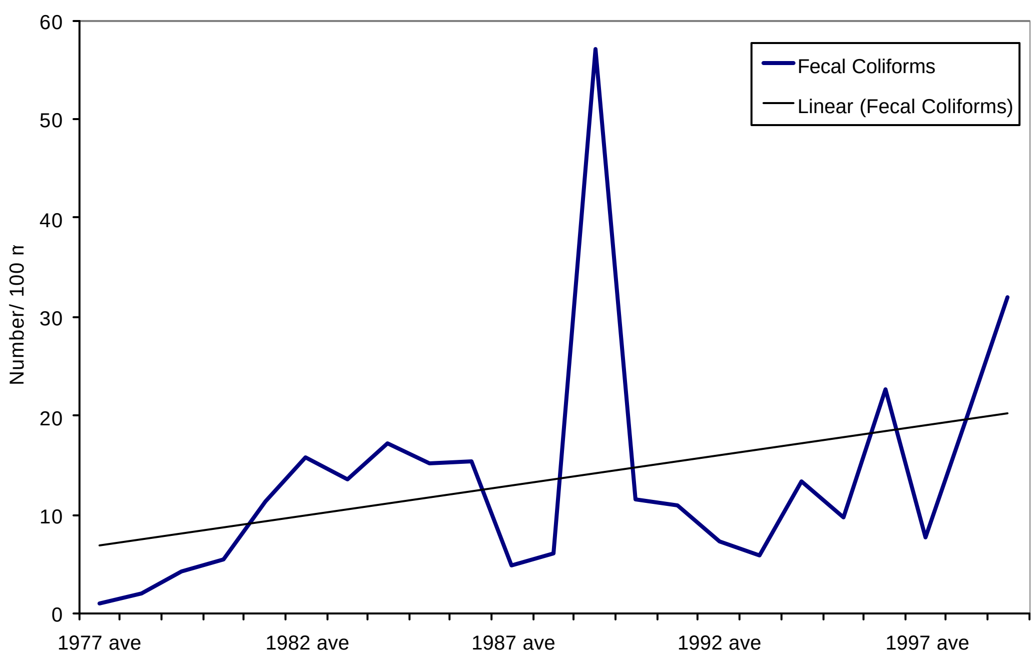


Figure 15: Annual Average of Monthly Fecal Coliform Counts for the Oldman River, Upstream of Lethbridge, 1970 to 1999

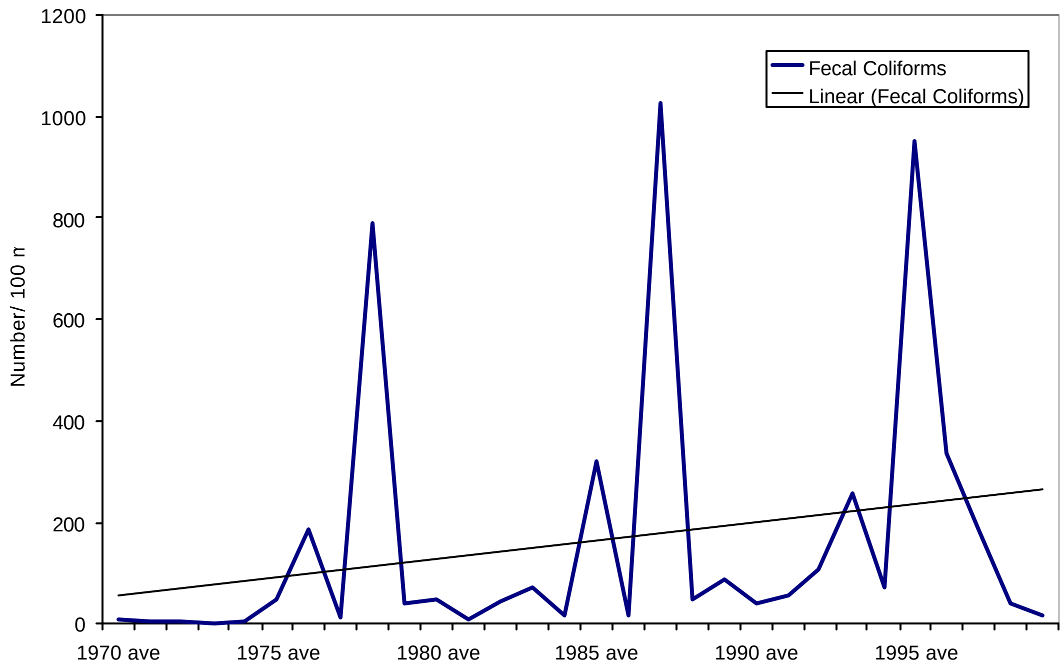
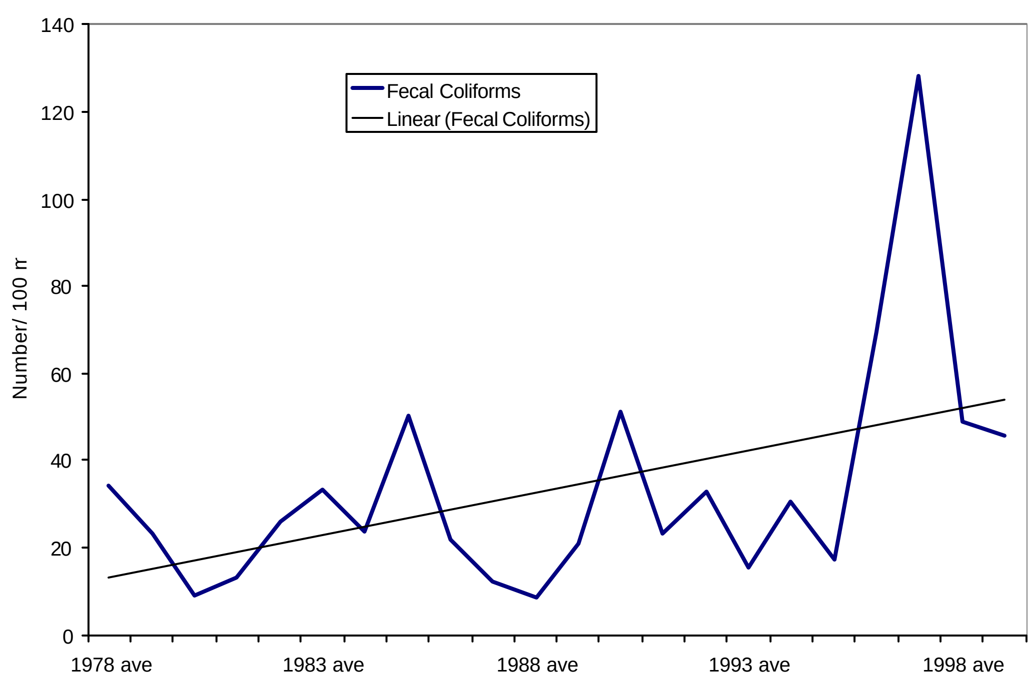


Figure 16: Annual Average of Monthly Fecal Coliform Counts for the Red Deer River, Upstream of Red Deer, 1970 to 1999



The worst occurrence of coliform bacteria was a reading of over 25,000/100 ml, measured downstream of Edmonton in 1996. Incidents when the fecal coliform value exceeded 1,000/100ml were reported downstream of Calgary, upstream and downstream of Red Deer, and upstream and downstream of Lethbridge. The peak values on the Oldman upstream of Lethbridge are higher than those downstream. This may be due to flows from storm sewers in Lethbridge; with the growth of the city, the upstream station is now within the municipal boundaries.

E. coli 0157:H7 is the specific form of the bacterium that caused over 2,000 illnesses and seven deaths in Walkerton, Ontario in 2000 due to contaminated water.[‡] Generic *E.coli* levels have been measured upstream and downstream of urban areas in Alberta since 1994. In general, the highest levels are recorded where the fecal coliform count is high. High *E. coli* values have been recorded both upstream and downstream of Red Deer and Lethbridge, and some high measurements have also been noted downstream of Edmonton and Calgary.

The number of human infections with *E. coli 0157:H7* fluctuates from year to year, and it is difficult to identify the source as contaminated water. *E. coli* can also contaminate meat products, causing what is known as "Hamburger Disease." The Lakeside meat packing plant northeast of Lethbridge recalled two major nation-wide consignments of ground beef in the first part of 2000 due to contamination.

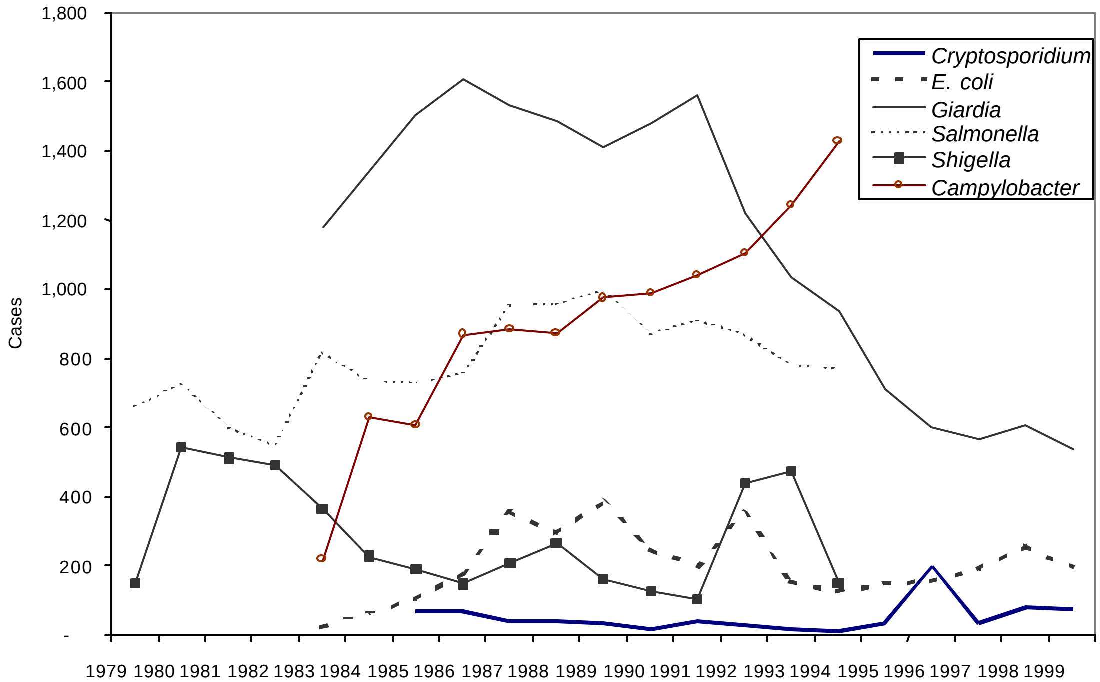
The incidence of *E. coli 0157* is higher in the Chinook Health region than in other parts of Alberta due to the greater concentration of intensive livestock operations. Over 350 farms and a million animals produce 2.6 million tons of manure a year.[2] However, while a direct link has been found between livestock activities and the increased incidence of an enteric disease caused by a different bacterium—*Campylobacter*—the connection with *E. coli* is not so straightforward. Alberta Health has a policy target of no more than four cases of *E. coli* incidents per 100,000 population.[3] In the past year, the Chinook Health Region experienced 25.6 cases of *E. coli 0157:H7* per 100,000 population, while the rates in Edmonton and Calgary were 2.3 and 6.8 per 100,000, respectively.[4] In Chinook, the infection rate by *E. coli 0157* has tripled since the late 1980s. Of those diagnosed with *E. coli 0157* in recent years, eight percent drank untreated water but only three percent said they worked or lived with animals (other than pets). It appears that *E. coli 0157* more often affects females, and people affected are more likely to be associated with others known or suspected to have the disease.[5]

Reported cases of *E. coli* in Alberta as a whole have increased since 1983, but have decreased in more recent years (Figure 17). On the other hand, cases of giardiasis (also known as "beaver fever") have dramatically decreased since 1983. Giardiasis is the most common enteric disease and typically results from drinking water contaminated by the protozoan *Giardia*.

