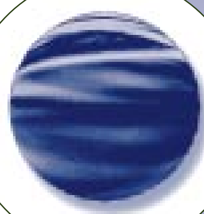
Canada

Environmental Emergencies Program



NOVEMBER 1998

Summary of Spill Events in Canada

1984 - 1995

EPS 5 / SP / 3

Environment Canada Environnement Canada

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Where there has been no finding of fact by a court of law in a criminal, civil or administrative proceeding, the facts set out in this report are alleged facts.

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MINISTER'S MESSAGE

The Honourable
Christine S. Stewart

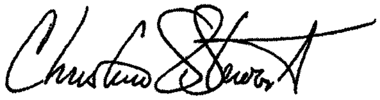
"Prevention and preparedness are key to reducing the frequency and severity of the impact of environmental emergencies."

Preventing and preparing for environmental emergencies is important in protecting the health of Canadians. Environmental emergencies, such as fires that involve or produce toxic substances and recent marine oil spills off the coast of Newfoundland, reinforce how important it is to have effective systems in place to prevent emergencies, and at the same time, to be prepared to deal with them when needed.

I believe that strong partnerships with other governments, communities and interested agencies are a vital link. This will result in a healthy and cleaner environment for all Canadians. Reports such as the *Summary of Spill Events in Canada, 1984-1995* provide us with the valuable data that help all of us to prevent and prepare for environmental emergencies.

This report provides a summary of spills that were reported between the years 1984-1995 and identifies key findings with respect to their impact on the environment. One of the findings worth noting is the identification of the five main activities most often associated with spills. For instance, we know that equipment failure and human error are the most common causes of spills. Armed with this knowledge, governments and industry can work together to develop better standards and more effective training and information programs to reduce spills in the future.

Environment Canada will continue to strengthen existing partnerships and build new ones so that together, we can achieve a healthier and cleaner environment as we enter the new millennium.



E X E C U T I V E   S U M M A R Y

Environment Canada receives and responds to spill reports involving hazardous substances, twenty-four hours a day, seven days a week. Spill-report information may be provided directly to Environment Canada by an individual caller reporting a spill, or via any one of Environment Canada's many partners, including other federal departments and provincial and territorial governments. All information received is entered into a national computer database called the National Analysis of Trends in Emergencies System (NATES) where it can be analyzed.

Summary of Spill Events in Canada, 1984-1995 provides a summarized view of spill information and the resulting trends for the period studied. It is a follow-up to the previous report, *Summary of Spills Events in Canada, 1974-1983*. The charts and tables presented in the report identify key findings with respect to spills that impact on the environment. Findings are presented on the number and quantity of spills in Canada, the causes of and reasons for the spills, seven major industrial and public sectors which incur spills, and effects on the receiving environment. Other sections of the report include an analysis of spills occurring in the federal sector, an evaluation of the most-spilled Major Industrial Accidents Council of Canada (MIACC) List 1 substances, a review of the major spills in Canada, and case histories profiling four significant environmental incidents in detail.

The report is divided into four parts:

1. The introduction describes Environment Canada's role in environmental emergencies, outlines partnerships with other agencies, and explains how spill information is collected and how it is used throughout the report.

2. Statistical analyses and spill trends are presented as a series of charts, tables and graphs that explore the following areas:

   - Spills in Canada and their distribution
   - Spills by industry sector
   - Causes, reasons and sources of spills in seven major sectors
   - Federal spills
   - Spills and environment affected
   - Spills of MIACC List 1 substances
   - Spills by material categories
   - Major spills in Canada

3. Case histories for four significant environmental incidents are presented. A detailed review of each incident is provided, along with an examination of how these occurrences contributed to changes in the management of environmental emergencies.

4. The last section summarizes the conclusions and observations emerging from the statistical analyses and trends presented in the report.

Key Findings

Key findings are identified to help focus the efforts of Environment Canada and other agencies involved in the prevention, preparedness and response to spills. These findings can be used to focus efforts on prevention strategies at locations where spills occur.

The following are key findings:

1. Spill reporting in Canada has improved steadily since 1984. More stringent legislation and increased awareness of spill-reporting requirements have contributed to better reporting and more complete data for analysis.

2. Forty-four percent of reported spills are smaller spills of less than one tonne.

3. The seven major sectors selected for analysis are implicated in 65% of all reported spills. These are the chemical, government (including all levels of government and their operational facilities and holdings), metallurgy, mining, petroleum, pulp and paper, and service industry sectors.

