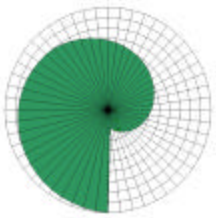

The Alberta GPI Accounts: Municipal and Hazardous Waste

Report # 27

by

Mary Griffiths
Sara Wilson
Mark Anielski

January 2002

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 waste indices that were 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.

This report examines municipal and hazardous waste in Alberta, and attempts to answer the following questions:

1. What is the volume of hazardous waste in Alberta? Is it increasing?
2. How much hazardous waste is treated at the Alberta Special Waste Treatment Centre at Swan Hills, how much is recycled and how much is landfilled?
3. How much oilfield waste would be classified as hazardous, if oilfield waste were not exempt from classification as hazardous waste?
4. How much waste is disposed of in deep wells in Alberta?
5. Given the fact that hazardous waste stored at the site where it is created is not included in the hazardous waste inventory for the province, what figures reported by the National Pollutant Release Inventory can be used to supplement the published hazardous waste data?
6. What is the extent of contaminated land in Alberta? How much of this land includes sites of former waste deposition, spills and leaks?
7. What are the economic and environmental costs to society of hazardous wastes in Alberta?
8. How much municipal waste is disposed of each year in Alberta? How much waste per capita?
9. How much municipal waste is recycled? How does Alberta compare with other provinces, and what schemes are in operation to recycle municipal waste?
10. What are the environmental non-market costs to that result from municipal waste?

 ISBN 0-921719-80-9

About the Authors

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.

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 capital, 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.

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.

Acknowledgements

The authors thank a number of individuals for their contributions to this document. Some provided data while others gave their time to review draft material, discuss the issues and offer valuable comments that helped improve the content. We particularly acknowledge the following:

Cathie Browning, Approvals Coordinator, Municipal Program Development Branch, Environmental Services Division, Alberta Environment; Walter Ceroici, Branch Head, Industrial Program Development Branch, Alberta Environment; Tony Fernandes, Manager, Hazardous Waste, Alberta Environment; Art Garland, Nelson Environmental Remediation Ltd.; Dennis Hambleton, Alberta Used Oil Management Association; Steve

Johnson, Regional Municipal Engineer, Environmental Services Division, Parkland Region, Alberta Environment; Pat Lang, Head of Municipal Program Development Branch, Alberta Environment; Roy Neehall, Manager, Waste Management, City of Edmonton; Licia Paddison, Waste Reduction Specialist, Alberta Environment; Mark Polet, President, Ecomark Ltd; Chris Powter, Program Manager, Land Management, Alberta Environment; David Schindler, Killam Professor of Ecology, Department of Zoology/Botany, University of Alberta; Ken Tsang, Responsible Care® Leader, Environmental Health and Safety, Western Canada Operations, Dow Chemical Canada Inc.; Doug Wright, Executive Director, Tire Recycling Management Association; Staff at the Alberta Energy and Utilities Board.

The high quality of the data compiled by Statistics Canada and the opportunity to use this data enabled us to undertake a much more thorough analysis than would otherwise have been possible.

In addition, we thank Kim Sanderson for her editing assistance to this project. 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. 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

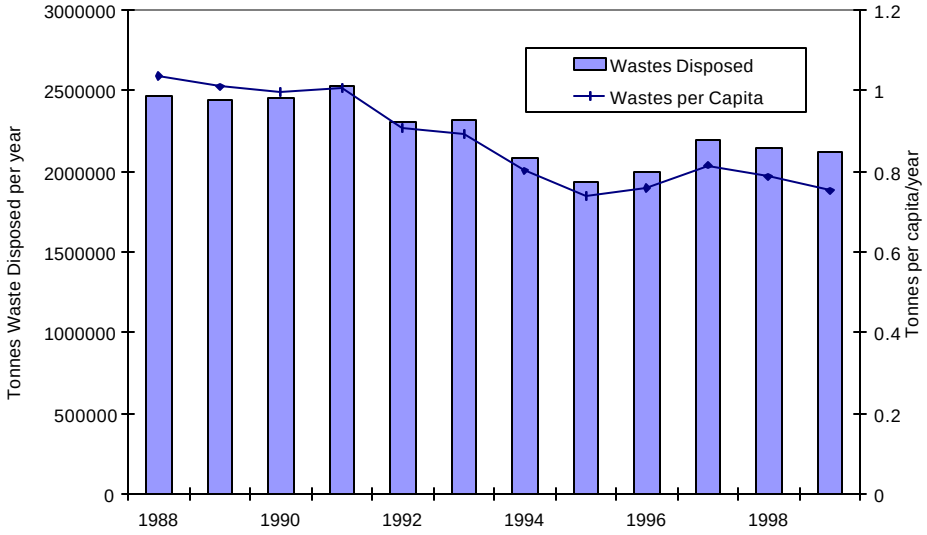
1.1 Municipal Waste

Only three provinces generate more non-hazardous waste per capita than Alberta. Furthermore, Alberta recycles or reuses only 17 percent of its waste, the lowest rate in Canada. The amount of municipal waste sent to Alberta landfills dropped from 1.03 tonnes to 0.75 tonnes per capita between 1988 and 1999, but this is only half way to reaching the provincial target of a 50 percent reduction in per capita waste from 1988 levels. Despite programs for recycling beverage containers, used tires, used oil and pesticide containers across the province, too much waste is going to landfill. Relatively low landfill fees may be one reason for this. Where landfill space is short or expensive, municipalities are forced to find other solutions. Edmonton is a prime example of what can be achieved. Faced with a shortage of landfill space in the late 1980s, it initiated a comprehensive domestic recycling program that now recycles 15-18 percent of the waste stream. With its new composting plant, 70 percent of Edmonton's municipal solid waste is now diverted from landfill. The figure below shows the changes in Alberta waste disposal patterns from 1988 to 1999.

Noteworthy

- Alberta's goal for 2000 was a 50% reduction in municipal solid waste per capita, from 1988 levels.
- By 1999, the per capita reduction was only 28%.
- Alberta generates 1.07 tonnes of non-hazardous waste per person, compared with the Canadian average of 0.98 tonnes.
- In Alberta, 0.87 tonnes of non-hazardous waste were disposed of per person in 1998, 26% more than the Canadian average of 0.69 tonnes. The rest is recycled or reused.
- Alberta recycles or reuses only 17% of total waste, less than any other province.
- In 1998, 40% of Alberta's materials for reuse or recycling came from residential sources. 82% of Albertans surveyed took part in recycling.
- Waste management businesses generated $292-million in revenue in Alberta in 1998.
- Local government spent $89-million on waste management operations in 1998.
- Tipping fees in Alberta are about half the rate of some parts of Canada.

Total and Per Capita Municipal Waste Disposal in Alberta, 1988 to 1999



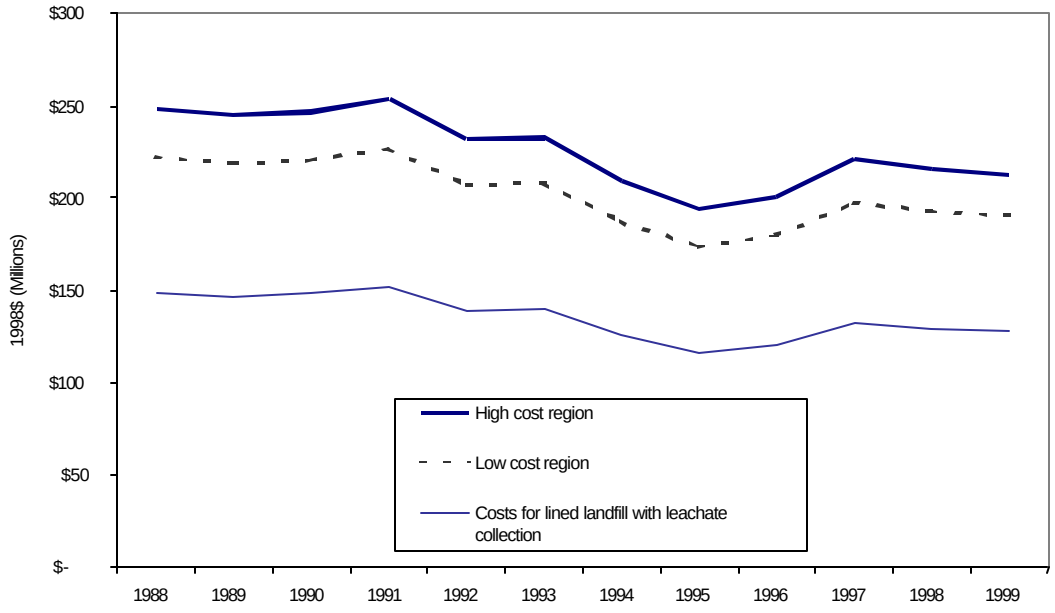
Source: Alberta Environment

Alberta needs to work harder to reduce per capita waste and to increase the proportion of reused or recycled materials. Of course, the best solution is to reduce waste at source. Some companies, such as Interface and IKEA, view waste as lost profits. If more companies adopted that perspective we would encourage production processes that avoid toxic waste, reduce material input and throughput, and improve energy and resource eco-efficiency.

Operational costs for waste management contributed approximately $345-million to Alberta's GDP in 1998. In addition to the operational costs of collection, transportation and disposal of waste, there are also environmental costs associated with solid waste disposal. Such costs have been estimated from a number of U.S. studies and begin at $60.27 (1998$) per tonne of solid waste in a lined landfill with leachate collection. Without such environmental protection measures, the environmental costs associated with solid waste disposal range from $89.73 (1998$) to $100.44 (1998$) per tonne of solid waste. The figure below shows three estimates for the environmental costs of waste disposal. Total environmental costs for waste disposal in Alberta equal the cost per tonne times the total volume of municipal waste in the particular year. Thus, if all of Alberta's landfills were lined and had leachate collection, the environmental costs from waste disposal in the province would amount to $128-million (1998$). With no lining or leachate collection, the environmental costs in 1999 increased to $212-million (1998$).

The cost of municipal solid waste in Alberta in 1999 was $387-million (operational costs of $328-million plus $59-million in capital costs), not including the environmental costs Environmental costs amounted to an additional $128- to $212-million. This results in a conservative estimate of $515-million for 1999.

Three Estimates of the Environmental Cost of Municipal Solid Waste in Alberta, 1988 to 1999

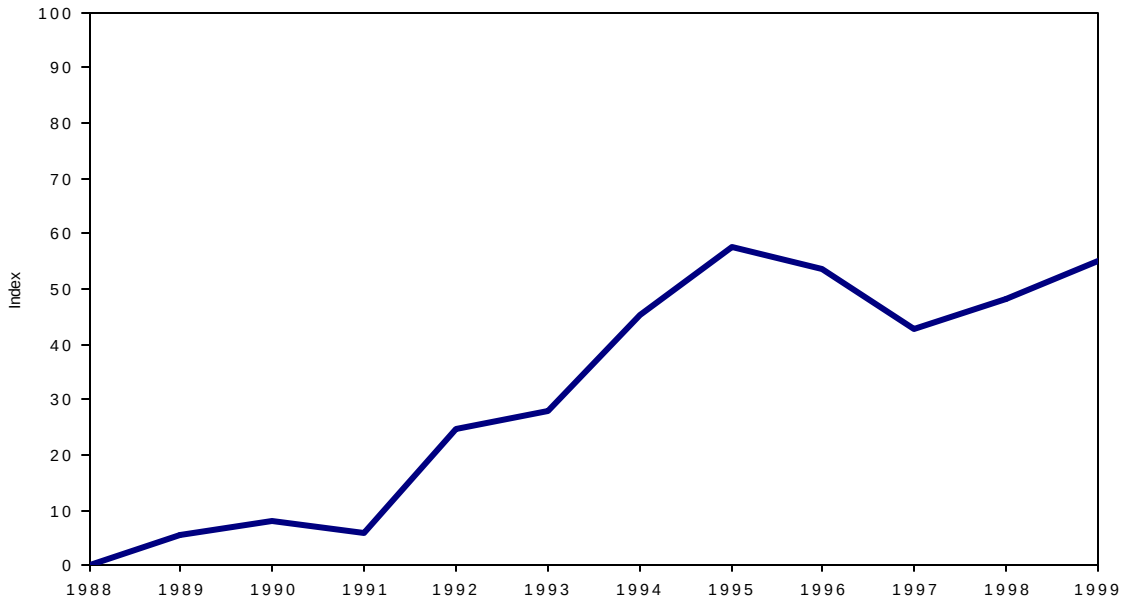


Sources: Based on estimates from Stone and Ashford 1991, Tellus Institute 1991, and Repetto 1992

1.1.1 Alberta's Municipal Waste Disposal Index

The target of 100 on the index below is a 50 percent reduction in municipal solid waste per capita from 1988 levels. The index for 1999 is 55, as the volume of waste only declined to 72 percent of 1988 levels, little better than half the original goal that was set for the year 2000.

