CRITERIA FOR THE SITING OF HAZARDOUS WASTE MANAGEMENT FACILITIES: A MANITOBA PERSPECTIVE

by

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A Practicum Submitted in Partial Fulfillment of the Requirements
for the Degree, Master of Natural Resources Management

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ABSTRACT

The objective of this project was to ascertain the criteria necessary to meet economic and environmental concerns for the siting of hazardous waste management facilities in Manitoba. A constraint mapping exercise demonstrated how the criteria may be applied to determine areas which hold the best potential for management facilities. Three areas in southern Manitoba are identified as warranting detailed study as potential locations for a hazardous waste treatment, storage and disposal facility. The need for management facilities in the Province of Manitoba is immediate in consequence of the 20,235 tonnes of hazardous waste that are generated annually. The value increases dramatically to 52,261 tonnes per year if air emmissions and present waste recycling are also considered.

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INTRODUCTION

1.1 PREAMBLE

Less than 1 percent of total industrial output is waste. Yet, an alarming 10 to 15 percent of this waste is considered to be hazardous to man and his environment (Environment Canada 1981 and Institute for Chemical Waste Management 1980). If they are not properly treated, stored, transported or disposed of; hazardous wastes pose a potential threat to human health and the environment, because of their quantity, concentration, corrosiveness, flammablity, mutagenicity, toxicity or chemical, physical or infectious characteristics. Hazardous wastes are recognized as one of the major environmental and societal problems of the 1980s and 1990s. They pose not only a technical challenge but an institutional challenge as well (Higgins 1984).

Fortunately hazardous wastes are manageable. Recycling, storage, treatment by appropriate technologies, or disposal in special landfill sites, may eliminate or contain the hazard. Some wastes require prior treatment to neutralize hazardous qualities before safe disposal can occur. The Manitoba Government, recognizing the inherent danger undertook the development of a hazardous waste management system in late 1982 (Manitoba Environment 1983).

Interest in the management of hazardous wastes, is shared by government, industry, and the general public. management of hazardous wastes. Studies conducted since the late 1970s have contributed greatly to the knowledge of hazardous waste management in western Canada. W.L. Wardrop & Associates Ltd. (1979) compiled an inventory of hazardous wastes generated in northwest Ontario, Manitoba, Saskatchewan, Alberta, and the Northwest Territories. The Report concluded that:

> The proper disposal of these hazardous wastes is a major environmental problem. Current disposal practices are inadequate and no economically acceptable disposal facilities exist for the proper disposal of hazardous wastes in the region.

Reid, Crowthers, and Partners Ltd. (1980) produced a report on hazardous wastes in northern and western Canada, and concluded:

1. There is a need for a comprehensive hazardous waste management system to treat and dispose of the wastes generated in the area.
2. The environmental and public health implications of not implementing the waste management system are serious.
3. One of the most important tasks in the overall management of hazardous waste materials is the selection and approval of sites for waste management facilities.

The Reports shared the common conclusion that each province should direct immediate attention to developing a management plan. Wardrop and Reid, Crowthers examined the feasibility of locating a central hazardous waste management facility to serve the three prairie provinces. They presumed that a single facility could handle all of the hazardous wastes generated from within this region. Because of political, economic and social problems arising out of the transport of hazardous waste across provincial boundaries, the siting of such a facility in a single province was determined to be infeasible. Since no province desired to be the sole recipient of wastes from the entire region, the only reasonable response was for each province to manage and dispose of its wastes within its jurisdictional boundary.

Due to differences in survey methods, widely different quantities of hazardous wastes have been identified as being generated in Manitoba. Reid, Crowther, and Partners Ltd. (1980) estimated that Manitoba industries generated 37,000 tonnes of hazardous waste annually. Gore & Storrie Limited (1982) calculated that Manitoba industries generated 29,458 tonnes per annum. A report by the City of Winnipeg and the Province of Manitoba (1983) concluded that Winnipeg industries generated approximately 12,000 tonnes annually. The Manitoba Department of Environment and Workplace Safety and Health established a Hazardous Waste Information Exchange with provincial industries in 1983. The Exchange records indicate that a minimum of 20,235 tonnes of hazardous waste are generated annually in the Province.

Environment Canada's Environmental Protection Service (EPS) commissioned this study to identify Manitoba's requirements for hazardous waste facilities to ensure the safe treatment, storage, transportation, and disposal of provincially generated hazardous waste. The study is directed towards an understanding of the physical, social and economic extent of Manitoba's hazardous waste problem and its significance to the population of Manitoba.

One question that every researcher should address is how the specific study relates to the problem that is being examined. This study should help the Environmental Protection Service and the Manitoba Department of Environment and Workplace Safety and Health understand the present state of hazardous waste management in the province. The maps developed for this study show the geographic distribution of hazardous wastes and identify potential sites in southern Manitoba where collection, treatment, storage, and disposal facilities would be most effectively located in terms of geographic, socio-economic and environmental considerations. Finally, the study provides recommendations for future direction of hazardous waste management in Manitoba.

1.2 MANITOBA'S HAZARDOUS AND SPECIAL WASTES MANAGEMENT PROGRAM

On November 5, 1982, The Honourable Jay Cowan, then Minister of Environment, announced the initiation of a Hazardous and Special Wastes Management Program in Manitoba. The purpose of the program is to establish a comprehensive waste management system in Manitoba encompassing reduction of hazardous waste through re-use, recycling and reclamation, and appropriate treatment and disposal of hazardous wastes. The Minister emphasized that extensive public participation would be incorporated into each step of the program (Yee 1984).

In November, 1982, the Environment Minister announced a three-phase Hazardous and Special Waste Management Program for Manitoba. Phase One began in January, 1983, when the Minister announced that a non-government steering committee had organized a Manitoba symposium on hazardous waste for March 16-18, 1983. The objectives of the symposium were to promote open and frank discussion among a variety of groups and individuals about the hazardous waste problem, to familiarize all Manitobans with the problem and possible options for solution, and to assess provincial initiatives (Yee 1984).

A major component of Phase One was the development of The Dangerous Goods Handling and Transportation Act (S.M. c.7-Cap.D12) to provide the government with the authority to protect the environment from the adverse effects arising from activities involving 'dangerous goods' (hazardous and special wastes). The legislation was initiated by the Minister in August, 1983, as a draft proposal and public consultation meetings were held in October and November, 1983, in several key communities in Manitoba. Appendix A provides a breakdown of the towns and cities where the Clean Environment Commission public hearings were held. The legislation was redrafted to incorporate the input and comments provided at the consultation meetings, re-introduced to the Legislature, and passed in June, 1984.

During September and October, 1983, the Environmental Management Division of Manitoba Environment established an information exchange with approximately 750 Manitoba businesses. This information exchange provided industry with information on the management program. In addition the exchange elicited information from industry relating to the types and quantities of hazardous waste generated, and the methods of storage, treatment and disposal of these wastes currently in use in Manitoba. This information was used as the basis of a public report on the problem of hazardous waste in Manitoba and is to be used by the Clean Environment Commission for a second set of public hearings (Yee 1984).

As part of Phase One, the Clean Environment Commission held public hearings between December 5, 1983, and February 2, 1984, to provide a broader range of public consultation and participation in the Hazardous and Special Waste Management Program. Phase One will be completed after the second set of hearings is conducted to examine Manitoba's hazardous waste problem, and the management system needs and criteria required to address the problem.

Phase Two of the program will proceed on the basis of the needs and criteria identified in the first phase. The planning process will require extensive public involvement, especially in the selection of a site (or sites) for a hazardous waste facility (or facilities).

In Phase Three, a system will be developed and selected, based on public input, and other pertinent information, from Phases One and Two. Emphasis in the third phase will be on public education towards ensuring the initiation of an acceptable hazardous waste management system in Manitoba.

1.3 RESEARCH OBJECTIVES

The primary objective of this study was to ascertain the criteria necessary to meet economic and environmental concerns for the siting of hazardous waste management facilities in Manitoba. Secondary objectives of this study were:

1. To identify the various concepts which constitute hazardous waste management.
2. To develop an understanding of the present generation and disposal trends of hazardous waste generating industries in the Province.
3. To map areas within the province that satisfy the determined siting criteria and which reflect the nature of Manitoba's hazardous waste situation.
4. To identify areas (sites) within the province where hazardous waste management facilities may be located.
5. To recommend the type of management system required in Manitoba for the efficient and effective management of provincially generated hazardous wastes.

1.4 RESEARCH METHODS

This section summarizes the methods that were applied during the research and development of this report. The first phase was to identify the various concepts of what constitutes hazardous waste management. Management concerns were identified by a literature search, discussions with knowledgeable professionals and a visit to a West German hazardous waste management facility. The literature review was aided by a computer search from Dialog Information Services Inc.. Information was also provided by the various provincial and state authorities responsible for hazardous waste management. A trip was undertaken to Bavaria to examine one of its hazardous waste facilities to learn what Manitoba may require for its management system. Bavaria was chosen because it has one of the most advanced hazardous waste management programs in the industrialized world.

The next phase consisted of analyzing the results of the Hazardous Waste Information Exchange. This analysis provided an understanding of the present distribution of wastes within Manitoba. The resulting tables illustrate present trends in the generation and disposal of hazardous waste. This information was important in determining potential locations for management facilities.

The third phase ascertained the criteria necessary to meet environmental and economic concerns for the siting of hazardous waste treatment, storage and disposal facilities. In this phase, siting criteria from other provinces and countries were applied, along with consideration of the spatial distribution of Manitoba's hazardous waste, to determine potential areas for a provincial hazardous waste management facility. A series of constraint maps were developed using the siting criteria in order to locate potential locations for management facilities. The mapping exercise demonstrated the application of the determined siting criteria and identifies three areas in southern Manitoba that warrant detailed study for consideration as potential hazardous waste management facility locations.

The final phase provides a management system required in Manitoba for the effective management of provincially generated hazardous wastes. The proposed hazardous waste management system was based on discussions with professionals and on experience elsewhere, as well as on the evaluation contained here in this study.

1.4.1 Delimitations

This study determined Manitoba's requirements solely in terms of generated industrial hazardous wastes within the province. The lack of available data did not permit the inclusion of hazardous wastes found in individual homes and at non-industrial locations. These wastes are presently disposed of in landfills along with other municipal garbage. Nuclear wastes were not considered since their management is a federal responsibility and requires management technology very much different from that required for conventional industrial wastes. It is noted, however, that low-level radioactive wastes are manageable within the proposed system.

Chapter II

CONCEPTS OF HAZARDOUS WASTE MANAGEMENT

2.1 INTRODUCTION

Central to this study are the concepts of what constitutes hazardous waste management. The chapter begins by identifying the government agencies responsible for hazardous waste management in Manitoba. Of primary importance to management are the Acts and Regulations which define hazardous wastes and which address the questions of transportation and disposal of such wastes. In context with the discussion of hazardous waste definitions, two frequently asked questions are then answered: are all hazardous wastes manageable? and where do hazardous materials fit into the management plan? The various management alternatives available for implementation are discussed. Since the issue of public opposition to the siting of hazardous waste management facilities has brought social issues to the forefront, a section has been devoted to examining public concerns. Factors which influence hazardous waste growth are presented as these influencing factors ultimately determine the quantities of waste which the management system must handle. The following section introduces the legal conditions which have a bearing on the management of hazardous wastes. Finally, with an understanding of how hazardous wastes may be managed, the Gesellschaft Zur Beseitigung Von Sondermull in Bayern MBH (Bavaria, West Germany) is presented as a case study of an operating hazardous waste management system.

2.2 RESPONSIBLITY FOR HAZARDOUS WASTE MANAGEMENT IN MANITOBA

Concern about Manitoba's approach to hazardous waste handling and disposal is shared by the general public, industry and by the federal and provincial governments. The federal agency responsible for hazardous waste management is the Environmental Protection Service (EPS), an agency of Environment Canada. The Environmental Protection Service was formed to ensure that the Federal government's responsibility for the protection of the environment is carried out in a manner consistent with national policy.

Historically, the responsibility for hazardous waste management rested with the provincial departments of health (Castrilli 1982). British Columbia, Alberta, Manitoba and Ontario have since moved in the direction of consolidating authority within their environment departments. These environment departments have, or are developing the expertise in hazardous waste management.

There are three provincial environmental agencies in Manitoba. The Manitoba Department of Environment and Workplace Safety and Health is the principal environmental protection agency in the Province. The Department administers and enforces the _Clean Environment Act_ (S.M. 1972, c.76 as am.) and its regulations, Clean Environment Commissions Orders, and several regulations under the _Public Health Act_ (S.M. 1965, c.62 s.1).

The Manitoba Clean Environment Commission is a quasi-judicial body mandated by the _Clean Environment Act_. Its primary function is to make recommendations to the Environment Minister for Orders regulating the emission of contaminants by companies, individuals, or government agencies to the air, water, and soil. The Clean Environment Commission is also responsible for conducting investigations on environmental issues at the Environment Minister's request. The Commission may hold public hearings to gather information, to receive evidence, and to hear representations concerning environmental matters.

The Manitoba Environmental Council is a citizens' advisory group which reports to the Environment Minister on environmental problems and issues. The Council's main objective is to identify and review environmental issues, and then to provide the findings to the Minister. A further objective is to keep the public informed on environmental issues.

2.3 HAZARDOUS WASTES DEFINITIONS

> Central to any program to manage hazardous waste is development of a definitional scheme which separates those wastes controlled by the management system from the universe of non-hazardous wastes. This scheme is designed to suit the nature of the environmental problem to be solved, as well as to accomodate the existing socio-political and economic conditions (Lehman 1981).

This section explores the definition of hazardous waste.

2.3.1 Canadian and Manitoba Definitions

At the suggestion of the Canadian Chemical Producers' Association, the federal Environmental Protection Service convened a Task Force on the Definition of Hazardous Wastes, with representatives from federal and provincial governments, the National Research Council, industry and others. In January 1980, the following definitions were agreed on:

Waste: A waste is any substance for which the owner or generator has no further use and which he discards.

Hazardous Wastes: Those wastes which, due to their nature and quantity, are potentially hazardous to human health and to the environment and which require special disposal techniques to eliminate the hazard.

The consequences of a hazardous waste definition may be felt in the social-economic-political environment where the definition is enforced. The extent of regulatory enforcement determines how the definition will affect public health and the environment.

In order to examine what constitutes a hazardous waste the term must be explored. An economic definition of waste is 'the non-marketable output of an industrial process' (Quinn 1985). Therefore, wastes, by definition, are outputs for which the owner or generator can no longer derive further economic benefit.

'Hazardous' is difficult to define because it is open to interpretation and regulatory influence. Before attempting to define the term, it is essential to consider the criteria which classifys a material as being hazardous. Wastes may be hazardous in one or more ways. They may be carcinogenic, chemically reactive, corrosive, irritant, flammable, genetically disruptive, infectious, toxic, or cumulative in the food chain (Lehman 1981). The hazardousness of a waste may be estimated through consideration of the potential problems that may impact the environment and/or human health. From this, it follows that hazardous may be defined as 'any material which poses a potential threat to the general well-being of society in terms of health and/or environment. For this study, a hazardous waste may be considered to be any material without current economic value, which meets criteria which identify it as being potentially dangerous to human health and/or the environment.

A hazardous waste definition for Manitoba may be found in <u>The Dangerous Goods Handling and Transportation Act</u> (S.M. 1984, c.7-Cap.D12). The Act defines a hazardous waste as "any substance or group of substances so designated by the regulations or conforming to the criteria set out in regulations". This regulatory definition makes comprehension of hazardous waste difficult for the general public. From the Act, a more general definition of a hazardous waste can be derived which would define a hazardous waste as any waste that:

1. is foreign to or in excess of, the natural constituents of the environment, or
2. affects the natural, physical, chemical or biological quality of the environment, or
3. is or is likely to be injurious or damaging to the health or safety of a person.

2.3.2 Hazardous Waste Classification

Waste classification is an essential key in identifying which materials are hazardous.

> A sufficiently precise classification of the wastes is of special importance for control purposes. It permits, on one hand, control measures with regard to special wastes (example: preparation of analyses, disposal or treatment, utilization of certain wastes) to be strengthened and, on the other hand, a clear definition also permits control to be restricted to selected problematic wastes (Lehman 1981).

There is no general consensus as to the most suitable classification system for hazardous wastes. Wastes may be classified according to generator, physical waste characteristics, specific constituents, or applicable treatment processes. A full appreciation of the problem requires the application of each of these criteria in defining a waste classification scheme. The classification system is a management tool and must reflect an interest in management factors such as applicable and feasible treatment, storage, and disposal methods.

2.3.3 The Canadian Approach to Hazardous Waste Classification

Government departments interpret and elaborate upon the broad statutory definitions for hazardous wastes in a regulatory context. The efforts result in criteria, categories, or listings of hazardous wastes to be used in the regulated community. In Canada, a joint Federal/Provincial/Industry Working Group established national criteria which identifys hazardous wastes. A copy of the "Criteria for Dangerous Goods Handling and Hazardous Waste List" may be found in Appendix B.

The United Nations has designated nine basic classes of dangerous goods which have been adapted to meet Canadian conditions:

Class 1 - Explosives, including explosives within the meaning of the Explosives Act (Canada)

Class 2 - Gases: compressed, deeply refrigerated, liquefied or dissolved under pressure

Class 3 - Flammable and combustible liquids

Class 4 - Flammable solids; substances liable to spontaneous combustion; substances that on contact with water emit flammable gases

Class 5 - Oxidizing substances; organic peroxides

Class 6 - Poisonous (toxic) and infectious substances

Class 7 - Radioactive materials and prescribed substances within the meaning of the Atomic Energy Control Act (Canada)

Class 8 - Corrosives

Class 9 - Miscellaneous products; substances or organisms considered by the Governor in Council to be dangerous to life, health, property or the environment when handled, offered for transport or transported and prescribed to be included in this class.

In Canada, Class 1, Explosives, and Class 7, Radioactive materials are regulated under federal legislation. The Canadian classification system adopted the United Nation's format and criteria and that from the Inter - Government Maritime Consultative Organization (IMCO). If a waste may be classified as being dangerous or hazardous by either designation by the UN or IMCO classification criteria, or by meeting the criteria or characteristics presented for a particular waste class in the Canadian classification scheme, then that hazardous waste will be managed by the provincially designated hazardous waste management department. The Canadian Chemical Producers' Association (1980) believes that 'Canadian government agencies should establish "hazard criteria" to determine if a waste classified as "hazardous" should be granted an exemption from such classification in Canada if the level of hazard can be demonstrated to be minimal'.

2.4 HAZARDOUS WASTE MANAGEMENT CONSIDERATIONS

The management of hazardous wastes requires basic considerations. Two prominent questions frequently asked are: where do hazardous materials fit in to the management system? and are all hazardous wastes manageable?

The first consideration to be discussed is the concept of hazardous materials. The non-marketable output of an industrial process destined for recycling or redistribution elsewhere, cannot correctly be classified as a hazardous waste. This recycleable or exchangeable output must be defined as 'hazardous material', since the concept of economic value is retained.

This difference in economic value requires different approaches in both management and economic analysis. Only in the event of an accidental release would a hazardous material lose economic value and become a waste. Hazardous materials can be managed through the same system that applies presently to the movement and storage of chemicals,explosives, and other potentially dangerous goods. Traditional economic techniques such as risk analysis would be applicable. The management concepts presented for hazardous wastes would apply to hazardous materials that would be managed under the proposed management system. Since great emphasis is placed on the recycling, redistribution or reuse of hazardous wastes, theoretically, all 'hazardous wastes' have potential to revert to 'hazardous materials'.

The second consideration is the question whether all hazardous wastes are manageable. Unfortunately, not all waste streams which meet the hazardous waste criteria can be managed in the system. Economic and technological restrictions make total waste management an unrealistic and sometimes an undesirable management goal. Air emissions are examples of where it may not be realistic to expect industrial compliance to eliminate one hundred percent of the hazardous air emissions. High economic costs and/or restrictive technology may make this goal impossible. In view of economic and technological considerations, hazardous waste managers and the general public must be realistic in their expectations for hazardous waste management and of what constitutes a manageable hazardous waste.