4. The top five reasons for spills are equipment failure, human error, corrosion, material failure and storm or flood.

5. The largest spills are consistently sewage or effluent spills, often the result of a storm or flood.

6. The environmental medium most frequently affected by spills is land.

7. The main reported consequences of spills are vegetation and property damage.

8. Fifty-eight percent of the total number of reported spills involve oil and petroleum products.

9. Wastes and effluents account for 89% of the total quantity of reported spills.

10. Generally speaking, the number and quantity of spills increased steadily from 1984 into the early 1990s, followed by an overall decline to the end of the study period in 1995.

11. There is a trend toward a high number of small spills being reported possibly indicating a greater awareness and sensitivity to all types of environmental emergencies.

The Path Forward

Spill reporting has improved considerably over the 1984-1995 period. With current harmonization efforts, the reporting should improve even more, both regionally and nationally. Environment Canada will continue working with partners to improve spill reporting as well as the quality of reporting in Canada. More complete and better quality data will allow for trends to be identified with increasing reliability, making them more effective indicators in the process of developing new strategies for pollution prevention as well as in the measurement of performance of policies and programs.

Sharing information with other government departments, industry partners, and the public is an important component of efforts to prevent spills, both small and large, and to reduce the impact of spills on the environment. Creating greater awareness is essential to achieving a cleaner and safer environment.

A C K N O W L E D G E M E N T S

There are many people to thank for their contributions to this report. The Project Team gratefully acknowledges the kind and expedient assistance of all those who supplied data, information and comments. Also, special thanks to those in the Environmental Emergencies Branch who assisted and helped steer the Project Team in the right direction.

The National Analysis of Trends in Emergencies System (NATES) database is only one component of the source data; several data sets were used for the report. Not all of the data provided to Environment Canada could be used in the preparation of this report, but all data will be entered into the NATES database for future use.

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Alberta Environmental Protection
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Ontario Ministry of Environment
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Saskatchewan Environment

The Self-Directed Work Team

In the spring of 1997, the Environmental Emergencies Branch elected to undertake the spills summary report project through the approach of a self-directed work team.

This approach builds on the efforts of individuals working together, each bringing their strengths and talents to the project. It also gives team members a chance to learn new skills and abilities. The team members who produced this report are: Dora Boersma, Patricia Charlebois, Gilles Cloutier, Asit Hazra, Carol Lau and Raj Thakur.

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INTRODUCTION

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1.1 Purpose of the Report

The purpose of this report is to provide a summary review of reported spill incidents in Canada, including the identification of spill trends, covering the years 1984 to 1995. The data used in producing the report were gathered by Environment Canada, or provided by various regional or provincial agencies and other government departments.

The following eight key areas are examined:

1. Spills in Canada and their distribution
2. Spills by industry sector
3. Causes, reasons and sources of spills in seven major sectors
4. Federal spills
5. Spills and environment affected
6. Spills of MIACC list 1 substances
7. Spills by material categories
8. Major spills in Canada

Using simple statistical techniques, results of the analyses are summarized and presented in the report as tables, graphs and pie charts. The report provides information on causes and reasons for reported spills, and the number and sources of those spills. Users of this information will be able to look at trends and focus on specific problem areas. The results presented are meant to help Canadians in their efforts to reduce the frequency of spills and the severity of their environmental impact.

While the focus of the report is to identify spill trends, four selected case histories in which Environment Canada was involved are included (Section 3.2). The case histories provide insight into Environment Canada's role in a major spill event, a glimpse at how various agencies work together, and an understanding of how assessments of these events have led to improvements in the way emergencies are handled.

This report is a follow-up to an earlier publication which examined trends for the period 1974-1983 (Environment Canada, 1987).

1.2 Context

Environment Canada derives its mandate for the Environmental Emergencies Program from a 1973 Cabinet Decision. This Decision assigned the responsibility for developing and maintaining a national spill reporting system and database to Environment Canada.

The Environmental Emergencies Branch of Environment Canada administers the national spill database NATES (National Analysis of Trends in Emergencies System). This database was established in 1973 as a part of the overall Environmental Emergencies Program. Its role is to record information received through voluntary reporting of pollution incidents involving hazardous substances.

The objective of the Environmental Emergencies Program is to prevent, or to reduce the frequency, severity and consequences of environmental emergencies which affect Canadians. During a major event, Environment Canada is available to advise clients and partners, and to ensure that the environment is protected. The Environmental Emergencies Program co-ordinates all related departmental expertise with respect to the handling and management of hazardous substances, weather information, wildlife protection, and the development and application of new environmental technologies.