Municipal Waste Disposal Index



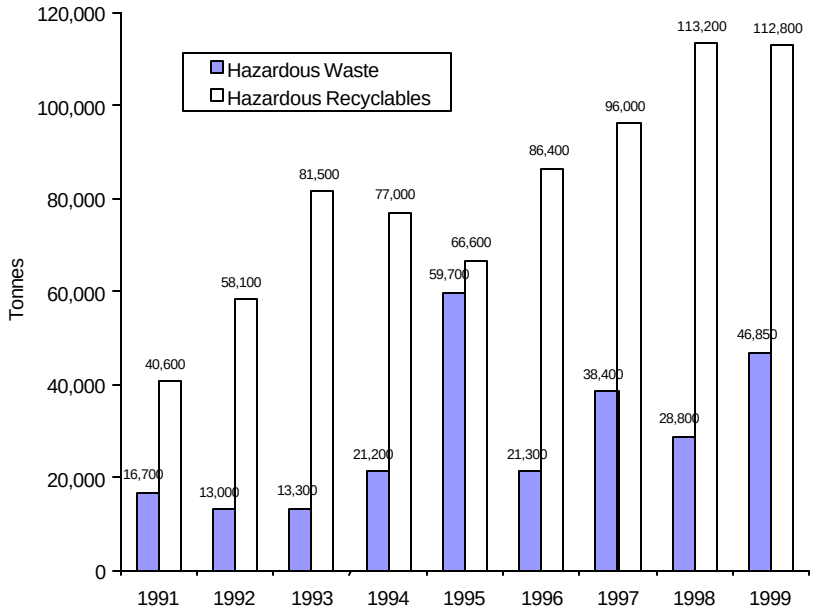
1.2 Hazardous Waste

The recorded volume of hazardous waste increased threefold in Alberta from 1991 to 1999. This does not include wastes that remained on the site where they were created or dangerous oilfield waste, which is not classified as hazardous waste even if the chemical composition is identical. Nearly 47,000 tonnes of hazardous waste were moved off site for disposal or treatment in 1999, while nearly 113,000 tonnes of hazardous waste were recycled. The total volume of oilfield waste was nearly 900,000 tonnes, but there are no published figures for the proportion that was not dangerous. Environmental contamination comes not only from waste but from the release of pollutants to air, water and land. National Pollutant Release Inventory (NPRI) figures show that the on-site release of pollutants grew 50 percent from 1993 to 1998. Waste disposal has contaminated former industrial sites, and leaking underground storage tanks require costly replacement.

Noteworthy

- Alberta ranked 3rd highest among Canadian provinces for releases of pollutants to air, water, landfill and underground in 1997.
- Over 14,000 tonnes of industrial chemical waste and about 40,000 cubic metres of oilfield waste were injected in deep wells in 1998.
- Alberta accounts for 90% of all deep well injection of waste in Canada.
- The Alberta Special Waste Treatment Centre at Swan Hills treats about 1/5 of Alberta's hazardous waste.
- Since 1996, over 60% of waste treated at Swan Hills came from outside Alberta.
- Leaks from the Swan Hills plant have contaminated fish and wildlife within 30 km.
- When the Swan Hills plant shuts down, "perpetual care and monitoring of the site will be required."
- About ⅗ of Alberta's hazardous wastes are recycled.
- Two-thirds of used oil was recycled in 1999.
- Nearly half the pollutants released in 1998 were released to the air; these included benzene, which causes cancer.
- Conservatively estimated, the environmental cost of hazardous waste increased from $1.7-million in 1991 to $4.7-million in 1999.

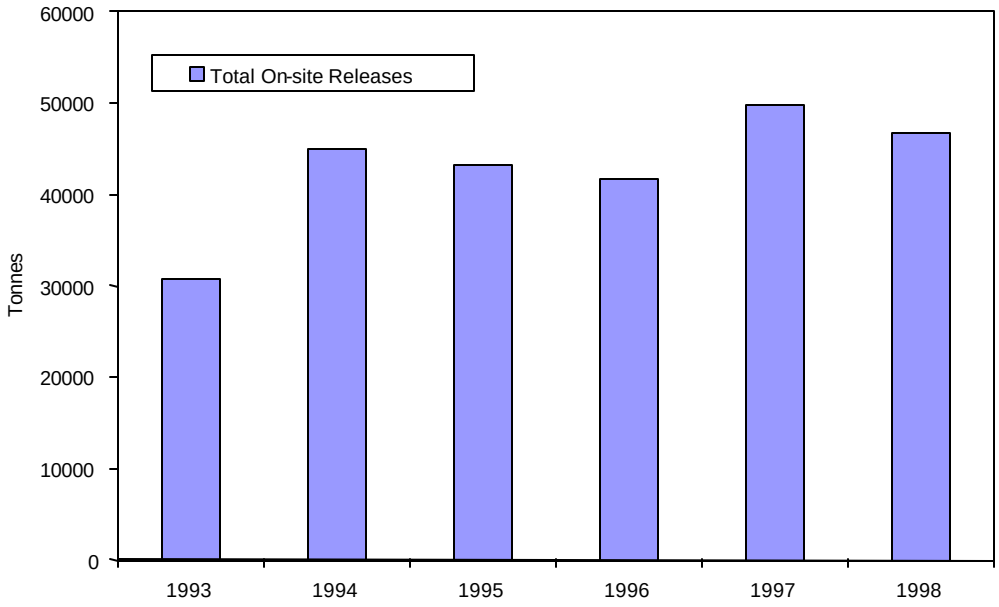
Alberta's Hazardous Waste and Recyclables Moved Off Generator's Site, 1991-1999



Source: Alberta Environment

A sustainable society would no longer produce toxic waste, yet in Alberta the total volume of hazardous waste requiring disposal increased in the last decade. The Alberta Special Waste Treatment Centre contaminated the environment and was so expensive that four-fifths of Alberta's hazardous waste was injected into deep wells, landfilled or sent out of province. Deep-well disposal of chemical wastes and disposal of oilfield wastes may cause future problems. Society should adopt the precautionary principle since the long-term environmental and health risks associated with the disposal of toxic waste are largely unknown. The figure below shows the extent of on-site pollutant release between 1990 and 1998 in Alberta.

On-Site Release of Pollutants in Alberta, 1990-1998



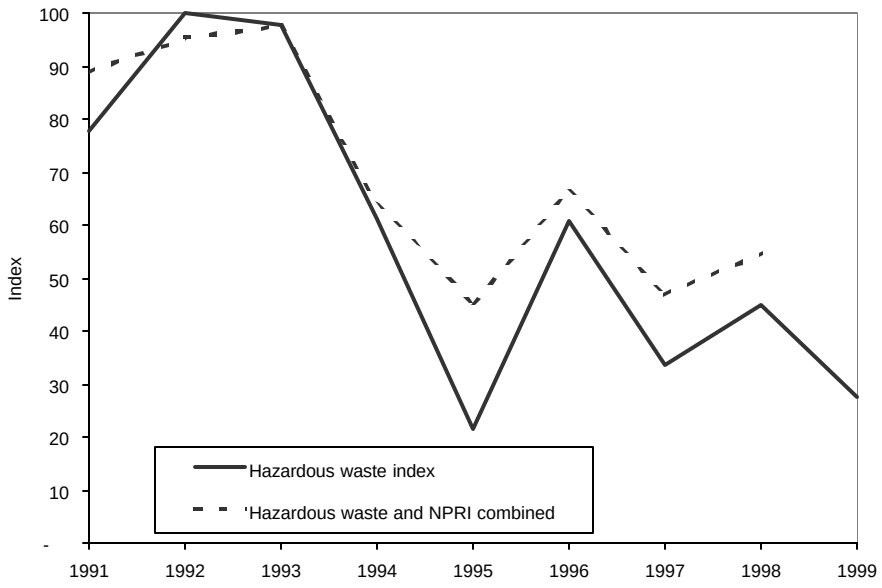
Source: National Pollutant Release Inventory, Environment Canada

1.2.1 The Hazardous Waste Index

Taking 1992, the best year of the 1991-1999 period as the benchmark of 100, the hazardous waste index for 1999 was 28. A second index (benchmark year = 100) includes the on-site release of pollutants as a proxy for the on-site storage of hazardous waste for which there are no figures. The combined index had a value of 55 in 1998.[a] Although the long-term environmental and human health impacts of hazardous waste are unknown, estimates place the cost of hazardous waste at $54.7-million when a conservative estimate for the environmental costs is included ($4.7-million). The following figure graphically illustrates the hazardous waste and pollutant release index for Alberta for this time period.

[a] When the research for this report was completed, 1998 was the most recent year for which data were available.

Hazardous Waste and Pollutant Release Index for Alberta, 1991 to 1999



Source: Derived from Alberta Environment Data on Hazardous Waste Moved Off-site for Treatment or Disposal and Environment Canada 's National Polllutant Release Inventory for On-site Releases

1.2.2 The Price

The cost of toxic waste treatment to Alberta taxpayers has averaged $50-million per year for the last 10 years (sum of the Alberta Special Waste Treatment Centre costs, costs associated with cleaning up old industrial sites and environmental costs). The Alberta Special Waste Treatment Centre cost Alberta taxpayers about $44-million per year. Cleaning up old industrial sites cost over $2-million per year. Although the environmental costs of hazardous waste are considerably higher than municipal solid waste, in the absence of a more appropriate estimate, the cost per tonne can be applied to Alberta's hazardous waste disposal as a very conservative estimate. In the case of hazardous waste, the high-end estimate (Stone and Ashford 1991, Repetto 1992) is used to calculate the environmental cost of hazardous waste disposal (US$75/ton or approximately $100 Cdn1998$/tonne). Thus, the environmental cost was an estimated $1.7-million in 1991, peaking in 1995 at $6-million, and amounting to $4.7-million in 1999. The peak in 1995 was caused by the cleanup of one site, but apart from this there has been a general increase.

This is an increase over the environmental cost in 1991, which amounted to $1.7-million. In addition, it will cost taxpayers another $80-million to deal with leaking underground storage tanks. We identify these costs as "regrettable" environmental expenditures since, in the absence of toxic waste production, governments, business and taxpayers would not incur these direct and societal costs. The actual toxic waste disposal costs borne by industry are unaccounted for in this preliminary analysis; however, future GPI accounts should explore the full costs of toxic waste disposal and cleanup by industries producing them.

2 Municipal Waste

> *Like Europe, Canada will eventually hit its limit. Then it will be forced by sheer scarcity of trees and other natural resources to use less, waste less, and spend less energy. But why wait? ... the reason to do better now is simply financial .... Canada will have a more prosperous future for longer if it is thrifty now with its natural wealth*.[1]

2.1 Volume of Municipal Waste in Alberta

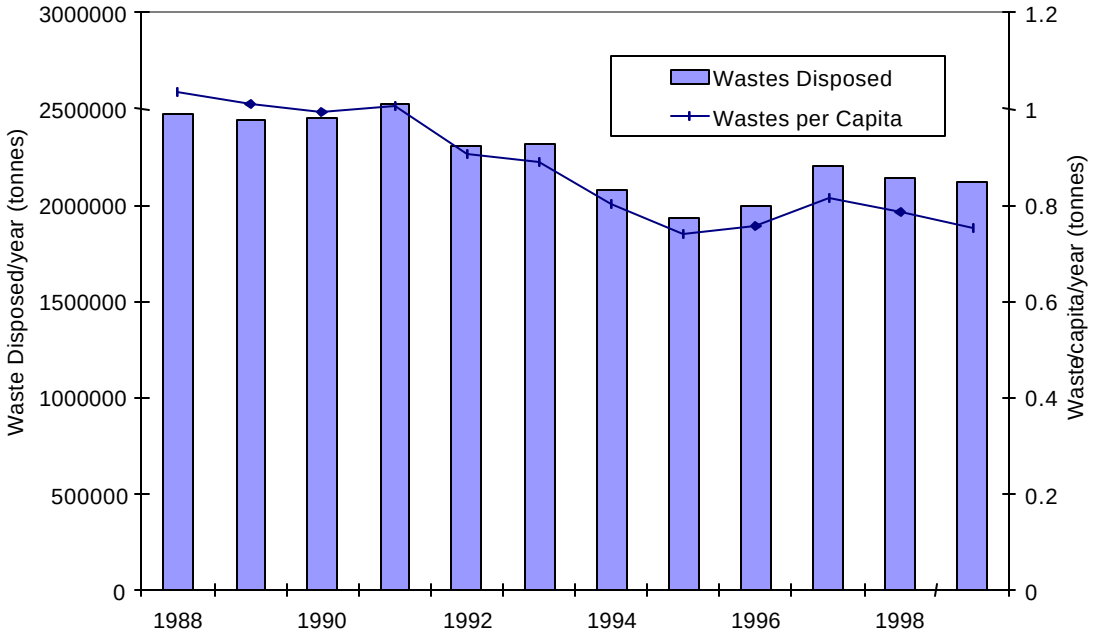
Municipal solid waste is the waste that is managed by municipalities and includes waste from homes, businesses, institutions, industries, and construction and demolition activities. It does not include waste from industrial processes or biomedical or hazardous wastes. The handling of municipal waste has greatly improved over the last decade, with the rapid increase of recycling.

Traditionally municipal waste went to landfills. Many Alberta municipalities have old dumps containing all types of waste, including substances that are now classified as hazardous. In 1976, the Alberta government set up its Waste Management Assistance Program. This program provided financial assistance to groups of municipalities to develop regional waste management plans, including regional sanitary landfills, waste transfer stations and waste diversion facilities. About 40 regional waste management systems were set up as a result and many local landfills were closed or became transfer stations as new regional landfills were constructed.

Responsibility for landfills was transferred from Alberta Health to Alberta Environment in the mid-1990s and Alberta Environment's regional offices are now responsible for managing and monitoring landfills within their area. Although potentially hazardous sites were probably identified under the former Help End Landfill Pollution program (see section 3.6), it appears there are no figures on the total number of closed landfills in Alberta nor is there a central program to ensure ongoing monitoring of these old "dumps." Currently operating landfills that accept more than 10,000 tonnes of waste per year require an approval, but smaller ones usually need only to be registered. There is, however, no central record of the number of landfills in the different categories.[2] Modern landfills rely on leachate collection systems to remove landfill liquids that could potentially harm groundwater, but these are not required in smaller systems. Therefore, the potential for future contamination is unknown.

In 1989, the Canadian Council of Ministers of the Environment set a nationwide goal of a 50-percent reduction from 1988 levels in the per-person weight of municipal solid waste by the year 2000.[3] Alberta Environment accepted this challenge and through its Action on Waste program encouraged municipalities to adopt measures to reduce the waste sent to landfills. It set a 50-percent reduction in waste between 1988 and 2000 as a provincial government "performance measure," but between 1988 and 1999, the per capita reduction in municipal waste was only 28 percent (Figure 1).[4] While the progress until 1995 was good, per capita waste has not declined since then and even increased for two years. The per capita reduction was greater at urban disposal sites than at regional disposal sites, perhaps because recycling programs in urban areas have easier access to markets for recycled materials. With an increasing population, the actual decline in the total volume of municipal waste was only 14 percent in the 12-year period.