Campylobacter levels increased dramatically between 1983 and 1994 (Figure 17), while enteric diseases caused by *Salmonella* and *Cryptosporidium* remained at about the same level. Cases of shigellosis fluctuated throughout the 1980s, increasing in the early 1990s and declining in the final year reported, 1994.

[‡] *Escherichia coli* is the full scientific name of this common fecal bacterium.

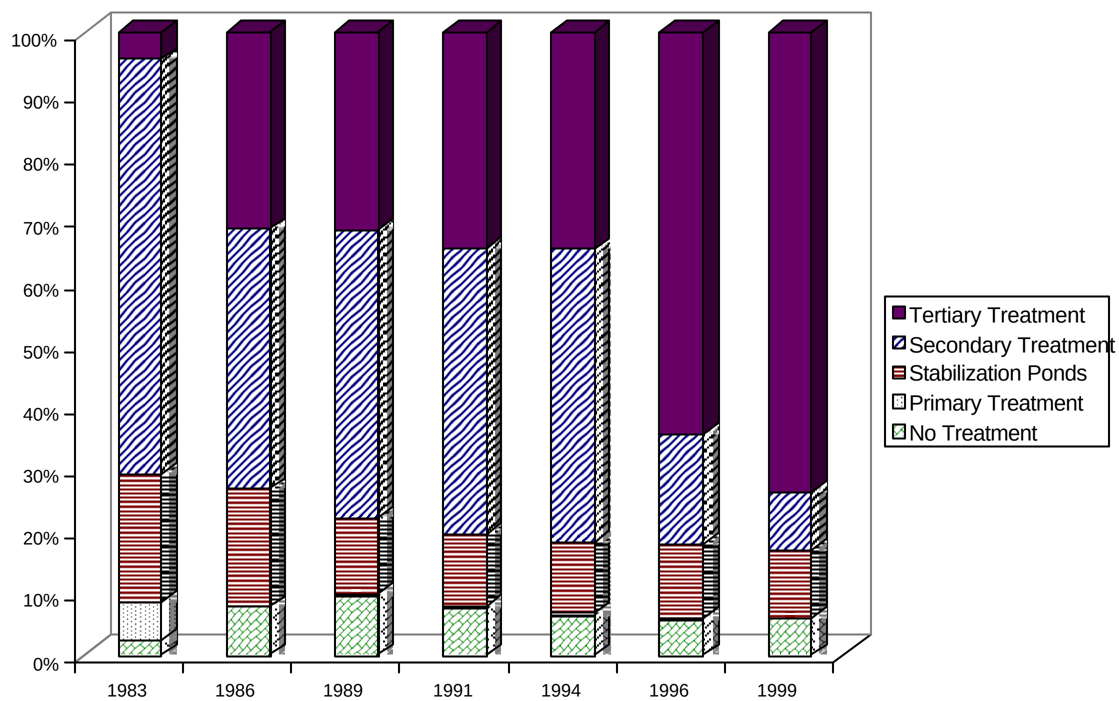
Figure 17: Reported Cases of Enteric Disease in Alberta, by Causal Agent, 1979 to 1999



4. Sewage Treatment

The level of Alberta's municipal sewage treatment has improved (Figure 18), and upgrading of sewage treatment plants in Calgary (1997) and Edmonton (1998) has led to some improvements in nearby surface water quality. Surface water quality improvements were noted in the preceding section on upstream and downstream water quality analysis. However, water quality downstream of Edmonton is still only fair as many storm sewers discharge directly into the river. Edmonton's plan for a further upgrade to tertiary sewage treatment will be completed in 2005.[6]

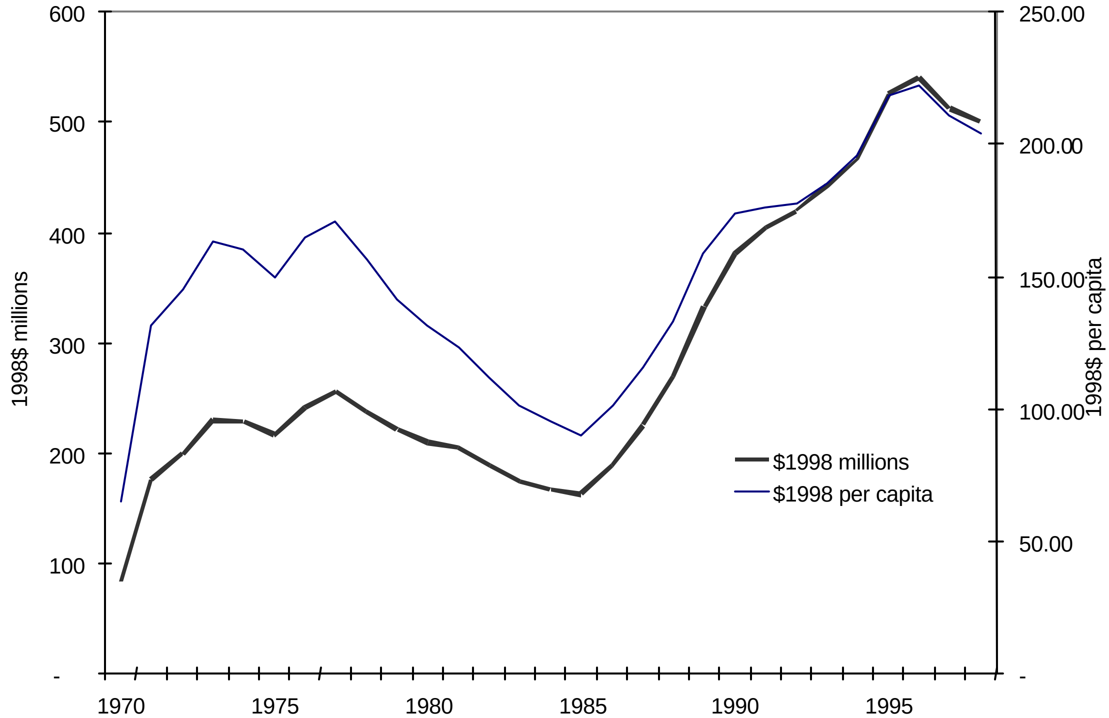
Figure 18: Municipal Sewage Treatment, 1983 to 1999



Source: Data from Municipal Use Database, 1983,1986, 1989, 1991, 1994, 1996,1999

As populations increase, so too does the demand on surface water systems and the respective sewage treatment costs. Based on Statistics Canada data[7] for government pollution abatement expenditures we estimated the trends in the costs of federal, provincial and municipal sewage treatment costs for Alberta (based on pro-rated national figures). Expenditures on sewage treatment by all levels of governments increased overall from 1970 to 1998 (Figure 19), while sewage treatment expenditure estimates for Alberta rose in the mid-1980s in both gross and per capita terms. Sewage treatment is considered a defensive expenditure, meaning that it is an investment to protect water supply, public health and water quality from contamination, and therefore a necessary expenditure.

Figure 19: Sewage Treatment Expenditures by All Levels of Government (Proportion for Alberta Estimated), 1970 to 1998, in 1998 dollars (millions and per capita)

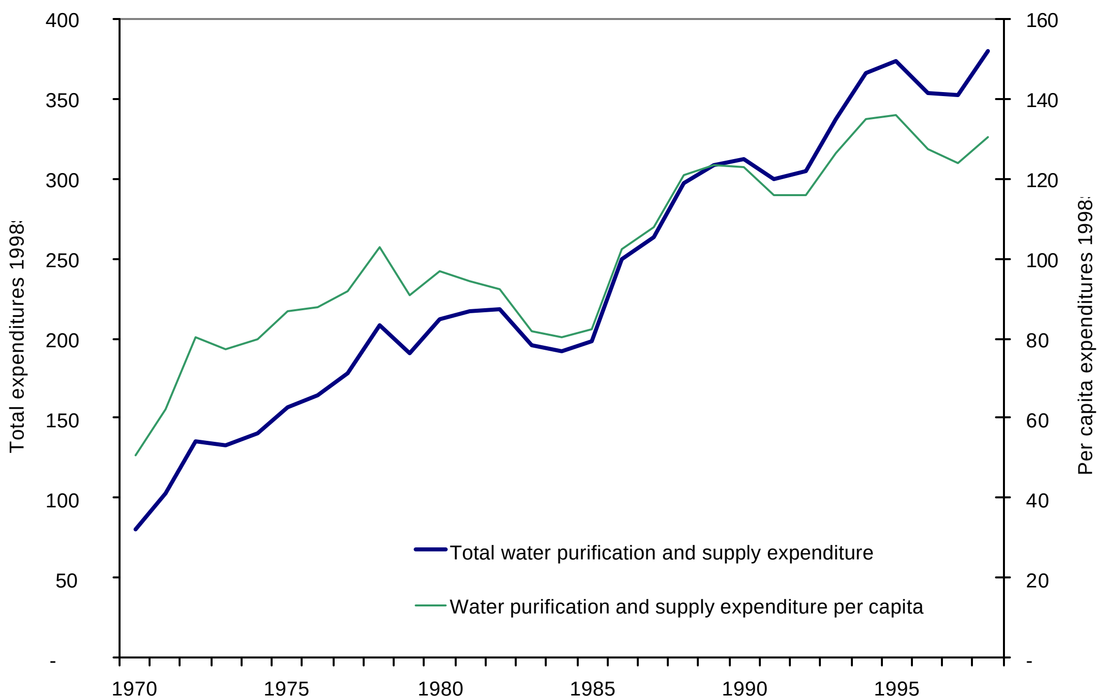


Source: Statistics Canada, Environment Accounts and Statistics Division; Public Institutions Division

5. Water Purification and Supply Costs

Another proxy for the quality of municipal drinking water is the rate of increase in water purification and supply costs by federal, provincial and municipal governments. Based on Statistics Canada data on government expenditures on pollution abatement, Figure 20 shows estimated cost of water purification and supply for Alberta in total and per capita real (1998 dollar) terms from 1970 to 1998.[§] Real costs per capita have increased steadily over the past 30 years, by 157 percent. The question arises whether rising costs of supplying clean drinking water suggest an overall decline in water quality. Higher costs of purifying water may indicate mounting levels of water pollution from many sources. Part of this increase in costs is undoubtedly due to population increases, particularly in the larger urban municipalities.