The Environmental Emergencies Program focuses on preventing releases of hazardous substances to the environment, and contributes to the achievement of the "Clean Air" and "Clean Water" objectives of the federal government's agenda. The Program also meets the requirements of the *Emergency Preparedness Act* (1995) under which each federal minister is responsible for developing and maintaining civil-emergency plans related to the departmental mandate. In the case of Environment Canada, the Minister is responsible for maintaining plans covering identification, assessment and mitigation of environmental hazards and their associated risks.

There are an estimated 20 000 spills reported in Canada each year. Although the majority of these spills are minor and have marginal impact on the environment, there are some releases which have the potential to input a greater quantity of a hazardous substance to the environment than combined chronic releases of the substance over many years. In some cases — depending upon the substances released and the location, season or sensitivity of the area — even relatively small spills can have a severe impact on the environment.

Factors which increase the risk of accidental releases include changes in manufacturing patterns, aging distribution systems (pipeline, infrastructure, etc.), and the types of materials transported. Increased resource development and traffic volumes also add to the risk.

Environmental protection is a multi-jurisdictional responsibility shared by all levels of government, industry and individual Canadians. Working together in partnership is required to ensure that the environment is adequately protected.

Recognizing this interdependency, the Canadian Council of Ministers of the Environment (CCME) recently signed a Canada-wide Accord on Environmental Harmonization and three sub-agreements pursuant to this Accord. In addition, the Council directed officials to develop further sub-agreements, one of which will address the area of environmental emergencies. These federal-provincial joint initiatives are intended to enhance environmental protection by preventing overlapping activities, and by identifying and remedying gaps and weaknesses in the Canadian emergencies-management system.

1.3 National Analysis of Trends in Emergencies System (NATES) Database

The NATES database was established in 1973 by Environment Canada to record information from voluntary reporting of pollution incidents involving hazardous substances.

The database contains spill information entered under a number of data fields, including location, material spilled, quantity, cause, source, and sector.

NATES captures the most significant of the spill events reported each year. For the sake of clarity, the name 'NATES' is used to encompass all of the data sources for the analyses presented in this report. However, NATES is only one of the data sets used; data were also obtained through the Department's co-operative agreements with the provincial and territorial reporting agencies and other government departments. The other data sources are identified in the Acknowledgements prefacing this report.

The following subsections briefly describe the data collection and compilation procedures and arrangements employed to create the data set used for analysis.

1.3.1 Environment Canada Spill Data

Environment Canada records spill data 24 hours a day, seven days a week through hotlines operating at the National Environmental Emergencies Centre (NEEC) and the regional and district Environmental Emergencies offices. Callers may contact Environment Canada to report leaks, spills, releases, explosions or fires that they believe may impact the environment. The Environment Canada spill-reporting telephone numbers are listed on the inside front cover of this report.

The initial spill information is captured by Environment Canada staff on a standard pollution incident report (PIR) form. The form is designed to record answers to the 'five Ws' of an incident: who, what, when, where and why.

The majority of spill reports received by the NEEC are forwarded from regional Environmental Emergencies offices, and are based on information about the spill event that has been called in by industry, municipal, provincial and federal government offices.

Once an incident is over, regional staff re-examine the incident and prepare a detailed report identifying variables such as cause, reason, source and sector. This is done by completing a coding form. The coding form captures some of the basic information in the initial pollution report and also includes the more detailed information not usually available until the incident is over.

The information in the coding forms becomes part of the database which is used to analyze trends in emergencies. Some regional offices maintain databases of their own and occasionally produce regional spill-trends reports, which are listed in the reference section.

1.3.2 Provincial and Territorial Data

In Canada, the lead response agency for most spills is the environmental authority in the province or territory, all of whom have legislated reporting requirements. As a result, most incidents are reported directly to the provincial or territorial governments rather than to Environment Canada. Spill data for these incidents are obtained by Environment Canada through informal information-exchange agreements. Some provinces and territories have published spill-trends reports, which are listed in the reference section of this report.

1.3.3 Federal Government Data

Environment Canada has agreements with other government departments, similar to those the Department has with the provincial and territorial governments. In coastal provinces, the St. Lawrence Seaway and the Great Lakes Region, a large majority of marine spills are initially reported to the Canadian Coast Guard (CCG). Significant incidents with an environmental impact are then communicated to the appropriate Environment Canada regional office. The aim of these agreements is to keep Environment Canada informed of incidents and to clarify Environment

Canada's role in providing scientific support to lead agencies. Some of the data collected are subsequently recorded in NATES.