Figure 1: Total and Per Capita Municipal Waste Disposal in Alberta, 1988 to 1999

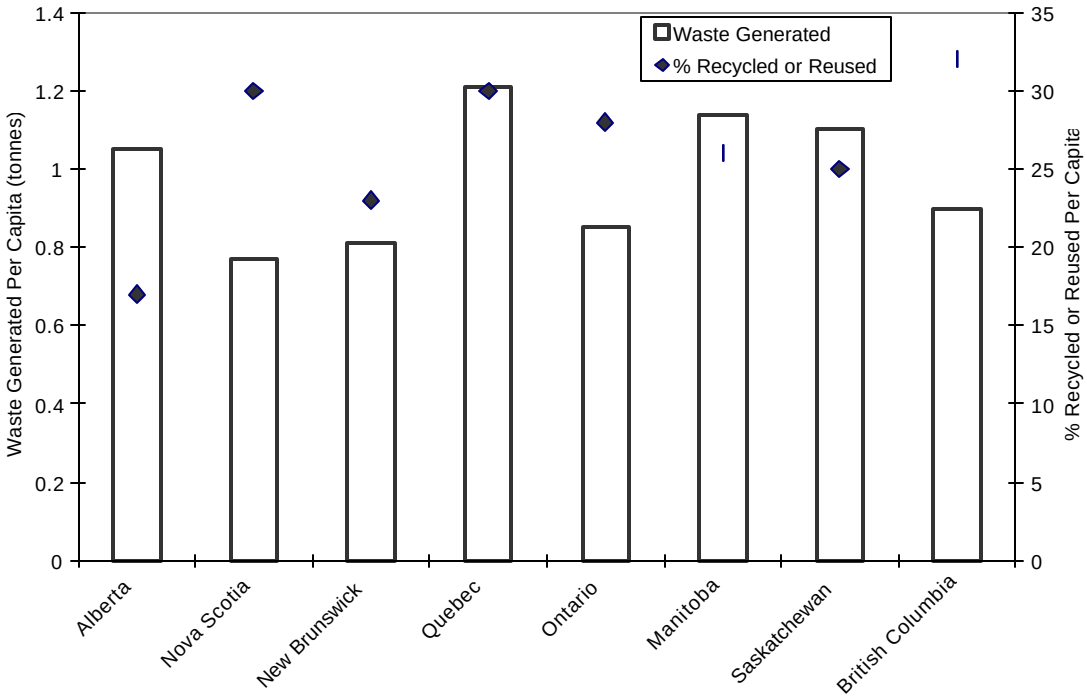


Source: Alberta Environment, 2000

The reduction in wastes is probably due partly to a reduction in the volume of waste produced and partly to diversion of waste from landfills to reuse or recycling. Despite the failure to meet the target, recycling has increased significantly, encouraged by municipal and provincial government programs. Provincial programs include those for beverage containers, used tires, and used oil and oil filters. In a spring 2000 study, 82 percent of Albertans surveyed said they recycle.[5]

While the Alberta Environment statistics focus on municipal waste, it is important to review all types of non-hazardous waste. Statistics Canada data total the non-hazardous wastes from residential and non-residential sources. The data show that Alberta generates more waste per capita than British Columbia, Ontario, New Brunswick and Nova Scotia, as shown in Figure 2.[6] While the average Canadian generated less than a tonne of waste per capita per year in 1998 (0.98 tonnes), each Albertan generated on average 1.05 tonnes of total waste. The difference between the Alberta and Canadian averages is even greater in the figures for waste disposal. Albertans disposed of 0.87 tonnes of non-hazardous waste per person in 1998, 26 percent more than the Canadian average (0.69 tonnes). Figure 2 clearly shows that Albertans not only generate more waste than the average Canadian, they recycle and reuse less. In fact, they recycled or reused a lower percentage of their waste than any other province. Thus, while Canada, on average, recycled or reused 30 percent of its waste in 1998, Alberta recycled or reused only 17 percent. In contrast, Nova Scotia has diverted 50 percent of its waste from landfill, suggesting that Albertans have room for improvement.

Figure 2: Waste Generated and Recycled per Capita in Alberta and Other Provinces, from All Sources, 1998



Source: Statistics Canada,Waste Management Industry Survey: Business and Government Sectors, 1998

There are few specific figures on how Alberta has reduced its waste in different sectors, although reduced packaging is responsible for some of this success. Canada's goal for a 50-percent diversion of packaging from 1988 levels of disposal was achieved by 1996, four years ahead of the 2000 target.[7] However, it was not possible to identify the relative contribution made by different provinces. Nor was it possible to distinguish between industrial and consumer or household packaging, although it is thought that reductions in shipping, manufacturing and distribution packaging were the main sources of reductions.

While Canada has made some progress in reducing packaging and increasing recycling, as a whole it is far behind Europe. Household waste in Canada is about one-half tonne per person per year, twice that of some European countries.[8] In Europe, reduction, reuse and recycling are the responsibility of the product manufacturers as well as governments and consumers. As a result, the amount of packaging has also been reduced. For example, the European Union set targets for the recycling of packaging in 1994, putting the onus on product manufacturers. In other words, if a company makes a product such as a jar of peanut butter, it is responsible for the jar. In the Netherlands, the government worked with manufacturing companies to establish an agreement where the firms re-designed products so that packaging would be reduced and to reuse the packaging used. The amount of glass used to produce a wine bottle was reduced by 100 grams, and the glass used to produce a milk bottled declined by 210 grams. Most importantly, even as the economy and population have grown, the amount of packaging in the market has not.[9] In 1998, waste management in Canada took in revenues of $2.9-billion for hauling commercial, industrial, institutional and residential garbage. In Alberta, waste management businesses

generated $292-million in revenue in 1998, with more than half the revenue coming from transportation for disposal or reuse.[10] Local government in Alberta spent nearly $89-million on collection and transportation, operation of disposal facilities, recycling, and organics processing facilities.[11] Of this amount, 62 percent was spent on their own employees, 36 percent was paid to contractors and 2 percent paid to other government.[12] Thus, local government spent an additional $57-million (that is, 64 percent of $89-million) on waste management, on top of the $292-million that was generated by waste management companies. This amounted to a total of $349-million for expenditures on waste management in Alberta in 1998, or about $116 per person.

In addition to the operational expenditures, local government in Alberta invested nearly $17-million in capital expenditures in 1998.[13] If we add capital expenditures to the $349-million in operational expenditures, then the total contribution of waste management to Alberta's gross domestic product was about $366-million in 1998.

One reason that Alberta's record on waste reduction may not be as good as other parts of Canada is its low tipping fees. While tipping fees are $80 to $100 in some parts of the country, they were found to be between $30 and $45 in a brief survey of six municipalities of various sizes, selected at random in Alberta. Even hard-to-handle industrial wastes are only charged $60 per tonne in Calgary, while the municipal rate is $30 per tonne. Such low prices provide little incentive for municipalities to divert wastes from landfill through recycling, which may explain why only 100 municipalities—about half those in the province—operate recycling programs.

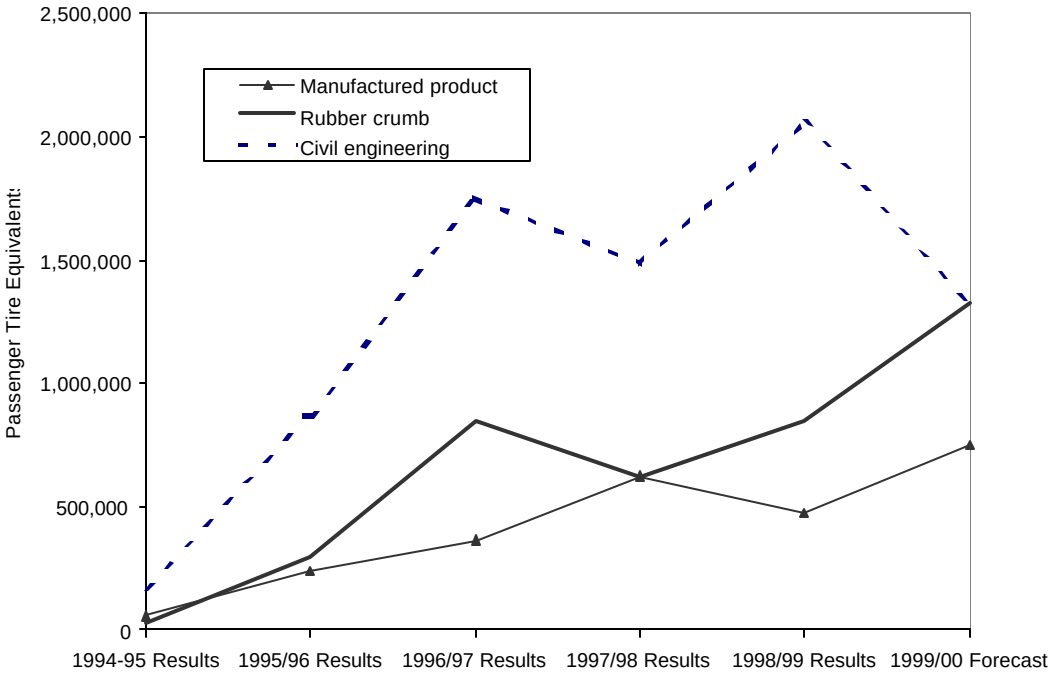
Data from Statistics Canada also provide some insight into the relative level of tipping fees in Alberta.[14] Alberta disposed of 2.5 million tonnes of non-hazardous waste in 1998, or 12 percent of the Canadian total of 20.8 tonnes.[15] However, the expenditure of waste management businesses on tipping fees in Alberta was only eight percent of the Canadian total,[16] and the tipping fees collected by local government in Alberta were only five percent of the total tipping fees in Canada.[17] It is beyond the scope of this project to investigate tipping fees further, but it seems that the amounts spent on and collected from tipping fees in Alberta are small, relative to the proportion of Canada's waste that is disposed of in Alberta.

Waste management is a cost that appears in the GDP. In the GPI accounts, good expenditures that contribute to better waste management are not separated from expenditures that do not contribute to well-being. In fact, it is quite the opposite. Reducing waste would save resources and improve the environment by reducing the space required for landfills, reducing greenhouse gas emissions (methane), and reducing contamination liability from landfills, but such benefits would register as a decline in the GDP because waste handling costs would go down.

Although Alberta's recycling efforts now appear to rank poorly compared with other provinces, it did make an early start. The earliest program for recycling began in 1972 with Alberta's *Beverage Container Act*. The Beverage Container Management Board administers a recycling program that is operated by about 220 privately owned beverage container depots across the province. The program started with bottles and cans, and recently expanded to include waxed cartons and tetrapaks. At the time this report was written, only milk containers (cartons and plastic jugs) were not included. Under the program, the purchaser pays a deposit that is refunded in full when the beverage containers are delivered to the depots. The manufacturers pay a handling commission to the depots for the containers recovered, so there is no government subsidy. The bottle depots collect about 500 million containers per year or about 80-85 percent of returnable beverage containers sold in the province.[18]

In addition to beverage container recycling programs, a Tire Recycling Management Board was set up in 1992 to recycle used tires, which until then, were sent to landfill or stockpiled. Stockpiled tires represent a fire hazard, creating a potential risk of air and water pollution. Albertans discard about two million tires a year. As a result, the Tire Recycling Management Association (which replaced the Tire Recycling Management Board) has been dealing with over three million tires a year, reducing the province's stockpiles. Between 1993 and 1996, over three million tires were burned as fuel. Tire burning was discontinued in 1997, as other markets for tires and tire-shred developed. Figure 3 demonstrates the growth in tire recycling in Alberta (excluding tires that were burned).

Figure 3: Tire Recycling in Alberta, 1994 to 1999



Source: Tire Recycling Management Association

Old tires are first shredded and then about half of these, in Alberta, are reduced to crumb. Markets for recycled tire products manufactured from crumb have gradually been increasing and about 20 percent of the crumb is now re-manufactured. Forty percent of the crumb is used in Alberta for playgrounds, riding rings and in turf management to reduce compaction, while about 50 percent is exported.[19] In the past few years, approximately half of the total volume of tires processed has been used as shred in civil engineering end-uses, including the construction of leachate collection systems under landfills. The recycling program is financed by a $4 levy on the purchase of new passenger tires, which brings in about $11-million a year, covering the costs of processing, and creating a reserve fund of $25-million for processing tires in the future. The program appears to be working and stockpiles have been reduced to fewer than one million tires, which provides a flow for processing.[20]

Composting has also become an important means of reducing the waste being sent to landfill. Stimulated by a lack of landfill space, Edmonton investigated ways to recycle garbage in the late 1980s. Having achieved a 15 to 18 percent reduction in waste going to landfill through its city-

wide blue-box recycling programs, the City proceeded, through a contract with a commercial enterprise, to set up a composting system that will handle a large portion of the city's municipal waste.[21] The composting facility, which opened in 2000, is considered to be an exemplary development. It produces Class B compost, which is sold for commercial use, and Class A compost for domestic use. Some of the compost is being used to help decontaminate hydrocarbon-contaminated soils.[22] In addition, the facility uses household waste and sewage sludge. Alongside its recycling programs, Edmonton is diverting 70 percent of its residential waste from landfill, more than any other Canadian city. The plant expects to produce 125,000 tonnes of compost per year for land reclamation, agriculture and perhaps residential use.

The province-wide Household Toxic Round Up program enables Albertans to dispose of unwanted household chemicals, such as aerosol cans, antifreeze, corrosive liquids and paint. The program started in 1988 and some 65 communities now have an annual one-day roundup. Some cities like Edmonton, Calgary and Lethbridge have permanent centres where toxic products can be dropped off throughout the year. Since 1988, 4.5 million litre-equivalents of household hazardous waste materials have been collected.[23]

Another provincial program provides for the collection of used pesticide containers. About 100 centres across Alberta collect empty, rinsed, non-returnable containers. After rinsing, both metal and plastic containers can be recycled. Plastic containers have been made into fence posts, guard rail posts and curb stops, while some have been burned to generate energy.[24] The program was run by the Alberta Special Waste Management Corporation from 1989 until 1995 but is now completely privatized and managed by an industry association, the Crop Protection Institute of Canada.