Figure 20: Water Purification and Supply Expenditures (Alberta as a portion of Canada's population) by all Governments, 1970 to 1998, in 1998 dollars and 1998 dollars per capita



[§] The costs are prorated calculations for Alberta based on Statistics Canada's aggregate expenditure data for Canada.

6. Northern River Basins Study

When a major pulp mill was approved on the Athabasca River in 1991, northern residents raised concerns about the impacts of industrial development on the rivers that flow north to the Arctic. In response, the provincial, federal and territorial governments initiated a $12.3-million study of the Peace, Athabasca and Slave river basins. After 4½ years of scientific work and 150 reports, it was evident that the concerns were justified. Municipal sewage and effluent from the seven pulp mills in Alberta and the four in northern B.C. were directly affecting the rivers, with high mercury levels presenting a further concern.[8]

The state of the rivers was reflected in the fish. While pathological abnormalities such as tumours, lesions, deformities and parasites occurred in less than one percent of most fish species, higher frequencies occurred in fish sampled near pulp mill effluent discharges. The pulp mill effluent also appeared to affect the sexual development of fish. Fish caught downstream of the mills had lower sex hormone levels, and a higher proportion were sexually immature compared with fish taken at sites upstream. Changes in pulp mill technology caused the levels of dioxins and furans to decline significantly during the study period, but these compounds were still being found in fish in certain river reaches when the study ended. The levels were such that the Study Board recommended a revision of fish consumption guidelines to protect the health of northern peoples. The revised guideline for the Athabasca River Drainage Basin recommends eating fish no more than once a week because of dioxins and furans; mountain whitefish from the Peace system should not be eaten at all.[9] However, such guidelines will not protect wildlife, which in the lower reaches of the Athabasca and Peace Rivers show evidence of contaminants with pulp mill signatures. There is also a fish consumption advisory for mercury for some rivers and lakes across Alberta, but most mercury appears to come from natural sources in soils and sediments.[10]

As well as adding contaminants, pulp mills add nutrients to the rivers, which increase phosphorus and nitrogen levels. Sewage treatment plants and lagoons also add to the nutrient level. As a result of human and natural sources, many reaches of the Athabasca and Wapiti/Smoky river systems have excessive levels of nutrients during the fall when flows are at their lowest. This in turn increases the abundance of plants, benthic invertebrates[**] and, subsequently, fish by providing additional food. Although these high nutrient levels stimulate growth, when the organisms die and decompose, they use up oxygen, thus reducing the available oxygen in the water. The Study found that "oxygen levels in the Athabasca River may currently be affecting animals at localized sites," with fish in the early life stages being especially vulnerable.[11]

The cumulative impact of high nutrient levels, low dissolved oxygen and contaminants are especially evident in some reaches of the rivers, with the situation being most serious on the Smoky/Wapiti Rivers downstream of Grande Prairie. The Study Board was concerned about the human health implications of fish consumption and recommended immediate "action to protect the Wapiti/Smoky river system from further development-related stress."[12] The Grande Prairie sewage treatment facility was upgraded in 2000, which should reduce nutrient levels.[13] The health implications of fish contamination were also considered serious below Hinton and Ft. McMurray and this situation was monitored in other locations too.[14]

The quality of human drinking water was another concern for the Study Board, mainly due to deficiencies in the operation of water treatment plants in small communities. The Human Health Monitoring Program, initiated in 1994 by Alberta Health at the request of the Northern River

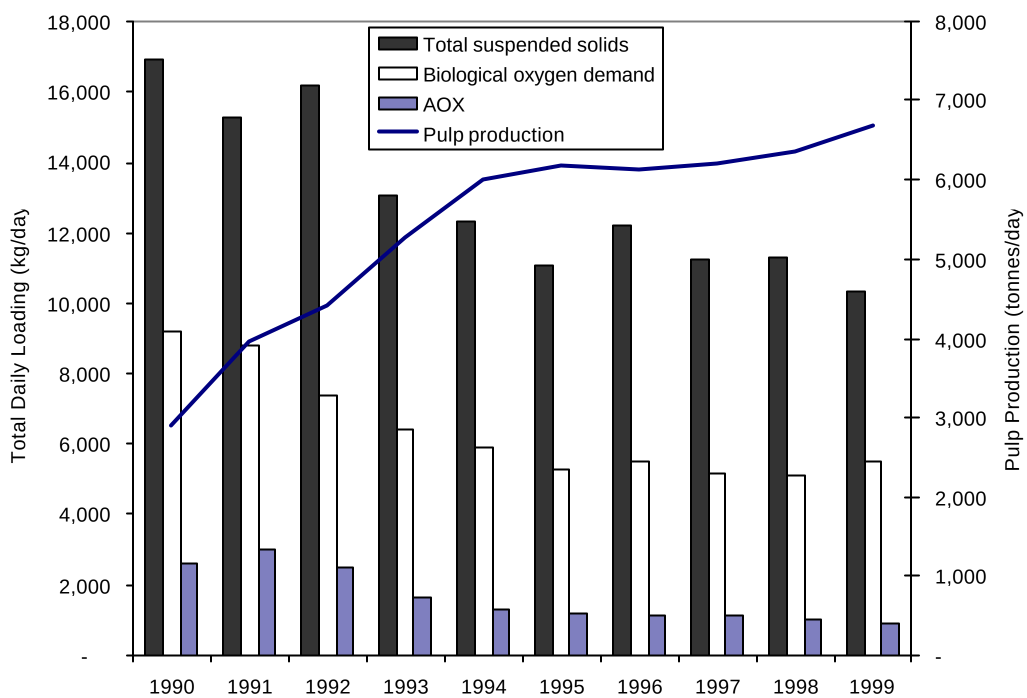
[**] Benthic invertebrates are spineless, insect-like organisms that live in sediments.

Basins Study, found there was a connection between water supplies in some smaller communities and human health problems, with higher levels of stomach illness including giardiasis (beaver fever) and shigellosis.[15] These findings were consistent with other areas in North America where smaller communities often have poorer water treatment.

Contaminants in the food chain are a concern for those who rely on locally caught fish and wildlife. However, the Human Health Monitoring Program failed to develop a complete environmental database so, with the exception of water treatment, it was unable to determine if there are links between contaminants and the health of the population.

Further studies of the natural environment are now being conducted through the Northern River Basins Ecosystem Initiative, established under the auspices of the Mackenzie River Basin Transboundary Waters Master Agreement to carry out recommendations made by the Northern River Basins Study. It is evident that some aspects of the environment have improved since the early 1990s. Pulp mill loadings to the northern rivers have declined despite the increase in pulp production (see Figure 21),[16] and improvements are being made to some sewage treatment facilities.

Figure 21: Effluent Loadings and Pulp Production in Alberta, 1990 to 1999



Source: Alberta Environment

But challenges still remain. Although the total nutrient loading from pulp mills has declined, the phosphorus loading increased by nearly 50 percent between 1995 and 1998.[17] Polychlorinated biphenyl (PCB) contaminants in fish remain at levels similar to those found in the Northern River Basins Study and work continues to determine the source of the PCBs in the river system. The Endocrine Disruption Study did not start until the fall of 1999, so developments with respect to hormone levels and the sexual maturity of fish (that were identified as problems in the Northern River Basins Study) are not yet known.

7. Agricultural Impacts on Surface Water Quality

Industry and municipal sewage are not the only factors affecting water quality in Alberta rivers. Runoff from livestock operations and crops carries disease-causing organisms, nutrients and pesticides into surface waters. As described in Report 19 in this series,[††] cattle numbers have increased more than 50 percent in the last 25 years and the number of farm acres on which pesticides and fertilizers are used has tripled.[18]

In the mid-1990s the CAESA study monitored 27 streams and 25 lakes in agricultural areas across Alberta and compared the results with 1991 Census data. The study found that, "Although nutrients and bacteria occur naturally in the environment, their concentrations in shallow groundwater and in surface waters in agricultural areas tended to be high, often exceeding water quality guidelines. Pesticides were detected frequently, sometimes at concentrations that exceeded guidelines."[19] The contamination was highest in high intensity agricultural areas, as measured by livestock numbers and pesticide and fertilizer sales. The levels of nutrients, nitrogen and phosphorus often exceeded water quality guidelines for the protection of aquatic life in streams in both high and moderate intensity areas, due to both livestock operations and runoff from fertilizer applications. Nutrient losses from some fields accounted for nearly 40 percent of nitrogen and 16 percent of phosphorus applied in the previous growing season in one area (Haynes Creek).[20] Intensive feedlots are a source of contamination, but runoff from cattle wintering grounds also contained high nutrient levels.

Indeed, moderate intensity agriculture is an important source of contamination. Levels of fecal coliform and total enterococcal bacteria exceeded the guidelines for recreational use of water more frequently in moderate intensity agricultural areas than in the high intensity areas.[21] However, in all areas fecal coliform bacteria levels exceeded human and livestock drinking water guidelines more than 90 percent of the time. Agricultural sources were often responsible, although wildlife and other human activities also contributed to the contamination. The agricultural influence was clearly seen in irrigated areas where the return flow after irrigation was more contaminated than the source water. The study did not measure microorganisms such as *Cryptosporidium* and *Giardia*, which have more recently become a cause for concern.

While pesticide levels did not usually exceed human or livestock consumption guidelines, low levels of herbicides were frequently detected. Herbicides were often found in spring meltwater, indicating that they persist in the soil for longer than is usually thought. Two herbicides (MCPA and dicamba) frequently exceeded irrigation water quality guidelines, not only in irrigation canals but also in streams and small lakes in high intensity agricultural areas. The study reported that, "Although there have been no obvious concerns raised by irrigation farmers to date, these results raise significant concerns about potential crop damage during the irrigation season."[22] It was also reported that pesticides can leach into shallow groundwater and their persistence in the soil needs to be further investigated.[23] Concerns about pesticides in wetlands are described in Report 23 in this series, *Wetlands and Peatlands*.