2.5 HAZARDOUS WASTE MANAGEMENT ALTERNATIVES

This section identifies a set of preferences for the manner in which wastes should be handled. These preferences are not absolute or final, but represent a preferred sequence for the management of hazardous wastes as recognized today.

2.5.1 Do Not Generate Wastes

The most appropriate form of hazardous waste management is not to generate hazardous wastes in the first place. While in theory this approach would be ideal, in practice it is not feasible and is overly optimistic except in rare circumstances. Industrial processes by their nature will continue generally to produce uneconomic byproducts.

2.5.2 Reduction in the Production of Hazardous Wastes

It is frequently possible for industry to reduce the production of hazardous wastes by the selection of appropriate technology, by the alteration of processes or by use of greater care in the processes. This would reduce the quantity of wastes requiring handling in the management system. The implementation of waste reduction technology may prove uneconomic to industry at the present time, since without financial penalties industry has little incentive to do so. The development of a strict hazardous waste management system, the regulation of unsafe disposal practices, and the introduction of charges for the treatment of hazardous wastes would create positive economic incentives for industry to reduce the production of hazardous wastes.

2.5.3 Recycling or Reuse of Hazardous Wastes

Of the options presented, this alternative is the most promising and the most feasible. If hazardous wastes can be recycled or reused, 'waste' becomes a useful 'raw material'. Rams and Simcoe (1981) suggest that according to companies that deal in resource recovery, as much as 80 percent of hazardous waste could be recycled. Major economic and legal barriers must be overcome before large scale waste recycling or exchange can occur. There are a number of problems facing industry and government that discourage large scale waste recycling.

Government fiscal policies, including tax laws discourage waste recycling and reduction while encouraging the use of raw materials in industry. For example, it is cheaper to buy virgin oil because there is a higher tax on recycled oil. The high start up costs often deter small firms from internal reduction or recycling programs.

At present, it is cheaper for industries to dispose of wastes at landfill sites or elsewhere than to consider recycling. A study prepared for the federal Department of Environment, entitled 'Breaking the Barriers', says the true costs of landfill sites have not been properly calculated in terms of environmental, social and economic costs. The study says provinces should charge more for disposing of wastes at landfill sites, and, as in about 20 U.S. States, use the extra income to finance recycling and reduction programs.

Further, a lack of information about the availability of recycling technology, its cost-benefits and importance, affects decisions made by government, industry and the public.

Another incentive to recycling would be to increase use of the services of the Canadian Waste Materials Exchange in Mississauga, Ontario. This service provides a listing of waste materials that are available in different locations throughout the country. About 3700 participating companies exchanged 210,350 tons of waste, worth $6.16 million in 1983 (Laughlin 1984). Many of the waste materials may be of interest to the other industries, since companies may find that the material which is considered to be waste by one firm, may be exactly what they need in their own processes. In January, 1985, the Recycling Council of Manitoba began operation. The Recycling Council sees itself as part of the education process, providing consumers with a modest blueprint for personal waste management. According to Environment Department spokesman Mark Stefanson, waste recycling has become a high priority in Manitoba because "there are a number of environmental and economic benefits".

2.5.4 On-Site Treatment

On-site treatment of hazardous wastes may ensure that the wastes are handled by those most familiar with their characteristics and properties. The cost of disposal is paid by the generator. The economics of on-site treatment may make such an approach feasible for larger waste generating firms. A potential problem area is the use of secure landfill sites at the plant. Difficulties arise in the control and inspection of landfill sites on private property, unless laws make provisions for government supervision. It will be shown later that on-site treatment is sensitive to transportation costs and treatment/disposal fees charged by the management facility.

2.5.5 Disposal by the Hazardous Waste Management System

If the non-economic product of the industrial process cannot be reused, recycled, or disposed of safely on-site, it must be directed to the hazardous waste management system. Within the hazardous waste management system, wastes are disposed by the most economic method which is compatible with the overriding criterion of public and environmental safety.

2.6 SOCIAL CONCERNS

Proponents and government agencies have concentrated on the administrative, economic and technical aspects of hazardous waste management. Increased public opposition to the siting of hazardous waste treatment and disposal facilities, has brought social concerns to the forefront. Indeed, many people involved in hazardous waste management, now believe that social aspects create far more problems than the technical ones.

Polls conducted by Robert Cameron Mitchell of Resources for the Future conclude that 86% of those surveyed identified hazardous waste disposal as an issue which worried them a great deal (Darmstadter 1983). The public realizes that the proper disposal of hazardous wastes requires treatment facilities. Citizens are not clear about the risks involved in the operation of such facilities, and misconceptions often lead to strong citizen resistance upon the siting of a treatment facility. The major concerns which arise, in the order in which the public emphasized them in an Alberta Environmental Review, are:

1. effects on human health,
2. effects on the environment,
3. risk and safety,
4. policy considerations,
5. site planning factors,
6. quality of life (Krawetz 1979).

There is a fear that the presence of a hazardous waste treatment, storage and disposal facility will result in an influx of hazardous materials into an area, thereby increasing the risk to the local populace. These fears are genuine and include concerns such as the following: the probability that exposure to hazardous wastes may result in malformations, cancer, genetic damage, birth defects and miscarriages; the potential damage to water supplies; the possibility of accidental discharge into the environment; and the potential decrease in property values. These and other fears are aggravated by public awareness of the shortage of hazardous waste facilities, leading residents to fear that a facility originally designed to dispose of local waste will also deal with wastes generated outside local boundaries. Public opposition to hazardous waste siting arises when citizens do not perceive a facility as solving a local problem. They profess to feel no need to solve a problem not created locally.

Any attempt to locate a hazardous waste treatment and disposal site must be conducted in a way that permits citizens to obtain easily information regarding the proposed facility and the operator. Social acceptability is enhanced by the availability of useful and pertinent information. Typically, information about waste management has focused on the technical processes and as a result has not been readily understood by non-technical audiences. The result of an absence of clear, easily comprehended information is increased public hostility. Information made available to the public should include:

1. substantiation of the premise that the facility should be near the major sources of waste generation,
2. the process used to select the site,
3. information on the viability of the plant,
4. long-term responses and liability,
5. the operator's experience,
6. technology to be used,
7. types, sources and amounts of hazardous wastes,
8. the siting criteria,
9. measurements taken to protect the health of workers and residents.

The credibility of a company or agency proposing the facility also influences the public response. Citizen reaction depends on perceptions of the ability of the company or agency to operate the facility safely. Financial capability and responsibility for liability are also essential in building public confidence. Finally, the public expects government to play a major and visible role in planning and siting waste management facilities. The need for early public involvement to avoid opposition owing to the lack of public involvement in the planning process, must be emphasized.

2.7 FACTORS INFLUENCING HAZARDOUS WASTE GROWTH

Industrial production rates, recycling incentives, and legislative and regulatory actions are factors that influence the quantity of hazardous waste generated. The United States Environmental Protection Agency has reported that national production and consumption rates are increasing each year (4% - 6%) while resource recovery of wastes has not maintained this level. Thus waste generation increases and a direct correlation exists between industrial production, population growth and the generation of wastes.

Incentives for recycling are generally lacking in western Canada. Ontario however, took the lead in Canada by introducing and supporting the Canadian Waste Materials Exchange. The Exchange is hampered by a lack of information on the types, quantities, and locations of hazardous wastes throughout Canada. Further development of such an Exchange is inhibited by economic considerations. A well managed recycling/recovery program would decrease the amounts of hazardous wastes requiring treatment, storage, and disposal.

The results of legislative and regulatory actions towards hazardous wastes have already been felt in Canada. In the 1970s, the main thrust of the legislation was directed at water and air pollution. Effluent and emission standards and controls, converted and redirected to land disposal sites wastes that were previously discharged to water bodies or into the atmosphere. This meant that more hazardous wastes were being sent to landfill sites, pits, and dumps which were not environmentally acceptable for hazardous waste disposal. Unless production processes are changed, more stringent legislation means more waste will require special treatment, storage, and disposal.

2.8 HAZARDOUS WASTE LAW, LEGISLATION, AND REGULATION

This section introduces some of the legal conditions that affect the management of hazardous waste. Several common law remedies are applicable for actions against improper waste disposal. However, as the discussion points out, common law actions may provide inadequate public defence against poor management practices. This section then examines the federal government and provincial government roles (concentrating on Manitoba), in the formulation of laws, legislation and regulations that apply in hazardous waste management. This section is by no means an all-encompassing view of hazardous waste law, but instead attempts to provide an overview of the legal devices, and their limitations, that affect the management of hazardous wastes.

2.8.1 Common Law Actions

Several tort law remedies are theoretically available for damage to health and property caused by the unsafe management of hazardous wastes. These include nuisance, trespass, negligence, strict liablity and riparian rights. While damages or an injunction may be obtained, a combination of factors presents serious limitations to public and individual claims from hazardous waste related damage. These obstacles include procedural barriers as to who may sue for damage; problems in establishing cause and effect; defences to liablity; and prohibitive expense (Castrilli 1982).

2.8.1.1 Nuisance

The Common Law has evolved two forms of action, those of public and private nuisance. The tort of private nuisance has severe limitations since, where the plaintiff is an individual, the plaintiff must prove that he has suffered damage beyond that suffered by a significant class of the public.

There are two aspects to the tort of private nuisance: the interference with the use and enjoyment of someone's property, and the actual physical damaging of another's property. In the latter action, the plaintiff does not have to establish nuisance, but only that he has suffered damage by an act of the defendant which could properly be called nuisance. Where the complaint is for the interference with the use and enjoyment of one's property, there is a balancing of factors, including the utility of the defendant's conduct on his land against the damage incurred by the plaintiff. There are two types of remedies applicable to this sort of action: the granting of an injunction or a restraining order, and the assessment of damages. When the court assesses damages, they are based on the devaluation of the enjoyment value of the land. The problem with the tort of private nuisance is that the plaintiff must establish cause and show a departure from normal reasonable action. Thus, illegal dumping of hazardous waste would appear to be amenable to a private nuisance action because of the low social value of such a practice. However, if there is statutory authorization for the activity then the defendant may be able to avoid liability if the firm is operating within the terms of approval.

The tort of public nuisance has disadvantages in environmental law. A public nuisance is defined as an act or omission that causes damage to rights held in common by all the public. It is not necessary for the public at large to be affected, only those who will come in contact with the presumed nuisance. A problem arises in that the Attorney General for the Province or for the Federal Government must initiate action. If a private individual can prove that he is suffering damage beyond that suffered by the general public, he may have a cause of action for a public nuisance suit. It is possible for a private individual to bring a suit as guardian of the public interest, if he is able to persuade the appropriate Attorney General; however this is rarely used. Class actions are not maintainable for nuisance.

2.8.1.2 Trespass

The tort of trespass may be defined as the act of entering on the lands of another, without consent or lawful right, or after a lawful entry, refusing to leave when ordered to do so by the owner. Only the former part of the definition may be applicable to environmental law cases. There are not many trespass cases in environmental law. Further, there are no legal precedents in Canada for trespass in environmental law. Despite this theory's narrow application, it is arguable, for example, that a landowner whose groundwater has been rendered unfit for his use by subsurface migration of hazardous waste, could sue in trespass, unless the courts characterized such invasions as indirect (Castrilli 1982).

2.8.1.3 Negligence

In general, common law environmental actions are brought against defendants under the various torts of nuisance (nuisance, strict liability and riparian rights). Negligent conduct is not required to establish liability in nuisance. Negligence is generally the consequence of the act, and not the act itself. For this reason, most environmental law suits are not brought as negligence actions since proof that the defendant's conduct fell below some legal obligation of care is difficult. Negligence may play an important part in actions where the defendant claims the defence of statutory authorization to nuisance actions. The problem arising from the tort of negligence is that the plaintiff must demonstrate causation. Given the nature of hazardous waste, persons engaged in the handling of such waste would be required to adhere to a higher standard of care, making the demonstration of causation difficult to prove.

2.8.1.4 Strict Liability

The modern rule of strict liability in Canada is found in the 1868 English case of Rylands v. Fletcher ((1868), L.R. 1 Ex. 265 (Eng. H.L.)). Over the years, the rule has been applied in cases involving isolated escapes of dangerous materials and wastes accumulated on the land in contradiction to nuisance actions, usually brought for a continuing interference with the use and enjoyment of one's land. It is not necessary that the substance cause damage in order for a liability to attach, but rather that the defendant is liable for all damage caused by the mere escape of the substance from his land, even though the release was neither intentionally nor negligently inflicted.

There are diverse opinions on the applicability of the Rylands v. Fletcher rule. Strict liability only has a curative impact on those with sufficient assests to meet liability awards but little or no impact on those who would otherwise be unable to meet such claims or who may have already gone out of business. In heavy industrial areas it is possible that hazardous waste activity would not be considered a non-natural, exceptional use of land. The result could be that there would be no compensation for injury under this theory in such areas. Acts of God, deliberate acts of third persons and statutory authority are among the defences available to defeat a strict claim (Castrilli 1982).

2.8.1.5 Riparian Rights

An action which is similar but not identical to the private nuisance actions is the interference with an owner's riparian rights. These rights are not propriety in the sense that one actually owns the waters of the lakes, rivers and streams appurtenant to one's property, but rather the right to utilize such water, and to receive the water with no diminution in quality or quantity. The plaintiff does not have to prove damage since the introduction of the pollutant is an actionable wrong, even without proof of damage. In precedent, the court has held that it was unnecessary and irrelevant to show the importance of the defendant's business to the community or its economic necessities, in order to succeed in the action.

While tort theories of recovery have potential application to the modern problems posed by hazardous waste, there are substantial barriers extant to their systematic use in this area. In Canada, there is little precedent for the use of common law remedies in environmental law. At present, the burden of proof for risk of damage rests with the plaintiff. In situations where there is conflicting scientific opinion, potential risk may be difficult to prove. Since regulatory schemes for hazardous waste management do not provide remedies for third party damage, reform of tort law to meet such gaps appears necessary. In time, as environmental law cases become more prevalent, precedents will be established changing the nature of common law actions in environmental cases.

2.8.2 The Federal Government Role

In the early 1970s federal environmental legislation was directed to controlling air and water pollution. The issue of industrial toxic chemicals was not dealt with until the mid-1970s when parliament passed the Environmental Contaminants Act (S.C. 1974-75-76, c.72). While the Act addresses the import, manufacture and use of toxic chemicals, no federal law addresses the disposal or management of hazardous waste except for polychlorinated biphenyls (PCBs) under the above mentioned Act. This is the case, notwithstanding that the federal government regards hazardous waste as ranking as one of the "highest priority environmental concerns in all regions of the country" (Rathay 1979). The review of federal efforts with respect to regulating hazardous waste will concentrate on the regulatory program contained in the Transportation of Dangerous Goods Act. The Transportation of Dangerous Goods Act (S.C. 1980-81, c.36), administered by Transport Canada since it was passed in mid-1980, evolved from the need for a manifest system to track dangerous goods and hazardous waste movements from generation to final treatment and disposal. The Act and regulations established a system of compliance with safety standards, safety marks, and requirements applicable to dangerous goods. The Act makes it an offence to handle, offer for transport or transport any dangerous good, unless the applicable safety requirements and markings are in compliance with the Act. The Act also includes a provision for federal-provincial agreements for implementing and enforcing the law's provisions within a province.

John Roberts, Federal Minister of Environment, at the time of the Act's passage, stated

> that the Act would make it possible to control the international and interprovincial shipment of hazardous waste from "cradle to grave" through the development of a nation-wide manifest system to assist federal and provincial governments in the overall management of hazardous waste (Environment Canada 1980).

The Minister, addressing the division of responsibilities in the waste management area, emphasized that "It is a matter of great concern to the provinces, which have management responsibility for hazardous waste disposal..." (Environment Canada 1980).

Other federal legislation may influence the management of hazardous waste. Specific uses of regulatory law have, in fact, contributed to a waste disposal problem on land. For example, the development and enforcement of regulations concerning air and water emissions have forced industry to dispose of its sludge wastes in landfills. Federal legislation, such as the Environmental Contaminants Act has contributed to the disposal problem because of the toxic substances it has banned or restricted. This Act has pressured present disposal practices by forcing to landfill or storage, substances potentially harmful to human health and the environment. The Ocean Dumping Control Act (S.C. 1974-75-76, c.55) may also influence the land disposal of hazardous wastes. The Act places pressure on waste disposal facilities on land, as the Act requires that no ocean dumping of waste takes place except in accordance with the terms and conditions of a permit issued by Environment Canada.

2.8.3 The Provincial Government Role

Provincial governments have substantial constitutional authority to deal with hazardous waste disposal and related matters (The Constitution Act, 1867 as am., s.92(13)). Provincial legislation, like federal law, has concentrated on the control of air and water pollution discharges. The inadequacy of legislation to deal with the problems of land disposal of hazardous waste, as well as the limitations of early provincial legislative schemes directed to traditional waste disposal, have prompted provincial governments to address the various legal facets of hazardous waste management. Such is the case in the Province of Manitoba.

The Manitoba Government's response to the inadequacy of legislation concerning the management of hazardous waste was the proclamation on August 20,1984 of The Dangerous Goods Handling and Transportation Act (S.M. 1984, c.7-Cap.D12). The Act enables the government to establish general standards for the generation, storage, transportation, disposal and use of dangerous goods, including hazardous wastes. Hazardous waste which is recycled, reused or recovered is classified as a dangerous good and not a hazardous waste. The Act provides for the control of aspects of hazardous waste management including: siting, monitoring, inventory, recycling, reuse, recovery, transboundary movement of waste, perpetual care and financial responsibility, as well as outlining the role of the public.

Under the legislation, a manifest system and a registration and licensing process addresses the issues of inventory, monitoring and movement of wastes. Hazardous waste transporters and facilities are required to be licensed and hazardous waste generators are required to register with the province. Legislative control over facility siting is assured by the requirements, under the Act, to obtain a license, to assess public opinion and to complete an impact study.

Financial responsibility is dealt with in the license, which covers bonding and adequate insurance. In the case of an environmental accident, responsibility rests with the agency in custody or control of the hazardous waste. A mechanism for cost recovery has been established in the legislation by allowing for recourse to the civil courts. Perpetual care is a condition of the license.

Other provincial legislation may influence the management of hazardous waste in Manitoba. The main statute governing waste management in Manitoba is the Clean Environment Act (S.M. 1972, c.76 as am.). This is a very comprehensive statute, dealing with all aspects of environmental pollution. The Act enables the Manitoba Environment Department to set standards on environmental quality and to prevent contamination of the air, water and soil. Under this Act hazardous waste or materials are dealt with via special Orders which the Minister is empowered to issue. As this Act contained no regulations governing hazardous waste management, Ministerial Orders were, in effect, tailor-made, mini-regulations which applied to specific sites and operations which endanger the environment. The Dangerous Goods Handling and Transportation Act will avoid the Ministerial need to custom-design regulations to deal with provincially generated hazardous waste.

The following Acts and regulations also may have some impact on hazardous waste management, subject always to being superseded by The Dangerous Goods Handling and Transportation Act. General wastes are regulated by the Waste Disposal Grounds Regulations (Man. Reg. 208/76) pursuant to the Clean Environment Act. These regulations set out registering requirements, standards, location, classification of sites and ground operational requirements. Division V of the Sanitation Regulations (R.R.M. 1971, P210-R3) under the Public Health Act (S.M. 1965, c.62, s.1) specifies that the handling and storage of industrial waste must be approved by a medical officer of health. These regulations also set out requirements for waste disposal grounds. Disposal of pesticides in Manitoba is to be carried out in compliance with the Clean Environment Act and the Public Health Act and their regulations as specified by the Pesticide and Fertilizer Control Act (S.M. 1976, c.19).