1.4 Data Standardization

Data used in this report were collected from various sources and some standardization was required in order to compile the data for analysis. There are four aspects of the data which required standardization:

- formatting changes to make the data accessible;
- changes of units (e.g. volume to mass);
- standardization of substance names (e.g. sulfuric vs. sulphuric acid, muriatic vs. hydrochloric acid); and,
- re-categorization (e.g. grouping categories or chemicals and sectors or, conversely, breaking a large category into sub-categories when enough details were provided).

The standardized database, which compiles data from all listed sources is referred to as 'NATES' throughout the report.

Although every effort was made to capture all available spill data for the 1984-1995 period, there are data missing for some locations and periods. For example, there are limited spill data from the Province of Quebec, and a very complete data set for the Province of Ontario. Although this may not significantly affect the overall trend analysis results on a national basis, it does show biased trend results for Quebec when compared with other provinces. There are also periodic gaps in the data provided by some provinces.

1.5 Harmonization of Spill-Reporting Systems

Each province and territory has somewhat different spill-reporting requirements and collects data in a slightly different way. The differences in the federal, provincial and territorial databases requiring standardization are outlined in Section 1.4.

The incompatibility of the various sets of data underscores the importance of working with partners to harmonize federal-provincial spill reporting systems on both regional and national levels. Progress has been made towards establishing harmonized federal-provincial spill-reporting systems in some regions of the country. Environment Canada has recently completed a study on Spill Notification Systems in Canada (Environment Canada, 1997).

1.6 Spill-Reporting Databases in Canada

In Canada, there are a number of databases which capture information on incidents involving spills and leaks of hazardous substances. A brief description of some of the databases follows.

1.6.1 National Pollutant Release Inventory (NPRI)

In addition to NATES, Environment Canada also maintains a national database called the National Pollutant Release Inventory (NPRI). It is designed to collect and make available to the public, on a yearly basis, comprehensive national data on releases to air, water and land, transfers in waste, and ongoing emissions of specified substances. Under the authority of the *Canadian Environmental Protection Act*, owners or operators of facilities that manufacture, process or otherwise use one or more of the 176 specified substances under prescribed conditions are required to report to the NPRI.

The NPRI reports for the years 1994 and 1995 can be found on the Environment Canada web site (http: / / www.ec.gc.ca / pdb / npri /).

One of the main differences between NATES and NPRI is that reporting to NATES is voluntary, while reporting to the NPRI is mandatory. Also, NPRI covers all emissions including spills, whereas NATES covers only spills. In addition, the thresholds and reporting criteria exempt many fixed facilities from reporting to NPRI, whereas all spills may be reported to NATES.

1.6.2 Dangerous Goods Accident Information System (DGAIS)

Transport Canada maintains the Dangerous Goods Accident Information System (DGAIS). All transportation incidents resulting in spills must be reported to the Transport Dangerous Goods Directorate by the person responsible for the dangerous goods consignment at the time of the incident. Since July 1985, dangerous goods incident information has been submitted under the reporting requirements of Section IX of the Transportation of Dangerous Goods Regulations.

1.6.3 Provincial and Territorial Databases

Generally, a provincial or territorial government is the lead agency for most spills. All provinces and territories have legislative reporting requirements. A large portion of the data used to produce this report has been obtained from provincial and territorial governments. The Environmental Emergencies Branch of Environment Canada has compiled a list of all federal, provincial and territorial legislation which describe spill reporting provisions (Environment Canada, 1992).

1.7 National Environmental Emergencies System (NEES)

Maintaining an up-to-date and user-friendly national database for recording spill occurrences is an important component of the broader emergencies-management system. Recognizing the incompatibilities among the various Environment Canada regional spill databases, the Environmental Emergencies Program began developing the National Environmental Emergencies System (NEES) in the fall of 1993.

NEES has been developed with the varying needs of the regional offices in mind. Input from user-group meetings and study of the evolution of other systems have contributed to the system's development. The NEES now incorporates historical data tables from the regional systems, as well as the NATES database and data from various contributing agencies.

The NEES is capable of storing data from pollution incident reports as well as historical data for trends analysis. Taking advantage of the technology of the application, most of the trends requirements are automatically transferred from the initial incident report, thus reducing the time and effort required to obtain these data for trends analysis. The system has taken into consideration quality control and consistency in reporting, and has been developed with quality-control checks where problem areas were noted in past systems.

1.8 Spill-Data Analysis

The NATES spill data set used for the purpose of this study contains over 94 000 spill reports for the period 1984-1995. There are over 1 000 substances listed in the database.

In reviewing the results presented in this report, it should be kept in mind that there are some limitations to the completeness and accuracy of the data, which may have some bearing on the interpretation of the results.