The CAESA study's key findings were that "Agricultural practices are contributing to the degradation of water quality" and that "The risk of water quality degradation by agriculture is highest in those areas of the province which use greater amounts of fertilizer and herbicides, and have greater livestock densities."[24] As indicated in GPI Report 19 on agriculture, the study found that current management practices were often not adequate to sustain water quality, particularly in the high and moderate intensity agricultural areas of Alberta.[25]

[††] Report #19 is entitled *The Alberta GPI Accounts: Agriculture.*

8. Agricultural Impacts on Groundwater Quality

Contamination of groundwater often occurs slowly and can go unnoticed for a long time. Abandoned water wells are a potential threat to the future quality of groundwater in the province. As the water level falls and better equipment is available, farmers drill new, deeper wells and fill in the old wells. No records have been kept of these abandoned wells, yet they can act as conduits, leading contaminants into groundwater.[26] This situation is of special concern because of intensive livestock operations with sewage lagoons from feedlots and hog barns. Spring runoff from manure-saturated fields where cattle have over-wintered also poses a threat.

Until recently, very little was known about the quality of water on Alberta's 57,000 farms. The Farmstead Water Quality Survey, conducted between 1994 and 1996, found that 32 percent of the 857 wells samples exceeded the Canadian Drinking Water Quality Guidelines for maximum acceptable concentration of at least one parameter.[27] Ninety-three percent exceeded one or more of the aesthetic objectives (for sodium, iron total dissolved solids, etc). Surface contaminants are obviously reaching the water, for 14 percent of the wells contained fecal coliforms at detectable levels. Three percent of the wells had detectable levels of herbicides and on three occasions exceeded the maximum acceptable concentration. Some wells had high levels of nitrates and nitrites that could have come from an agricultural source. This does not necessarily mean that the aquifer is contaminated; surface contaminants could be entering the well directly, especially as a significant number of contaminated wells were less than 100 metres deep. The CAESA study found that agricultural contaminants were rarely found in any of the 448 deep groundwater wells that they monitored throughout the province.[28]

The future cost of this contamination is unknown, but "the effects of poor water quality can significantly impact both the health and economic well being of farm families."[29]

Nitrates and nitrites in groundwater are a health concern. "Large amounts of nitrites may cause irritation to the gastrointestinal tract and bladder. As well, nitrates at higher concentration have been associated with increased rates of non-Hodgkin's lymphomas … Nitrates can also cause cyanosis or methemoglobinemia (blue baby syndrome) in infants. Water is considered unsafe to drink if the nitrate + nitrite concentration reaches more than 10 mg/l."[30] The Farmstead Water Quality Survey found that six percent of samples tested exceeded the maximum acceptable concentration of 10 mg/L. The average concentration in these wells was 27 mg/L, showing that some wells must have had exceptionally high levels. In all cases, the high levels were found in shallow wells less than 125 feet deep (38 metres).

While some aquifers in Alberta have naturally high nitrate levels, nitrate from manure and fertilizer is a major source of contamination. A study on irrigated land in southern Alberta found that "Nitrate from manure and inorganic fertilizer was leached to shallow groundwater through both sandy and clay-rich sediments when fertilizer or manure were applied at rates greater than crops required. Nitrate from fertilizer occurred at two to 30 times the level acceptable for human drinking water in very shallow groundwater (up to 7 m below ground level) below fertilized fields."[31] The study points out that shallow aquifers are very vulnerable to contamination, and discharge from contaminated aquifers could adversely affect surface water quality. The same study warns that "…in planning future development, such as the location of intensive livestock operations and selection of land for manure spreading or intensive cropping practices, groundwater setting must be considered, including the depth to aquifers and the permeability of overlying materials."

There is no long-term time series of data to show how nitrate levels in the soil have changed, but it can be assumed that levels have been increasing in the irrigated area since the 1960s.[32]

Although the cumulative impacts of extensive operations are a major issue, intensive livestock operations have become a focus of public concern in Alberta. There is increasing resistance to the location of intensive livestock operations as many rural people are concerned that manure from overflowing sewage lagoons or from runoff after landspreading will contaminate their wells. As the province only has guidelines for the location and operation of intensive livestock operations and has delayed the introduction of stringent legislation, these concerns are justified. The experience at Walkerton, Ontario shows that water contamination can also be caused by conventional livestock operations and that those receiving treated water as well as those using well water can be affected. Better groundwater protection is imperative and requires strict regulation of all contaminants that can enter groundwater.

The CAESA study expressed concern that about 60 percent of the nearly 1,000 households surveyed had not tested their drinking water within the last five years or had not tested it at all. “This is a major concern because of the health problems associated with poor quality water. More effective education and awareness programs are required to ensure that all water is tested and, where required, treated before domestic use.”[33]

9. Energy Industry Impacts on Groundwater

The extraction of oil and gas, which occurs across much of Alberta, can have serious impacts on groundwater, although the extent, severity and long-term implications are not fully known. Seismic holes can form conduits for surface pollutants to enter the ground. They can also intercept an aquifer and change underground water flows. Hundreds of thousands of seismic holes are drilled each year in Alberta in the search for oil and gas. Although abandoned water wells have to be filled, seismic holes are only plugged for the top 1.5 metres. The Alberta Surface Rights Federation is worried that seismic holes allow contaminants to enter the groundwater, especially as holes are often drilled in ditches and plugs sometimes blow out.[34] They want the entire hole plugged, as is required in Wyoming.

Oil and gas extraction can also disrupt groundwater and create pollution. In the Cold Lake area, steam injection for oilsands extraction has lowered the water table. Water wells have been drilled deeper and a few wells contain arsenic at levels that exceed the maximum acceptable concentration. The arsenic is probably from natural sources, but might have become mobilized by the fluctuating water table, or it could be due to the fact that a fall in the water table required the drilling of deeper wells. Some oil well blowouts in the area are known to have affected the groundwater immediately adjacent to the well, and the diameter of the affected area may increase over time.[35]

Partly because concerns about arsenic were raised during hearings into the oilsands expansion, a more detailed study was conducted in several northern health regions.[36] It appears that naturally high levels of arsenic are associated with certain geological strata. Concentrations of arsenic in excess of 25 ì g/L were found in almost 22 percent of raw water samples in Lakeland and in 20 percent of samples in Keeweetinok health regions. In Keeweetinok, 12 percent of raw samples exceeded 50 ì g/L. In treated water the proportion of samples that exceeded 25 ì g/L was slightly lower: 16 percent in Lakeland Regional Health Authority and 13 percent in Keeweetinok. These high levels were found in domestic water wells in areas underlain by three specific geological formations and were most common in wells deeper than 50 feet (15 metres). The report does not mention energy industry activity. The health effects of high arsenic levels include elevated levels of some types of cancer, and the government recommends that if arsenic levels in domestic well water consistently exceed 25 ì g/L, an alternate source of potable water should be used for consumption or food preparation.[37]

The Alberta Energy and Utilities Board (EUB) regulates the oil and gas industry in the province and has long been aware that surface casing vent flows create a potential risk to groundwater. The problem often occurs when a well is drilled through a gas-bearing zone at a shallower depth than the one that is targeted for production. The shallower gas has a tendency to move towards the well bore and migrate into the steel pipe (surface casing) that surrounds the production pipe. In 1996, the Board made an effort to address the problem and various measures were used to deal with nearly 400 serious vent flows. The Board now has more stringent standards but still relies on industry accountability for quickly addressing problem wells.[38]

The EUB keeps a log of all reported surface casing vent flows and in mid-August 2000, 68 wells reported serious surface casing vent flows with gas contaminating groundwater aquifers.[39] This included one township near Rocky Mountain House (038-07W5) where 45 older wells were causing a problem. This number changes as new leaks are reported and as old leaks, which have to be sealed within a year, are removed from the list. The system does not allow for the analysis of historical data so there is no record of trends in the number of contaminated sites or number of aquifers affected. There does not appear to be any record of whether the leaks cause long-term problems.

Old, non-operative oil and gas wells can also enable pollutants to enter the groundwater. The EUB now has an orphan well fund to ensure that wells for which no owner can be found are properly abandoned, but it is not known what contamination may have resulted in the interim.

While data exist for groundwater monitoring wells in Alberta, and individual spills and leaks are reported, there has been no comprehensive study to determine whether spills or leaks have affected groundwater or whether any aquifers have been affected. Given the large number of orphan well sites and buried oilfield wastes across the province, this is a matter of concern.

Alberta Environment has been responsible for dealing with problem water wells. Between January 1997 and October 2000, the Department investigated 104 complaints. In about half the complaints (54 cases), the owners alleged that reduced yield, a change in water quality or sediment was caused by nearby oilfield activity. In many cases inspectors found that poor well maintenance, lack of chlorination, over-pumping or the failure of the water well casing was the cause. In five cases (about five percent of all complaints) the presence of ethane gas showed that oilfield interference was responsible and the EUB was called in to resolve the problem with the companies involved.[40] Of course, the fact that there was no direct effect on a well does not mean that the energy industry was not in some cases indirectly responsible for a deterioration in well water quality.

Whatever the cause of water contamination, as a recent government report points out, “The responsibility for the safety of private well drinking water lies with the property owner.”[41] There is no routine provincial testing of the quality of water in domestic wells and the usual tests that a homeowner has done from time to time do not include tests for possible energy industry contaminants unless they are specially requested. As it can be extremely difficult, if not impossible, to prove the actual source of groundwater contamination, the individual homeowner is left to pay the bill for an alternative water source, even if they were in no way responsible for the contamination. It is not surprising that many people are concerned about the protection of groundwater, both from industrial and agricultural sources. Concerns about deepwell disposal of hazardous wastes are dealt with in GPI Report 27, *Municipal and Hazardous Waste*.

10. Groundwater Levels

Groundwater levels are a concern independent of groundwater quality. Water withdrawals by industry could be affecting the long-term volume of Alberta aquifers. Withdrawal of water to create steam for oilsands injection has been a factor in lowering the water level in the Cold Lake area, but there is no province-wide picture of changes in the water table. Alberta Environment has records from several hundred groundwater observation wells across the province dating from the 1950s. These wells record the depth of the water table and show that levels have fluctuated with changing climatic conditions. However, there has been no systematic evaluation of the trends to determine whether water levels have declined and whether human influences are the cause.[42] Indeed, it appears that we know more about the reserves of oil and gas in Alberta than the state of the province's groundwater. Water has been regarded as an abundant resource in the past in central and northern Alberta, but the protection of groundwater is more important than the province's oil and gas resources for the long-term sustainability of the province.