In general, the municipal waste story is positive with the removal of many hazardous wastes from the municipal waste stream, and an increase in recycling, as well as the introduction of composting in some locations. Albertans pay deposits for recycling programs, which is an appropriate form of "user pay." However, large volumes of waste are still going to landfill, and Alberta lags behind other provinces in rates of recycling. Measures are needed to further reduce the province's waste stream at source and to promote an increase in reuse and recycling. Various programs have reduced the hazardous materials in landfilled waste, but where hazardous wastes are still reaching municipal landfills, they could cause problems. It is unfortunate that there is neither a central record of the state of the province's landfills, nor monitoring to ensure that they will not harm the environment. Alberta Environment is trying to improve the management of landfills and hopes to bring out new, more stringent standards and guidelines for municipal landfills in 2001, implying that there is need for improvement.

Another recycling program, for used oil and oil filters, is described in section 3.1.

2.2 The Environmental Costs of Municipal Solid Waste

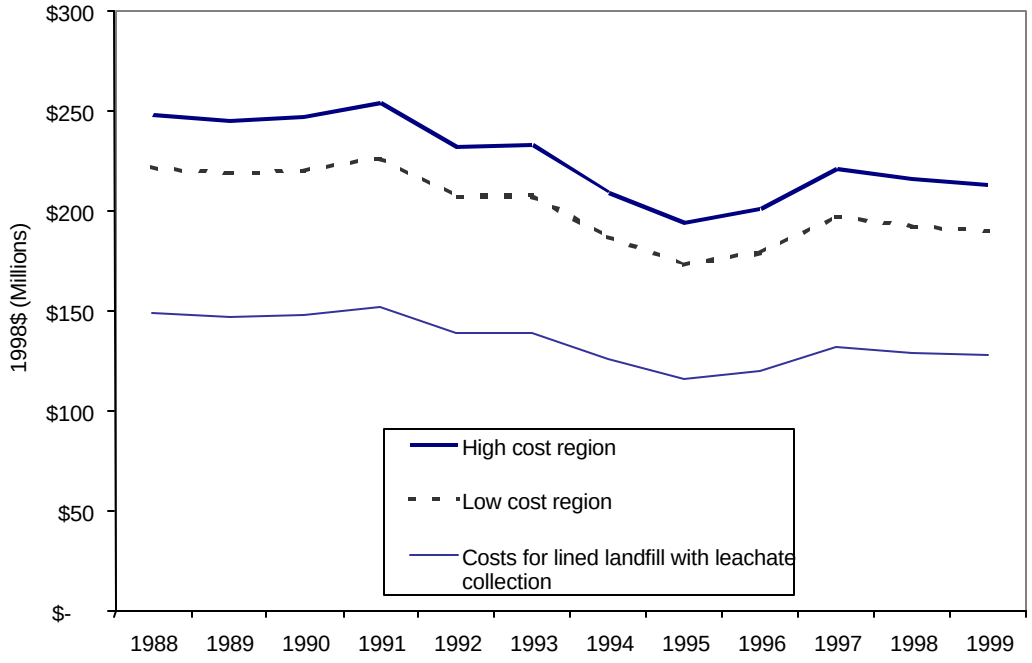
Currently, the average cost of disposing of garbage is between $80 and $100 per tonne in Canada—about one-third of the cost in some parts of Europe. These costs do not reflect the hidden environmental costs of landfilling waste. Landfills contribute to greenhouse gas emissions due to the methane they emit; they also pose an unknown contamination risk to groundwater and, in some cases surface water. Europe has major motivators for citizens to reduce, reuse, and recycle. In the Netherlands, where government has banned organic materials (compostables) from landfill, the cost for disposal is $300 per tonne—three times the Canadian average. In Britain, where the percentage of waste recycled is similar to the Canadian average, the government introduced a national landfill tax to pay for the hidden costs of landfill, such as water

contamination and methane emissions. The landfill tax was set at £10 (English pounds) or about $22 (Cdn) per tonne in 1998, increasing by £1 each year to internalize the real costs of landfill and promote reductions in waste. The British goal is to achieve 67-percent diversion by 2015.

Municipal and private tipping fees generally do not reflect the non-market environmental costs of waste disposal. Based on the British landfill tax, the environmental costs can be estimated at about $59.40 (2015 tax) per tonne. Several studies have estimated the costs due to the risk of air and water pollution. Stone and Ashford estimated the non-market costs of landfill disposal at US$75 (approximately Cdn$91, 1998$) per ton in Massachusetts, and the Tellus Institute estimated costs of US$67 (approximately $81 Cdn1998$) per ton for a lined landfill with leachate collection.[25] Repetto adopts the Massachusetts example for the marginal non-market disposal costs (US$75 per ton) and estimates a marginal cost of $45 (about Cdn$52, 1998$) per ton for a region that has moderate waste disposal costs.[26]

From the above U.S. studies, estimates range from US$45 to US$75 per ton. The lowest estimate equals $60.27 (Cdn 1998$) per tonne, which reflects the non-market environmental costs for a lined landfill with leachate collection. The mid-range estimate (equals Cdn$89.73, 1998$) per tonne), was for a region with lower waste disposal costs; whereas the high range estimate (equaling Cdn$100.44, 1998$, per tonne) was for a region with high waste disposal costs. The total cost for Alberta is the cost per tonne times the total volume of municipal waste. The estimated total volume of municipal waste declined from 2.47 million tonnes in 1988 to 2.12 million tonnes in 1999. All three estimated costs are illustrated in Figure 4, as Alberta's non-market costs for municipal solid waste disposal from 1988 to 1999. In 1988, the total estimated environmental costs were between $149-million and $248.3-million and in 1999, the estimated total environmental costs were between $127.7-million and $212.8-million.

Figure 4: Three Estimates of the Environmental Cost of Municipal Solid Waste in Alberta, 1988 to 1999



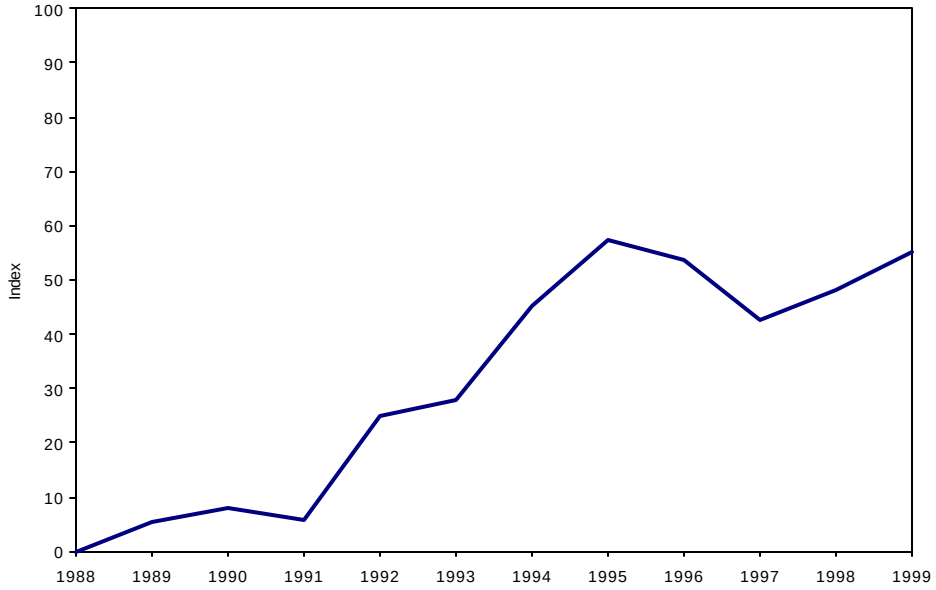
Sources: Based on estimates from Stone and Ashford 1991, Tellus Institute 1991, and Repetto 1992

We are paying less in environmental costs today than we did in 1988 because we are disposing of less waste. However, after an initial decline from 1990 to 1995, the amount of waste and associated environmental costs has begun to increase marginally again. Overall, the non-market environmental costs can be avoided by reducing, reusing, and recycling so greater emphasis is needed on waste reduction. For each tonne of municipal solid waste diverted from landfill, there is a financial benefit, associated with environmental costs, ranging from $60 to $100. Non-market costs are not the only costs associated with municipal waste disposal, as waste disposal costs at landfills amount to $30 to $40 per tonne in Alberta. Thus, it can be estimated that the total cost per tonne of municipal waste ranges from $140 to $200.

2.3 Municipal Waste Index

The municipal waste index is based on the Canadian Council of Ministers of Environment's (CCME) 1988 target for a 50-percent reduction in the volume of waste disposed, using CCME figures. The target of a 50-percent reduction is 100 on the index (Figure 5). In 1999, the volume of waste disposed had decreased by 72 percent in relation to 1988 levels, so Alberta was just over half way to the target; the index score for 1999 was 55.

Figure 5: Municipal Solid Waste Disposal Index



3 Hazardous Waste

3.1 Volumes of Hazardous Waste and Pollutants in Alberta

No source presently reports the total production and use of industrial and hazardous waste in Alberta. Hazardous waste shipped off-site for treatment or disposal has to be identified through a shipping manifest, but Alberta Environment has no record of what stays on site. The Alberta Energy and Utilities Board has recently started reporting the estimated quantity of Alberta's oilfield wastes that are recycled or disposed, but there are no published records for earlier years or for accumulated stocks that have not been dealt with.

Environment Canada's National Pollutant Release Inventory (NPRI) requires industries to report on-site and off-site pollutants released to the air, water, landfill and underground. According to the Commission for Environmental Cooperation, Alberta ranked 28th among the 63 states and provinces in the U.S. and Canada[b] in terms of its NPRI industrial pollutant releases and transfers in 1996.[27] However, Alberta ranked higher, at 17th for the NPRI industrial pollutant releases and transfers per capita. In 1997, Alberta's ranking improved in relation to the rest of North America, declining to 31st on the list.[28] Between 1995 and 1997, Alberta ranked 3rd highest among Canada's provinces, but also reported the 3rd greatest decrease (19 percent) in total NPRI releases and transfers.[c]

In the early 1980s there was not even a record of the annual production of wastes, and estimates varied considerably, as shown in Table1.[d] But in 1980, Reid Crowther conducted one of the first comprehensive studies of hazardous waste in Alberta.[29] Their survey of industry indicated that 92,000 tonnes of hazardous waste were generated in Alberta each year, of which three-quarters were high priority wastes requiring immediate attention. At that time any landfill could accept hazardous waste since no distinction was made between hazardous and other municipal or industrial waste. Thus hazardous wastes from the petrochemical industry, refineries, upgraders, fertilizer plants, metal fabrication and transportation could join household hazardous wastes in the local landfill. The report describes the liquids (leachate) leaking from a major landfill in Edmonton, with their chemical composition reflecting the hazardous waste stream entering the landfill.

Two years later, a Canadian survey extrapolated the volumes of waste in each industry group, based on the size of company and the volumes of waste created by comparable companies in the U.S.[30] This method suggested that Alberta created over 200,000 tonnes of hazardous waste each year, more than twice that identified in the 1980 Alberta-based survey. Recognizing the need to better manage hazardous wastes, the Alberta government and its partner Bovar Inc. built the Alberta Special Waste Treatment Centre at Swan Hills, which opened in 1987. While only 6,000 tonnes of hazardous waste went for destruction at the plant in 1989, Chem-Security, the plant's operator, estimated that Alberta's total annual volume of waste available for off-site treatment was 55,000 tonnes.[31] There was an estimated backlog of 89,000 tonnes.

Another study, carried out for Chem-Security in 1991, concluded that there was an inventory of over 200,000 tonnes of hazardous waste in the province, but that much of this was to be managed

[b] Ranking first indicates the highest total.
[c] The Commission for Environmental Cooperation has released its report based on 1998 pollutant releases. The report is available online at http://takingstock.cec.org.
[d] While industry surveys have been conducted to estimate the volume of on-site waste, these have not been comprehensive. Attempting to reconcile figures from different sources is even more difficult if one tries to compare two separate waste streams, as the wastes may be classified or combined in different ways. It is also difficult to establish the quantity of hazardous wastes when the concentration in liquids is not stated.

on site.[32] The study focused on the "residual" waste that would require off-site treatment and the report stated that, "Under existing conditions, 47,500 tonnes/year from ongoing operations will require final disposal. An additional 32,500 tonnes/year could also require final disposal if the orderly processing of inventory wastes occurs."

Both of the Chem-Security estimates of hazardous waste were intended to determine the volumes that would be available for future disposal at the Alberta Special Waste Treatment Centre and to justify the plant's proposed expansion.[e] In fact, these and other calculations greatly over-estimated the volumes of hazardous waste that would require off-site treatment and be shipped to the plant.[33] [34] [35] One reason for this was that the estimates included oilfield waste. Another reason was the special conditions under which Chem-Security was operating the treatment facility until 1996, which gave the company's owners a guaranteed rate of return on investment.

Table 1: Estimated Hazardous Waste Volumes in Alberta, 1980 to 1992

Annual Production, in tonnes, for off-site disposal, unless otherwise stated

	1980(a)	1982(b)	1990(c)	1991(d)	1991(e)	1992(f)	1992(g)
Oilfield	46,000	26,532		21,971			22,000
Total	*92,000	*215,944	55,000	**47,500	***39,914	29,530	****40,935

(a) Reid, Crowther & Partners Limited, 1980. Hazardous Wastes in Alberta, An Inventory and Review of Practices and Technology. Vol.1,2,3, Alberta Environment. Figures represent total waste generated.