An inherent limitation of most spill information collected in Canada is that the end result generally does not look back to the point of origin. For example, spill hotlines capture the initial spill report information and disseminate it as appropriate. However, once the initial information has been circulated, follow-up information and activities are generally not filtered back up to the initial contact point.

Spill volume is an example of first report information that can change over the course of an incident, but is not usually updated on the initial spill report. The volume of a spill is usually underestimated at the beginning of an incident. Also, if a mixture of substances are spilled, it is not usually known what concentration of each substance is present in the actual spill. For these reasons, the volumes recorded may be approximations. In spite of some of the inaccuracies, this information is still quite useful in providing an overview of relative increases and decreases over the years.

Since reporting spill incidents to NATES is not mandatory, the data do not represent a comprehensive picture of all spills reported in Canada. The data do, however, provide a good sampling of information with which to perform analyses and obtain trends. While the actual numbers presented may not be definitive, the resulting trends are useful in identifying areas where Canadians can be more proactive in reducing the number of spills of substances harmful to our environment.

1.9 Spill Data and Client Needs

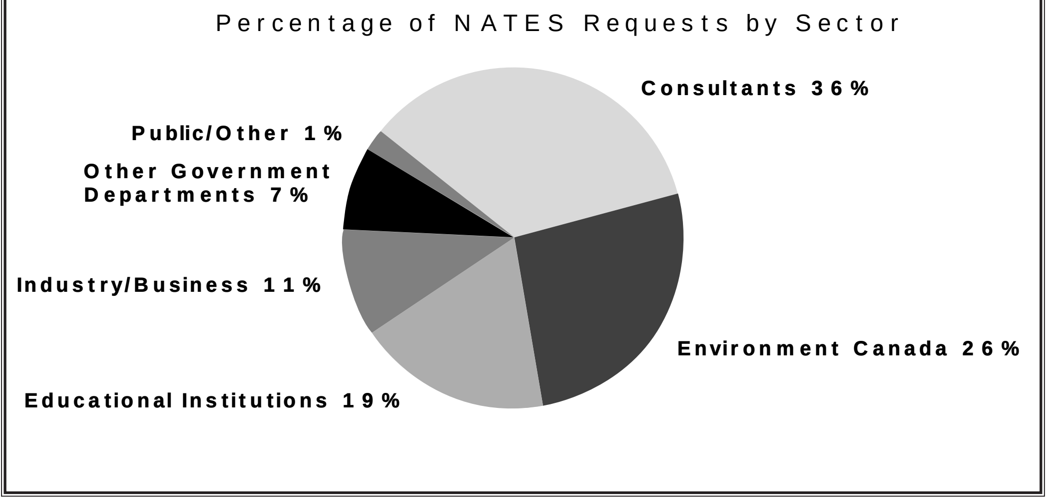
An initiative was undertaken to identify existing clients and other potential users of spill data, so that the information and results provided in this report could be optimized for usefulness to both clients and our partners (including other government departments and provincial and territorial governments).

The following information was used to identify the potential clients for this report and to determine their needs:

- the clients who have requested spill data searches over the last several years;
- the clients who requested *Summary of Spill Events in Canada, 1974-1983*; and
- additional clients who may not have been covered by the above items.

Figure 1.1 shows recent requests for NATES data by sector. The client list includes: Environment Canada, other government departments, industry and business, consultants, and educational institutions.

Figure 1.1



Input was solicited from both existing and potential clients; their advice and guidance has been extremely helpful in shaping this report.

N A T I O N A L S P I L L S T A T I S T I C S A N D T R E N D S

2

NATES is a database that is comprised of data reported voluntarily from many sources. These data were used as the basis for the trends and analyses presented in this report. Although NATES does not contain information on all spills occurring in Canada, it has captured the more significant spills that have occurred in all provinces and territories over the past 22 years.

The present report summarizes spill events for the period 1984-1995. The previous trends report titled *Summary of Spill Events in Canada, 1974-1983* (Environment Canada, 1987) is available from Environment Canada.

Summary findings for each section are presented in bullet form on the introductory page of the section.

2.1 Summary Findings for Reported Spills in Canada, 1984-1995

- The number of reported spills increases in the late 1980s and remains relatively constant since that time. This increase is attributed to the implementation of spill-reporting legislation and better awareness of spill-reporting requirements. The sudden increase in 1988 is also a result of the implementation of a more advanced reporting system by the Province of Ontario.

- The majority of reported spills are less than one tonne.