11. The Long-term Sustainability of Water in Alberta

> *Pure water, the source of life, no longer exists in Alberta, if anywhere. Even the meltwater from glaciers in the Rocky Mountains, that feed the provinces major rivers, is contaminated with airborne pollutants. The ice now melting is releasing DDT, toxaphene and PCBs that were in widespread use when the snow and ice were being formed.*[43]

We have seen that this initial contamination is greatly increased as rivers pass through farmlands, ranchlands and towns in Alberta. Water quality has improved, especially downstream of major urban centres, but some rivers and streams still contain high levels of pollution from urban sources and from agricultural runoff. Concerns also remain about the impact of agriculture and the energy industry on Alberta's groundwater. To these must be added further concerns about the impact of global climate change on the province's water resources.

While Alberta has abundant water in the northern part of the province, rivers flowing through the dry areas of southern Alberta are being used to capacity. During dry seasons, irrigation agriculture demands conflict with the need to keep water levels high enough to ensure the health of aquatic species. Much of the water in Alberta's rivers originates in the Rocky Mountains. The South Saskatchewan and its tributaries, which supply water to southern Alberta, are particularly vulnerable to climate change that is already affecting the icefields at the river's source. Dr. David Schindler, quoted above, points out that the Athabasca Glacier has receded over 1.5 kilometres in the last century and the annual loss of ice is now over 16 million cubic metres greater than the annual recharge. He warns that, "Further recessions of mountain glaciers may jeopardize prairie water supplies."[44] Shortages of water will be exacerbated as global climate change is expected to bring higher temperatures and increased evaporation. As a result of this increase in temperature and decrease in precipitation, smaller streams could dry up and wetlands will decline in area, irrespective of human activities. As the quantity of water in rivers and streams declines, the proportion of pollutants will increase unless they are likewise reduced. Noting that several cases are already before the courts, challenging Canada's refusal to export water, Schindler says that until the outcomes are clear, water export must also be regarded as a threat to Canadian water security. He further points out that climate change will affect fish species and will have impacts across Canada: "Global warming, increased pollutant loads and water exports will degrade freshwater fisheries that are already savaged by overharvesting, destruction of habitat, dams, diversions, introductions of diseases, parasites and alien fishes."[45]

The dry, southern parts of Alberta will obviously be affected, but drier conditions could also affect lakes in northern Alberta. Schindler has observed changes in Ontario boreal lakes over the last 20 years that could, to some extent, apply to Alberta. Longer ice-free seasons and an increase in surface water temperature cause biological changes in phytoplankton that, in turn affect fish.[46] Forest fires, which are probably related to higher temperatures and drier conditions, change the runoff to streams and lakes. Depletions in stratospheric ozone have increased the amount of ultraviolet radiation that penetrates the water and may accentuate other changes associated with climate warming (and, in some locations, acidification). As Schindler points out, "The biological consequences are still largely unknown," but they will probably be compounded by human activities, including logging.[47]

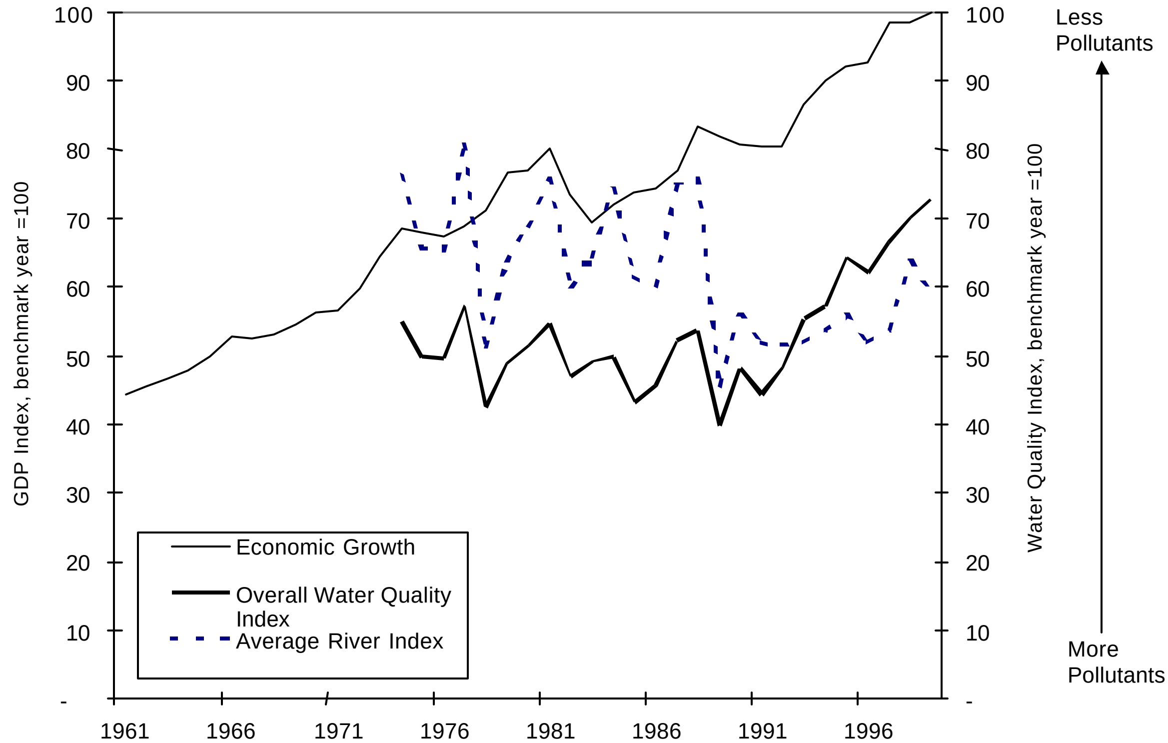
Thus, even if human efforts manage to reduce pollution and conserve water resources in Alberta, other changes are underway that could have far-reaching effects on the province's water supply, on its quality and on the species that live in its streams, rivers and lakes.

Ideally, we need to establish accounting systems to track overall conditions in each watershed. This would mean conducting a study such as the Northern River Basins Study for each river basin in the province. In addition to the type of studies undertaken for the northern rivers, that tracked overall conditions and pollution, such a system should also monitor depletion rates and recharge rates within each major river basin. This is important not only for southern Alberta where resources are fully allocated, but also for northeastern Alberta where dry conditions occur periodically.

12. Water Quality Index

The water quality index reflects only surface water conditions in rivers, as no data are available for the creation of a groundwater index. To assess water quality, indices, where the best year equals 100, were constructed based on data for: a) pulp effluent; b) percentage of municipal population with tertiary sewage treatment; c) cases of enteric diseases related to *Giardia* and *Cryptosporidium*; and d) long-term monitoring of dissolved oxygen, nitrogen, phosphorus and fecal coliforms along six major rivers (see Appendix B for data sources). The first three indices were averaged to produce an aggregated average index, and a second index was created based on the overall index for each river. The overall water quality index is an average of these two aggregated indices, giving a weighting of 50 percent to each (see Figure 22). In 1974, the index score was 55 and by 1999, had risen to 73. Most of the improvement is due to better-quality effluent from pulp mills and better sewage treatment in municipal areas. At the same time, the average river index declined, which is a result of additional problems discussed above that are not represented by the other indicators used as indices. This index declined from 76 to 59, over the same time period.

Figure 22: Water Quality Index, 1961 to 1999



13. Recommendations for Further Study

With more time, it should be possible to estimate the costs associated with illness due to contaminated water. This would include the costs associated with water degradation as well as the cost of cleaning it up. A system of full watershed accounting is needed to track overall conditions, depletion and recharge rates and pollution rates for each major river basin.

Appendix A. List of Alberta GPI Background Reports

A series of Alberta GPI background reports accompanies the *Alberta Sustainability Trends 2000* report and this report. These documents are being released in late 2001 and early 2002 and will be available on the Pembina Institute's website at www.pembina.org.

Table 1: Alberta GPI Background Reports and Sustainability Indicators

GPI Background Report	GPI Accounts Covered by Report
1. Economy, GDP and Trade	• Economic growth (GDP) • Economic diversity • Trade
2. Personal Consumption Expenditures, Disposable Income and Savings	• Disposable income • Personal expenditures • Taxes • Savings rate
3. Money, Debt, Assets and Net Worth	• Household debt
4. Income Inequality, Poverty and Living Wages	• Income distribution • Poverty
5. Household and Public Infrastructure	• Public infrastructure • Household infrastructure
6. Employment	• Weekly wage rate • Unemployment • Underemployment
7. Transportation	• Transportation expenditures
8. Time Use	• Paid work time • Household work • Parenting and eldercare • Free time • Volunteerism • Commuting time
9. Human Health and Wellness	• Life expectancy • Premature mortality • Infant mortality • Obesity
10. Suicide	• Suicide
11. Substance Abuse: Alcohol, Drugs and Tobacco	• Drug use (youth)
12. Auto Crashes and Injuries	• Auto crashes
13. Family Breakdown	• Divorce
14. Crime	• Crime
15. Gambling	• Problem gambling
16. Democracy	• Voter participation
17. Intellectual Capital and Educational Attainment	• Educational attainment
18. Energy (Oil, Gas, Coal and Renewable)	• Oil and gas reserve life • Oilsands reserve life
19. Agriculture	• Agricultural sustainability
20. Forests	• Timber sustainability • Forest fragmentation

GPI Background Report	GPI Accounts Covered by Report
21. Parks and Wilderness	• Parks and wilderness
22. Fish and Wildlife	• Fish and wildlife
23. Wetlands and Peatlands	• Wetlands • Peatlands
24. Water Resource and Quality	• Water quality
25. Energy Use Intensity, Greenhouse Gas Emissions and Air Quality	• Energy use intensity • Air quality-related emissions • Greenhouse gas emissions
26. Carbon Budget	• Carbon budget deficit
27. Municipal and Hazardous Waste	• Hazardous waste • Landfill waste
28. Ecological Footprint	• Ecological footprint

Appendix B. Water Resource and Quality Data

Table 2: Raw data for water resource and quality data for GPI accounts and indices, including estimated environmental cost of human wastewater pollution

	Average Water Quality Index	Environmental Cost of Human Wastewater Pollution (millions of 1998 dollars)
1961		0.26
1962		0.27
1963		0.27
1964		0.28
1965		0.28
1966		0.28
1967		0.29
1968		0.30
1969		0.30
1970		0.31
1971		0.32
1972		0.33
1973		0.33
1974	55.02	0.34
1975	49.73	0.35
1976	49.58	0.36
1977	57.26	0.38
1978	42.59	0.39
1979	48.83	0.41
1980	51.39	0.42
1981	54.79	0.44
1982	47.01	0.46
1983	49.13	0.46
1984	49.75	0.46
1985	43.25	0.46
1986	45.65	0.47
1987	52.16	0.47
1988	53.72	0.47
1989	39.86	0.48
1990	48.14	0.49
1991	44.35	0.50
1992	48.24	0.51
1993	55.34	0.52
1994	57.11	0.52
1995	64.33	0.53
1996	62.13	0.54
1997	66.51	0.55
1998	70.24	0.56
1999	72.73	0.57