2.9 CASE STUDY: THE BAVARIAN HAZARDOUS WASTE MANAGEMENT SYSTEM

Bavaria had started a state wide system for the disposal of hazardous wastes before the Waste Disposal Act was drafted in the Federal Republic of Germany. The Bavarian system comprises 10 regional collection stations and 3 central treatment plants (Schweinfurt, Schwabach and Ebenhausen/ Gallenbach), seen in Figure 1. With the exception of the treatment plant of Schwabach, which is run by a municipal co-operative, all the other facilities and collection stations are run by the Gellschaft Zur Beseitigung von Sondermull in Bayern MBH (Company for disposal of Special Waste in Bavaria Ltd.), GSB for short. This section examines the Bavarian Special Waste Management System by looking at the operation of the Ebenhausen Treatment Plant and Gallenbach Landfill Site, which the author visited in May 1984.

In Bavaria, special wastes (hazardous wastes) are defined as "those residues which, due to their quality and quantity, cannot be removed with municipal waste, and which

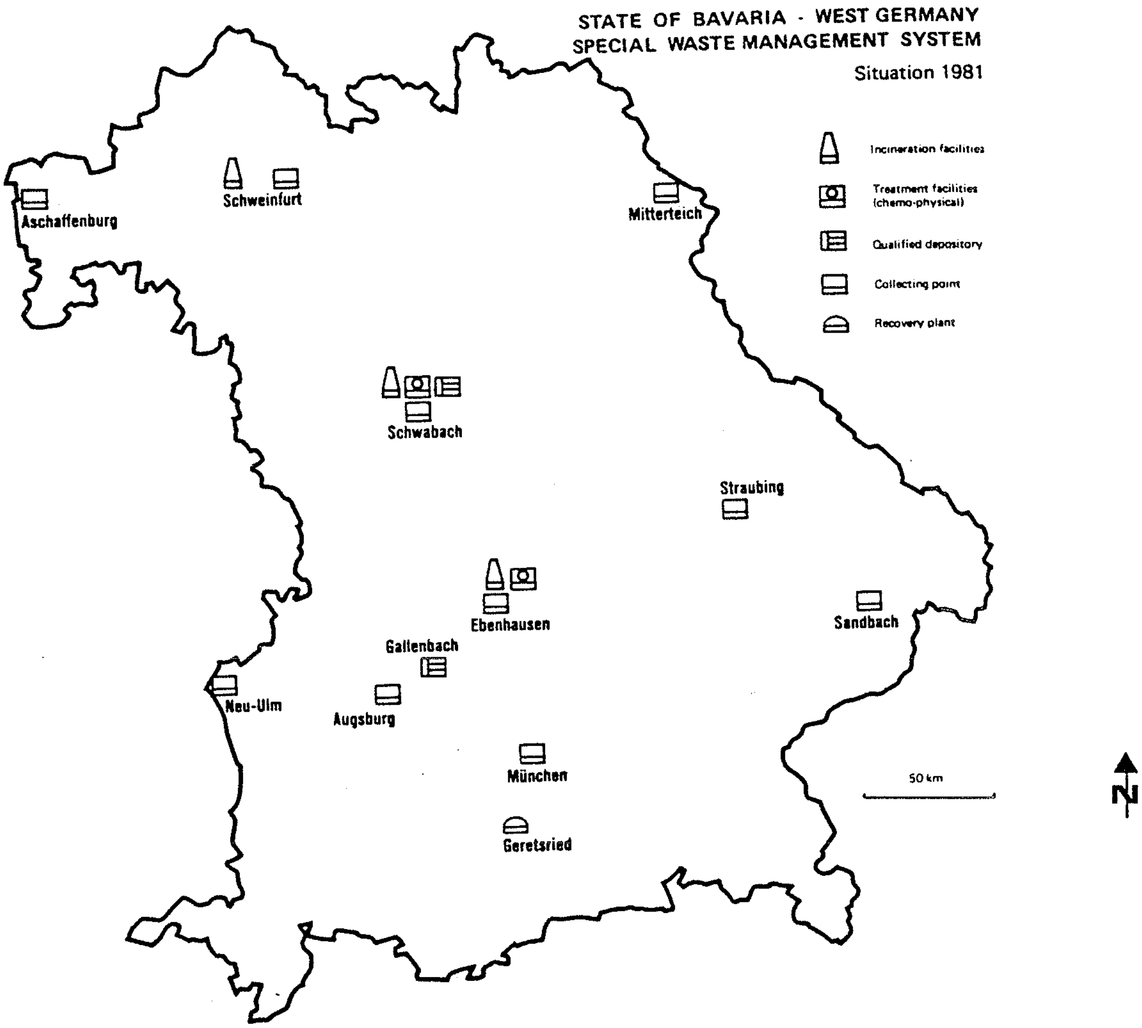


Figure 1. Hazardous Waste Management System in Bavaria

are not accepted by any of the existing institutions such as hospitals, private shredder plants, processing plants for carcasses, central deposits for nuclear residues, etc." (GSB 1983). In West Germany The Waste Disposal Act (1977) created 3 categories of individual waste:

1. Group 1: Waste which may be dumped, provided that certain precautions be taken to avoid contamination of soil, water and air.

2. Group 2: Waste of organic origin which can be incinerated with or without pretreatment. The combustion gases must be cleaned from dust and harmful gases.

3. Group 3: Waste of organic and inorganic nature may be dumped only after chemical or physical pretreatment.

GSB was established in 1970 as a co-operative with the shareholders being the Bavarian State (78%), 3 municipal organizations (8%), and 56 industrial companies (14%) (Defregger, 1981). GSB'S task is to provide and operate the facilities necessary for the treatment of special waste and for the recovery of raw materials from hazardous wastes generated in Bavaria. It is a public service non-profit company.

The biggest and most modern of the Bavarian hazardous waste facilities is the facility Ebenhausen/Gallenbach which was started up in 1976 on a 4-hectare site in Ebenhausen near Ingolstadt and a 17-hectare landfill in Gallenbach 40 km away (no suitable site was available next to the treatment plant).

The Ebenhausen plant is a fully integrated facility and comprises three areas. The "General Part" with a building for offices, laboratory, personnel rooms, cafeteria, weigh scales for trucks, workshops, stores and garages. The "Chemical-Physical Treatment Plant" for inorganic substances like used acids, alkalies, galvanizing and other inorganic sludges and solutions containing chrome, cyanides, nitrites and heavy metals. After treatment, the sludges are dewatered and the effluents are discharged into the river, whereas the solids from the dewatering are either fed to the incineration plant or land-filled. In the "Incineration Plant" all those substances which contain organic matter are burnt and are pretreated or not, depending on their nature.

Prior to the treatment, waste samples are taken and analysed by the laboratory to determine the type and sequences of processes to be applied. Wastes are delivered to Ebenhausen by 40 to 60 trucks per day. About 40% of the waste trucks come from GSB collection stations and the remaining 60% is delivered directly from the plants where the wastes are generated. The laboratory check ensures that the waste identification given by the supplier is correct. After the delivered wastes are weighed, checked and classified, they are discharged to the appropriate pit or tank, depending on the treatment process required.

The landfill site in Gallenbach comprises 17 hectares and is located on a 8-18m thick clay-loam layer. This layer prevents contaminated water and other liquids from soaking through to the deeper ground-water level. Sand, gravel and moraine deposits above this layer must be removed as extensions for further landfilling become necessary. Gallenbach has a capacity of approximately 1.4 million cubic metres of waste. GSB estimates that it has a 20 year life. An operational building is at the employees' disposal with office, rest and social rooms, and a test room for checking of the hazardous refuse delivered. A shed is provided for the earthmoving equipment and a weigh scale is installed as well.

The outer slopes of the landfill are grassed and planted during extension of the dumps so that the appearance of the landscape is changed for a relatively short time only. The inside of the landfill is scaled with a clay lining, a minimum of 40cm thick. Leachates are collected by means of drains with filter gravel bed down to about 2m below the floor level and are taken to a retention basin with a capacity of 3000 cubic metres, in which they are subjected to treatment. Two basins are provided for the surface water. If the water quality in these basins, once tested, is found to be satisfactory the water is discharged in the receiving stream, the Paar. Sampling pipes are installed down to the ground water level so as to allow continual monitoring of the ground water.

The GSB Ebenhausen facility provides 70 full time jobs and is the second largest employer in Ebenhausen. The company has a good public relations program, as GSB extends much effort effort to investigate complaints and to ensure problems are alleviated. A public open house is held twice yearly to familiarize residents with plant operations. Officials stated that public fear caused opposition to two proposed sites before the present location was established. Once the Ebenhausen/Gallenbach facility was in operation, public concerns were reduced because none of the anticipated problems materialized.

Chapter III

HAZARDOUS WASTE MANAGEMENT ECONOMICS

It is estimated that ninety percent of hazardous wastes are handled improperly in Manitoba (Manitoba Department of Environment 1982). The problem of mismanagement of hazardous wastes is the result of the failure of the market system to allocate the cost of proper management to the waste generators. This chapter examines the private and social costs of hazardous waste management and the economic and policy methods available to reallocate these costs to increase overall social well-being.

3.1 PRIVATE VERSUS SOCIAL COSTS

This section examines the costs that hazardous waste disposal presents to both the waste generator and society. Social costs are those costs which society must absorb because of improper disposal in terms of its health, economy, or environment, or in terms of financial costs paid in the forms of subsidies or for government enforcement of regulations. Private costs may be defined as those costs which waste generators must pay for the proper disposal of hazardous wastes and/or the costs that will accrue to them because of improper disposal.

It is a fundamental principle of economic theory that the free operation of perfectly competitive markets will lead to an efficient allocation of resources in the absence of externalities. The problem is that neither environmental quality nor the pollution that degrades it, is currently included in the market system. Any firm or individual may discharge wastes into the air, water, or soil without payment, subject only to existing pollution control legislation.

In a competitive market economy firms trying to maximize profits will seek to reduce their overall production costs as much as possible. The generators of hazardous wastes are aware of the potential implications of improper storage and disposal. These wastes have been improperly handled because of the economic costs associated with the safe disposal. In the absence of strict legislation, regulations, or disposal fees, generators will dispose of their non-economic output cheaply and efficiently (in their perspective) through discharge into surface waters or sewers, burial in municipal landfill sites, or incineration with little concern for air pollution control.

Economic studies define a solution to the environmental problem in terms of a single criterion: maximizing social welfare or, as it is sometimes referred, social efficiency. Social efficiency means achieving a pollution control level such that any further control would impose abatement costs greater than the savings in pollution damage or welfare benefits that would result. If it is not possible to define a social welfare (well-being) function, then the objective can be stated in terms of Pareto efficiency. Pareto efficiency requires pollution control until the point at which no person could be made better off by more or less pollution without making others worse off. Maximizing social efficiency, may in some cases, reduce to determining policies which minimize the risk of serious environmental harm at a resonable cost.

Social welfare will be improved if a polluter is compelled to reduce polluting activity below the amount that would occur in a perfectly competitive private market. The polluter should produce at the point where the sales price equals the marginal social cost of an additional unit of output. One way to achieve this result, would be to force the firm to pay for the damage caused by its pollution. If this external effect is recognized in a market transaction, then private profit maximization will require establishing output such that the price equals the marginal cost of production plus the marginal damage that must be compensated. Levying a tax schedule upon the producer equal to his marginal damage, will automatically bring his production into a welfare maximizing position. If the polluter is faced with a price for his pollution output, he is then free to choose between reducing output and installing pollution controls to maximize his own profits. It is clear, however, that the government must act to impose a tax if this welfare maximizing state is to be achieved.

Environmental problems will arise in the absence of government administration of a hazardous waste management system. These problems will consist of pollution levels greater than would be socially desirable. Because the generator of hazardous wastes does not pay for the use of the environment, the firm's production costs will be less than the real costs of its production to society as a whole. The external costs of industries improper disposal methods (or externalities), are borne by society, creating a divergence between private and social costs, and market failure. Under these circumstances the waste generator has no incentive to make more efficient use of the environmental resources by disposing of his hazardous wastes properly.

A variety of economic solutions to this type of market deficiency have been suggested (creation of property rights, establishment of market prices, effluent charges) in the past in response to other forms of pollution. However, owing to the special nature of hazardous wastes, these solutions may not be applicable to the case in question.

3.2 THE SPECIAL NATURE OF HAZARDOUS WASTES

The economics of hazardous waste management are special and unusual. This is because the overriding criterion is safety. Hazardous wastes must be transported safely, stored safely, and disposed of safely. This makes the traditional approaches to the analysis of pollution control inappropriate and comprehensive cost-benefit or risk-benefit analysis unfeasible. The public perception is that the need to protect human health and the environment from hazardous wastes, far outweighs the financial costs of building facilities, controlling them, or legislating against the production of specific toxic materials. Given the nature of hazardous wastes and the interest shared by the general public, industry, and the federal and provincial governments in the management of these wastes, improper disposal is no longer an option to be considered.

Polls conducted by Robert Cameron Mitchell of Resources for the Future conclude that 86% of those surveyed identified hazardous waste disposal as an issue which worried them greatly (Darmstadter 1983). The public has come to demand the safe disposal of hazardous wastes. It is only within the constraints of safety that we can begin to explore ways of handling hazardous wastes with the greatest economy. The economic question is not 'What is the socially optimal balance between safe disposal and unsafe disposal?' but rather 'What is the socially optimal allocation of the costs of safe disposal of hazardous wastes?'

3.3 HAZARDOUS WASTES ECONOMICS

3.3.1 Costs Associated with Hazardous Waste Disposal

Given the special nature of hazardous wastes, and societal expectations for the safe management of these wastes, the question of the allocation of the costs of safe disposal can be addressed. Four types of costs are associated with hazardous waste disposal:

1. avoidance costs = costs of proper disposal

2. abatement costs = costs of removal and cleanup after improper disposal

3. compensation costs = injury costs incurred between improper disposal and cleanup

4. transaction costs = administrative and legal costs of controlling and allocating the costs of hazardous wastes. (Harvard Law Review 94 1981).

The allocation of the costs of waste disposal should be to minimize the sum of these four costs in order to maximize social welfare.

In the long run the most economic and socially optimal method of hazardous waste management is safe disposal. Examples indicate that the abatement costs associated with improper disposal are much higher than the estimated avoidance costs. Yet the lack of proper disposal, in pre-regulatory time, indicates that the hazardous waste generators found the actual costs of improper disposal (no treatment), plus the potential but unlikely future compensation and abatement costs, to be much less than the costs of avoidance. Various methods are available to deter unsafe disposal to decrease the social costs of hazardous waste disposal.

3.3.2 Economic Incentives for Reducing Unsafe Disposal

The focus of this section is on the economic aspects of dealing with the external costs of hazardous waste disposal. A variety of economic programs can be brought to bear on members of industry to encourage safe disposal of generated wastes. Some possible means of government intervention - effluent charges, incentive payments, enforcement of quality standards and disposal fees - are considered in this section.

3.3.2.1 Tax-Subsidy Solutions

Economists have long held the belief that in a Pareto-relevant external diseconomy situation, a negative price would be placed by a government agency upon the external diseconomy. An external diseconomy, such as hazardous waste discharge, can be counteracted by levying a tax upon the acting party in direct proportion to the amount of diseconomy that is created. Alternatively, the desired baseline level of hazardous waste generation could be calculated and the government could subsidize the acting party for reductions in the level of waste discharge. Tax-subsidy solutions leave substantial discretion to hazardous waste generators to determine and implement the least-cost method of pollution abatement. Each waste generator may choose how much abatement to provide, subject always to the constraint that taxes must be paid. Figures 2 and 3 respectively show the effects of both a flat rate and variable effluent tax on unabated pollution (ie unmanaged hazardous waste). Effluent taxes generate revenues for the government which will reduce the public costs for the management of hazardous wastes. These taxes provide a continuing incentive for improved abatement performance through waste reduction technology.

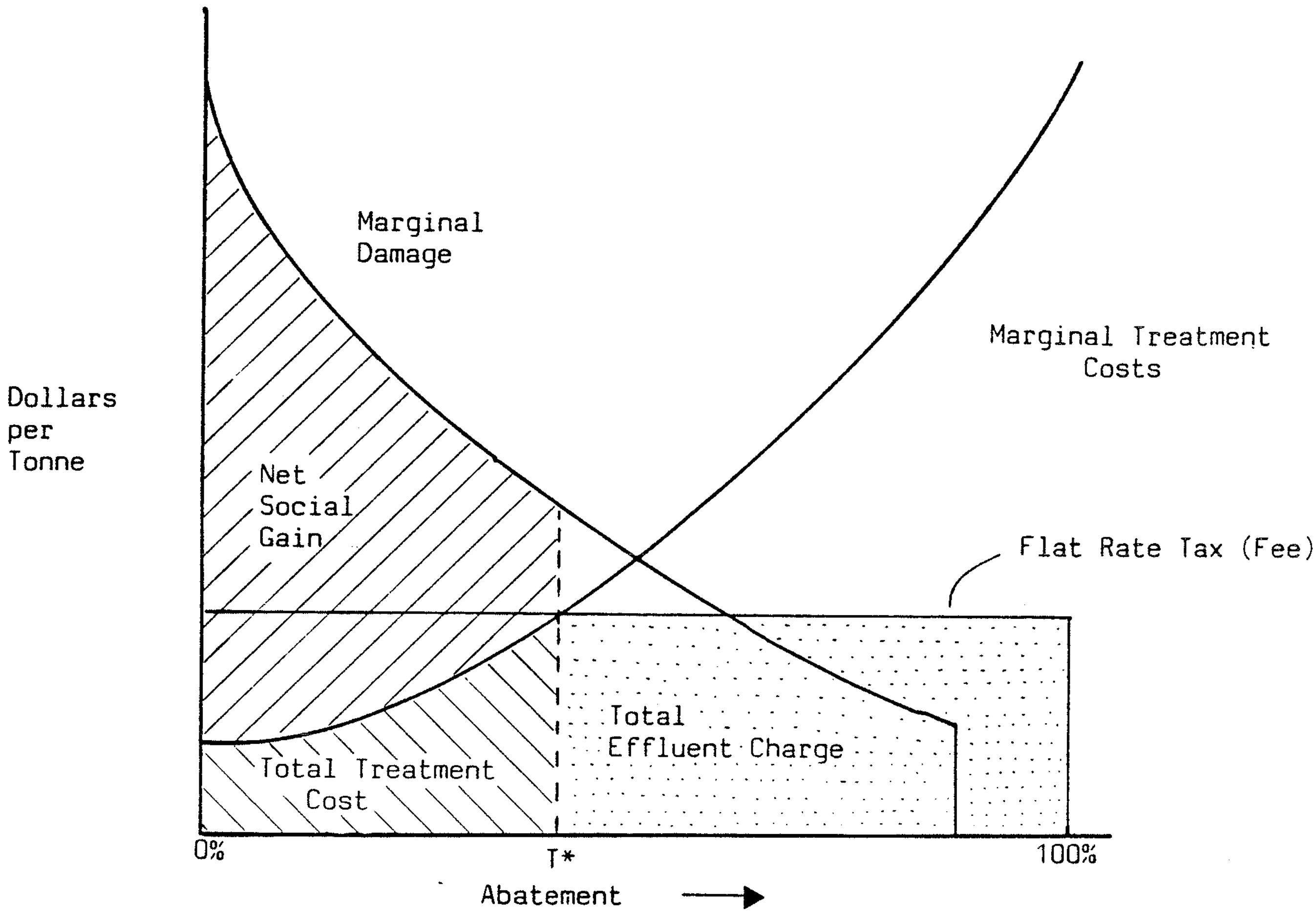


Figure 2. **Flat Rate Marginal Effluent Tax (Disposal Fee)**

Firm is charged only for the wastes it does not treat (or a flat fee related to firms size and the nature of the waste).

T* - least cost point for firm.