- Large peaks in total tonnes spilled during a given year are usually attributed to one or more large-scale incidents involving the release of extremely large quantities (usually sewage or effluent spills).

- The highest number of reported spill incidents occurs in the Province of Ontario. This can be attributed to the industry concentration, the volume of transportation of hazardous substances and a good reporting system.

- The months with the largest numbers of reported incidents are the summer months of June, July and August.

- Business, more specifically industry, incurs the greatest number of spills. This is primarily a result of the volume of product being handled, stored and used by this sector, compared with the other sectors examined.

2.1.1 Number of Reported Spills by Year

The number of spills reported has more than doubled during the period 1984-1995 (Fig. 2.1.1). In 1988, there is a substantial jump in the number of reported spills. This increase can, in large part, be attributed to the implementation of Ontario's provincial spill-reporting requirements. The general increase in the number of spills reported can be attributed to better spill reporting — largely a result of more stringent reporting requirements put in place by provincial and federal agencies. From 1988 to 1995, the number of spills reported remains relatively constant with a median of 9 133 spills per year and a range of 8 300 - 10 600 per year. In comparison, there was a median of 2 181 spills reported during the 1974-1983 period in the previous trends report (Environment Canada, 1987). Spill reporting has become a standard function for organizations handling hazardous substances. It appears that the annual spill numbers are leveling off, with minor fluctuations.

Figure 2.1.1

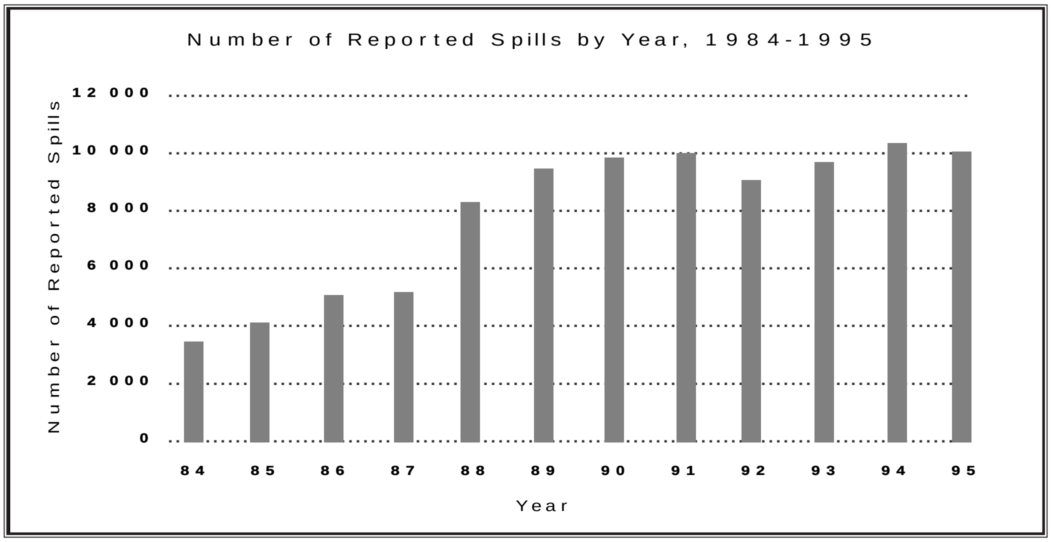


Table 2.1.1

Number of Reported Spills by Year, 1984-1995

Year	Total Number of Reported Spills
1984	3 361
1985	4 308
1986	4 997
1987	5 114
1988	8 260
1989	9 246
1990	9 764
1991	9 938
1992	9 020
1993	9 711
1994	10 578
1995	9 913
Total	**94 210**

2.1.2 Total Quantity of Reported Spills by Year

Significant increases in the total quantity spilled annually appear to have occurred in the years 1987, 1992, 1993 and 1995 (Fig. 2.1.2). Further analysis reveals that several large sewage spills were reported during these years. If these sewage spills are excluded and an average is taken for all years analyzed, the average amount spilled by year is 413 000 tonnes. This average value is consistent with the reported quantities spilled by year.

Note: The spill quantity is the weight of the total discharged product and not the weight of the contaminant. In Canada, the majority of large spills consist of effluent, sewage and mine tailings (see Section 2.9).