Table 3: Water quality sub-indice data including: a) pulp effluent; b) percentage of municipal population with tertiary sewage treatment; c) cases of enteric disease related to *Giardia* and *Cryptosporidium*; and d) long-term monitoring of dissolved oxygen, nitrogen, phosphorus and fecal coliforms along six major rivers[*]

	River quality index[†]	Pulp effluent index[‡]	Tertiary water treatment index[§]	*Giardia* and *Cryptosporidium* cases index	**Average Water Quality Index**[**]
1961					
1962					
1963					
1964					
1965					
1966					
1967					
1968					
1969					
1970					
1971					
1972					
1973					
1974	76.16	23.21	5.58	72.85	**55.02**
1975	65.58	23.21	5.58	72.85	**49.73**
1976	65.28	23.21	5.58	72.85	**49.58**
1977	80.63	23.21	5.58	72.85	**57.26**
1978	51.29	23.21	5.58	72.85	**42.59**
1979	63.77	23.21	5.58	72.85	**48.83**
1980	68.90	23.21	5.58	72.85	**51.39**
1981	75.69	23.21	5.58	72.85	**54.79**
1982	60.14	23.21	5.58	72.85	**47.01**
1983	64.38	23.21	5.58	72.85	**49.13**

[*] The subindices are based on raw data from Alberta Environment and can be requested from the authors of this report.

[†] Average river quality index is based on data for dissolved oxygen, nitrogen, phosphorus and fecal coliforms along six major rivers: the Smoky River, Red Deer River, Oldman River, North Saskatchewan River, Bow River and Athabasca River, taken from Alberta Environment data.

[‡] The pulp effluent index is derived from Alberta Environment data for 1990 to 1999 based on BOD (biological oxygen demand), AOX (adsorbable organic halides), TSS (total suspended solids) and colour data. In the absence of historical data, figures for 1971 to 1989 are estimated and assumed to be constant at 1990 levels.

[§] The tertiary water treatment index is derived from estimates of the number (population) and percentage of Albertans who are served by from tertiary water treatment systems, which have been sourced from Environment Canada's Municipal Use Database.

[**] The overall water quality index for rivers (surface water) is constructed based on data for: a) pulp effluent; b) percentage of municipal population with tertiary sewage treatment; c) cases of enteric disease related to *Giardia* and *Cryptosporidium*; and d) long-term monitoring of dissolved oxygen, nitrogen, phosphorus and fecal coliforms along six major rivers. The first three indices were averaged to produce an aggregated average index, and a second index was created based on the overall index for each river. The overall water quality index is an average of these two aggregated indices, giving a weighting of 50 percent to each.

	River quality index	Pulp effluent index	Tertiary water treatment index	*Giardia* and *Cryptosporidium* cases index	**Average Water Quality Index**
1984	74.33	23.21	15.05	37.25	**49.75**
1985	61.47	23.21	21.46	30.43	**43.25**
1986	60.17	23.21	43.83	26.32	**45.65**
1987	74.94	23.21	33.99	30.97	**52.16**
1988	75.84	23.21	40.08	31.47	**53.72**
1989	45.64	23.21	45.17	33.86	**39.86**
1990	55.96	23.21	50.86	46.88	**48.14**
1991	51.81	30.88	49.06	30.72	**44.35**
1992	51.48	38.17	61.04	35.80	**48.24**
1993	51.98	57.80	66.05	52.29	**55.34**
1994	53.76	75.89	47.97	57.54	**57.11**
1995	55.88	85.37	75.77	57.23	**64.33**
1996	51.95	80.47	88.43	48.02	**62.13**
1997	53.85	85.99	84.17	67.36	**66.51**
1998	63.68	89.95	87.52	52.96	**70.24**
1999	59.31	99.34	100.00	59.09	**72.73**

Appendix C. U.S. GPI Methodology for Cost of Water Pollution

The U.S. GPI estimates include an estimate of the cost of air pollution as a deduction against the GDP, calling it a regrettable cost of economic growth that reflects the depreciation of natural capital in the form of water quality. These and other detailed GPI methodological descriptions for the U.S. GPI analysis can be found in Anielski and Rowe (1999).[48] Below is a description of the U.S. GPI methodology taken from the same report. Data sources cited in this Appendix are noted at the end of the Appendix on the next page.

The Cost of Water Pollution in the U.S. GPI

Water is the one of the most precious of all environmental assets yet the national income accounts provide neither an inventory of the quantity or quality of water resources nor an account for the value and cost of damage to water quality. The cost of water pollution as estimated in the GPI is not the money spent to clean up polluted water. Sewage treatment and water treatment plants do not improve the quality of water but rather prevent the condition of a river, lake or groundwater from deteriorating. More pollution simply means more treatment is required to bring the quality of the water to a benchmark level. If treatment expenses were counted as positive, that would indirectly mean that pollution adds to the well-being of America. On the other hand, treatment costs are not subtracted here as defensive expenditures because those are mainly government and corporate expenditures and therefore are not directly related to the GPI baseline, which is based only on personal (household) consumer expenditures.

The costs of water pollution arise from: 1) damage to water quality, and 2) damage from siltation, which reduces the lifespan of water impoundments or channels. Although this may involve some double counting (insofar as siltation also damages water quality), on the whole they understate damage because of the lack of data on non-point sources of pollution. Ironically, despite the importance of water to human existence, studies of the economic costs of damage to water quality, whether surface (river) or groundwater, are rare.

Damage to water quality: The cost of damage from water pollution in 1972 was estimated as $12.0-billion, or $39.3-billion in 1992 chained dollars. This is based on the upper range of estimates in three studies of point source damage to recreation, aesthetics, ecology, property values, and household and industrial water supplies (Freeman 1982, chapter 9). The less conservative figures were used because data were not available for non-point sources (urban and farmland runoff). These at least double the total pollutant load in many river basins and increase it several-fold in others. As of the late 1970s, non-point sources contributed 57 percent of biological oxygen demand, 98 percent of suspended solids, 83 percent of dissolved solids, 87 percent of phosphorous, and 88 percent of nitrogen discharged into U.S. waterways (see Giannessi and Peskin 1981, p. 804, Table 1).

According to the Conservation Foundation, "the years 1974 to 1981 saw little change in water quality with respect to the conventional pollution indicators" (Conservation Foundation 1985). This overall lack of improvement means that regulatory efforts were offset by the growth of population and polluting activities. In contrast to the relative stability of the 1970s and 1980s, water quality is assumed to have declined during the 1950s and 1960s at three percent per year, before the concerted national effort to address the issue.

A recent U.S. Department of Agriculture report, *Agricultural Resources and Environmental Indicators 1996-1997* (1998)[49] noted that, "the Great Lakes continue to suffer serious pollution, even though progress has been made in reducing the worst cases of nutrient enrichment (particularly in Lake Erie). Only three percent of the assessed shoreline miles fully support designated uses (EPA 1995). Most of the Great Lakes shoreline is polluted with organic chemicals, primarily PCBs and DDT."

The USDA further reports that with respect to the largest estuary in the world, Chesapeake Bay, "While an aggressive program has reduced phosphorous, nitrogen concentrations remain high, leaving the bay overenriched," with the water quality being degraded by agricultural development, population growth and sewage treatment plant emissions.

In terms of groundwater quality, a recent survey of 38 states found that overall groundwater quality in 1992 for 29 of the 38 states was judged to be good or excellent (EPA 1994).[50] The EPA's National Survey of Pesticides in Drinking Water Wells, conducted in 1988-1990, found a low proportion of wells containing a particular pesticide or pesticide degradate. Agriculture was cited as a major source of groundwater contamination.

In the absence of more current economic analysis of the cost of water pollution to surface water and groundwater in the U.S., we continue to apply Freeman's 1982 estimates of $12.0-billion for 1972, which converts to $39.3-billion in 1992 dollars. In the absence of more current estimates, we assume that the economic cost from damage to water quality remained constant from 1972 to 1997 at $39.3-billion.

Damage from siltation: Erosion from farmland, streambanks, roadbanks and construction sites imposes costs in the form of reduced river navigability, siltation of water impoundments, sediment-related flooding, and other off-stream effects. The Conservation Foundation estimated that this damage was in the range of $3.2- to $13.0-billion in 1980. The geometric mean was thus around $6.5-billion.

No definitive estimates of the changes in siltation over the years are included in the GPI. The National Resources Inventory, conducted by the Soil Conservation Service in conjunction with Iowa State University in 1977 and 1982, estimated total erosion at a constant level of 6.5 billion tons of soil loss per year.[51] Our calculations assume that this five-year trend has continued to the present, and that it began in 1972. From 1950 to 1972, we estimate that erosion increased by an average of one percent per year. Even if farmland erosion remained constant before 1972, other causes of sedimentation presumably increased due to urban growth, construction and the development of the interstate highway system.

As with the damage to water quality, we assume cost of water pollution due to siltation to remain constant at 1972 levels, namely at $10.8-billion per year in 1992 dollars.

Combining the damage to water quality and the damage due to siltation, the total cost of water pollution used in the GPI account was estimated at $50.1-billion in 1997.

Data Sources

Conservation Foundation. 1985. *State of the Environment: An Assessment at Mid-Decade*. Washington, D.C.: Conservation Foundation.

Freeman, Myrick. 1982. *Air and Water Pollution Control: A Benefit-Cost Assessment.* New York: John Wiley and Sons.

Gianessi, Leonard P. and Henry M. Peskin. 1981. "Analysis of National Water Pollution Control Policies: 2. Agricultural Sediment Control." *Water Resources Research* 17(4): 803-821.

Appendix D. Australian GPI Methodology for Cost of Water Pollution

This appendix outlines the Australia GPI cost of water pollution as is described in *Tracking Well-being in Australia The Genuine Progress Indicator 2000*. Appendix A of that report contains a complete set of Australia GPI data organized into a series of columns. Thus, references to "columns" in the description below relate to the columns as presented in the Australian publication. Hamilton and Denniss (2000) estimated the urban water pollution and cost of irrigation water use, which they deducted from GDP to derive the GPI estimates (see also Alberta GPI report #19 on Agriculture). Their methodological approach is described below.