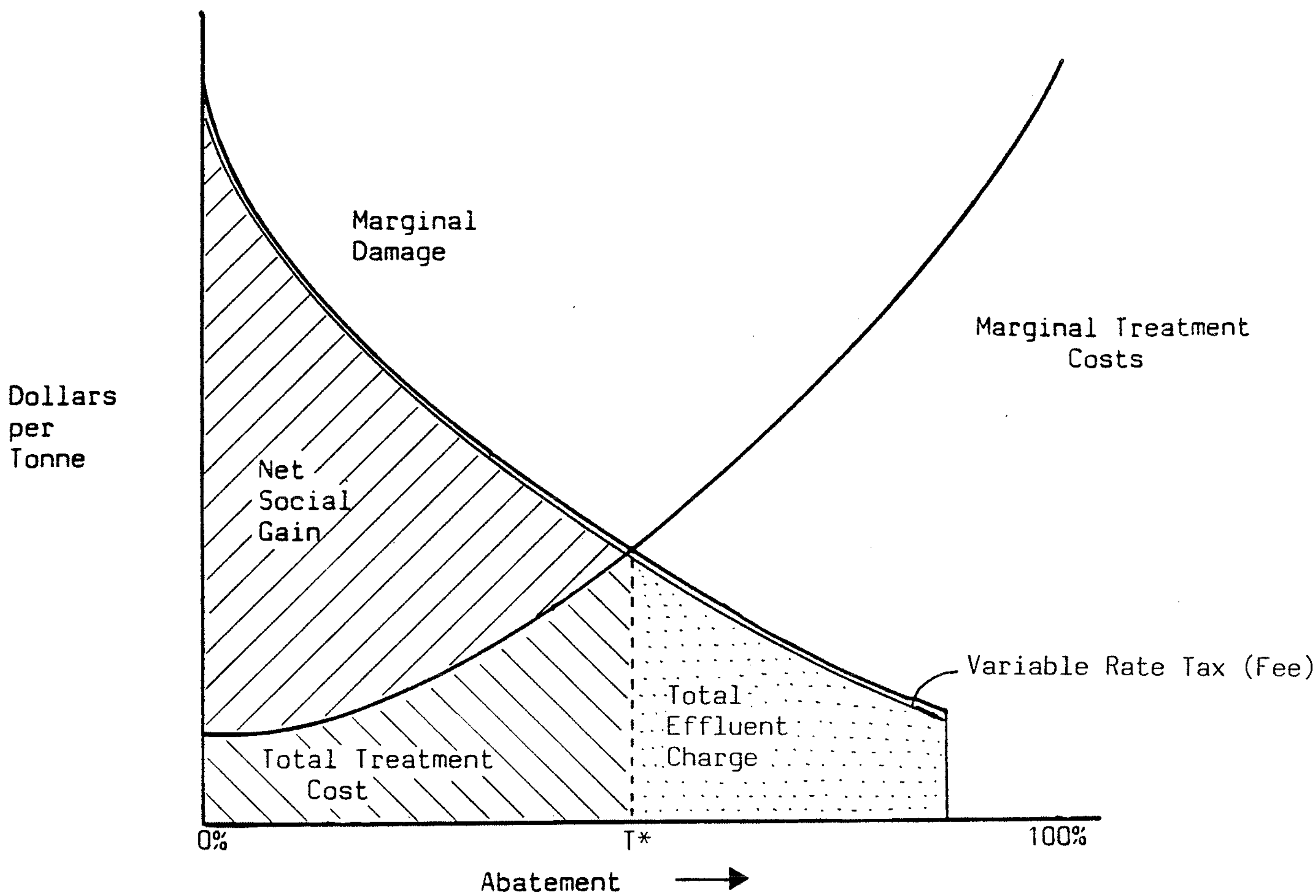


Figure 3. Variable Rate Marginal Effluent Tax (Disposal Fee)

Firm is charged fully for the damage imposed on others (or for the full costs of disposal).

T* - least cost point for firm.

3.3.2.2 Government Regulations

An alternative approach to the problem of external diseconomy is for the government agency to directly regulate the quantity of external diseconomy that will be permitted. The creation of government regulations for the handling and disposal of hazardous wastes and the establishment of penalties for unsafe disposal, may provide the economic incentive necessary to make firms pay avoidance costs. Penalties may take various forms: fines per unit of emission beyond the standard, fines for each day the standard is exceeded, lump-sum fines, or jail terms for violaters. Figure 4 illustrates how government regulations or standards affect hazardous waste disposal. For regulations to be effective, the fines must be large enough to exceed the treatment costs, so that the generator will be interested in disposing of his wastes safely. The transaction costs of enforcing such a regulatory system may be very high compared to the benefits (Harvard Law Review 94 1981). Without strict government enforcement there will be strong economic incentive for improper disposal.

3.3.2.3 Disposal Fees

A third alternative would be a disposal fee system that would be used to establish a non-profit government run disposal facility. Through mandatory licensing of all waste generators, a flat fee could be imposed which would be related to the size of firm and the nature of waste. This fee

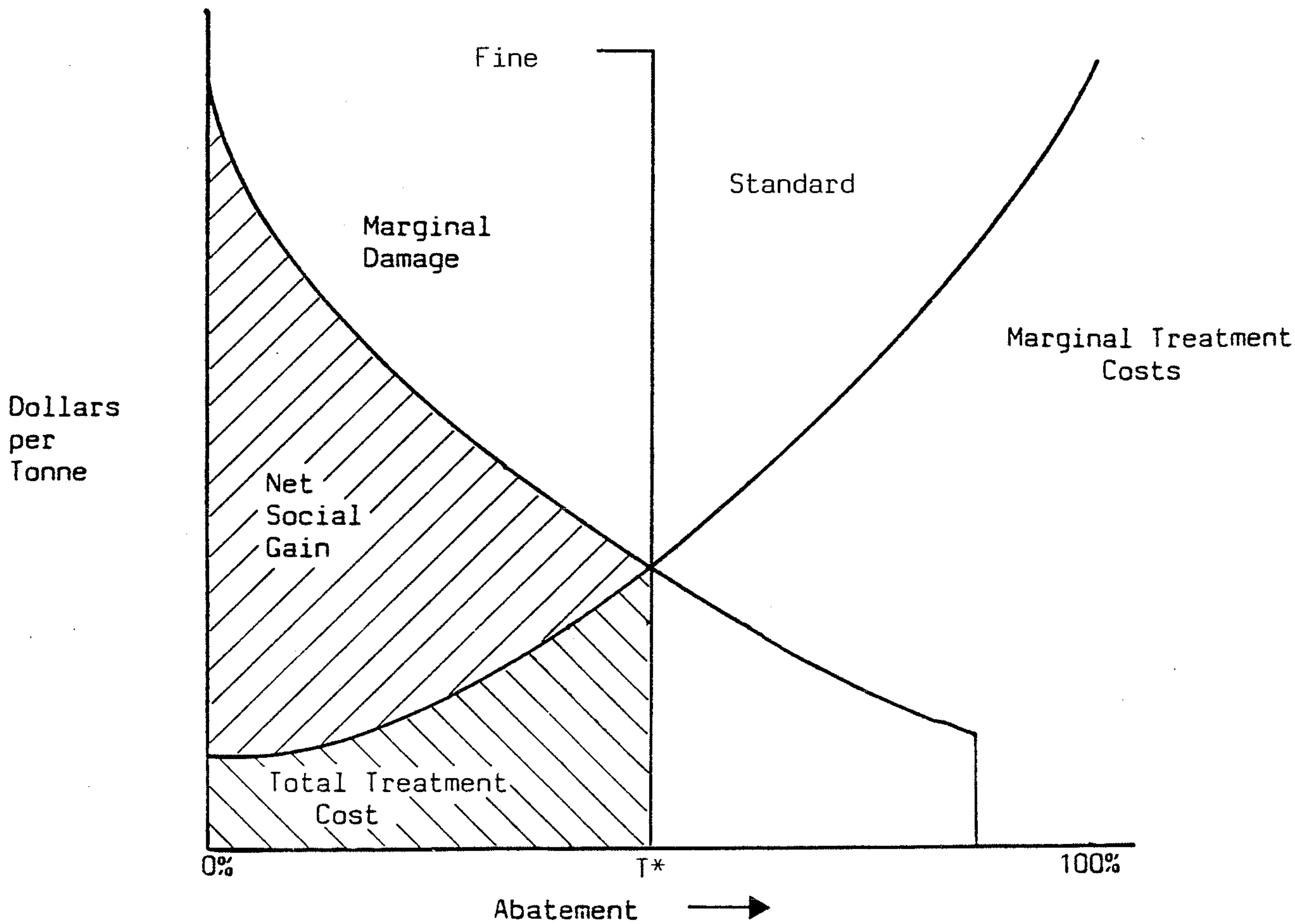


Figure 4. **Effluent Regulations or Standards**

The government regulates the amount of abatement that the firm must provide. The fine must be large enough to exceed the treatment costs to be effective.

T* - least cost point for firm.

would not be closely associated with the exact volume of waste generated, so that there would be no incentive for generators to hide wastes (via dumping) (Harvard Law Review 94 1981). A system of this nature eliminates incentives to firms to lower their production of hazardous wastes, but it also eliminates the high external costs of improper disposal. Figures 2 and 3 also illustrate the effects of both a flat rate and variable rate disposal fee on hazardous waste disposal. The figures represent the lowest cost to the firm. Ideally, a variable rate disposal fee would charge firms for the full costs of disposal; however, it is very costly and difficult to obtain the information that is necessary to charge firms correctly.

3.3.3 External Costs

Transportation is a major cost in the disposal of hazardous wastes and is sensitive to the number and the location of the waste treatment sites. In economic terms, there is generally a trade-off between plant economies of scale and transportation costs in the treatment of hazardous wastes. The construction of several small scale plants would reduce the the transportation costs and risk, because of shorter hauling distances. The construction of small plants sharply increases the capital expenditure, and total system operating costs will rise if transportation cost savings are insufficient to offset the lost economies of scale.

The amount of hazardous wastes that require transportation to an off-site disposal facility is dependent on economic costs. If the tariffs charged at a central treatment facility, combined with the transport costs, result in very high costs, two things may happen. Waste generators may develop on-site facilities or they may resort to dumping. Should the tariffs on the other hand be low, firms with the ability and liabilities to dispose on-site may find it economical to use the central facility. Consequently, the off-site disposal facility would have to treat a much greater volume of waste.

The volume of hazardous wastes that require off-site treatment will be strongly affected by changing technology. Waste products today could be recycleable tomorrow or they may be eliminated or reduced through advances in technology. Advances in technology may also alter the economics of on-site disposal. More firms may choose to process and dispose of their own hazardous wastes if the economic conditions are suitable. Technologic advancements add another uncertainty in the estimation of the volumes of hazardous wastes that will require disposal in the future.

3.3.4 Reducing Hazardous Wastes

As government regulations concerning disposal of hazardous wastes are enforced, and the penalties for improper disposal become severe, hazardous waste reduction through recovery, recycling, or exchange will become more economically attractive to waste generators. There are other benefits as well. Waste generators that recycle, or exchange, do not have to worry about future abatement and compensation costs. Valuable resources can be recovered and reused, and firms can reduce dependence on increasingly scarce and expensive raw materials.

According to the United States Environmental Protection Agency, only 3 to 5 percent of hazardous wastes are currently subject to resource recovery. Companies specializing in the marketing of resource recovery techniques suggest up to 80 percent of present hazardous wastes could be recycled (Rams & Simcoe 1981). Those areas identified as having the greatest potential for recovery, include energy and materials recovery from concentrated organic liquid waste, and the recovery of metals from industrial sludges and metal plating wastes.

In the United States and, to a lesser extent, in Canada, the idea of exchanging wastes among industries is being promoted. A waste exchange is an agency established to reduce the amount of waste generated by industry. What may be useless waste to one industry may be a useful raw material to another; a waste exchange helps industry both to dispose of unwanted waste through sale to another industry and to acquire certain raw materials derived from wastes generated by other industries. In short, a waste exchange benefits industry through reduced costs and reduction of the quantity of wastes generated.

The Canadian Waste Materials Exchange (CWME) is such an agency which has operated since 1978. Funded by government and industry, CWME publishes quarterly reports listing wastes wanted and wastes available according to ten different categories of waste. Those wastes most likely to be exchanged are acids, catalysts, solvents, combustibles, residues with high metal content, and spent oil (Durso-Hughes & Lewis 1982). Although this represents only a small portion of the total hazardous wastes produced, by exchanging these wastes, the total disposal needs for hazardous wastes is reduced.

3.3.5 Paying For Past Disposal Problems

The costs of past improper disposal are often borne by society because legal action is not possible when the firm responsible cannot be identified or when it is protected from assuming liability. To eleviate some of the burden of these abatement and compensation costs, U.S. state and federal governments have legislated funds which are supported with fees paid by hazardous waste generators.

The most prominent of these is the United States 'Superfund' established under the Comprehensive Environmental Response, Compensation, and Liability Act. Superfund, enacted in December, 1980, sought to create a $1.6 billion trust fund over a five year period starting in 1981, to provide for emergency and long-term cleanup of chemical spills and abandoned hazardous waste sites. Superfund receives 87%

of its funding from taxes on oil and on 42 specific chemical compounds. The remaining 13% comes from general tax revenues (EPA Journal 1981).

Fee payments are ineffective in the deterrence of improper hazardous waste disposal, because these payments are not related to a firm's disposal practices. If the fees were imposed on the basis of the volume of hazardous wastes generated, there would be increased proper disposal of hazardous wastes. The main contribution of these funds to minimization of total social costs, is their ability to provide abatement and compensation costs with lower transaction costs than through legal channels.

3.4 SUMMARY

Given the potential threat that the improper disposal of hazardous wastes presents to human health and the environment, improper disposal is no longer an option for society to consider. The problem is compounded by the fact that the hazardous waste problem will not go away. As industries continue to grow, so may the volumes of hazardous wastes that will require management. Some hazardous wastes are by their nature bio-accumulative and non-degradeable, so they will remain in the environment for a long time. As technology advances, new chemicals and new processes will add to the growing list of known hazardous wastes. These wastes will have to be adopted into the management system. As awareness of the problem increases, more cases of improper disposal will be discovered and which will require attention.

From society's point of view, avoidance costs associated with proper disposal techniques are still much less than the abatement and compensation costs associated with improper disposal. However, the increasing costs of proper disposal in landfill sites, and by other more secure methods are beginning to create incentives for firms to reduce the amount of hazardous waste they produce. Recovery, recycling, and exchange will help to lessen the potential social costs of hazardous waste disposal by reducing wastes, and hence, the problem.

Chapter IV

THE FUTURE OF HAZARDOUS WASTE MANAGEMENT IN MANITOBA

Manitoba must develop a diversified management approach for dealing with provincially generated hazardous wastes. This chapter examines hazardous waste disposal trends in the province and proposes improvements to the present system. Chapter IV begins by considering the criteria essential to ensure environmental and societal acceptability for the siting of management facilities. The Hazardous Waste Information Exchange's data base was compiled to accurately portray the present hazardous waste disposal and generation trends in the Province. A constraint mapping exercise makes use of the criteria and the information base to develop a series of map overlays to screen out unacceptable areas in the southern Manitoba study area. Finally, the chapter concludes by applying the information contained in this report to present a hazardous waste management plan for the Province of Manitoba.

4.1 SITING CRITERIA

Of primary importance to a hazardous waste management system is the siting of collection, treatment, storage and disposal facilities. This section explores the options available for the siting of management facilities.

4.1.1 Facility Requirements

How the facility components might be geographically distributed is a critical issue to be considered in the process of selecting sites. The essential components of a waste management system - collection stations, incineration and physical/chemical treatment facilities, and landfills - need not necessarily be located at the same site. A central consideration is whether these technologies can or should be located at one site (a centralized facility), where all the siting requirements for each technology can be found; or on more than one site (a decentralized facility) with the technologies appropriately allocated to several locations.

The centralized system would support treatment and storage facilities and a secure landfill at the same site, which would be supported by regional collection stations. Collection stations store and assemble for trans-shipment hazardous wastes from local industries. Where economically feasible for specifically large volume wastes, a degree of pre-treatment at a collection station would reduce the waste volume requiring transport to the central facility. A centralized facility must satisfy several exacting conditions:

the facility must meet demanding environmental standards for a secure landfill and/or the facility must have access to a sewage system with adequate capacity for reduction of toxicity; the facility should be located as close as possible to major waste generation areas; the facility must have atmospheric conditions suitable for dispersal of incinerator flue gases; and the facilty would require more land than any individual site in a decentralized system (OWMC Phase 1 Report 1982). However, a centralized facility may result in lower capital and operating costs than a decentralized system.

A decentralized system may contain many possible siting variations and could incorporate regional collection facilities. Possible combinations of a decentralized system may include: dispersed facilities with the engineered landfill, the physical/chemical treatment plant and the incinerator each located at separate sites; and partially dispersed facilities with two of the three treatment and disposal components located at one site with the other located at another site. The number of components that may be located on one site is dependent upon the conditions each site possesses.

4.1.2 Factors Affecting Location

The assessment of system options must include several siting factors - social, environmental, economic, technical and engineering - and each must be studied thoroughly before a preferred system can be selected (OWMC Phase 1 Report

1982). This section highlights some of the criteria that must be considered when determining potential sites for hazardous waste management facilities. Site criteria are used to select potential facility sites and to compare potential sites.

Criteria for selecting sites for collection, treatment and disposal of hazardous wastes are defined under five main considerations: physical and biological, transportation, landuse, socio-economic and technical/financial.

4.1.2.1 Physical and Biological

Stability and permeability of the earth's surface are of prime importance in the determination of siting for any waste handling facility. The nature of a hazardous waste management facility dictates selection of a site which offers maximum natural protection of the subsurface against accidents, construction faults or other means by which contaminants may escape containment (Moell 1982). For this reason, natural surficial deposits beneath such a facility must be capable of providing a first line of defence against groundwater contamination. Surficial materials best suited to a waste management site are fine-textured lacustrine deposits or glacial till exhibiting textures classified as clay loam or finer. The materials should be greater than 15 metres thick, and should exhibit an in-situ hydraulic conductivity (permeability) of 10^{-6} cm/sec or less (Moell 1982).

Steep slopes may be subject to slumping and erosion, especially if vegetation is removed. For this reason, areas with steep topography would not be desirable. A relatively level topography is preferred for ease of construction and for safety purposes.

Drainage must also be considered to prevent contamination of surface waters. All surface water must be ruled out and the beaches, backshores and adjacent lands along lakes and river corridors must be protected, as existing vegetation is essential for the environmental quality of the waterbodies. Areas subject to flooding must also be avoided since a flood would release contaminants to surface waters.

Areas containing wetlands must also be avoided. These areas may require remedial drainage and/or excavation and filling for the construction of facilities. More importantly, wetlands serve a natural function of regulating stream flow and have biological importance in that they support aquatic life and vegetation on which wildlife and migratory waterfowl depend.

The siting of treatment facilities must take into consideration meteorological trends within the study area. For example, incinerators must be located in an area that ensures optimal dispersion of scrubbed gases from the incinerator stacks.

Finally, consideration must be given to eliminate environmentally significant areas from the site selection process. These areas are commonly referred to as Significant

Environmental Units (SEU's). SEU's may contain populations of rare or uncommon plants animals, or waterfowl; have specific unique ecological communities; or represent significant geological formations.

4.1.2.2 Transportation

To minimize the costs and risks associated with waste transportation, the waste management facilities should be located as close to major waste generation areas as possible. Facilities must have year round rail and road access. It is desirable to use the existing provincial highway system to provide the major access to the facility components. The accident rates for provincial highways tend to be lower than for local roads. Transportation considerations are key factors in determining the network of collection stations and must be considered for treatment facilities to ensure low risk to the public from the accidental release of transported wastes.

4.1.2.3 Land Use

To prevent development of incompatible land use patterns and to protect environmentally sensitive areas, management facilities should not be sited within urban residential areas or on prime agricultural land. Highly productive soils within a favorable climate for producing agricultural crops are in short supply in Canada (OWMC Phase 1 Report 1984). The loss of such land to non-agricultural uses limits future food production potential and local agricultural economies. In some cases, however, it becomes necessary to locate a facility on prime or near-prime agricultural land when no suitable lower class land exists. In Bavaria, for example, an Alberta Hazardous Waste Management Committee group touring the GSB Facility noted that farmers with land adjacent to the facility had suffered no ill effects as a result of the plant's operation (Alberta Hazardous Waste Management Committee 1980).