Figure 2.1.2

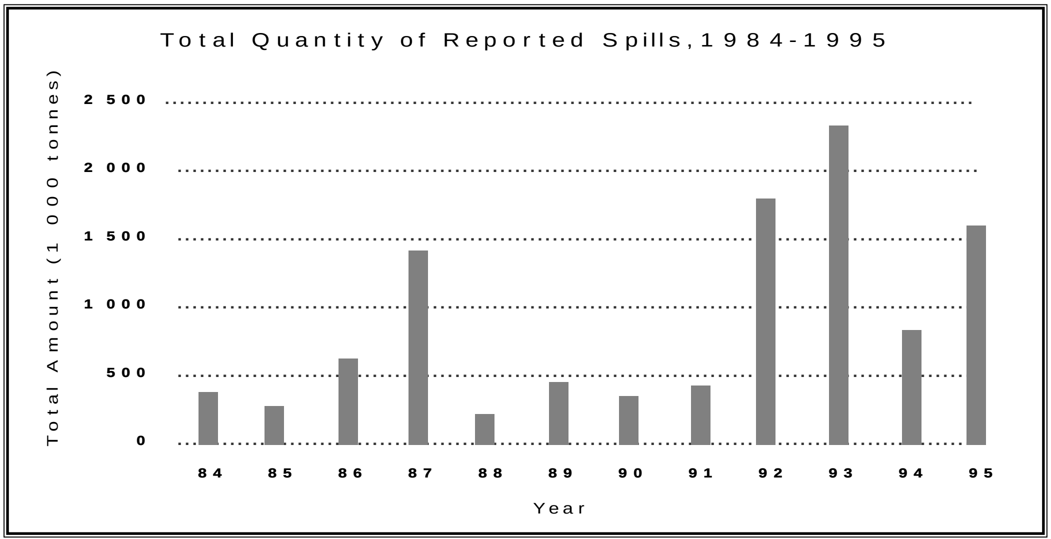


Table 2.1.2

Total Quantity of Reported Spills, 1984-1995	
Year	Total Quantity (tonnes)
1984	367 421
1985	274 017
1986	633 965
1987	1 403 892
1988	200 472
1989	462 376
1990	320 983
1991	442 672
1992	1 793 201
1993	2 284 921
1994	788 217
1995	1 711 869
Total	**10 684 006**

2.1.3 Number of Reported Spills by Province and Territory

The number of reported spills by province and territory shows large differences, making it appear as though some provinces experience more spills than others (Fig. 2.1.3). However, these numbers are a reflection of the number of spills *reported* rather than the actual incidents. For example, the chart shows a great difference in incident numbers between Ontario and Quebec. With similar rates of reporting, the expected result is that Quebec would have only marginally lower numbers of incidents than Ontario. This assumption is based on the size of industry and transportation sectors in the Province of Quebec.

The large volumes of hazardous materials produced and handled explain why Ontario and Alberta show the largest number of reported spills. Alberta has a large petroleum industry, handling and transporting large volumes of product, resulting in more frequent spills. Ontario has a large number of spill incidents due to a large and diversified industrial base and a high volume of transportation of hazardous materials. Good data capture by multiple organizations in these two provinces is also a factor.

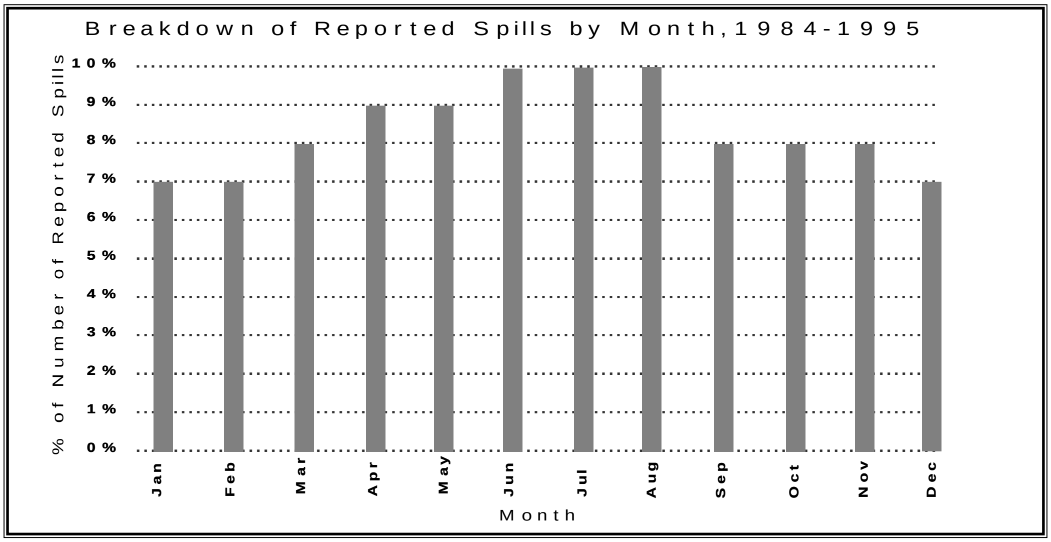
Figure 2.1.3

Number of Reported Spills by Province & Territory, 1984-1995

2.1.4 Reported Spills by Month and Season

The summer months of June through August show the greatest number of reported incidents (29% of total events). This could be attributed to an increase in transportation activities during these months.