Costs of urban water pollution in Australia's GPI

The environmental costs of urban water pollution include damage to habitat, decline in conservation and recreational values and impacts on downstream users. After reviewing the available information on the environmental costs associated with wastewater treatment and disposal, a study by the National Institute for Economic and Industry Research (NIEIR) settled on a control cost approach as the only feasible method. Extrapolating from data for Sydney, Australia, NIEIR estimated the annual cost of internalizing wastewater externalities in Australia in 1994 at $3.5-billion (DEST 1996a: 80-81[52]). This estimate—$3.58-billion in 1989-90 dollars—is adopted for the GPI. It translates into a cost of $2.20/ML (million litres).

To derive a series for 1950 to 2000, we assumed that the real environmental cost of a litre of wastewater remains constant over the period. The series is thus derived from estimates of the volume of wastewater in Australia and a price deflator. The price deflator employed is the implicit price deflator for public expenditure on fixed capital (RBA 1996: Table 5.6a).[53]

Estimating the volume of wastewater in Australia is difficult as until recently no national figures had been collected. As a rule of thumb, each person generates 250 L of wastewater per day (Chris Davis, Australian Water and Wastewater Association, personal communication). Currently, around 85 percent of households have access to the sewage system. In 1950, around 50 percent of households were sewered. However the environmental problems associated with wastewater disposal from non-sewered households are worse than those from sewered households. Therefore the volume of wastewater used to form a series is taken to be 250 L per person per day for the whole population. Note that this method of estimating total sewage volumes gives a figure for 1993-94 of 1.63 million ML, which compares with the estimate by the Australian Water and Wastewater Association of 1.67 ML, of which 1.18 million ML is metropolitan and 0.49 million ML non-metropolitan (AWWA 1996).[54]

Sources

Hamilton, C. and R. Denniss. 2000. *Tracking Well-being in Australia, The Genuine Progess Indicator 2000*. The Australia Institute. Number 35. December 2000.

Appendix E. GPI Atlantic

Researchers at GPI Atlantic, headed by Dr. Ron Colman, are advancing the methodological framework for assessing the cost of water pollution as part of a set of GPI accounts for Nova Scotia. Abstracts for two of their reports are included in this Appendix. More information is available online at www.gpiatlantic.org.

Nova Scotia's Water Resource Values and the Damage Costs of Declining Water Resources and Water Quality

July 2000, 242 pages, $45.00
Source: http://www.gpiatlantic.org/ab_waterquality.shtml

Prepared by Sara Justine Wilson, MSc.

ABSTRACT

More Nova Scotians have clean and healthy drinking water than they did 15 years ago, but the quality of the province's rivers, lakes and coastal waters has declined, shows a ground-breaking new study to be released tomorrow (July 27) by GPI Atlantic. The province's water resources provide a wealth of benefits to Nova Scotia worth more than $11 billion a year, including drinking and industrial water supply, recreation, waste treatment, food production, nutrient cycling, erosion control, and other vital ecosystem services.

The 230-page study marks the first ever assessment in Canada of the full value of a province's water resources, and pulls together vast quantities of published and unpublished information from a wide range of federal, provincial and municipal sources.* The GPI water quality study is the first in a series of natural resource accounts to be released in the coming months by GPI Atlantic, a non-profit research group that is building the first Genuine Progress Index (GPI) in Canada as a measure of well-being and sustainable development.

According to report author, Sara Wilson, "the GDP and other market statistics send the wrong message to policy-makers and the public about the health of our environment, because they count the depletion of natural capital as economic gain. The more trees, water and fish we consume, the faster the economy grows. The more pollution we have and the more we spend on clean-up, the more the GDP will grow. By contrast, the GPI shows that our natural resources provide enormous value to society and the economy, and that we have to use them responsibly if we want to benefit the economy and future generations."

The study found a 3.2 percentage point improvement from1987 to 1998 in municipal water samples that were free from coliform bacteria; a 29% improvement in the percentage of Nova Scotia's population with drinking water conforming to national health guidelines; and a 16.7% improvement in water complying with aesthetic objectives. Two municipal water supplies still have lead above the maximum acceptable concentration, and 3% of municipal water samples showed the presence of coliform bacteria that could cause health problems.

Still, more than one third of Nova Scotians don't trust their drinking water and spend an estimated $265 a year per household on bottled water and water filtration systems, injecting $32.8 million a year into the provincial economy. "Here's a case where less spending is better," says Wilson. "If everyone trusted their drinking water, people could save a lot of money."

But while drinking water quality has actually improved, the province's wetlands, rivers, lakes, and coastal waters are in decline, causing hidden damage to the economy, and threatening the well-being of future generations. Nova Scotia's rivers have suffered more from acid rain than any other province, and only 20% of the province's former salmon rivers still have healthy fish stocks. Atlantic salmon are extinct in 22% of NS rivers, 31% have only "remnant" populations, and another 25% have depleted stocks. In 1999, only 22 of Nova Scotia's 72 salmon rivers were still open to recreational salmon angling.

Since 1985, the number of brook trout caught in the province has dropped by half, likely because of previous over-fishing, acid rain, and sedimentation of stream beds due to logging, agriculture and development. The GPI report estimated a loss to Nova Scotia of $22 million over 10 years due to the decline in recreational fishing. As well, the closing of the commercial salmon fishery has cost the federal government another $1 million to buy back licenses.

Along the coast, the number of shellfish closures, due mostly to bacteriological contamination, has more than doubled in the last 15 years, at an annual estimated cost of $8 million a year in lost revenues. In the last four years alone, the closed shellfish area has increased by 38%.

Metro lakes are faring no better, with nearly one-quarter "aging" rapidly due to high concentrations of phosphorus, nitrogen and other nutrients that come from fertilizer run-off, and from households, agriculture and forestry. Four metro lakes are already classified as "eutrophic," meaning that nutrient levels are so high that dissolved oxygen levels have been significantly reduced, and another seven are "mesotrophic," with intermediate levels of nutrients and oxygen. When oxygen is depleted, fish and other aquatic organisms die.

But the highest costs are the most hidden ones, with wetland loss due to development costing Nova Scotia an estimated $2.3 billion a year in lost ecological services. "Wetlands are among the most productive ecosystems in the world," says Wilson. "They perform a host of incredibly valuable functions, including waste and nutrient cycling; protection against erosion, floods and storms; water purification; food production; and are one of the richest known wildlife habitats and an essential link in the food chain."

"If we lose the benefits of natural, functioning ecosystems, not only do we lose habitat and species diversity, we also have to cope with the loss in ecosystem services by investing in expensive waste treatment and water purification plants, and engineering projects to control erosion and flood damage. Currently the loss of wetland services is invisible in our economic accounts, and we count the cost of expenditures to compensate for these lost services as a gain to the economy. This is bad accounting. We have to recognize, appreciate and value nature's vital and irreplaceable life-support services."

The GPI report notes that Nova Scotia has lost 62% of its saltwater wetlands and 17% of its freshwater wetlands since colonization, and it urges immediate conservation measures to prevent further loss.

The GPI report also estimates that Nova Scotia's uncut forested watersheds provide $2,750 per hectare in services per year protecting water supply—filtering and intercepting water, controlling run-off, and removing air pollutants. The estimate is based on what it would cost to replace those services with man-made water filtration plants and storm-water retention systems if the forests were clear-cut.

One “good news” piece in the GPI report is a significant reduction in contaminants in pulp and paper mill effluent as a result of federal government regulations implemented in 1992, with all five major Nova Scotia mills now averaging 99% compliance with federal standards. The GPI report recommends further regulation including lowering acceptable carbon dioxide levels below 100 mg/litre using aeration or pH adjustment, in order to reduce contaminants that still cause stress to fish.

The GPI study also details the value of Nova Scotia’s water resources for recreation ($150 million a year); investments needed for improvements in wastewater disposal ($532 million) and municipal water supply upgrades ($136 million); water pollution abatement and control expenditures ($180 million); contaminated well claims ($548,000 a year); and a range of other water resource values and pollution costs.

The GPI report has 15 recommendations to the province to protect and conserve the value of Nova Scotia’s water resources, including greater source control to reduce toxic discharges to harbours, rivers and lakes; investments in wetland restoration, watershed protection, sewage and water supply upgrades, and salmon habitat restoration; and the explicit recognition of water resource values and pollution costs in the province’s core economic accounts.

“At a time of budget cuts, we need to keep in mind the necessary investments to maintain our water resources,” says Wilson. “If water values are not protected, and if adequate investment in sewage treatment, pollution control and conservation are not made, then damage costs and water intake costs will definitely increase, and we’ll have to pay much more in the future.”

Wilson notes that, following earlier cuts, the provincial Department of Environment has had its 2000-2001 slashed by 16% to $13.1 million from $15.6 million the previous year, making essential inspection, monitoring and enforcement more difficult. The GPI report contains a section entitled “The Lessons of Walkerton,” detailing the costs of inadequate monitoring and enforcement of drinking water quality, and warning that “disinvestment in environmental protection produces major costs to society and the economy.”

The GPI Water Quality account is the first in a suite of GPI natural resource accounts to be released later this year, on which GPI Atlantic researchers have been working for more than two years. In the coming months, GPI Atlantic will release its greenhouse gas account for Nova Scotia; an ecological footprint analysis for the province; natural capital accounts for forests, fisheries, and soils and agriculture; an air quality component, and a full-cost accounting analysis of different modes of transportation in Nova Scotia.

GPI reports to date have focused on social components of the Genuine Progress Index, including the value of voluntary work, the value of unpaid household work, the cost of crime in Nova Scotia, and several population health indicators. Work is also currently proceeding on other social and economic indicators in the GPI.

Funding for the GPI Water Quality Account was provided by Environment Canada, Halifax Regional Municipality, and the Halifax Regional Water Commission, with in-kind support from the Nova Scotia Department of Environment and the Clean Nova Scotia Foundation.

* Databases and information in GPI Water study are from: Environment Canada, Department of Fisheries and Oceans, Statistics Canada, Health Canada, NS Department of Environment, NS Department of Natural Resources, NS Department of Transportation and Public Works, NS Department of Municipal Affairs, Halifax Regional Municipality, Halifax Regional Water Commission, Soil and Conservation Society of Metro Halifax, North American Commission for Environmental Cooperation, and a variety of academic and independent research studies.

The Costs and Benefits of Sewage Treatment and Source Control for Halifax Harbour

March 2000, 62 pages
Source: http://www.gpiatlantic.org/ab_halharbour.shtml

This report serves as an appendix to *Nova Scotia's Water Resource Values and the Damage Costs of Declining Water Resources and Water Quality* and is also available separately.

ABSTRACT

Halifax Harbour Clean-Up: A Full-Cost Accounting Analysis

Like crime and sickness, pollution is "good" for the economy. Whenever money is spent, the GDP goes up, which in turn is taken as a sign of progress and well being. In the Genuine Progress Index, pollution is regarded as a cost. Like crime (and in contrast to measures of progress based on the GDP), "less" is "better."