Non-SEU Woodlots that are greater than 20 hectares may have value as a forestry or recreational resource or provide wildlife habitat and as such should be avoided. Other lands which have potential for resource development, such as sand and gravel extraction, must be identified during the siting process.

Finally, consideration and respect must be given for present land use patterns and plans. Ideally, treatment facilities should be sited on industrially designated land. This eases the problem associated with zoning changes. Next in preference would be publically owned land, as it escapes the potential difficulties that may be associated with acquiring or managing privately-owned land.

4.1.2.4 Socio-economic

There are a number of socio-economic considerations that must be addressed when the siting process is occurring. Waste treatment facilities should not be located where they would be incompatible with local land use patterns. Facilities must be located with consideration given to population characteristics, density and distribution. Land containing archaeological sites, recreational and tourist areas, must be withdrawn from further consideration. Residential areas are considered to be inappropriate for locating hazardous waste management facilities.

Areas designated as industrial lands may be suitable to siting hazardous waste facilities. Industrial areas are generally well removed from residential areas where it is anticipated that industries will create noise, some airborne emissions, rail and truck traffic etc.. Rural lands which have limited and poorer agricultural capability are potentially suitable. The use of publically owned lands would minimize impacts upon private landowners.

4.1.2.5 Technical/Financial

Finally, there are a number of technical and financial considerations which must be addressed when determining the suitability of a potential site. For a facility to function, it requires a range of services such as hydro, sewerage systems, access, etc. It would be uneconomic to locate a facility where access to such services is non-existent and/or costly to develop. Financial considerations must also be taken into account if it is necessary to acquire privately owned lands.

4.2 IS THE PRESENT SYSTEM ADEQUATE?

Shortly after Jay Cowan announced the Hazardous and Special Wastes Management Program, a Hazardous Waste Information Exchange was instituted in Manitoba. This section uses the Exchange's information base to examine present generation and disposal trends in Manitoba.

Beginning in 1983, the Hazardous Waste Information Exchange's base of information was compiled through the efforts of personnel of the Department of Environment and Workplace Safety and Health. The Department used the Manitoba Trade Directory, the Manitoba Telephone Services Yellow Pages and file records to provide a broad base sample of waste generating industries, on which to build the Information Exchange. Personnel from the Department of Environment by letter and then follow up telephone call, surveyed the 712 industries which were presumed to be generators of hazardous waste in the Province. Of these industries, 252 replied that they produced no hazardous waste, 32 replied that they were no longer in business in Manitoba and 17 industries refused to grant an interview. Personal interviews were conducted with management in the 411 companies that reported to be hazardous waste generators. The results presented in this report are based on those interviews. For simplicity, Department personnel considered a litre of volume to be equivalent to a kilogram of weight or mass. Figure 5 shows the Hazardous Waste Management Regions that are refered to for the remainder of this report. Appendix C provides a breakdown of the towns and cities included within each management region.

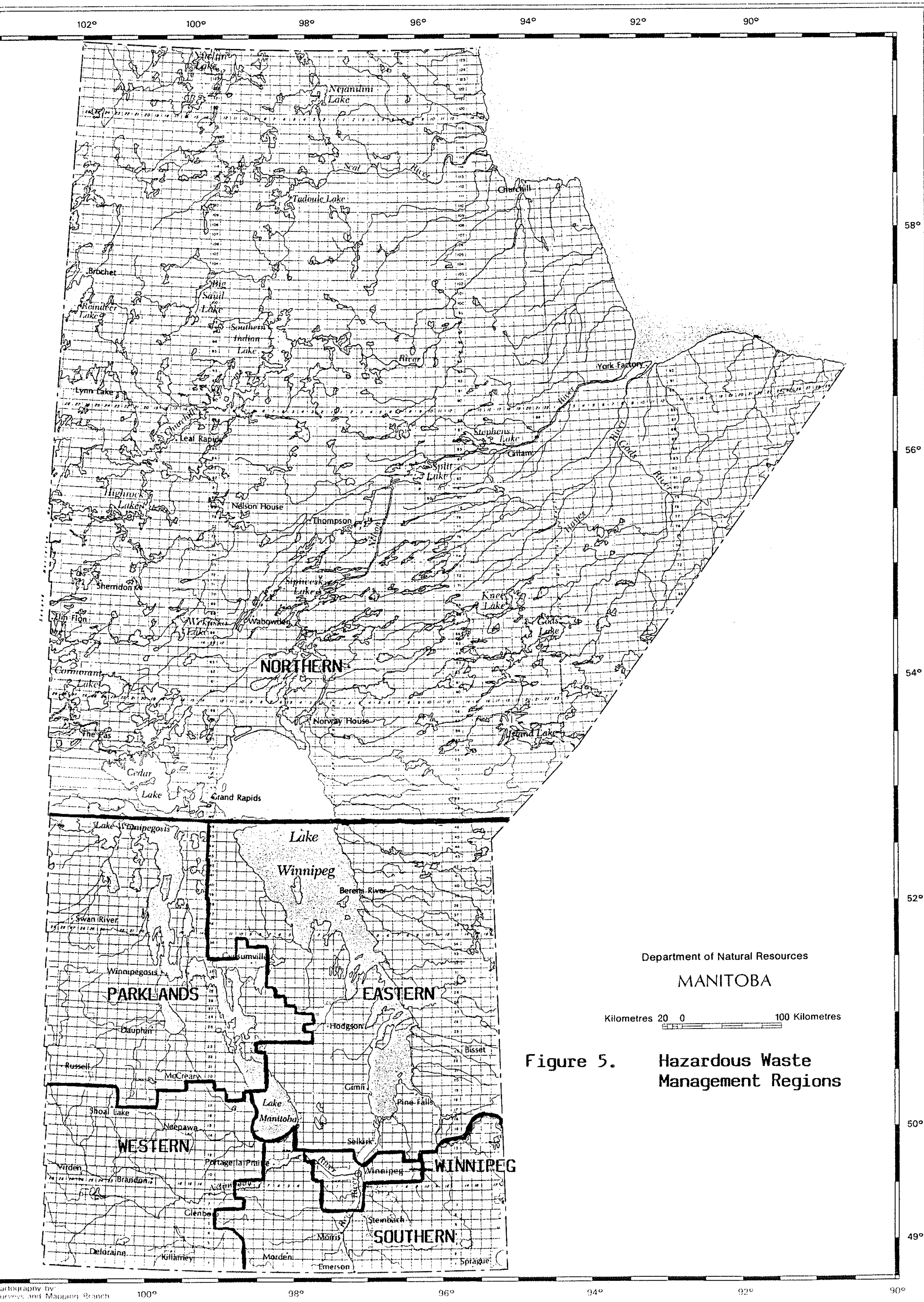


Figure 5. Hazardous Waste Management Regions

Cartography by: Surveys and Mapping Branch

4.2.1 Results

The Hazardous Waste Information Exchange has ascertained that 20,235 tonnes of hazardous wastes are generated annually in Manitoba (Appendix D, Table D-1). This quantity does not include atmospheric emissions or presently recycled hazardous wastes. Table 1 provides a graphic representation of the quantities of hazardous wastes generated in the province. Table 1 also illustrates the distribution of hazardous waste by UN class. Table 2 shows the methods of treatment/disposal which the wastes presently receive. The most common disposal method is discharge into the local sewerage system (referred to in the tables as sewering), the second preference is deposition in municipal landfills (Appendix D, Table D-2). The category labelled "other" (24.4% of the hazardous waste) includes several different treatment technologies, each of which account for a small percentage of the total. Table 3 illustrates the proportions of hazardous wastes generated by different industry types in Manitoba. Chemical-based industries generate 33% of all hazardous waste, followed by wastes from printing and from fabricated metal based industries (Appendix D, Table D-3).

Regionally, most hazardous wastes are generated in the Winnipeg area (39% of the total), followed by the Eastern, Northern and Parklands Regions (Appendix D, Table D-4 to D-9). The regional distribution of hazardous waste generation is presented in Table 4. If air emissions are considered, then 55.6% of all waste is generated in the Northern

TABLE 1. PROVINCIAL DISPOSAL QUANTITIES BY UN CLASS

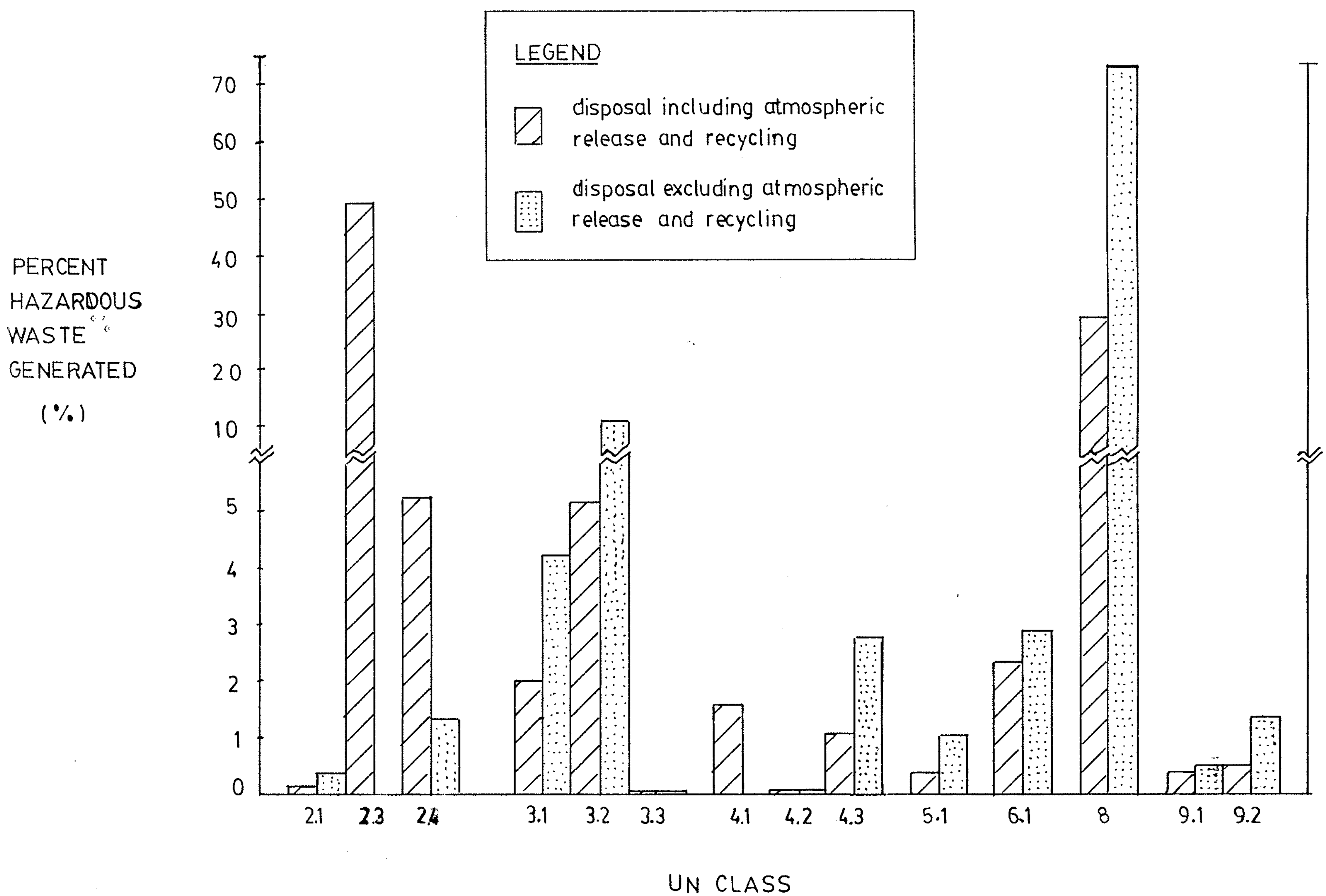


TABLE 2. PROVINCIAL DISPOSAL QUANTITIES BY DISPOSAL METHOD

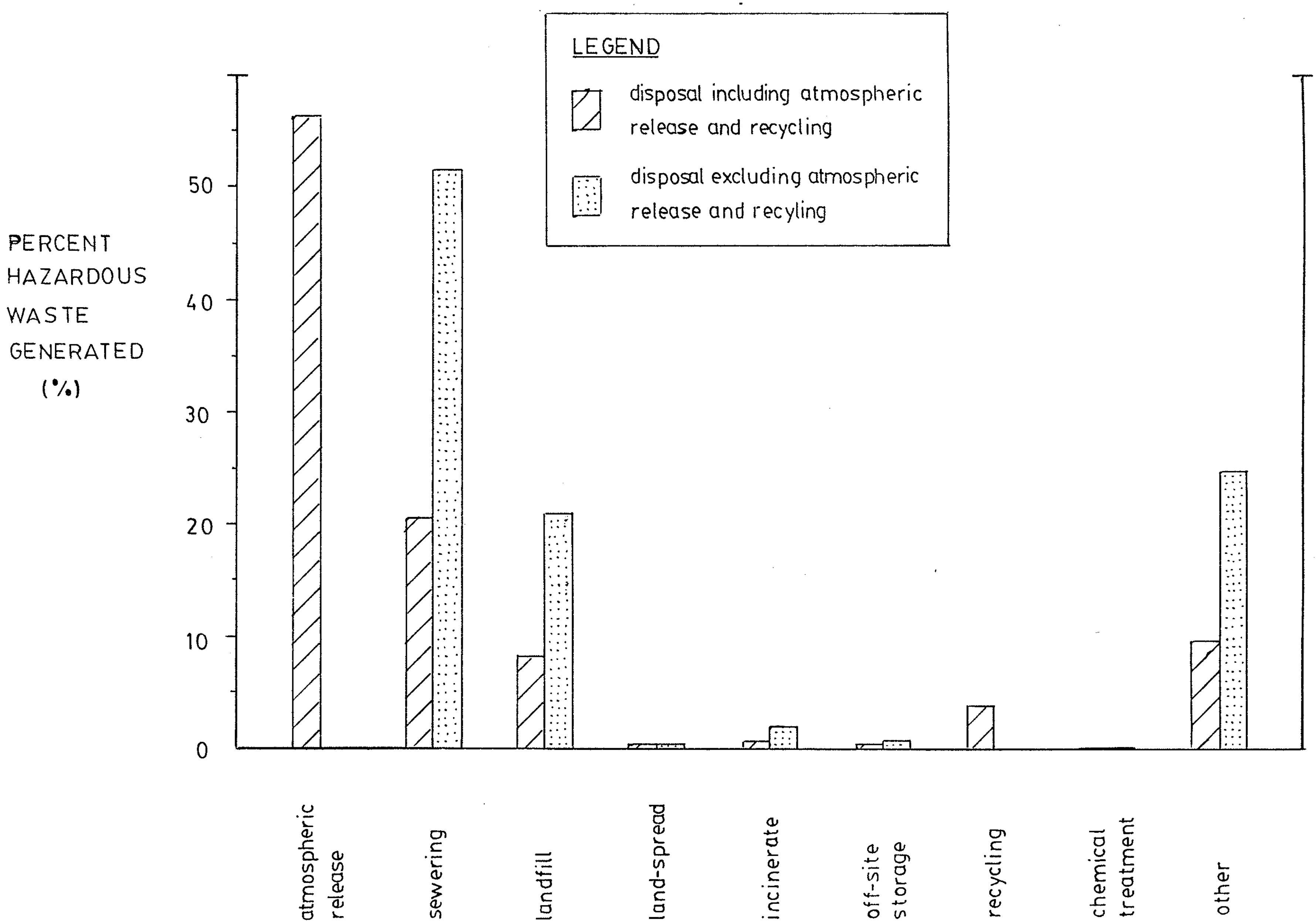


TABLE 3. PROVINCIAL DISPOSAL QUANTITIES BY INDUSTRY

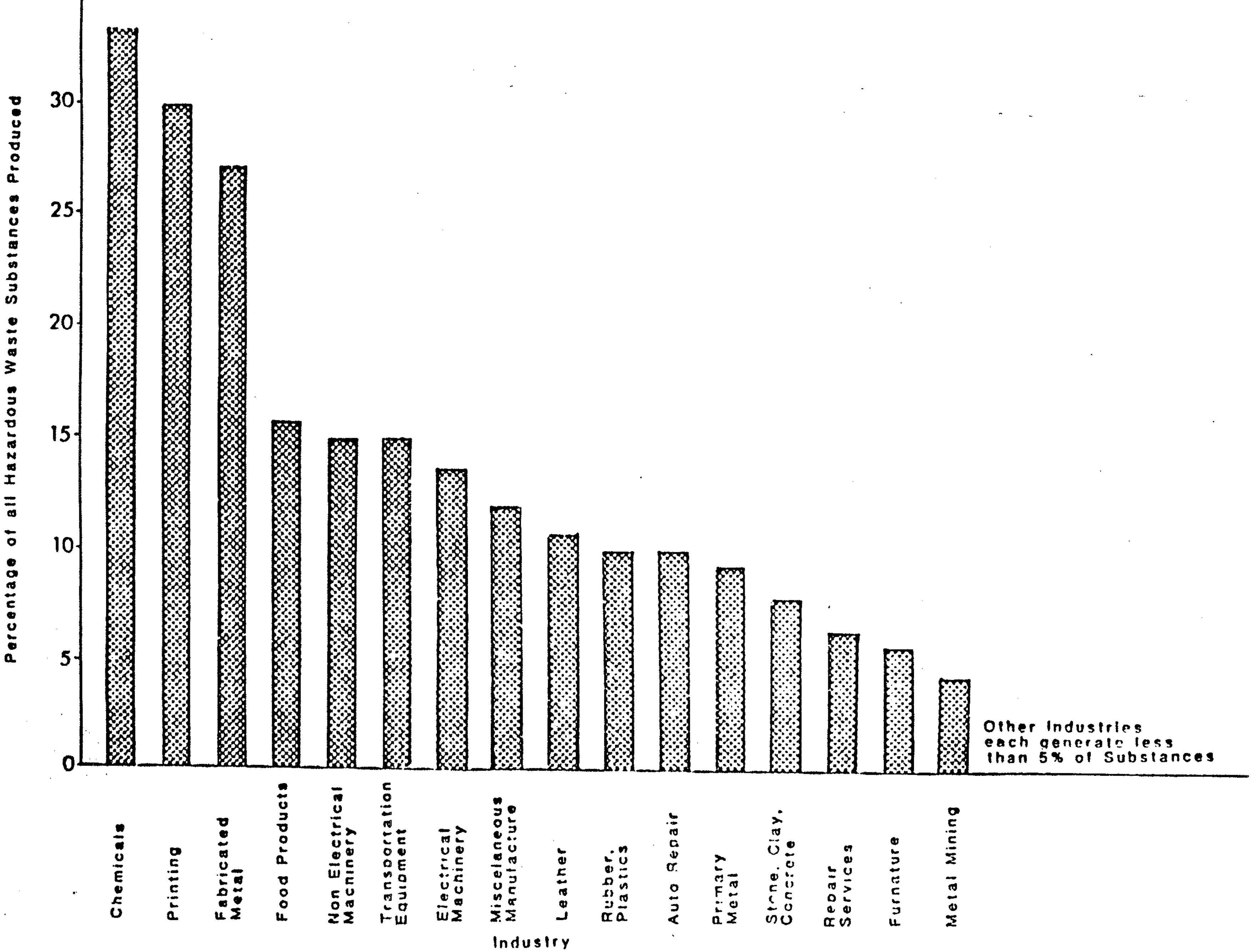
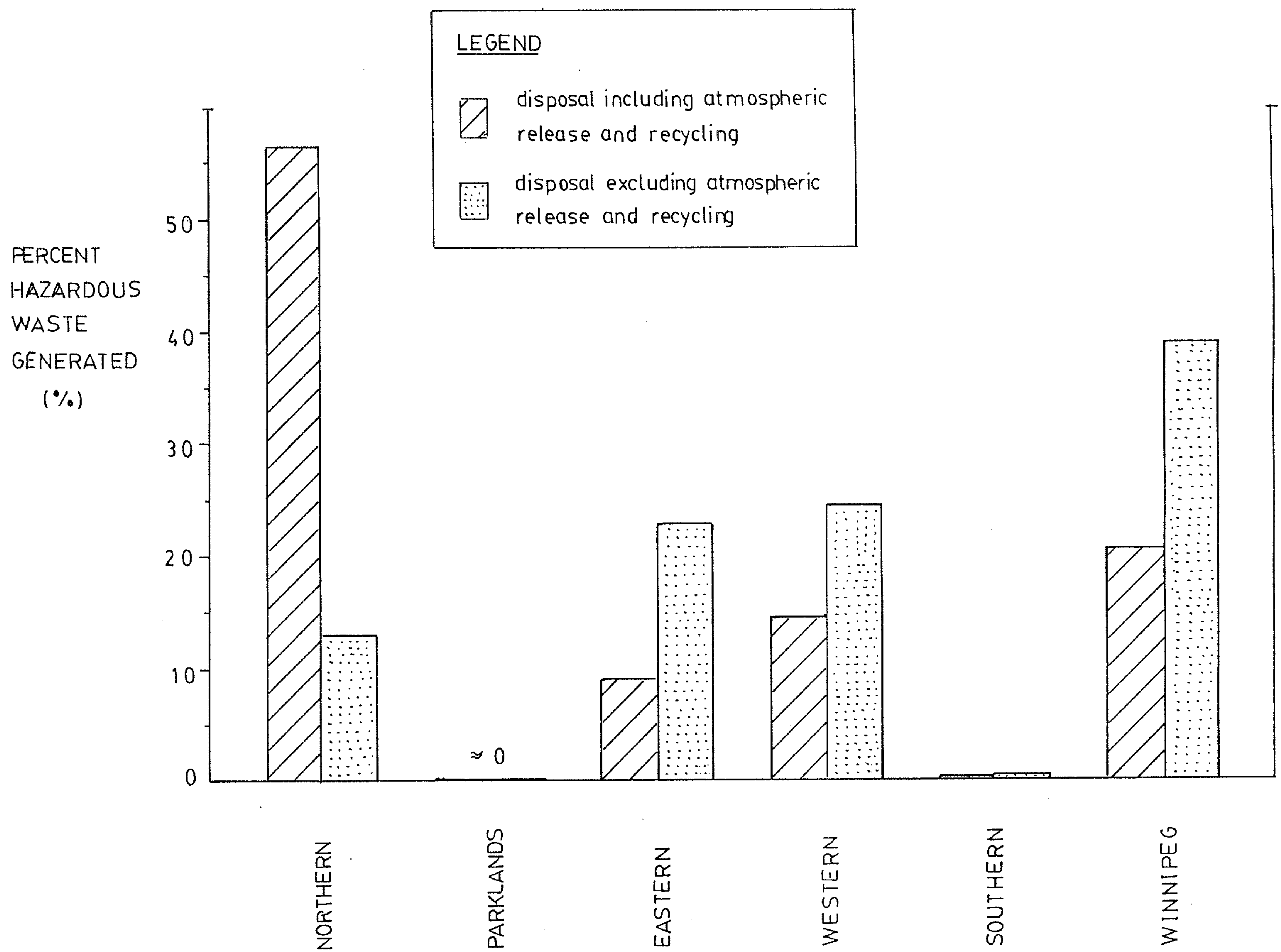