(b) Gore and Storrie Limited, 1982. *Canadian National Inventory of Hazardous and Toxic Wastes.* Vol 1,2,3, Environment Canada. Figures represent total waste generated.
(c) Chem-Security (Alberta) Ltd., 1991. *Proposed Expansion of the Alberta Special Waste Treatment Centre*, Environmental Impact Assessment, Vol II.
Estimated volume for on-going generation, available for off-site treatment.
There was also an estimated backlog of 89,000 tonnes.
(d) David Bromley Engineering (1983) Ltd, 1991. *Hazardous Waste Volumes and Residual Wastes in the Province of Alberta.*
(e) Manitoba Hazardous Waste Management Corporation, 1993. Prepared for Canadian Council of Ministers of Environment Western Canadian Task Force on Hazardous Waste.
(f) Edmunds, R, 1992. Manitoba Hazardous Waste Management Corporation. *Western Canadian Hazardous Waste Inventory.* Prepared for Canadian Council of Ministers of Environment Western Canadian Task Force on Hazardous Waste.
(g) Sensor Consulting Group, 1993. *The Demand for Hazardous Waste Treatment and Specialized Services in the Province of Alberta*, prepared for the Alberta Special Waste Management Corporation.

* Total hazardous waste, for both on-site and off-site treatment.

** Annual "residual" waste, that required off-site treatment. Bromley calculated that an additional 32,500 tonnes/yr could require disposal if the orderly processing of inventory wastes occurred (estimated at 2.1 million tonnes, of which 1.8 million tonnes were from oil and gas operations).

*** Total quality of hazardous waste generated in Alberta during 1991 and manifested to off-site facilities. This was estimated to be approximately 27% of the total quantity of hazardous waste that required off-site management for disposal, recycling or treatment.

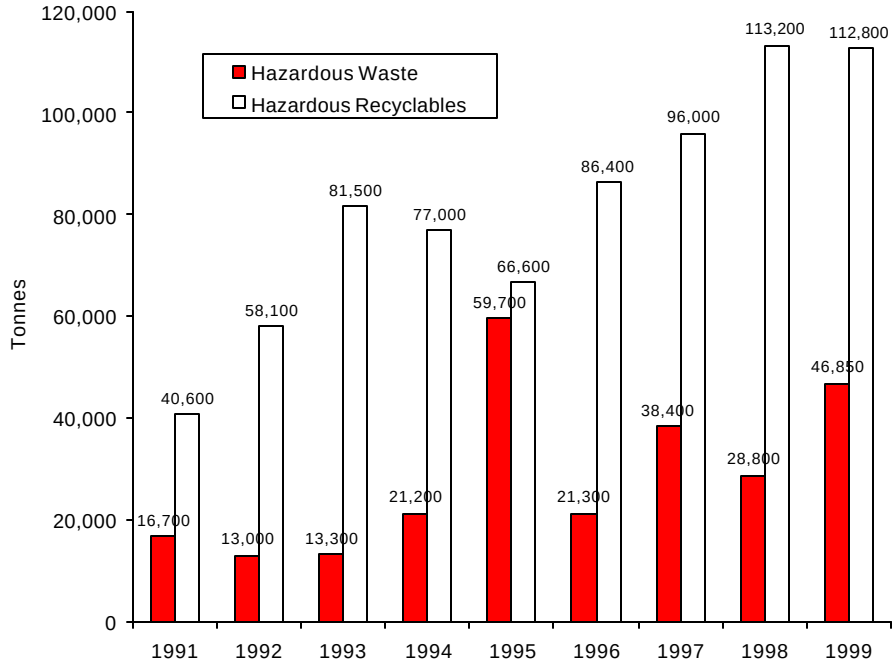
**** Sensor estimated the total volume of hazardous waste at 264,858 tonnes/yr, of which 224,563 received on-site treatment. Sensor included wastes from ongoing operations as well as those resulting from the orderly management of inventories from past operations.

[e] When Chem-Security applied for an expansion of the Special Waste Treatment Plant at Swan Hills in 1991, they cited extrapolations of earlier surveys that suggested there would be a total of over 325,510 tonnes hazardous waste in Alberta in 1992, of which 182,530 tonnes would require off-site treatment. In their request to expand their incinerator at Swan Hills, Chem-Security indicated that there was a backlog of 90,000 tonnes of organic waste that needed treatment, in addition to ongoing production of 50,000 tonnes of organics and 4,500 tonnes of inorganic wastes a year. They estimated that about 55,000 tonnes of the on-going waste generation would be attainable for treatment at their plant. Chem-Security (Alberta) Ltd., June 1991. Source: *Proposed Expansion of the Alberta Special Waste Treatment Centre*, Environmental Impact Assessment, Volume II: Main Report, Table 3-2 and p.3-3.

In 1992, the draft regulations to the *Environmental Protection and Enhancement Act* indicated that in the future, waste would be classified not by its source but by its properties. Thus all hazardous waste would be subject to the same legislation. However, as a result of strong lobbying from the energy industry, waste from the oil and gas sector was exempted from the final text of the *Environmental Protection and Enhancement Act.* The treatment of oilfield waste is discussed in section 3.3.

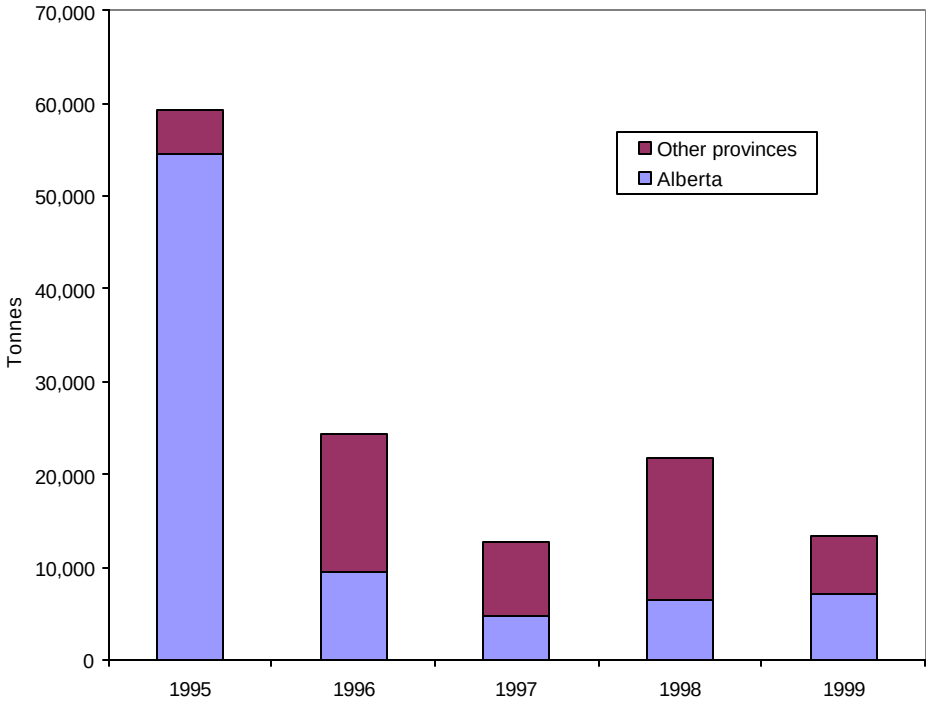
There is still no estimate of the total volume of hazardous waste generated in the province each year, as only hazardous wastes that are shipped off site for treatment or disposal must be reported.[36] Hazardous wastes that are sent off site may go to the Alberta Special Waste Treatment Centre, to approved deep wells or to Class I landfills, or be shipped out of province for disposal elsewhere. Figure 6 shows the amounts of all hazardous wastes shipped off site in Alberta. The data in Figure 6 are for Alberta-generated waste and do not include imports of waste from other provinces, which are shown in Figure 7.

Figure 6: Alberta's Hazardous Waste and Recyclables Moved Off the Generator's Site, 1991 to 1999



Source: Alberta Environment

Figure 7: Hazardous Waste Treated at the Alberta Special Waste Treatment Centre, Swan Hills, 1995 to 1999[37]



Source: Alberta Environment

The volume of hazardous waste sent to the Alberta Special Waste Treatment Facility has fluctuated. However, since 1995, when a large volume of waste resulting from the clean up from one site was shipped to the facility, the average amount of Alberta hazardous waste treated at Swan Hills has been about 7,000 tonnes per year. This is only about one-fifth of the total waste sent off site for the period 1996-1999.[38] Two major factors affect the volume of waste being sent to Swan Hills: government regulation and treatment costs. It is less expensive to recycle, ship the waste out of province, or send the material to a landfill or for deep well disposal, where this is permitted. Deep well injection and landfill disposal are critical hazardous waste management options and the regulation of these practices greatly affects how waste is managed in Alberta. Deep well disposal is described in section 3.4.

A Class I landfill that is permitted to accept hazardous waste is constructed to a higher standard than a Class II landfill, which takes municipal or non-hazardous industrial waste. Class I landfills must have a double liner (with at least one synthetic liner), a leachate collection and removal system, and groundwater monitoring. Two Class I landfills in Alberta are licensed to take third-party wastes; these are located at Ryley and Cynthia, near Drayton Valley. Between 1996 and August 2000, these landfills took a total of 7,361 metric tonnes or an average of 1,635 tonnes per year, but the volumes fluctuated considerably from year to year, with no trend. Another Class I landfill is operated by a private company for its own waste only. The landfill at Swan Hills was constructed to Class I standards, but is only allowed to take wastes from the facility's incinerator and other treated wastes. Even this landfill, which was "state of the art" when it was constructed in the late 1980s, has had problems. It was discovered in the early 1990s that one of the cells was leaking and the cell had to be emptied and reconstructed.[39]

As Figure 6 shows, the volume of hazardous material that is recycled is increasing at about the same rate as the increase in hazardous waste volumes, and the proportion recycled has fluctuated between 70 percent and 80 percent of the total hazardous waste volume since 1991. Used oil is an important hazardous substance that was formerly part of the waste stream but is now frequently recycled. Some of the recycling is done through the Alberta Used Oil Management Association. In 1999-2000, the Association's second full year of operation, it collected almost 59 million litres of used oil, a recovery rate of 67 percent, and 5 million used filters, a recovery rate of 78 percent.[40] This collection is financed by a levy on the wholesale price of oil.

3.2 Alberta Special Waste Treatment Centre at Swan Hills

The Alberta Special Waste Treatment Centre was built to enable the safe destruction of provincial hazardous wastes. Contamination of the local area has occurred nevertheless. As early as 1991, monitoring studies revealed increasing levels of PCBs in voles (small animals similar to mice) close to the plant. An evaluation of 1993 monitoring data stated that, "The conclusion for PCBs was that concentrations near the Treatment Centre are approaching levels where adverse effects may occur." The study recommended that measurements should be taken in larger mammals higher up the food chain,[41] but such tests were not conducted at that time. The Natural Resources Conservation Board decision to allow imports of hazardous waste from other provinces expressed concern about the levels of fugitive emissions from the plant and required that sources be identified before imports were allowed.[42]

Several minor emissions were reported to Alberta Environmental Protection in mid-1996, and in October a major leak occurred due to a break in a pipe leading from the transformer furnace to the main kiln. High levels of PCBs, dioxins and furans were released, contaminating local fish and game. Alberta Health subsequently issued an advisory against eating fish and game caught in the Swan Hills area due to PCB and dioxin and furan contamination caused by the leak[43] and, later, the high levels of contamination were revealed. Dioxin and furan levels in the fat of deer caught within 30 km of the plant were 30 times higher than in control animals, while those in liver were 1,300 times higher.[44] The level of PCBs, dioxins and furans in Chrystina Lake, about 3 km to the northeast of the plant were 80 to 800 times the levels in other lakes.[45] In July 1997, an explosion at the plant raised PCB levels in the atmosphere to five times the average for the area.

Dr. David Schindler, Killam Professor of Ecology at the University of Alberta, pointed out to the Environmental Appeal Board that,

> *Fugitive emissions from the Swan Hills Toxic Waste Treatment plant have contaminated an area of at least 2800 km^2 to a level where consumption advisories have been issued by Alberta Health for game animals that are a staple in the diets of aboriginal people. At sites where long-term records are available, wildlife has been contaminated to a degree where ecosystem health may be impaired.*[46]

High PCB levels found in snow in the winter of 1998 indicated that PCBs were still escaping from the plant.[47] The research was not continued in subsequent years, so it is not known if the levels remained high. A modified version of Alberta Health's advisory was still in place in 2000, warning people not to eat more than one meal per week of fish caught within a 20-km radius of the Swan Hills Waste Treatment Centre and to avoid or limit consumption of game caught within 30 km of the plant.[48]

Despite the contamination of the area, the Alberta government, which had already allowed imports of hazardous waste from other Canadian provinces in 1994, opened the borders to waste from outside Canada in December 1999. Instead of cleaning up hazardous waste in Alberta, which was the original intention of the facility, the plant now can receive wastes from around the world. This step was taken for financial reasons because insufficient Canadian waste was being sent to the facility. Between 1996 and 1999, 62 percent of waste treated at the Swan Hills plant came from outside Alberta. However, the plant failed to attract enough waste even with the relaxed access, so in October 2000, Bovar Inc., the plant's owner, announced that it intended to hand it back to the government at the end of the year.[49]

In 1996, when the Alberta government transferred ownership of the Alberta Special Waste Treatment Centre entirely to Bovar Inc., which had previously been a joint partner with the Alberta government, the province retained liability for the landfill cells and for the decommissioning and cleanup of the site when it closes. These decommissioning costs were estimated to lie between $31- and $57-million.[50] A more detailed analysis conducted by Stanley Environmental in 1995 described three decommissioning scenarios, ranging in cost from $8.9-million, if the buildings and equipment were simply put in a landfill on the site, to $21.6-million if they were first decontaminated by washing.[51]

The report suggested that it may be acceptable to put PCB-contaminated materials into a landfill and that "a total mass of 100 kilograms of PCB material may be deposited in such a manner without posing an unacceptable risk of adverse effects to aquatic receptors." However, the report also said, "This assumes that the liners are installed correctly and that flaws do not develop," which some would consider an unrealistic expectation. Whatever means of disposal is selected, the report stated that, "Perpetual care and monitoring of the site will be required." The studies on decommissioning costs were carried out before the 1996 leak and 1997 explosion raised contamination levels, so decontamination costs could now be considerably higher. Alberta taxpayers have already contributed over $440-million to the operation of the Alberta Special Waste Treatment Centre since it opened in 1987.[52] When the costs of decommissioning and perpetual monitoring of the site are included, these costs will be even higher. Since Bovar has returned the plant to the province, the Alberta government will have to decide its future.