The GPI regards pollution clean-up costs as "defensive expenditures" that compensate for past environmental degradation. Rather than signifying an absolute advance in well being, as measures of progress based on the GDP imply, these defensive expenditures seek to restore an earlier state of greater well being.

Statistics Canada's new Canadian System of Environmental and Resource Accounts contains a set of Environmental Protection Expenditure Accounts that allows analysts to calculate the value of a "net domestic product" or "green domestic product" in which pollution abatement expenditures are subtracted or counted as costs. That is the basic principle underlying the GPI approach to pollution clean-up expenditures.

At the same time, this does not mean that such expenditures should not be undertaken. Indeed, they are essential if our well being is not to decline further. They are seen as necessary re-investment in natural capital assets that will produce future benefits and services as environmental quality is restored. For that reason, a full benefit-cost analysis, that includes social and environmental costs and benefits, can be very useful in evaluating pollution clean-up and abatement projects.

The GPI is intended not only as a macro-measure of societal progress, but also as a practical tool that policy makers can use to assess whether different investment strategies will produce long-term benefits to society or carry hidden costs that may adversely impact future generations.

This case study looks at the proposed sewage treatment plants for Halifax Harbour, taking into account potential impacts on tourism, property values, ecosystem and population health, and residents' "willingness to pay" for a cleaner harbour, assigning dollar values to benefits and costs wherever possible on the basis of previous empirical studies. The study will constitute one chapter in the GPI Water Quality module scheduled for completion in April, 2000.

June 2000. 20 pages, including tables. Price $17.50

Endnotes

[1] CAESA. 1997. Canada-Alberta Environmentally Sustainable Agriculture Agreement. *Alberta Farmstead Water Quality Survey,* Alberta Agriculture, Food and Rural Development.
[2] Pedersen, R. 2000. "E-coli Cases Up Sharply in Alberta," *The Edmonton Journal*, Aug. 19, p. A6.
[3] Pedersen, R. 2000. "E-coli Cases Up Sharply in Alberta," *The Edmonton Journal*, August 19, p. A6.
[4] Pedersen, R. 2000. "Rise in E-coli Cases Baffles Officials," T*he Edmonton Journal*, September 15, p. A8.
[5] Hasselback, P. Medical Officer of Health, Chinook Regional Health Authority. Paper presented to the 2001 Oldman River Basin Water Quality Initiative.
[6] Sierra Legal Defence Fund, 1999. *National Sewage Report Card*.
[7] Statistics Canada, Environment Accounts and Statistics Division, Public Institutions Division. 2000. *Government Expenditures on Pollution Abatement and Control by Level of Government 1970-71 to 1998-99*; table 7-2. Unfortunately, provincial-specific data for Alberta were not available to us.
[8] Northern River Basins Study Board. 1996. *Northern River Basins Study: Report to the Minister,* Edmonton. The Board was established by the Governments of Canada, Alberta and Northwest Territories.
[9] Alberta Environment. 2000. *Alberta Guide to Sportfishing Regulations,* p. 6.
[10] Alberta Environment. 2000. *Alberta Guide to Sportfishing Regulations,* p. 16.
[11] Northern River Basins Study Board. 1996. *Northern River Basins Study: Report to the Ministers,* Edmonton, p. 87.
[12] Northern River Basins Study Board, 1996. *Northern River Basins Study: Report to the Ministers,* Edmonton, p. 9.
[13] Town of Grande Prairie Utilities Department, personal communication.
[14] Northern River Basins Study Board. 1996. *Northern River Basins Study: Report to the Ministers,* Edmonton, p. 136.
[15] Alberta Health and Wellness. 1999. *Northern River Basins Human Health Monitoring Program.*
[16] Alberta Environment. 1999. *Northern Rivers Ecosystem Initiative 1998-2003, First Progress Report,* at http://www.gov.ab.ca/env/water/nrei/nrei_report.pdf
[17] Alberta Environment. 1999. *Northern Rivers Ecosystem Initiative 1998-2003, First Progress Report*, p.7 at http://www.gov.ab.ca/env/water/nrei/nrei_report.pdf,
[18] CAESA. 1998. Canada-Alberta Environmentally Sustainable Agriculture Agreement. *Agricultural Impacts on Water Quality in Alberta: An Initial Assessment,* Alberta Agriculture, Food and Rural Development.
[19] CAESA. 1998. Canada-Alberta Environmentally Sustainable Agriculture Agreement. *Agricultural Impacts on Water Quality in Alberta: An Initial Assessment,* Alberta Agriculture, Food and Rural Development, p. 27.
[20] CAESA. 1998. Canada-Alberta Environmentally Sustainable Agriculture Agreement. *Agricultural Impacts on Water Quality in Alberta: An Initial Assessment,* Alberta Agriculture, Food and Rural Development, p. 54.
[21] CAESA. 1998. Canada-Alberta Environmentally Sustainable Agriculture Agreement. *Agricultural Impacts on Water Quality in Alberta: An Initial Assessment,* Alberta Agriculture, Food and Rural Development, p. 28.
[22] CAESA. 1998. Canada-Alberta Environmentally Sustainable Agriculture Agreement. *Agricultural Impacts on Water Quality in Alberta: An Initial Assessment,* Alberta Agriculture, Food and Rural Development, p. 88.
[23] CAESA. 1998. Canada-Alberta Environmentally Sustainable Agriculture Agreement. *Agricultural Impacts on Water Quality in Alberta: An Initial Assessment,* Alberta Agriculture, Food and Rural Development, p. 82.
[24] CAESA. 1998. Canada-Alberta Environmentally Sustainable Agriculture Agreement. *Agricultural Impacts on Water Quality in Alberta: An Initial Assessment,* Alberta Agriculture, Food and Rural Development, p. 25.
[25] CAESA. 1998. Canada-Alberta Environmentally Sustainable Agriculture Agreement. *Agricultural Impacts on Water Quality in Alberta: An Initial Assessment,* Alberta Agriculture, Food and Rural Development, p.32.
[26] Hryciuk, D. 2000. "Abandoned Wells Pose Potential Disaster, Groups Say," *The Edmonton Journal,* June 25, p. A9.

[27] CAESA. 1997. Canada-Alberta Environmentally Sustainable Agriculture Agreement. *Alberta Farmstead Water Quality Survey,* Alberta Agriculture, Food and Rural Development.
[28] CAESA. 1998. Canada-Alberta Environmentally Sustainable Agriculture Agreement. *Agricultural Impacts on Water Quality in Alberta: An Initial Assessment,* Alberta Agriculture, Food and Rural Development, p. 25.
[29] CAESA. 1997. Canada-Alberta Environmentally Sustainable Agriculture Agreement. *Alberta Farmstead Water Quality Survey,* Alberta Agriculture, Food and Rural Development, p. 1.
[30] CAESA. 1997. Canada-Alberta Environmentally Sustainable Agriculture Agreement. *Alberta Farmstead Water Quality Survey,* Alberta Agriculture, Food and Rural Development, p. 21.
[31] Alberta Agriculture, Food and Rural Development. 2000. *Nitrates in Soil and Groundwater below Irrigated Fields in Southern Alberta*, in section on Groundwater Quality at www.agric.gov.ab.ca/irrigate/gwatqua.html.
[32] Rodvang,J., Irrigation Branch, Alberta Agriculture, Food and Rural Development, Lethbridge, personal communication.
[33] CAESA. 1998. Canada-Alberta Environmentally Sustainable Agriculture Agreement. *Agricultural Impacts on Water Quality in Alberta: An Initial Assessment*, Alberta Agriculture, Food and Rural Development, p.32.
[34] Nahirniak, T. Executive Secretary, Alberta Surface Rights Federation, personal communication.
[35] Bingham, D., Alberta Environment, Water Management, Monitoring Branch, personal communication.
[36] Alberta Health and Wellness, October 2000. *"Arsenic in Groundwater from Domestic Wells in Three Areas of Northern Alberta,"* Executive Summary.
[37] Alberta Health and Wellness. October 2000. *"Arsenic in Groundwater from Domestic Wells in Three Areas of Northern Alberta."* Recommendations, p.36.
[38] Alberta Energy and Utilities Board. 1997. *Industry Success in Addressing Environmental Problem,* News Release, April 24.
[39] Alberta Energy and Utilities Board, Operations Division, personal communication.
[40] Macpherson, J. ,Alberta Environment, personal communication.
[41] Alberta Health and Wellness. October 2000. *"Arsenic in Groundwater from Domestic Wells in Three Areas of Northern Alberta."* Executive Summary, p. 3.
[42] Bingham, D., Alberta Environment, Water Management, Monitoring Branch, personal communication.
[43] Schindler, D.W. 1998. Seminar presented to Environmental Research and Studies Centre, University of Alberta and reported in *The Edmonton Journal*, September 25, 1998.
[44] Schindler, D. 2000. "Canadian Freshwaters in a Climate of Change," *Encompass,* Vol. 4, No. 5, June/July, 2000, p. 5.
[45] Schindler, D. 2000. Canadian Freshwaters in a Climate of Change," *Encompass,* Vol. 4, No. 5, June/July, 2000, p. 6.
[46] Schindler, D. 1998. "A Dim Future for Boreal Waters and Landscapes," *Bioscience,* March, Vol. 48, No. 3, pp. 157-164.
[47] Schindler, D. 1998. "A Dim Future for Boreal Waters and Landscapes," *Bioscience*, March, Vol. 48, No. 3, p. 161.
[48] Anielski, Mark and Jonathan Rowe. 1999. *The Genuine Progress Indicator – 1998 Update*. Redefining Progress, San Francisco. March 1999. http://www.rprogress.org/pubs/pdf/gpi1998_data.pdf
[49]U.S. Department of Agriculture. *Agricultural Resources and Environmental Indicators, 1996-97*. By Margot Anderson and Richard Magleby. Agricultural Handbook No. 712. 356 pp, July 1997. See http://www.ers.usda.gov/publications/ah712/
[50] Since this reference came from another source (Redefining Progress) and was not sourced, we could not ourselves reference the correct source.
[51] Since this reference came from another source (Redefining Progress) and was not sourced, we could not ourselves reference the correct source.
[52] Department of Environment, Sport and Tourism (DEST). 1996a. *Subsidies to the Use of Natural Resources*, Environmental Economics Research Paper No. 2 (DEST: Canberra)
[53] Reserve Bank of Australia (RBA). 1996. *Australian Economic Statistics 1949-50 to 1994-95* (updated on disk), RBA Occasional Paper No. 8.
[54] Australian Water and Wastewater Association (AWWA) 1996, *The Australian Urban Water Industry* (Water Services Association of Australia: Melbourne).