TABLE 4. REGIONAL DISTRIBUTION OF DISPOSAL QUANTITIES



Region, with air emissions accounting for 50.5% of the total (Appendix D, Table D-4 to D-15).

The primary classification of 74 percent of all generated hazardous waste (20,235 tonnes per year) is corrosives (class 8), while 16 percent are flammable liquids (class 3) (Appendix D, Table D-1). The remaining five classes account for 10 percent of the total.

4.2.2 Discussion

The results from the Hazardous Waste Information Exchange indicate that at least 20,235 tonnes of hazardous waste are generated annually in the province. If air emmissions and present recycling are also considered, the value increases dramatically to 52,261 tonnes per year. These figures compare favorably with the estimates provided by the Reid, Crowther and Partners Ltd., Wardrop and City of Winnipeg Reports. The Exchange's percentage breakdown of the quantities per region, per class, per treatment/disposal and per industry must be considered to be sufficiently accurate for the purpose of determining a management system.

The Hazardous Waste Information Exchange emphasized industrially generated hazardous waste and thus, omitted hazardous waste generated from other sources that would require handling by the future management system. Pesticide containers are one such source. Assuming 80 ml of the pesticide residue remained in the 'empty can', up to 40 tonnes per year of pesticides may be discarded and have to be handled. Another source of hazardous waste not addressed was waste oil. Approximately 4,086,000 litres of lubricating oil are generated annually in Winnipeg (City of Winnipeg, 1983). Consolidated Waste Oil Service of the Winnipeg-based Prime Motor Oils Ltd. handles 90 percent of Winnipeg waste oil. The waste oil is recycled and sold as either a cheaper fuel for lime and cement kilns, or is used for dust control on rural roads.

Table 2 shows that over one-half (51.6%) of all wastes amenable to a management system enter local sewage systems as effluent discharge. If such practices are permitted to continue, they will be at the expense of future public and environmental health. The economics of treating hazardous wastes in diluted form is cost prohibitive. Sophisticated teatment technology is required to remove toxic chemicals during effluent treatment, and because of the high costs involved this becomes uneconomical. Present sewage treatment technology is unable to remove toxic substances from the effluent. Hazardous wastes which are presently discharged into the local sewage system should be stored on-site and then be collected for treatment at an appropriate hazardous waste treatment facility.

Table 2 also shows that over one fifth (21.1%) of all hazardous wastes are presently disposed of in landfills. Permanent landfilling ranks very low on the list of desireable management options. At the present time, there are economic and technologic constraints which prevent the elimination of inground waste disposal. The utilization of an appropriate treatment, storage and disposal facility would reduce the quantity and nature of hazardous wastes that are presently landfilled by municipalities. An appropriate management system must be designed to accommodate the short-term storage of hazardous waste until such time as an efficient and economic means of treatment are developed.

This discussion could be extended to cover all other methods of treatment and disposal which are presently employed in the province. It is clear, however, that provincially generated hazardous waste could be better handled in a management system designed to accommodate the nature and quantity of the waste. In view of the long term benefits that such a system would provide to the province, in terms of increased health and environmental safety, a properly designed hazardous waste management system must be considered necessary for the province.

With this conclusion in mind, the remainder of the report develops a hazardous waste management system for Manitoba. The management system presented uses the information gained by the Hazardous Waste Information Exchange and the experiences of other provinces and countries, to design and propose a hazardous waste management system for Manitoba.

4.3 THE MAPPING OF POTENTIAL AREAS

A constraint mapping exercise was undertaken to provide an example of how hazardous waste managers determine where potential locations for management facilities exist. The exercise makes use of the information this report has developed, including: the criteria for facility siting, the data from the Information Exchange, and the experiences of other countries during similiar exercises. The exercise was limited to a study area between Winnipeg and Portage la Prairie, and south of the Trans-Canada Highway to the Canada/U.S. Border for reasons which will become apparent. The resulting maps may be found in the back map pocket.

Since transportation is a major cost factor in the disposal of hazardous waste, it was important to locate the management facility in close proximity to the major waste sources. Results from the Information Exchange (Appendix D, Tables D-4 to D-9) indicate that the region with the largest quantity of manageable hazardous waste is Winnipeg (7880.89 tonnes/year), followed by the Western Region (4985.44 tonnes/year) and the Eastern Region (4611.83 tonnes/year). To minimize transportation costs a management facility close to Winnipeg was concluded to be most appropriate.

The decision to look at the Winnipeg/Portage la Prairie axis was based on the geologic history of this study area. One of the most important effects of glaciation on Manitoba was the formation of Lake Agassiz. The deposits of silt and clay produced by this prehistoric lake cover more than half of the province. Clay and silt deposited in the Lake Agassiz basin varies greatly in thickness. North and east of a line running through Neepawa, the southern end of Lake Manitoba, Beausejour, St. Anne and St. Malo, these deposits generally are thin (less than 6 metres) and patchy. South of that line, thickness increases to almost 15 metres at Portage la Prairie and to more than 36 metres along the International Boundary (Teller 1976). Another major feature related to Lake Agassiz is the Assiniboine Delta. This delta, covering about 6500 square kilometers of southern Manitoba, was located at the mouth of the Old Assiniboine River where it entered Lake Agassiz. Like most deltas, it is composed primarily of clays, silts and sands interbedded with Lake Agassiz clays. The delta which rises gradually west of Portage la Prairie comprises more silty and sandy soil. In attempting to meet hydrogeological constraints, the area of study was limited to areas east of the Assiniboine Delta and to the south of Winnipeg because of clay thickness limitations.

To eliminate from further consideration those areas with unsuitable hydrogeological characteristics, two maps were produced. The first of these maps identifies potential groundwater pollution hazard areas. The areas identified on this map represent important groundwater recharge areas. They also correspond with deltas that were formed during the last Ice Age. These recharge areas comprise of fine to coarse-textured silt and sand deposits. Since these areas are highly permeable and serve to recharge local groundwater, it would be undesirable to locate a hazardous waste management facility on the identified area. While it is recognized that a properly constructed and maintained facility would not pose a risk to groundwater contamination, the potential is there that an accidental release could not be adequately contained. This study avoids identified potential groundwater pollution hazard areas to ensure that there will be no future threat to groundwater.

The second map examines clay thickness in the study area. The desired minimum clay thickness for landfills that will contain hazardous waste is 10 metres. Map 3 shows clay thicknesses in the study area. The map illustrates the general trends of clay thickness in the study area as mentioned by Teller. The drawing of this original map was limited to existing data provided by the Manitoba Department of Mines, Resources and Environmental Management. Map 3 is used to eliminate those areas from further consideration which do not have at least a minimum of 10+ metres of clay thickness within 6 metres of the surface. The exact nature of the subsurface geology can only be confirmed by detailed drilling at a proposed site. It must be recognized that detailed drilling studies may show that this map may or may not share the identified clay thickness.

The next map in the constraint series identifies major study area rivers that are prone to flooding. Elimination of areas prone to flooding is essential to ensure that public and environmental safety is maintained . To ensure a reasonable level of safety, the map estimates those areas which would be flooded during the occurrence of a flood of given magnitude or greater that would be expected to occur in 100 years, referred to as a 100 year flood. Such areas would be unsuitable locations for a hazardous waste treatment, storage and disposal facility.

Consideration must be also given to those areas which contain significant archealogical, biological and economic resources. These include such areas as: national, provincial and municipal parks; wildlife management areas; community pastureland; and wildlife refuge areas. Map 5 identifies these areas along with identifying Crown land and provincial forests. Lands containing significant resources are not considered to hold potential for the location of a management facility.

The fifth map identifies major transportation corridors in the study region. Since the ultimate cost of treatment and disposal will be reflected in the distance the waste must travel, management facilities should be located as close as possible to main transportation routes as the other constraints will permit. The constraint maps have shown a large region in the study area where potential management facilities may be located. The purpose of the transportation map is to narrow the region down by introducing the consideration of transportation cost. The management facility should be located no more than 10 km from a major Manitoba highway. Ideally, it should be located where there is good road accessibility from the Trans-Canada, as the majority of hazardous waste from northern, western and eastern Manitoba will be transported at some time on this major highway. The transportation map also shows the major railway lines. At the planning stage of a management facility, the ability to have close rail access is an important constraint. Close rail access permits the option for reducing the costs of transportation from distant generators by using railways to move hazardous waste to the facility.

The final map of the series illustrates the areas that were constraint free. It is the opinion of the author that these areas hold the best potential for the location of a hazardous waste management facility. These areas require detailed studies to determine potential sites which have suitable hydrogeological conditions, and which meet public and governmental approval.

The map overlay-constraint technique has permitted a number of siting constraints to be considered together. These maps, along with the knowledge gained from the Hazardous Waste Information Exchange permit conclusions to be drawn.

4.4 A PROPOSED HAZARDOUS WASTE MANAGEMENT SYSTEM FOR MANITOBA

This, the final section to the report, presents a proposed hazardous waste management system for the Province of Manitoba. This section examines where management facilities may be located in order to best serve the interests of the provincial government, concerned industries and the general public of Manitoba. The information on which the proposed management system was based includes the following sources: the results of the Hazardous Waste Information Exchange; the constraint maps included with this report; examination of other management systems that are either proposed or in operation; and finally, discussions with working professionals. The discussion that follows on the proposed management system is illustrated in Figure 6. For ease of discussion each component of the system will be addressed separately.

The primary facility of the management system would be a centralized treatment, storage and disposal (TSD) plant. The plant would utilize the following technologies: physical/chemical treatment, rotary-kiln incineration and an engineered landfill, as well as appropriate storage, administration and labratory facilities. Hazardous wastes that could be recycled or exchanged would be stored until such time as an exchange was feasible. All other wastes would be treated, neutralized or destroyed, and the residuals would be concentrated and then consigned to the engineered landfill.

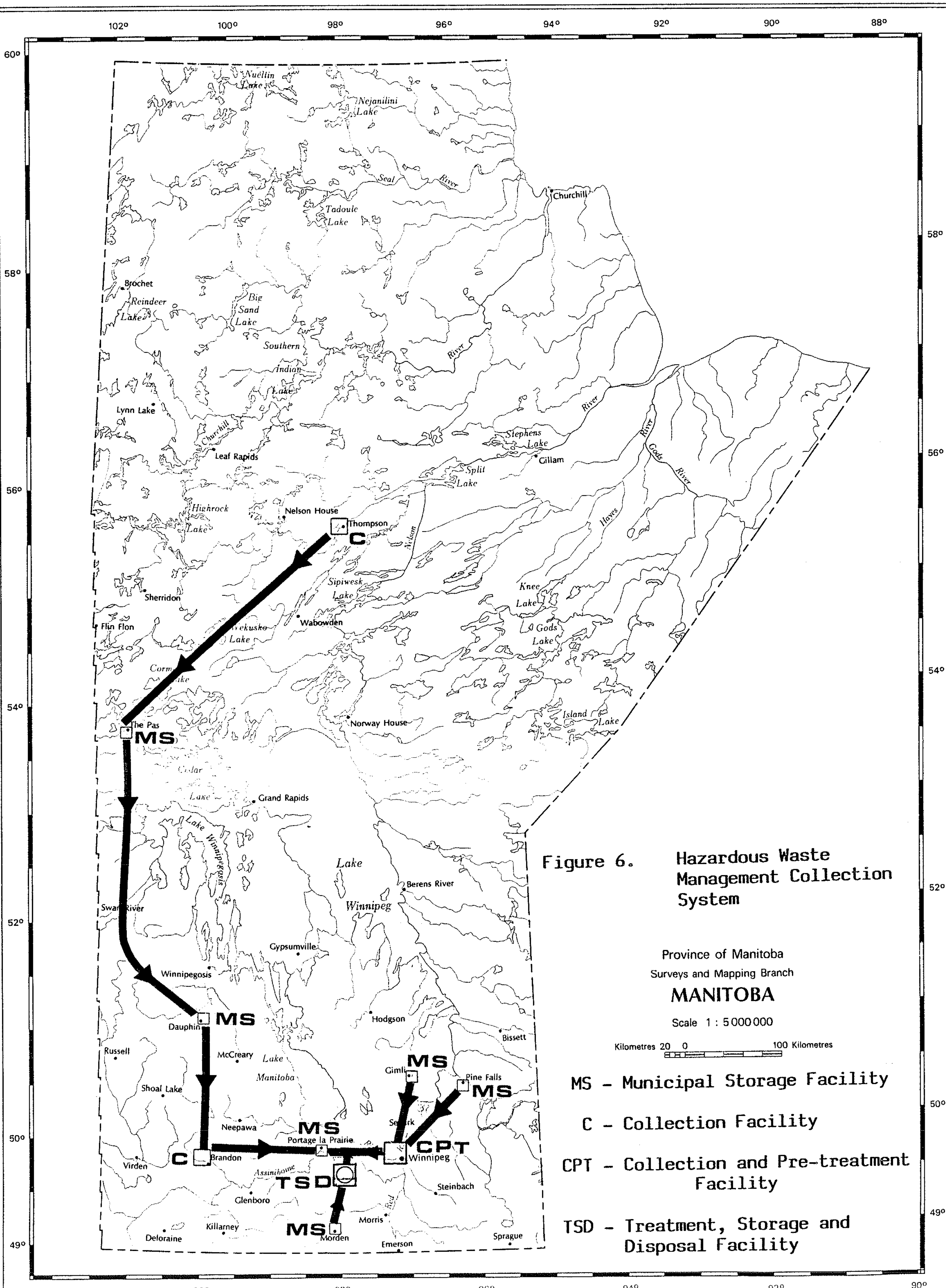


Figure 6. Hazardous Waste Management Collection System

Figure 6 shows the proposed transportation corridor for the movement of hazardous waste from the point of generation to the site of the central treatment, storage and disposal plant. To increase efficiency and decrease the economic costs to those who use the system, a series of intermediate collection facilities are proposed. These intermediate collection facilities would provide preliminary inspection and testing of locally generated hazardous wastes. These facilities would collect, store, label and repackage hazardous waste for shipment to the central plant. The technology available at these intermediate facilities would be dependent on the quantity and nature of the waste generated in the region the facility services. The intermediate collection facilities are identified in Figure 6 as municipal storage facilities (MS) or collection facilities (C). Similiar functions are expected for each. The larger collection facilities (C) would be designed to handle a greater variety and quantity of hazardous waste. A collection and pre-treatment facility (CPT) is proposed where the quantity and nature of hazardous waste from the region is sufficient to have the ability to pre-treat part of the waste. Pre-treatment technology helps to concentrate the waste by removing water, thus reducing transportation and final treatment costs. All management facilities would be run by Department of Environment trained personnel.

The transportation of hazardous waste under this management system would be carried out by government approved hazardous waste haulers and in accordance with the regulations of The Dangerous Goods Handling and Transportation Act (S.M. 1984, c.7 - Cap. D12). Highways are the primary routes for transportation of hazardous waste. A broad array of specialized vehicles and equipment are used, including stainless steel, rubber or epoxy-lined vacuum trucks; vacuum trailers with the ability to draw waste out of a holding tank; gravity-loaded bulk trailers; dump trailers for removal of contaminated soil resulting from a spill, or for transportation of sludge materials; tractors equipped with wet kits for hydraulic use as well as to pull trailers; and flatbeds for hauling barrels and drums. In smaller towns, waste generators would be required to arrange a schedule with the hauler to transport the waste to the nearest management facility. The movement of hazardous waste from facilities would occur on a regular basis.

In conclusion, the proposed management system would provide an efficient and economically feasible system of moving waste from the point of generation to the final point of disposal. Since transportation costs are a major economic factor in the overall costs of hazardous waste management, an attempt has been to reduce the overall costs of transportation. The system should provide the flexibility necessary to meet the growing and changing needs of industries which will use the system. The geographical distribution of waste sources in the province requires that the treatment, storage and disposal facility be located near the major sources of waste. Manitoba is fortunate to have suitable hydrogeological conditions where the majority of the waste is generated. The information from the Hazardous Waste Information Exchange and from the constraint maps lend support to the rationale for this proposed management system.