3.3 Oilfield Waste

Oilfield waste is exempt from the *Environmental Protection and Enhancement Act* and dangerous oilfield wastes do not have to be treated in the same way as other hazardous wastes, which is why they are not generally sent to the Alberta Special Waste Treatment Centre.

The 46,850 tonnes of hazardous waste recorded by Alberta Environment for 1999 appear small compared with the 886,000 tonnes (or m^3) of oilfield waste that were disposed or treated in 1999 according to the Alberta Energy and Utilities Board (EUB) records.[53] However, the EUB points out that its tracking system includes not only dangerous wastes for disposal but wastes that are recycled as well as some that would be classed as non-dangerous.[54]

In 1999, 43 percent of oilfield waste was landfilled, 24 percent was processed in oilfield waste management facilities and 10 percent was dealt with by on-site one-time biodegradation, which includes spreading or spraying the wastes on land, or mixing with soil and burying them. About four percent of oilfield waste was spread on roads in 1999. A similar percentage was sent to disposal wells (nearly 40,000 m^3).

The 1998 and 1999 figures for oilfield waste reported by the EUB greatly exceed the estimated values of 22,000 to 46,000 tonnes for 1980, 1982, 1991 and 1992 reported in Table 1. It might be possible to compare the separate waste streams to estimate the approximate rate of change, but such a comparison was beyond the scope of this project.

The EUB has directed that oilfield wastes are not to be disposed in small landfills (those taking less than 10,000 tonnes per year), but it could be argued that many of these wastes should not be landfilled at all.[55] The fact that oilfield wastes are managed differently from other wastes of similar chemical composition gives rise to concern. "The Energy and Utilities Board condones a number of oilfield waste disposal practices that have the potential to seriously pollute soils and surface waters. These practices include on- and off-site disposal of drilling muds, one-time on-site land treatment of oilfield wastes, and road spreading."[56] Landspreading, landspraying and other forms of land treatment rely primarily on the dilution of contaminants such as salts, metals and hydrocarbons, rather than an actual cleanup of the waste. Vapourization of hydrocarbons contributes to air pollution, while there is potential for other substances to gradually leach into the groundwater. Alberta Environment has standards for the reclamation of oilfield sites after wells or other facilities are closed, but landowners sometimes later discover buried wastes that are contaminating the soil and preventing healthy plant growth. Alberta has about 34,000 inactive and 2,500 abandoned wells[57] and any contamination at these sites will be awaiting cleanup. The EUB and industry have set up an orphan well program to deal with wells that no longer have an owner and to clean up and reclaim the land around the wells, but as the degree of contamination varies from site to site, no actual figure can be given with respect to the total amount of contamination. Individual landowners report problems relating to the disposal of oilfield wastes to the EUB or Alberta Environment, but there is no comprehensive record of the number of sites or the extent of contamination that may have been caused by the widespread dispersal of oilfield waste.

It has been suggested that the government should return to its original 1992 plans to regulate all Alberta waste under the same set of rules and require all dangerous oilfield waste to be treated as hazardous waste.[58] While various methods might be used to treat the waste, some would probably be sent to the Swan Hills facility. Burning oilfield wastes at high temperatures is preferable to disposing of them in some of the ways that are currently permitted in Alberta. However, given the nature of most oilfield wastes, the quantities produced and the cost of treatment at the Swan Hills facility, it is considered unlikely that a significant percentage of these wastes would be sent for treatment at Swan Hills whatever the legal scenario might be.[59] Although about one-fifth of hazardous waste treated off site in Alberta goes to Swan Hills, hazardous waste generators have three other options. They can treat their wastes on site at their own facility, send them for treatment or disposal out of province, or dispose of them off site in Alberta in a Class I landfill or in a deep well. The proportion of the waste going to the Special Waste Treatment Centre depends on market conditions, such as the costs associated with other management options compared with the costs of treatment at Swan Hills.

3.4 Deep Well Disposal of Hazardous Wastes

Both the energy industry and chemical companies deposit large quantities of hazardous waste in wells, with the volume of dangerous oilfield wastes being about twice that of hazardous wastes going into wells from other sources. Alberta is the only province that puts large volumes of waste into deep wells and Alberta accounts for about nine-tenths of all material that goes to deep well injection in Canada.[60] There are some concerns about the deep well disposal of wastes and it is probable that the practice depends not only on having suitable geological formations, but also on government policy.[f]

A survey of companies representing approximately 90 percent of the annual oil and gas production in Alberta found that 38,591 m^3 of **oilfield waste** (such as sludge and well work-over fluids) were sent to disposal wells in 1999.[61] However, the total volume of liquids disposed of in wells is much larger. When tracking started in 1998, some companies included produced water that was not classified as a dangerous oilfield waste in their figures. Thus the volume of waste from the oil industry disposed of in wells was reported to be more than 500,000 m^3 in 1998.[62] The total volume of wastes going to disposal wells in 1999 would be similar, but the figure for that year only identifies those that are classified as dangerous.

Thirty-one wells are currently licensed to take **chemical wastes** in Alberta (including five commercial wells that also take oilfield wastes). Twenty-three of these wells are concentrated in the Edmonton area and many are located on a company's site. Five approved Class Ia deep wells in Alberta are licensed to take off-site, non-oilfield waste. Sellers operates a well near Devon, while Newalta operates wells in Morinville, Hughenden, Brooks and Drayton Valley. About 86,000 m^3 of hazardous wastewater have been directed to these five wells since 1993.[63] Most wastes injected are aqueous solutions with heavy metals, oil wastewaters, washings and brines.

Although Alberta Environment only collects information on hazardous wastes that are shipped off site for disposal, additional information on company wells is available from Environment Canada's National Pollutant Release Inventory (see section 3.5). The NPRI collects data on substances that are injected into wells both at the generator's site and off site. However, as the Inventory's name suggests, NPRI figures do not give the total volume of wastes, but only the release of certain substances. In 1998, 14,556 tonnes of reportable substances were injected underground in Alberta, with ammonia and methanol being two important constituents. Over 100 tonnes of the carcinogenic substance benzene were also injected into deep wells.[64]

Industry and government claim that the porous Nisku and Leduc formations found in Alberta can absorb large quantities of liquids. However, although the wells are 1,300-2,000 metres deep and far below the level at which freshwater aquifers normally occur, there is no certainty that the chemicals in these wells will not affect aquifers in the long term. As geophysicist and retired University of Alberta professor, Edo Nyland, has said, "We haven't measured how water migrates from one area to another. We don't understand the physics of what's going on..."[65] It is generally thought that impermeable layers above and below the formation used for disposal will prevent migration, but according to Nyland, "There is no such thing as an impermeable layer. It's just that it takes longer for fluids to get through layers."[66] Thus, while there may be no current

[f] Deep well injection is permitted in the United States, where there are 163 Class I hazardous waste injection wells, located at 51 facilities. Most are located in Texas (78) and Louisiana (18). Source: U. S. Environmental Protection Agency, Office of Water, Groundwater and Drinking Water, www.epa.gov/ogwdw000/uic/classi.html

evidence of problems, we do not know if aquifers are safe in the long term. One company, Dow Chemical Canada, now severely restricts the use of its wells for hazardous waste, although they are still used for the disposal of brine, which occurs naturally at the depths where the brine is discharged.[67]

Despite concerns, the volume of substances reported to the NRPI that were injected into on-site wells increased by 65 percent between 1994 and 1998, from 9,507 tonnes to 14,556 tonnes. These volumes are in addition to the oilfield waste that is disposed in wells, which is reported by the EUB. While deep well injection may appear to be a "cheap option" and part of the "Alberta Advantage" in the short term, the rules governing this practice should be revised to ensure that deep well injection is prudently managed and does not result in future environmental liabilities.

3.5 Ongoing Pollution – The National Pollutant Release Inventory

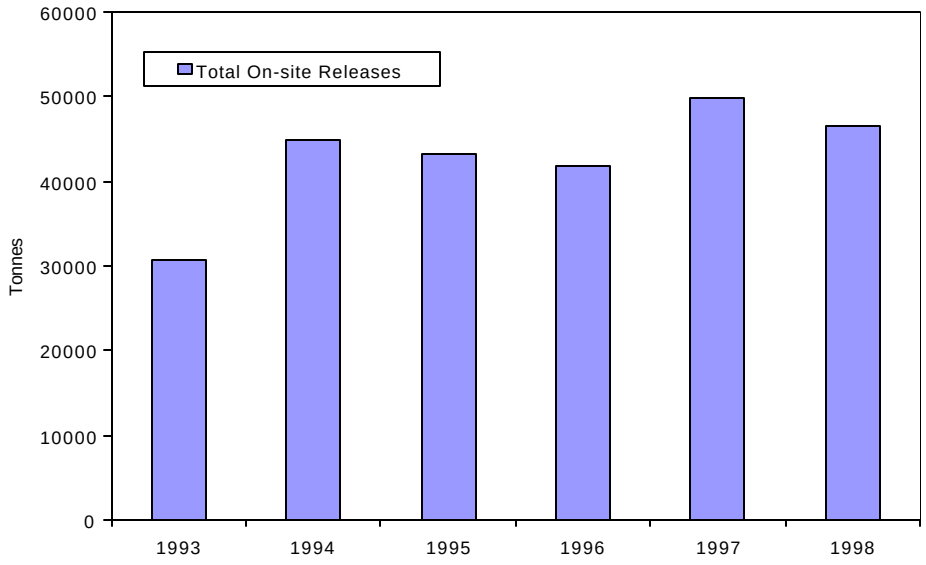
The most comprehensive figures on pollution in Alberta are provided by the National Pollutant Release Inventory (NPRI). The NPRI is the result of Environment Canada's requirement for companies to report their emissions of 176 substances that are released on site to the environment or transferred off site for disposal. The NPRI does not record actual volumes of waste, just the quantities of specific substances that are released to the environment. Also the inventory is not complete. The NPRI only includes substances reported by facilities that have at least 10 employees and use at least 10 tonnes of chemicals per year. It does not include:

- the full range of facilities that manufacture, process or use listed chemicals;
- non-point sources or non-industrial sources;
- small sources (gasoline service stations and dry cleaners), mobile sources (motor vehicles), area sources (farms, parking lots), or natural sources;
- all releases and transfers from a facility; or
- all substances of concern.

As Figure 8 shows, the total on-site releases of monitored substances have grown by over 50 percent since the first inventory in 1993. This is due partly to an increase in the number of companies reporting. A comparison of "matched data" for companies that reported in both 1995 and 1997 shows a decline of 32 percent in off-site disposal, although the on-site releases increased by 13 percent.[68] Of course, from an environmental viewpoint, it is the total emissions that are important. The number of companies reporting rose by 43 percent between 1993 and 1998 (from 176 to 252).

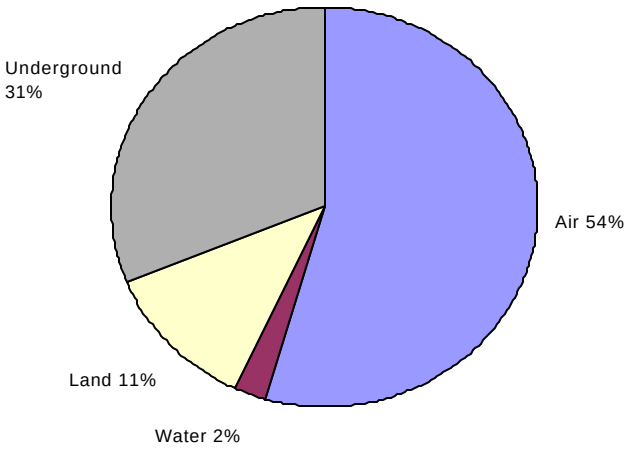
In 1998, over half the emissions were to the air and nearly one-third were to underground wells.

Figure 8: On-site Release of Pollutants in Alberta, 1993 to 1998



Source: National Pollutant Release Inventory, Environment Canada

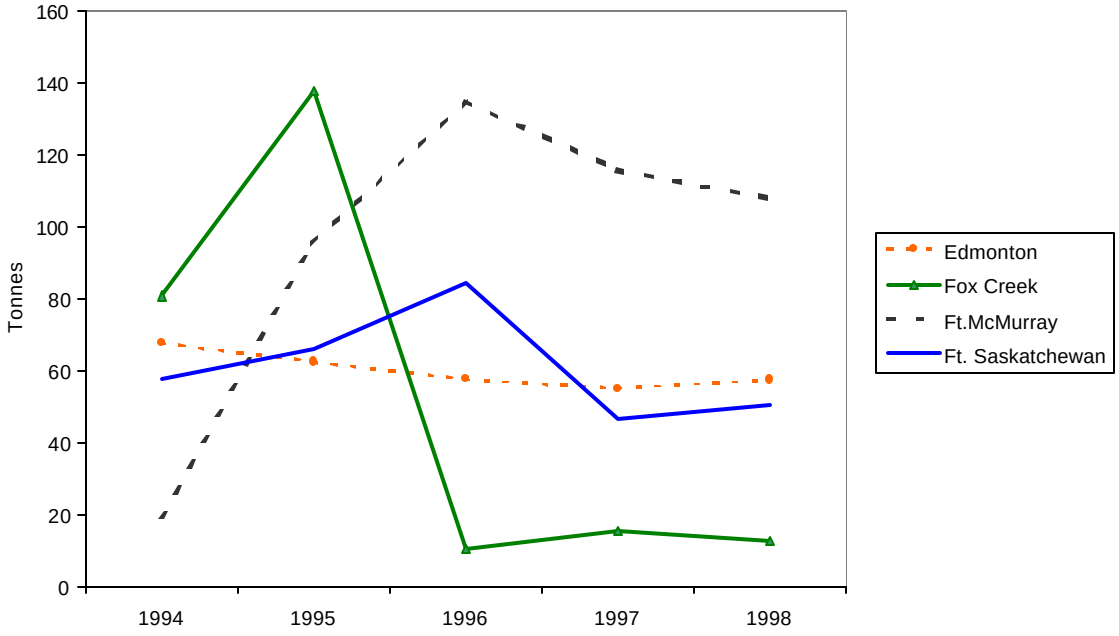
Figure 9: Alberta On-site Release of Pollutants, 1998 (percentage by environmental medium)



Source: National Po l lutant Release Inventory, Environment Canada

In 1998, the pollutants released in the largest quantities were ammonia (air and underground), methanol (underground and air), sulphuric acid (air), asbestos (land) and carbon disulphide (air). The most frequently released toxic or carcinogenic pollutants were asbestos (which was landfilled), formaldehyde (mainly air releases) and benzene. Over three-quarters of the benzene emissions were to the air, with the rest being injected underground. Despite the fact that benzene is classified as carcinogenic by the International Agency for Research on Cancer, nearly 350 tonnes were released to the air in 1998. As Figure 10 shows, the levels are highest in Ft. McMurray, which was the source of one-quarter of the total reported provincial benzene emissions. The Ft. McMurray emissions came from two large oilsands companies, while three gas plants are the source of the benzene in Fox Creek. A number of refineries and chemical plants are responsible for the emissions in Edmonton and Ft. Saskatchewan.