4.5 AN OVERALL HAZARDOUS WASTE MANAGEMENT PLAN

A number of factors must be considered in addition to specific collection, treatment and disposal facilities, before an overall hazardous waste management plan can be implemented in the Province. To be successful, a hazardous waste management system must ensure that wastes reach their intended destination. The flow chart in Figure 7 presents the basic movements of hazardous waste through the proposed management system. The management of hazardous wastes requires a comprehensive approach to ensure that all management concerns are considered. A description of the individual management concerns follows:

Waste Generator - The waste generator is identified as being a member of industry, or some other group which generates or uses hazardous wastes. The generators are expected to comply with the regulations the generation and handling of hazardous wastes. The waste generator would be responsible for the initial inventory of the waste's quantity and nature, and would be responsible for the safe storage of the waste until such time as the transportation system can remove it for treatment.

Transportation System - The transportation system serves as the mechanism for the transfer and transport of wastes throughout the management system. It is responsible for complying with the regulations set out under the regulations set out under The Dangerous Goods Handling and

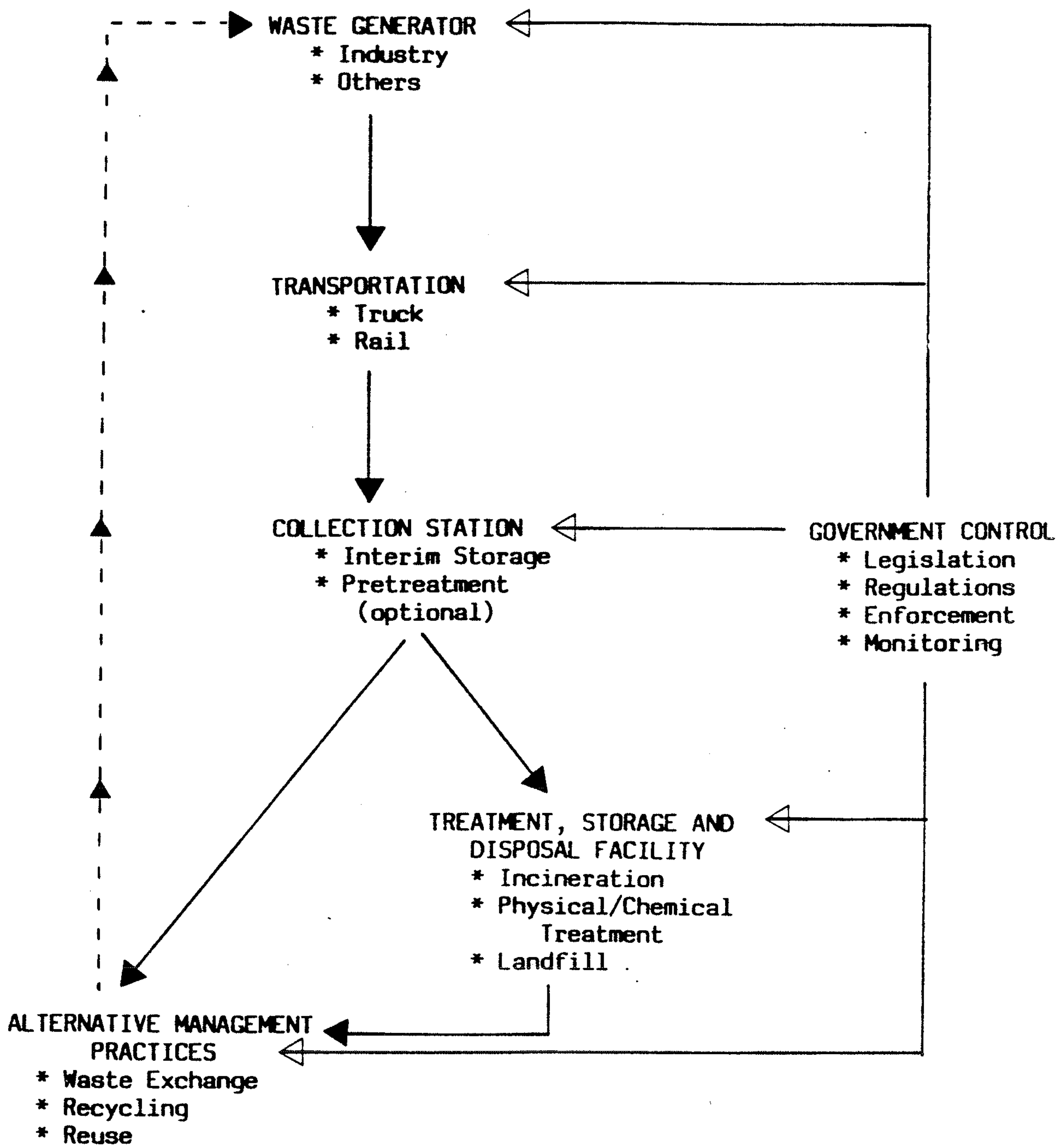


Figure 7. Hazardous Waste Management Flow Chart

Transportation Act.

Collection Station - The collection station functions as an intermediate storage facility, so as to reduce the cost and risks of transporting dangerous goods. Where fitting, the station may function as a pre-treatment facility to reduce the quantity of waste to be handled by the transportation system to the management facility.

Treatment, Storage and Disposal Facility - The treatment, storage and disposal facility provides one mechanism for the neutralization, detoxification and long term storage and disposal of hazardous wastes.

Alternative Management Practices - There are a variety of options available for the management of hazardous wastes which preclude treatment, storage or disposal. These options include waste exchange, re-use and recycling; which are in essence, the future direction of hazardous waste management. These options should be the area of stress for the management system. These practices reduce the economic costs of safe disposal to society while providing a beneficial service to other industries which would use these exchanged or recycled wastes. In all likelihood, firms' marginal costs would be reduced if they took advantage of re-using hazardous wastes, resulting in a more efficient utilization of the resources available.

Government Control - Government control is necessary for each component of the Hazardous Waste Management System. The controls include legislation, regulation and enforcement of these laws. All other components of the management system cannot function effectively without the systematic application of these controls. Monitoring is necessary to insure compliance by the participants in the system. It provides the required systematic tracking of hazardous wastes as they flow through the management system from point of generation to final disposal or re-use. Finally, monitoring ensures a degree of protection of public health and the environment.

The management of hazardous wastes is a highly complex and technical business. It requires constant government monitoring, supervision and enforcement to insure that industry complies with the regulations governing the disposal of hazardous wastes. The management plans presented in this chapter have illustrated the complex nature of hazardous waste management. Figure 6 shows a proposed schematic of a hazardous waste management collection system for Manitoba which is designed to address wastes generated in the Province. The hazardous waste management flow chart presented in Figure 7 concludes the report by illustrating the interrelationship of management concepts expressed throughout this study. The flow chart chart illustrates the basic trends in waste management and the interrelationship between government and industry in the role of hazardous waste management.

Chapter V

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY

New nonradioactive hazardous waste management facilities are needed to improve the current level of environmental protection from toxic materials (including some that were inadequately managed in the past), and to ensure the smooth functioning of the many industries generating hazardous wastes as a result of providing valuable products for Canada and other countries. This conclusion is supported by people with a wide-diversity of backgrounds and perspectives on hazardous waste management issues. Although the goal of obtaining new hazardous waste management facilities is shared by many representatives of environmental and other citizen organizations; municipal, provincial and federal government representatives; representatives of a diversity of industries; academics and others, achieving this objective is proving difficult for several reasons. There are significant differences in opinion about how, precisely, to encourage construction and safe operation of new treatment, storage and disposal (TSD) facilities (Craig 1984).

Society has, unfortunately, only incomplete and inaccurate information about the physical need for management facilities for hazardous wastes. The determination that new facilities should be sited soon, is based primarily on the professional judgement of those who are trying to solve the hazardous waste management problem. Public fear of hazardous wastes, in part, is a result of past mismanagement of wastes and the resulting publicity of serious problems. There also is heightened public awareness of the toxicity, persistence and pervasiveness of hazardous wastes. This public fear has resulted in intense public opposition to siting hazardous waste management facilities. Ironically, but sadly, this opposition may be leading to situations that could seriously threaten public health and the environment.

Major efforts should be made at the federal, provincial and municipal levels to educate the public about the acceptable means for safely handling wastes. Moreover, the concerned public should be involved at all stages of governmental and private sector decision-making concerning hazardus waste management. By being able to be a part of the decision-making process, the public will become better informed and more confident about proposals to provide new capacity for treating, storing and disposing of hazardous wastes. The Manitoba Government has gone to great efforts to involve the general public, and industry, in the development of the hazardous waste management plan.

This study permits the Federal Environmental Protection Service, Manitoba Environment, industry and the general public to better understand the complexities of hazardous waste management. Chapters 2 and 3 highlighted of the pertinent issues surrounding waste management in Manitoba. Manitoba Environment has the authority to manage and enforce regulations governing hazardous waste generation and disposal in the Province. Hazardous wastes are identified and defined by the regulations found in The Dangerous Goods Handling and Transportation Act. This Act sets out the methods which hazardous waste generators must initiate in response to the management system. This is only one of a number of Acts at the provincial and federal level which regulate the generation, transportation and disposal of dangerous goods (hazardous and special wastes).

There are a number of economic measures that the government may take to ensure compliance of industry with these regulations. The Manitoba government must determine how the management system will be financed. This may be through taxes on industry or by charging a disposal fee to those who are regulated to use the system. The greatest hopes of reducing the cost of waste disposal to society are through programs which promote the reduction, redistribution and recycling of hazardous wastes. These programs would be effective in reducing the overall costs of waste disposal while providing an overall net social benefit to the citizens of Manitoba.

The primary objective of this study was to determine the criteria that Manitoba Environment must consider for the siting of collection, treatment, storage and disposal facilities to handle provincially generated hazardous waste. There are five areas for consideration in the site selection process: physical and biological requirements; transportation requirements; present and future land use plans; socio-economic and technical/financial constraints and limitations. After presentation of these constraints, the mapping exercise demonstrated how the criteria are applied to determine which areas best have the potential for hazardous waste management facilities. In this study the waste generation trends of Manitoba industries determined that the study area would be limited to southern Manitoba due to the economic costs associated with transportation. The series of constraint maps have narrowed the study area to three areas which warrant detailed study as the potential location of a management facility.

The study concluded, by applying the knowledge gained from the mapping exercise, the results of the Hazardous Waste Information Exchange and the basic concepts of hazardous waste management, to propose a basic hazardous waste management plan for Manitoba. The proposed system shows where in the Province various management facilities might be located for the efficient and economic movement of hazardous waste from generation to final disposal.

The final section of this study proposed and developed an overall hazardous waste management system. Figure 7 shows the flow of hazardous waste through the management system and the interrelationship and importance of government control to the overall scheme of hazardous waste management. This flow chart identified the importance of legislative control and monitoring of hazardous wastes from generation to final disposal, to emphasizing the importance that waste recycling, waste exchange and waste re-use will play in the future of hazardous waste management:

> Industrial wastes are the unwanted, but necessary, byproducts of the manufacturing processes that are intrinsic to contemporary life. Today, much industrial waste is economically recycled. This trend will undoubtedly continue and will be fostered by further innovations in research and technology. Even so, however great progress in waste reduction and recycling, hazardous wastes will inevitably be produced in some form. Their safe disposal will therefore remain an important objective within the public policy elements that directly affect Canadian manufacturing industries (The Canadian Chemical Producers' Association 1980).

5.2 CONCLUSIONS

1. Five areas must be considered to satisfy geographic, socio-economic and environmental concerns in the siting of hazardous waste management facilities. The five areas are: physical and biological requirements; transportation requirements; present and future land use plans; socio-economic constraints and limitations; and technical/financial constraints and limitations.

2. Chapter's 2 and 3 discussed the various concepts which constitute hazardous waste management.

3. Approximately 20,235 tonnes of hazardous waste are generated annually in Manitoba. Further:
   - 74% are corrosives (class 8)
   - 39% are generated in Winnipeg
   - 51.6% enter local sewerage systems as effluent discharge

4. Three areas in southern Manitoba warrant detailed study for consideration as potential hazardous waste management facility locations.

5. In order for the efficient and effective management of provincially generated hazardous wastes, Manitoba requires a collection station approach to hazardous waste management.

5.3 RECOMMENDATIONS

The recommendations presented here are directed towards Environment Canada's Environmental Protection Service (EPS) and the Province of Manitoba. Province of Manitoba and Environment Canada's Environmental Protection Service. The recommendations take two forms: first, to show support for the work and direction taken by Manitoba Environment and EPS in their approach to hazardous waste management; and second, to propose additions and changes in management and policy direction which would benefit concerned governments, industry and the general public.

1. The Province of Manitoba must develop a management plan and network of facilities to handle and dispose of provincially generated hazardous wastes. It is imperative that work commence, immediately, on the development of the management system to prevent future health and environment problems.

2. The Province of Manitoba must support, develop and encourage the recycling and reduction of hazardous waste. Waste recycling and reduction should be viewed as economic and sound environmental governmental policy.

3. The Province of Manitoba must develop a collection station approach to its management plan. The benefits from this approach include: increased efficiency in movement of waste, reduced transportation risks, lower transportation costs, and reduced economic costs for the entire management system.

4. The Government of Canada and the Province of Manitoba must suggest that national criteria for siting hazardous waste management facilities be developed and adopted. They must establish guidelines for the

preparation of environmental and social impact assessments.

5. The Province of Manitoba must establish an Environmental Education Branch to provide industry and the general public with more information on environmental management concerns, including hazardous waste management.

6. The Province of Manitoba must establish a provincial monitoring program to document any environmental or public health problems occurring after the implementation of the management system. Monitoring, while costly, will ensure the public that no major problems will go undetected.

7. The Province of Manitoba must investigate the means available to establish industry compliance with The Dangerous Goods Handling and Transportation Act regulations. The Province must also establish a fair and equitable means of establishing a user-fee (charge) for using management facilities.

8. The Government of Canada and the Province of Manitoba must investigate the feasibility of transboundary movement of hazardous wastes. Any arrangements should be reciprocal. While not directly addressed, transboundary movements could support the development of highly specialized treatment processes which are not economically feasible at the provincial level.

9. The Government of Canada and the Province of Manitoba must take the initiative to propose the development of a National Center for Advanced Hazardous Waste Management Research, including epidemiology and toxicity research, and advanced treatment technology research.

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Appendix A

CLEAN ENVIRONMENT COMMISSION PUBLIC HEARINGS LOCATIONS

Clean Environment Commission Public Hearings Locations

Location	Date
Dauphin	December 5, 1983
Flin Flon	December 15, 1983
Winnipeg	January 11, 1984
Portage la Prairie	January 17, 1984
Brandon	January 18, 1984
Morden	January 25, 1984
Winnipeg	January 30, 1984
Winnipeg	January 31, 1984
Thompson	February 2, 1984

Appendix B

CRITERIA FOR DANGEROUS GOODS HANDLING AND HAZARDOUS WASTE LIST

CRITERIA FOR DANGEROUS GOODS HANDLING AND HAZARDOUS WASTE LIST

ABBREVIATION	DESCRIPTION
DUST	Means a mixture of solid particles and air in which 90 percent or more of the particulate material has a diameter not greater than 10 micrometers.
IMO	International Maritime Organization.
LC_{50}	Lethal concentration for 50 percent of test animals.
LD_{50}	Lethal dose for 50 percent of test animals.
NACE	National Association of Corrosion Engineers.
NIOSH	National Institute of Occupational Safety and Health.
N.O.S.	Not otherwise specified (Manifest regulations will require the technical name(s) (in the case of a mixture of dangerous goods or hazardous waste, at least two components that most predominantly contribute to its hazard) to be reported.)
PACKING NUMBER	Packing Group Number means one of four groups to which a product or substance is assigned according to the degree of danger that the physical, chemical or other properties of primary classification present.
PIN	Product Identification Number refers to the United Nations Number or North American Number used to identify the dangerous good.
SAE	Society of Automotive Engineers.
SIC	Standard Industrial Classification.
UN	United Nations (numbers and codes were developed internationally for dangerous goods).

Class 1—Explosives.

Covered by Federal Regulations. Refer to Transport of Dangerous Goods Act (Federal).

Class 2—Compressed Gases.

Dangerous goods, waste types and/or waste streams containing dangerous goods listed in the Dangerous Goods Handling and Hazardous Waste List that are designated by UN Class or IMO Class as 2 or meet the following criteria shall be considered as Class 2 dangerous goods or hazardous wastes:

A product or substance that is either liquified by compression; dissolved; liquified by deep refrigeration; or compressed and:

(a) has a critical temperature less than 50°C;

(b) has an absolute vapour pressure greater than 294 kPa at 50°C; or

(c) exerts an absolute pressure in the cylinder, packing, tube or tank in which it is contained greater than 275 ± 1 kPa at 21.1°C or 717 ± 2 kPa at 54.4°C;

(d) is a flammable liquid that has an absolute vapour pressure of more than 275 kPa at 37.8°C (using ASTM test D323);

(e) is a gas in the liquid state that has a boiling point less than -84°C at 101.325 kPa absolute;

falls into Class 2.

Class 2 is subdivided into four divisions as follows:

Class 2.1

Division 1; if it is a flammable as that:

(i) is flammable when in a mixture of 13 percent or less by volume with air at normal atmospheric temperature and pressure; or

(ii) has a flammability range of at least 12.

Class 2.2

Division 2; if it is a non-flammable, non-poisonous gas that is not included in Division 1 or Division 3 or Division 4.

Class 2.3

Division 3; if it is a poison gas that has an LC_{50} less than 5000 milliliters per cubic meter at normal atmospheric pressure.

Class 2.4

Division 4; if it is a gas that has an LC_{50} less than 5000 milliliters per cubic meter at normal atmospheric pressure by reason of corrosion of tissues of the respiratory tract.

Wastes of this division exhibiting Mammalian or Aquatic toxicity equal to or less than the following concentration and total quantity of toxic contaminant per batch are exempt from 2.3:

Mammalian Toxicity		Aquatic Toxicity	
Concentration	Total quantity	Concentration	Total quantity
1 part per million	10 grams	10 parts per million	10 grams

Waste Exemption Limits for Manifest Requirements:

	Waste Exemption
Class 2.1	less than 5 liters or 5 kilograms
Class 2.2	less than 5 liters or 5 kilograms
Class 2.3	less than 5 liters or 5 kilograms
Class 2.4	less than 5 liters or 5 kilograms

Class 3—Flammable Liquids

Dangerous goods, waste types and/or waste streams containing dangerous goods listed in the Dangerous Goods Handling and Hazardous Wastes List that are designated by UN Class or IMO Class as 3 or meet the following criteria shall be considered as Class 3 dangerous goods or hazardous wastes.

A flammable liquid is a liquid, a mixture of liquids, or a liquid containing solids in solution or suspension that has a flash point not greater than 61°C.

Class 3 is subdivided into three divisions, as follows:

Class 3.1

Division 1; if the dangerous goods have a flash point less than -18°C.

Class 3.2

Division 2; if the dangerous goods have flash point greater than -18°C but less than 23°C.

Class 3.3

Division 3; if the dangerous goods have a flash point greater than 23°C but not greater than 61°C.

Packing Group Number

I— has an initial boiling point of less than 35°C at an absolute pressure of 101.325 kPa.

II— has an initial boiling point greater than 35°C at an absolute pressure of 101.325 kPa, a flash point of less than 23°C.

III— has an initial boiling point greater than 35°C at an absolute pressure of 101.325 kPa and a flash point greater than 23°C but less than 61°C.

Waste Exemption Limits for Manifest Requirements:

	Waste Exemption
Class 3.1	less than 5 liters
Class 3.2	less than 5 liters
Class 3.3	less than 5 liters

Class 4—Flammable Solids, spontaneously combustible, substances, and dangerous—when—wet substances.

Dangerous goods, waste types and/or waste streams containing dangerous goods listed on the Dangerous Goods Handling and Hazardous Waste List that are designated by UN Class or IMO Class as 4 or meet the following criteria shall be considered as Class 4 dangerous goods or hazardous wastes.

Class 4 is subdivided into three divisions as follows:

Class 4.1 is a Flammable solid that:

(i) is readily combustible and burns vigorously and persistently, or

(ii) may cause or contribute to fire through friction or from heat retained from manufacturing or processing.