Figure 10: Benzene Emissions at Four Alberta Locations, 1994 to 1998



Source: National Pollutant Release Inventory

While on-site releases constitute the largest proportion of all releases, some substances were disposed off site or sent for recycling. The off-site transfers for disposal in 1998 in Alberta were about 1/10th the amount of on-site releases. The off-site transfers for recycling slightly exceeded those for disposal but, as 1998 was the first year that the reporting of recycling activities became mandatory, it is too early to identify a trend in on-site recycling.

3.6 Contaminated Land

In 1986, Alberta Environment initiated the Help End Landfill Pollution (HELP) program to inventory, assess and take corrective action at both active and abandoned industrial plant sites in Alberta. Of the 682 sites identified, 42 were orphan sites. During the assessment phase, 12 of the 42 orphan sites were identified as requiring investigation to determine if they posed a threat to human health or the environment. The 12 sites included five former refineries, five former wood treatment facilities, a chemical plant and an industrial waste disposal site. Action taken at the 12 orphan sites included removal of immediate hazards, an environmental site assessment and implementation of a risk management plan. The total cost of cleanup for these sites was estimated to range between $85-million and $100-million. The cost of cleaning up the Canada Creosote site in Calgary alone was put at between $34- and $50-million.[69] In fact, the total amount spent was much less. The federal and provincial governments agreed in March 1991 to each contribute $9.3-million to clean up high risk orphan sites, with an additional $2.3-million each to develop remedial technologies and demonstration projects.[70]

Risk management included soil and/or groundwater quality monitoring at many of the sites, rather than complete cleanup of the site. For example, contamination from the Canada Creosote site was contained by the construction of a barrier, at a cost of about $12-million, as it was felt that complete cleanup would pose further environmental risks.

Table 2: High Risk HELP Sites

Site	Location	Contaminant
Former Coutts Refinery	Coutts	hydrocarbons and lead ($2.4- to $3.4-million)
Former Deep Basin Wood Preservers	Elmworth	copper, chromium, arsenic ($53,000 to $245,000)
Alberta Osmose	Faust	arsenic and pentachlorophenol, dioxin impurities from wood preserving ($1.5-million spent)
Alberta Western Producers	Blackfalds	pentachlorophenol
Former North Star Refinery	Grande Prairie	oily sand clay in old crude oil lagoon ($0.6 to $2-million)
Former Gulf/MCREN Disposal Site	Calgary	phenols
Purity 99	Black Diamond/ Hartell	hydrocarbons, metals and other organic contaminants ($44-million)
Bonnyville refinery	Bonnyville	oil seepage related to waste oil disposal ($275,000)
Former Borradaile Refinery	Vermillion	hydrocarbon contamination from heavy crude ($2.9-million)
Former Peerless Wood Preservers	Cayley	pentachlorophenol and diesel ($2.7-million spent)
Canada Creosoting Company	Calgary	creosote and pentachlorophenol ($12-million spent; estimated total cleanup over $50-million).
Two Hills Chemicals	Duvernay	salts from brine wells and process fluids

Note: Figures in brackets are initial estimated cost of cleanup, unless otherwise indicated.[71]

The HELP program ended in 1996, so there are no longer any central records of the current status of these sites. The sites identified during the HELP program, like other contaminated sites, are regulated by Alberta Environment, and the *Environmental Protection and Enhancement Act* contains a variety of tools to promote compliance. However, it appears there is no public reporting of either the total area of contaminated land in the province or any potential risks associated with that land.

Another source of contaminated land is underground storage tanks. Recognizing the hazards that leaking underground tanks pose for human health (through fumes and contaminated water), fire and the environment, the Alberta government set up the Management of Underground Storage Tanks Program in 1989. It required the registration of all underground storage tanks and an estimate of the work required to upgrade each tank. The 1992 revision of the Alberta Fire Code required companies to inspect their sites and replace any leaking tanks. In 1994, the government handed responsibility for the management of underground storage tanks to an industry-run, delegated administrative organization, the Petroleum Tank Management Association of Alberta. However, the government remained concerned about orphan sites without a current owner.

In 1995, it was estimated that Alberta had 14,000 storage tanks at 4,454 sites and, of these, 1,152 tanks were abandoned (at 609 sites).[72] The estimated total cost to clean up the orphan tanks was $210-million and the Canadian Petroleum Products Institute (CPPI) proposed a levy of 0.7 cent/litre on the wholesale price of gasoline for five years to cover the cost. The government did not adopt the CPPI proposal, but studied the problem further. In October 2000, it announced an environmental remediation program that would provide $80-million to clean up contaminated soil due to leaks from underground storage tanks at gasoline stations in Alberta.[73] The program is aimed at helping municipalities with orphaned former retail sites and small retail fuel facility owners. It will provide up to $10,000 per site for an environmental impact assessment and up to $100,000 per site for remediation during the period until March 31, 2002. This fund will help defray the costs of cleanup but will not cover the total costs indicated in the CPPI report.

The oil and gas industry is another source of contaminated land. Contamination occurs at well sites when oilfield waste is incorrectly handled and when leaks occur.[74] For example, in 1999/2000 over 1,300 liquid spills from pipelines and other upstream oil and gas sources were reported to the EUB.[75] Even though 70 percent of the spills were small in volume, there were still nearly 400 spills that posed a threat to the environment (42 leaks) or were of mid-to high-volume releases (346 leaks). While most reported spills are cleaned up quickly, wastes that are improperly buried at wellsites and other sites can cause long-term contamination. As cases are often dealt with one at a time between industry and landowners, there is no overall record of the extent of the problem.

3.7 Costs of Pollution

Waste management imposes considerable costs on society. In the past we have paid for municipal landfills through property taxes and for the Alberta Special Waste Treatment Centre through provincial taxes. The Help End Landfill Pollution Program and the Management of Underground Storage Tanks Program were financed by public money. In the 1990s, the government initiated some programs that require industry to pay to remediate contaminated sites. In other cases, such as the recycling of used oil and oil filters and tires, the government has imposed a consumer surcharge to cover the recycling costs.[76] In these cases, more direct measures of the costs can be estimated (see Table 3). Table 3 does not include costs incurred directly by industry for dealing with hazardous wastes or the costs to industry or society for dealing with dangerous oilfield wastes. Nor does the table include the indirect costs of the emissions to air, land and water that are recorded by the National Pollutant Release Inventory.

Table 3: Estimated Public Cost of Selected Hazardous and Other Wastes in Alberta

	Paid Through Taxes	Paid by Consumer, Per Year	Estimated Total Cost
Alberta Special Waste Management Facility	$450-million, 1987-2000		$500-million, with cost of decommissioning[g]
Help End Landfill Pollution	$23.2-million allocated by federal and Alberta governments		$85- to $107-million for 12 orphan sites
Alberta Used Oil Management Association – environmental handling charge		$12.7-million in 1998-1999	
Underground petroleum storage tanks	$80-million for 2000-2002 for orphan sites		
Tire Recycling Management Association – recycling levy[h]		Approximately $11-million per year	

With the exception of the Swan Hills facility and underground petroleum storage tanks, we do not know the true burden that the disposal of wastes in Alberta is placing on the environment and human health. We do not know the future costs from wastes buried in the ground or injected into deep wells that may contaminate groundwater. The fact that these costs have not been measured, does not mean there is no risk. Even at the Swan Hills plant, the estimated cost of decommissioning the site (which ranged from $8.9- to $57-million, before the major leak of October 1996) covers only the site itself. The estimate does not include the impact of the environmental contamination on the surrounding area, nor the human and ecological costs resulting from contaminated fish, wildlife and habitat. This cost is in addition to the $440-million that the Alberta government has already spent as its share of the cost of building and operating the facility.

The Waste Control Regulation requires operators of private landfills and other waste management facilities to provide security to cover the cost of closing down, reclaiming and monitoring these facilities if an operator goes out of business. The security charge, which reflects the type and nature of the facility, ranges from $10,000 to $1.5-million. No security is required for municipal or regional landfills so the estimated future cost of closure of these landfills is unknown. When estimating the cost it would be useful to compare the amount of insurance or security that landfill operators in the United States are required to carry for the eventual cleanup and post-closure monitoring of their sites. Similar values could be applied to landfills accepting hazardous and municipal wastes in Alberta. These calculations would require considerable work and were beyond the scope of this report.

As noted, the government has allocated $80-million to clean up abandoned underground storage tanks. However, there are no readily available figures on the cost incurred by private industry for such efforts, although an earlier figure indicated that the total cost was about $210-million. The full cost to clean up 12 orphan contaminated sites was estimated at around $100-million, even

[g] While $50-million is near the higher limit of estimated costs of decommissioning the plant, this limit is taken, as the decommissioning estimates pre-date the major leak in 1996. Also those estimates did not include the cost of environmental pollution of a wider area, which resulted from that leak and other emissions.

[h] See section 2.1, "Volume of Municipal Waste in Alberta." While tires are not hazardous, they cause toxic fumes if they burn, so are included in this table.

though far less than this was actually spent. Assuming that industry has paid as much per site cleanup as has been spent by government, the total costs of dealing with contaminated sites in Alberta could perhaps exceed $500-million. All these expenditures have been inflating the GDP while they are really costs. Greater effort is needed to reduce waste and further increase recycling of hazardous substances.

Despite the contamination caused by the Alberta Special Waste Centre, improvements been made in the monitoring and management of most waste over the last 15 years. Yet it is possible that some of the current methods for land disposal of hazardous and oilfield wastes will create costs for future generations. Not only old landfills, underground storage tanks and old industrial sites cause contamination; new landfills, although constructed to higher standards, require adequate regulation to monitor for and control leakage, particularly because of the hazardous wastes disposed at these sites. Where landfills have been constructed with leachate collection systems, monitoring is necessary for some years after a landfill is capped and until all leachate has drained out, which will impose future costs on society. These costs have not been estimated in this report. Unfortunately, like the production of PCBs, CFCs and DDT, it is often takes many years and numerous studies to understand the true costs to ecological and human health.

In an ideal sustainable society we would no longer produce even one ounce of toxic waste. If Alberta were to adopt the conditions of The Natural Step[77] developed by Swedish oncologist Dr. Karl Heinrik-Robért, a society would be sustainable only if the following four conditions were met. Namely, that "nature's functions and diversity are not systematically:

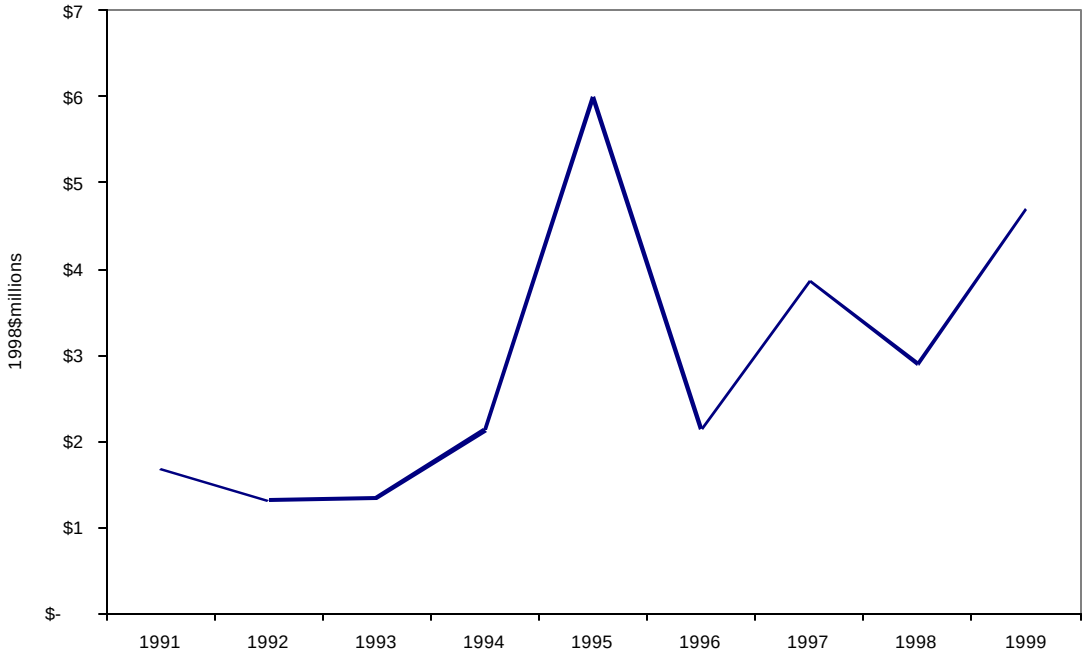
1. subject to increasing concentrations of substances extracted from the Earth's crust;
2. subject to increasing concentrations of substances produced by society; or
3. impoverished by overharvesting or other forms of ecosystem manipulation, and;
4. where resources are used fairly and efficiently in order to meet basic human needs worldwide."[78]

It is the second system condition that applies to toxic waste production. Companies like Interface (the world's largest carpet manufacturer) have begun to apply The Natural Step system conditions to their operations to eliminate toxic waste streams. The question is, can Alberta or Canada achieve the same objectives of zero toxic waste production if one company can? Although the Alberta Special Waste Treatment Centre was considered to be state of the art when it was built, there are now newer, less contaminating systems. But given the enormous uncertainty around short- and long-term impacts on human and ecosystem health, the precautionary principle suggests we should avoid creating these wastes in the first place. A sustainable future should be one in which no toxic waste has been allowed to accumulate and pose potential health and ecological liabilities.

3.8 The Environmental Costs of Hazardous Waste Disposal

Unfortunately, estimates of the environmental costs of hazardous waste disposal (e.g., water contamination) are difficult to estimate, and no direct studies were found during the research for this project. However, estimates do exist for the environmental costs of municipal solid waste to landfill. Although, the environmental costs of hazardous waste are considerably higher than municipal solid waste, in the absence of a more appropriate estimate, the cost per tonne can be applied to Alberta's hazardous waste disposal as a very conservative estimate. Several studies cited earlier provide a range of costs for municipal waste disposal (see section 2.2). In the case of hazardous waste, the high-end estimate[79 80] is used to calculate the environmental cost of hazardous waste disposal (US$75/ton or approximately Cdn$100, 1998$, per tonne). The estimated environmental costs were $1.7-million in 1991, $6-million in 1995 and $4.7-million in 1999. The peak in 1995 was caused by the cleanup of one site, but apart from this there has been a general increase.

Figure 11: A Conservative Estimate of the Environmental Cost of Hazardous Waste in Alberta, 1991 to 1999



Source: Based on non-market cost per ton from Stone and Ashford 1991, and Repetto et al. 1992

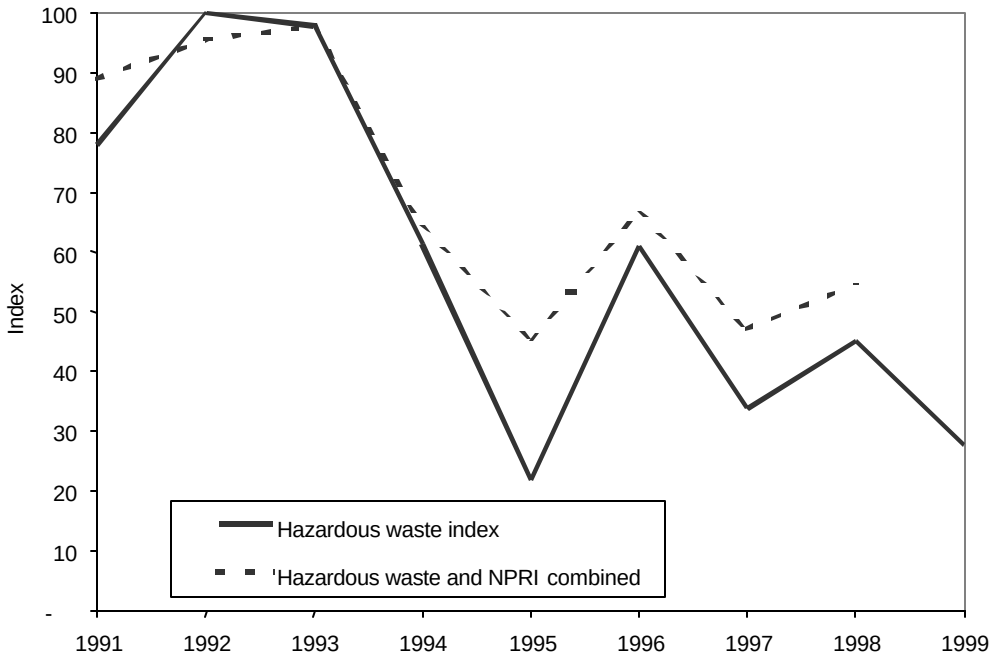
3.9 Hazardous Waste and Pollutant Indicator

It is difficult to create an indicator for hazardous waste prior to 1990. The estimates for the early 1980s include total hazardous waste, for both on-site and off-site treatment, but they measure the total waste inventory, not annual production. Thus, the most accurate figures for the construction of a hazardous waste index start in 1991, as shown in Figure 6. Data for the total volume of hazardous waste in Alberta that is moved from industrial sites for off-site treatment or disposal was used to create an index. The best year in the series, 1992, is taken as the target, or benchmark, and assigned a value of 100. However, it must be remembered that the data reflect only the volume of hazardous wastes moved off the site where they are generated and therefore do not indicate the trend for the full volume of hazardous waste created each year in Alberta.

A separate index was created from data in the National Pollutant Release Inventory, for the on-site release of substances, as shown in Figure 8. This gives some indication of the volume of activity on industrial sites in Alberta, but most of these releases (such as releases to the air and releases of non-hazardous substances) would not be classified as hazardous waste. This index is a proxy for the total volume of on-site releases because not all companies report to the NPRI.

The NPRI Index and the hazardous waste index were combined and are shown as a second line in Figure 12. The combined line closely follows that for hazardous waste moved off site, although it stops at 1998, the last year for which NPRI data were available. The indicator does not include oilfield waste, which is a major source of hazardous waste in Alberta. The absence of a detailed time series makes it impossible to calculate an index for dangerous oilfield waste.

Figure 12: Hazardous Waste and Pollutant Release Index for Alberta, 1991 to 1999



Source: Derived from Alberta Environment Data on Hazardous Waste Moved Offsite for Treatment or Disposal, and Environment Canada 's National Pollutant Release Inventory for On-site Releases

3.10 Recommendations for Future Work

Future research and development of hazardous waste GPI accounts should focus on the following priorities:

- estimates of the volume of dangerous oilfield waste prior to 1998 and comparison with reports from 1980, 1982, 1991 and 1992;
- survey of the volume of waste that is treated and/or disposed on a generator's site;
- more detailed estimates of the extent of contaminated sites and ongoing cost of remediation work and monitoring of HELP sites and other contaminated sites; and
- more detailed estimates of the full costs of treating and recycling hazardous waste.

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.

Alberta GPI Background Reports and Sustainability Indicators

GPI Background Reports	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 Reports	**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. Municipal Waste Index

The figures below show the percentage reduction in waste levels from 1988. The index is calculated taking 50 percent waste reduction as the target, with an index value of 100. This is the CCME method for calculation of waste reduction.

	Municipal Waste*	**Municipal Waste Index ****
1988	0	0
1989	2.696084	5.4
1990	3.998761	8.0
1991	2.946123	5.9
1992	12.41226	24.8
1993	14.04813	28.1
1994	22.70169	45.4
1995	28.73655	57.5
1996	26.82646	53.7
1997	21.31833	42.6
1998	24.17261	48.3
1999	27.51852	55.0

* The figures shown are the percentage reduction in waste levels from 1988.
** The index is calculated using a 50-percent reduction in waste as the target.

Appendix C. Hazardous Waste Index

The table below shows the data from which the hazardous waste and National Pollutant Release Inventory (NPRI) indices were derived. For the hazardous waste index, the index value of 100 is the target year 1992, which was the year with the lowest volume of hazardous waste. For the NPRI Index, the estimated value for 1991 is taken as the target year and given a value of 100. The values for 1991 and 1992 in the NPRI chart are derived from visual extrapolation from the years 1993 to 1998. The overall index is the arithmetic mean of the two indices. In 1998 it was 55.

	Haz. Waste (tonnes)	Haz. Waste Index	NPRI (tonnes)	NPRI Index	Haz. Waste and NPRI averaged
1991	16,700	78	30,000	100	89
1992	13,000	100	33,000	91	95
1993	13,300	98	30,749	98	98
1994	21,200	61	44,927	67	64
1995	59,700	22	43,232	69	46
1996	21,300	61	41,710	72	66
1997	38,400	34	49,743	60	47
1998	28,800	45	46,644	64	55
1999	46,850	28			

Endnotes

[1] Mitchell, A. 2000. "Waste Not: How Tricks from Tiny Holland Could Tame Canada's Garbage Beast," *Globe and Mail*. Nov. 18. p. F4.
[2] Cathie Browning. Alberta Environment, personal communication.
[3] Alberta Environment. *1995 State of the Environment Report: Waste Management*, p.5
[4] Alberta Environment. 2000. Data provided by Licia Paddison, Waste Reduction Specialist.
[5] "Albertans Care for the Environment, but will not give up their vehicles," Clean Air Strategic Alliance, News release, April 5, 2000.
[6] Statistics Canada. 2000. *Waste Management Industry Survey: Business and Government Sections 1998.* Catalogue No. 16F0023XIE. Table 2.7. Quantity of Municipal Solid Non-Hazardous Waste and Recyclable Materials Generated, Disposed of, and Diverted per Capita, all Sources, by Province and Territory, 1998. http://www.statcan.ca/english/freepub/16F0023XIE/16F0023XIE.pdf. It is apparent that the volume of waste generated per capita in Alberta in Figure 1, using Alberta Environment data, differs from the Statistics Canada value given in Figure 2. This is because the Alberta government figures are for municipal waste only, while the Statistics Canada figures are for waste from all sources.
[7] CCME. 1998. *National Packaging Protocol 1996 Milestone Report.*
[8] Mitchell, A. 2000. "Waste Not: How Tricks from Tiny Holland Could Tame Canada's Garbage Beast." *Globe and Mail*. Nov. 18. p. F4.
[9] Mitchell, A. 2000. "Waste Not: How Tricks from Tiny Holland Could Tame Canada's Garbage Beast." *Globe and Mail*. Nov. 18. p. F4.
[10] Statistics Canada. 2000. *Waste Management Industry Survey: Business and Government Sections 1998.* Catalogue No. 16F0023XIE. Table 3.2, Operating Revenues of Waste Management Businesses by Activity and by Province and Territory, 1998.
[11] Statistics Canada. 2000. *Waste Management Industry Survey: Business and Government Sections 1998.* Catalogue No. 16F0023XIE, Table 4.1, Local Government Current Expenditures on Waste Management by Activity by Province and Territory, 1996 and 1998.
[12] Statistics Canada. 2000. *Waste Management Industry Survey: Business and Government Sections 1998.* Catalogue No. 16F0023XIE. Table 4.2, Local Government Current Expenditures on Waste Management by Service Provider by Province and Territory, 1998.
[13] Statistics Canada. 2000. *Waste Management Industry Survey: Business and Government Sections 1998.* Catalogue No. 16F0023XIE, Table 4.4, Capital Expenditures by Local Governments on Waste Management by Service Provider by Province and Territory, 1998.
[14] Statistics Canada. 2000. *Waste Management Industry Survey: Business and Government Sections 1998.* Catalogue No. 16F0023XIE, See tables 2.1, 3.8 and 4.5.
[15] Statistics Canada. 2000. *Waste Management Industry Survey: Business and Government Sections 1998.* Catalogue No. 16F0023XIE, Table 2.1.
[16] Statistics Canada. 2000. *Waste Management Industry Survey: Business and Government Sections 1998.* Catalogue No. 16F0023XIE, Table 3.8.
[17] Statistics Canada. 2000. *Waste Management Industry Survey: Business and Government Sections 1998.* Catalogue No. 16F0023XIE, Table 4.5.
[18] Alberta Environment website, Action on Waste, and *1995 State of the Environment Report: Waste Management*, p. 39.
[19] Doug Wright, Alberta Tire Management Recycling Association, personal communication.
[20] More information on tire recycling can be found at the Tire Recycling Management Association website at http://www.trma.com/ tools/documents/uploads/Tire percent20Facts.doc
[21] Information on the City of Edmonton's waste management composting facility was obtained from http://www.gov.edmonton.ab.ca/am_pw/waste_management/compost_facility.html
[22] Dwayne Simmons, TransAlta, personal communication.
[23] Alberta Environment website, Action on Waste.
[24] Alberta Environment. 1995 *Alberta State of the Environment Annual Report: Waste Management*, p.34.
[25] Stone, R.F. and N.A. Ashford. 1991. *Package Deal: The Economic Impacts of Recycling Standards for Packaging in Massachusetts*. Massachusetts Institute of Technology. Tellus Institute. 1991. *Disposal Cost Fee Study: Final Report*. Prepared for California Integrated Waste Management Board. Tellus Institute. Boston.

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[28] CEC (Commission for Environmental Cooperation). 2000. *Taking Stock: North American Pollutant Releases and Transfers 1997*. CEC. Montreal, Quebec.
[29] Reid, Crowther & Partners Limited. 1980. *Hazardous Wastes in Alberta: an Inventory and Review of Practices and Technology* for Alberta Environment.
[30] Gore & Storrie Limited, 1982. *Canadian National Inventory of Hazardous and Toxic Wastes*, Environment Canada.
[31] Chem-Security (Alberta) Ltd. June 1991. *Proposed Expansion of the Alberta Special Waste Treatment Centre*, Environmental Impact Assessment, Volume II: Main Report, p. 3-3.
[32] David Bromley Engineering (1983) Ltd.1991. *Hazardous Waste Volumes and Residual Wastes in the Province of Alberta*. Report prepared for Chem-Security (Alberta) Ltd.
[33] Edmonds, R. 1982. *Western Canadian Hazardous Waste Inventory*, Manitoba Hazardous Waste Management Corporation prepared for Canadian Council of Ministers of Environment Western Canadian Task Force on Hazardous Waste.
[34] Manitoba Hazardous Waste Management Corporation. 1993. Study prepared for the Canadian Council of Ministers of Environment Western Canadian Task Force on Hazardous Waste.
[35] Sensor Consulting Group. 1993. *The Demand for Hazardous Waste Treatment and Specialized Services in the Province of Alberta*, prepared for the Alberta Special Waste Management Corporation.
[36] Tony Fernandes, Alberta Environment, personal communication.
[37] Data for the chart supplied by Tony Fernandes, Alberta Environment. Much of the large volume in 1995 was due to the cleanup of one contaminated site.
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