Class 4.2 is a spontaneously combustible substance that:

(i) is liable to spontaneous heating under conditions to which it will probably be exposed during transport, or

(ii) is liable to heating up in contact with air to the point where it begins to burn.

Class 4.3 is a dangerous-when-wet substance that:

(i) emits dangerous quantities of flammable gases on contact with water or

(ii) becomes spontaneously combustible on contact with water or water vapour.

Waste Exemption Limits for Manifest Requirements:

For all divisions of Class 4, the waste exemption limits are less than 5 liters or 5 kilograms; or the following substances:

PIN	UN Class	IMO Class	Substance Name
01362	4.2		Charcoal or Carbon, Activated
01361	4.2		Charcoal or Carbon, Animal or Vegetable origin
01363	4.2		Copra
01364	4.2		Cotton Waste, Oily
01365	4.2		Cotton Wet
01374	4.2		Fish Meal, Unstabilized
02215	9.1	4.2	Fish Meal, Stabilized
01327	4.1/4.2		Hay, Straw or Bhusa
01379	4.2		Paper (Unsaturated Oil Treated)
01856	4.2		Rags, Oily
01325	4.1		Rags, Wet
01386	4.2		Seed Cake with more than 1.5% Oil and 11% Moisture
02216	4.2		Seed Cake with not more than 1.5% Oil and 11% Moisture
01387	4.2		Wool Waste, Wet

Class 5—Oxidizing.

Dangerous goods, waste types and/or waste streams containing dangerous goods listed in the Dangerous Goods Handling and Hazardous Wastes List that are designated by UN Class or IMO Class as 5 or meet the following criteria, shall be considered as Class 5 dangerous goods or hazardous wastes.

Class 5 is subdivided into two divisions, as follows:

Class 5.1—causes or contributes to the combustion of other material by yielding oxygen or other oxidizing substances, whether or not the substance is itself combustible.

Class 5.2—is an organic substance that contains the bivalent "-0-0-" structure.

Waste Exemption Limits for Manifest Requirements:

For all divisions of Class 5, the waste exemption limits are less than 5 kilograms or 5 liters.

Class 6—Acute Toxic and infectious.

Dangerous goods, waste types and/or waste streams containing dangerous goods listed in the Dangerous Goods Handling and Hazardous Waste List that are designated by UN Class or IMO Class as 6 or meet the following criteria, shall be considered as Class 6 dangerous goods or hazardous wastes:

Class 6 is subdivided into two divisions, as follows:

Division 1; referring to Table I, substances that are poisonous (acute toxic) that:

(a) have LD_{50} for solids with oral toxicity not greater than 200 mg/kg;

(b) have an LD_{50} for liquids with oral toxicity not greater than 500 mg/kg;

(c) have an LD_{50} for substances with dermal toxicity not greater than 1000 mg/kg;

(d) have an LC_{50} for dusts or mists with inhalation toxicity not greater than 10,000 mg/m^3 at normal atmospheric pressure;

(e) have a saturated vapour concentration greater than 0.2 LC_{50} mL/m^3 at normal atmospheric pressure or;

inhalation toxicity not greater than 5000 mL/m^3 at normal atmospheric pressure.

Wastes of this division exhibiting Mammalian or Aquatic toxicity equal to or less than the following concentration and total quantity of toxic contaminant per batch are exempt from 6.1:

Packing Group	Mammalian Toxicity Concentration	Total Quantity	Aquatic Toxicity Concentration	Total Quantity
I	1 part per million	10g	10 parts per million	10 g
II	10 parts per million	100 g	10 parts per million	10 g
III	100 parts per million	1000 g	100 parts per million	100 g

(iii) the LD_{50} value of the total mixture shall be calculated from the following formula:

$$LD_{50} \text{ value of total mixture} = \frac{LD_{50} \text{ value of the substance with the small calculated } LD_{50} \text{ value}}{\text{percentage of the total mass of poisonous substances in the mixture}} \times 100$$

2 Where the LC_{50} value of a product is unknown, and

(a) the product is a mixture or solution containing only one poisonous substance, the LC_{50} value of the product shall be calculated according to the following formula:

$$LC_{50} \text{ value} = \frac{LC_{50} \text{ value of poisonous substance}}{\text{percentage of poisonous substance by mass}} \times 100$$

(b) the product is a mixture or solution containing more than one poisonous substance,

(i) the LC_{50} value of each poisonous substance shall be calculated according to paragraph (a);

(ii) the total mass of poisonous substances shall be obtained by adding the masses of all poisonous substance with an LC_{50} value referred to in criteria description Class 6, Division 1 paragraphs (d) to (e) for the substances referred to therein; and

(iii) the LC_{50} value of the total mixture shall be calculated from the following formula:

$$LC_{50} \text{ value of total mixture} = \frac{LC_{50} \text{ value of the substance with the small calculated } LC_{50} \text{ value}}{\text{percentage of the total mass of poisonous substances in the mixture}} \times 100$$

3 The formulas set out in subsection (1) and (2) shall not be used for mixtures containing both LC_{50} and LD_{50} values at the same time.

Waste Exemption Limit for Manifest Requirements

Class/Division	Packing Group	Waste Exemption
6.1	I	less than 5 liters or 5 kilograms
6.1	II	less than 5 liters or 5 kilograms
6.1	III	less than 5 liters or 5 kilograms
6.2		less than 5 liters or 5 kilograms

For Class 6.1

Bioaccumulation and Persistence Characteristics

Bioaccumulation and persistence can be significant indicators of environmental impairment and possible threats to human health. As such substances which have the potential to bioaccumulate (ie. trace metals and persistent organics) and recognized by the criteria system. These properties will result in a designation to the next higher hazard category for substances also exhibiting acute toxic properties.

The criteria designates high bioaccumulation as ≥6.00 log P(octanol/water)

and

High persistence as >52 weeks to biodegrade 50% (ie. half-life T ½ >52 weeks).

PERSISTENCE is described as the tendency of a substance to resist natural degradation process such as biological, photochemical, chemical and physical degradation. It is expressed using the half-life (T ½) of a substance, which is the time required for a 50% reduction in concentration to occur due to natural degradation processes in soil, air or water.

BIOACCUMULATION means the uptake and retention of a substance by an organism or tissue from its environment to such an extent that the organism eventually acquires a higher concentration in its system (or tissues) than that in its environment. Bioaccumulation is expressed as either (a) the ratio of the concentrations of a substance between n-octanol and water phases, called the partition co-efficient, P; or (b) the logarithm to the base 10 of the n-octanol/water partition co-efficient, $\log_{10}P$.

Division 2; organisms that are infectious or that are reasonably believed to be infectious to humans or to animals and the toxins of such organisms.

Determination of LD_{50} or LC_{50} of a poisonous mixture of solution

1 (a) the product is a mixture or solution containing only one poisonous substance, the LD_{50} value of the product shall be calculated according to the following formula:

$$LD_{50}\text{ value} = \frac{LD_{50}\text{ value of poisonous substances} \times 100}{\text{percentage of poisonous substance by mass}}$$

(b) the product is a mixture or solution containing more than one poisonous substance,

(i) the LD_{50} value of each poisonous substance shall be calculated according to paragraph (a);

(ii) the total mass of poisonous substances shall be obtained by adding the masses of all poisonous substance with an LD_{50} value referred to in criteria description Class 6, Division 1 paragraphs (a) to (c) for the substances referred to therein; and

TABLE I

ACUTE TOXICS

Packing Group	I	II	III
a) LD_{50} for solids with Oral Toxicity (mg/kg)	≤5	>5–50	>50–500
b) LD_{50} for liquids with Oral Toxicity (mg/kg)	≤5	>5–50	>50–2000
c) LD_{50} for substances with Dermal Toxicity (mg/kg)	≤40	>40–200	>200–1000
d) LC_{50} for dusts or mists with Inhalation Toxicity (mg/m³)	≤500	>500–2000	>2000–10,000
e) Saturated vapour concentration mL/m³	≥10 LC_{50}	≥LC_{50}	≥0.2LC_{50}
OR			
e) LC_{50} (rat) Inhalation Toxicity mL/m³	≥1000	≤3000	≤5000

Note: ">" means greater than, "≥" means greater than or equal to, "≤" means less than or equal to, "–" means up to and including.

Class 7—Radioactive Materials.

Covered by Federal Regulations. Refer to Transport of Dangerous Goods Act (Federal). Manifest is required for all waste radioactive substances.

Class 8—Corrosive.

Dangerous goods, waste types and/or waste streams containing dangerous goods listed in the Dangerous Goods Handling and Hazardous Waste List that are designated by UN Class or IMO Class as 8 or meet the following criteria shall be considered as Class 8 dangerous goods or hazardous wastes:

(a) causes visible necrosis of the skin tissue of an albino rabbit at the contact site when administered by continuous contact with the intact bare skin of the rabbit until necrosis occurs or for four hours whichever occurs first;

(b) corrodes SAE 1020 steel or 7075-T6 non-clad aluminum surfaces at a rate exceeding 6.25 mm per year at a test temperature of 55°C using test method NACE: TM-D1-69, or

(c) liquid wastes with pH factor less than 2.0 or greater than 12.5

Packing Group Number

I— if the visible necrosis of the skin tissue referred to in paragraph a, occurs after continuous contact for not more than three minutes or wastes that are preassigned.

II— if the visible necrosis of the skin tissue referred to in paragraph a, occurs after continuous contact for more than three minutes but not more than sixty minutes, or wastes that meet the pH criteria referred to in paragraph c.

III— if the visible necrosis of the skin tissue referred to in paragraph a, occurs after continuous contact for more than one hour, but not more than four hours or wastes that meet the criteria referred to in paragraph b.

Waste Exemption Limits for Manifest Requirements:

The waste exemption for Class 8 is less than 5 liters or 5 kilograms.

Class 9—Environmental Toxicity.

Dangerous goods, waste types and/or waste streams containing dangerous goods listed in the Dangerous Goods Handling and Hazardous Waste List that are designated by UN Class or IMO Class as 9 or meet the following criteria shall be considered as Class 9 dangerous goods or hazardous wastes.

Class 9 is subdivided into three divisions, as follows:

Class 9.1

Division 1; miscellaneous products, substances or wastes designated in the Dangerous Goods Handling and Hazardous Waste List.

Class 9.2

Division 2; substances or wastes that exhibit Aquatic Toxicity as follows:

Packing Group	Aquatic Toxicity TLM96 (Fish) or LC_{50} (Fish) mg/1
I	≤1
II	1-10
III	10-500

Wastes of this division exhibiting Mammalion or Aquatic Toxicity equal to or less than the following concentration and total quantity of toxic contaminant per batch are exempt from 9.2;

Packing Group	Mammalian Toxicity		Aquatic Toxicity	
	Concentration	Total Quantity	Concentration	Total Quantity
I	1 part per million	10g	10 parts per million	10 g
II	10 parts per million	100 g	10 parts per million	10 g
III	100 parts per million	1000 g	100 parts per million	10 g

Class 9.3

Division 3; substances or wastes that exhibit chronic Toxicity as follows:

Packing Group I	II	III
Human Carcinogen	Epigenetic	
Genotoxic animal carcinogen	Genotoxin	
Teratogen	Chronic Effect I	Chronic Effect II

Human Carcinogen—substances which have been demonstrated by epidemiological and/or chemical studies to cause cancer in man.

Epigenetic—non-genetic carcinogen.

Genetic Carcinogen—direct acting carcinogen that interact with genetic material to eventually induce cancer.

Genotoxic Animal Carcinogen—substances which have been demonstrated to cause cancer in animals and have been identified as genotoxic (see Genotoxin)

Genotixin—substances that directly interact with genetic material to eventually induce cancer.

Teratogen—chemicals shown by epidemiological evidence to be teratogenic in humans or demonstrated to be teratogenic in two animal species by oral, dermal or inhalation route of exposure, or demonstrated in one animal species in replicate studies to be teratogenic by the oral, dermal or inhalation route of exposure.

Chronic Effect I—means serious, irreversible toxic effects.

Chronic Effect II—means a significant chronic effect but not life threatening and, if it is permanent, it does not affect quality of life.

Wastes of this division meeting the following criteria are exempt from 9.3;

Packing Group	Component Concentration	Maximum Quantity of Component per Batch
I	1 part per million	1 gram
II	10 parts per million	10 grams
III	100 parts per million	100 grams

For Class 9

Bioaccumulation and Persistence Characteristics.

Bioaccumulation and persistence can be significant indicators of environmental impairment and possible threats to human health. As such substances which have the potential to bioaccumulate (ie. trace metals and persistent organics) and recognized by the criteria system. These properties will result in a designation to the next higher hazard category for substances also exhibiting acute toxic properties.

The criteria designates high bioaccumulation as ≥6.00 log P(octanol/water)

and

High persistence as >52 weeks to biodegrade 50% (ie. half-life T ½ >52 weeks).

PERSISTENCE is described as the tendency of a substance to resist natural degradation process such as biological, photochemical, chemical and physical degradation. It is expressed using the half-life (T ½) of a substance, which is the time required for a 50% reduction in concentration to occur due to natural degradation processes in soil, air or water.

BIOACCUMULATION means the uptake and retention of a substance by an organism or tissue from its environment to such an extent that the organism eventually acquires a higher concentration in its system (or tissues) than that in its environment. Bioaccumulation is expressed as either (a) the ratio of the concentrations of a substance between n-octanol and water phases, called the partition co-efficient, p; or (b) the logarithm to the base 10 of the n-octanol/water partition co-efficient, $\log_{10}P$.

Exemption Limits for Manifest Requirements:

For all Divisions of Class 9, the waste exemption is less than 5 liters or 5 kilograms.

Appendix C

HAZARDOUS AND SPECIAL WASTE MANAGEMENT REGIONS

Hazardous And Special Waste Management Regions

Cities And Towns Identified As Hazardous Waste Producers By Region

NORTHERN	Flin Flon			
	The Pas			
	Thompson			
PARKLANDS	Dauphin			
	Roblin			
	Russell			
EASTERN	Gimli			
	Pine Falls			
	Selkirk			
	Stonewall			
WESTERN	Boissevain	Glenboro	Minnedosa	Rivers
	Brandon	Hamiota	Neepawa	Shoal Lake
	Carberry	Killarney	Pierson	Souris
	Deloraine	Melita	Reston	Virden
SOUTHERN	Carman	Morden	Rosenort	Steinbach
	Dominion City	Morris	Rathwell	Tolstoi
	Fannystelle	Niverville	St. Anne	Treherne
	Grunthal	Plum Coulee	St. Jean	Winkler
	Lorette	Portage	St. Pierre	
WINNIPEG	Elie			
	St. Francois Xavier			
	Winnipeg			

Appendix D

HAZARDOUS WASTE INFORMATION EXCHANGE RESULTS

Table 5 Present Disposal of Hazardous Waste by UN Class

UN Class	Quantity (tonnes per year) Including Atmospheric Release And Recycling	Excluding Atmospheric Release And Recycling
2:1	105.15	72.06
2:3	25506.98	0.00
2:4	2682.27	263.19
3:1	1038.48	858.54
3:2	2659.89	2317.12
3:3	9.12	3.81
4:1	812.78	1.58
4:2	38.79	14.81
4:3	593.58	565.93
5:1	223.24	223.54
6:1	1236.23	592.60
8	15848.00	14939.86
9:1	232.72	109.86
9:2	273.87	272.17
	51261.11	20234.67

Table 6 Present Disposal Quantities by Disposal Method

Disposal Method	Quantity (tonnes per year)	% Including Atmospheric Release & Recycling	% Excluding Atmospheric Release & Recycling
1. Atmospheric Release	29071.56	56.7	-
2. Sewering	10435.49	20.4	51.6
3. Landfill	4270.35	8.3	21.1
4. Landspread	44.38	0.1	0.2
5. Incinerate	413.21	0.8	2.0
6. Off-site Storage	130.65	0.3	0.7
7. Recycle	1954.88	3.8	-
8. Chemical Treatment	1.67	0.0	0.0
9. Other	4938.92	9.6	24.4
	51261.11	100%	100%

Table 7 Present Generation of Hazardous Waste Substances by Industry Type

Industry Type	% Hazardous Wastes Substances Produced
Chemical	33.08
Printing	29.65
Fabricated Metal	26.25
Food Products	15.43
Non-electric Machinery	14.70
Transportation Equipment	14.70
Electrical Machinery	13.48
Misscellaneous Manufacture	11.52
Leather	10.40
Rubber, Plastic	9.80
Auto Repair	9.80
Primary Metal	9.07
Stone, Clay, Concrete	7.60
Repair Services	6.13
Furniture	5.39
Metal Mining	4.17
Other (each less than)	5.00

Table 8 Northern Region Generation Pattern

Class	Quantity (tonnes per year)	
	Including Atmospheric Release and Recycling	Excluding Atmospheric Release and Recycling
2	25867.55	0.00
3	23.86	20.41
4	3.00	3.00
6	534.01	534.01
8	1978.98	1960.81
9	108.02	108.02
	28515.42	2626.25

Table 9 **Parkland Region Generation Pattern**

Class	Quantity (tonnes per year) Including Atmospheric Release and Recycling	Excluding Atmospheric Release and Recycling
3	0.18	0.00
8	1.42	1.42
	1.60	1.60

Table 10 Eastern Region Generation Pattern

Class	Quantity (tonnes per year)	
	Including Atmospheric Release and Recycling	Excluding Atmospheric Release and Recycling
3	5.72	5.64
4	0.48	0.05
6	0.27	0.28
8	4606.66	4605.86
	4613.13	4611.83

Table 11 **Western Region Generation Pattern**

Class	Quantity (tonne per year) Including Atmospheric Release and Recycling	Excluding Atmospheric Release and Recycling
2	2156.46	262.86
3	14.10	9.80
4	2.19	2.19
5	4.57	4.57
6	5.64	5.64
8	5178.49	4698.59
9	2.47	1.79
	7363.92	4985.44

Table 12 Southern Region Generation Pattern

Class	Quantity (tonne per year) Including Atmospheric Release and Recycling	Excluding Atmospheric Release and Recycling
3	92.75	87.81
4	0.85	0.47
5	1.98	1.98
6	22.03	0.28
8	38.19	38.11
9	0.02	0.02
	155.82	128.67

Table 13 Winnipeg Region Generation Pattern

Class	Quantity (tonnes per year) Including Atmospheric Release and Recycling	Quantity (tonnes per year) Excluding Atmospheric Release and Recycling
2	270.39	72.39
3	3579.88	3055.64
4	1438.63	576.61
5	216.69	216.69
6	674.28	52.39
8	4044.26	3635.07
9	396.08	272.10
	10611.21	7880.89

Table 14 Northern Region Disposal Methods

Disposal Methods	Quantity (tonnes/year)
atmospheric release	25889.17
landfill	13.03
land-spread	4.20
sewering	1658.38
incinerate	397.20
off-site storage	108.02
other	445.42
	28515.42

Table 15 Parklands Region Disposal Methods

Disposal Methods	Quantity (tonnes/year)
land fill	1.26
sewering	0.34
	1.60

Table 16 Eastern Region Disposal Methods

Disposal Methods	Quantity (tonnes/year)
land fill	2.63
land-spread	0.27
sewering	4606.47
incinerate	2.46
recycle	1.30
	4613.13

Table 17 Western Region Disposal Methods

Disposal Method	Quantity (tonnes/year)
atmospheric release	2376.96
land fill	8.04
land-spread	4.43
sewering	1021.60
incinerate	0.74
off-site storage	0.11
recycle	1.52
other	3950.52
	7363.92

Table 18 Southern Region Disposal Methods

Disposal Method	Quantity (tonnes/year)
atmospheric release	21.74
land fill	66.20
land-spread	3.79
sewering	46.65
incinerate	10.46
recycle	5.41
other	1.57
	155.82

Table 19 Winnipeg Region Disposal Methods

Disposal Method	Quantity (tonnes/year)
atm. release	783.69
land fill	4179.19
land spread	31.69
sewering	3102.06
incinerate	2.34
recycle	1946.63
chemical treat	1.67
off site storage	22.54
other	541.41
	10611.21