Figure 2.1.4



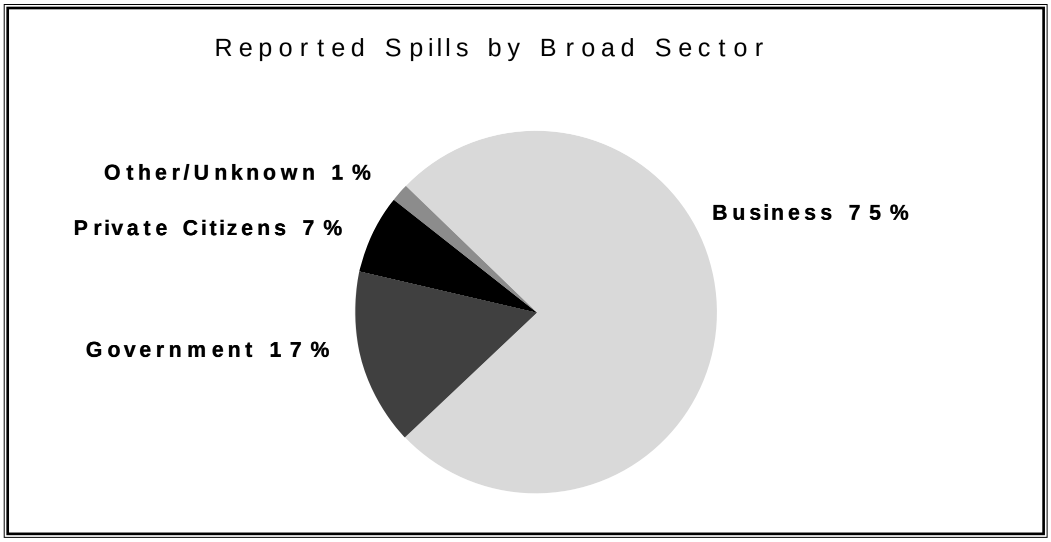
2.1.5 Reported Spills by Broad Sectors

Figure 2.1.5 indicates that the business sector reports the greatest number of incidents. This sector includes manufacturing, handling and transportation of hazardous materials, as well as their on-site use and storage. It should be noted that the business sector is generally very diligent in reporting spills. Public relations and profile in the community are key concerns for industry. Private citizens tend to spill frequently in smaller volumes but may not report because they are unaware of reporting requirements or concerned about possible enforcement action. Government (including all federal, provincial, territorial and municipal governments as well as government-owned facilities) accounts for 17% of all reported spills.

The ‘other / unknown’ category accounts for one percent of spills. In some cases, the details surrounding the incident may not be known at the time of the initial spill report. If little or no follow-up is carried out to amend the original report, or the information is not known the spill is accounted for under ‘other / unknown’.

Note: The government sector includes spills occurring on the property of or from holdings managed by federal, provincial, territorial and municipal governments. The facilities of interest in this category include military bases, large laboratories, research facilities, airports, reserves, ports, marine vessels and all other holdings managed by the federal and other governments.

Figure 2.1.5



2.1.6 Distribution of Spills by Quantity and by Year

Spills account for a significant amount of hazardous material released to the environment (Table 2.1.6). The environmental impact of a spill may be more dependent upon the receiving environment than on the volume of material spilled. Depending on the substance, it may be possible for a land spill to be cleaned up immediately, resulting in negligible environmental damage; whereas a spill to a waterway may not permit an immediate or full recovery of the material and may therefore cause significant environmental damage (Section 2.6).

The majority of reported spills are in quantities of less than one tonne (Fig. 2.1.6a). Comparison of two six-year periods, 1984-1989 and 1990-1995, indicates an increase of 69% in the number of reported spills of less than one tonne. This is likely a reflection of increased reporting, as a larger number of small spills are being reported. Nevertheless, these small spills can have cumulative effects on the environment and on humans. Focus on prevention efforts in this area is warranted.

The quantity spilled is often unknown when an incident is first reported. The ‘unknown’ category for spill size represents a significant number of spills (32%) and increases substantially over the study period. More accurate data reporting would allow for greater focus in prevention efforts.

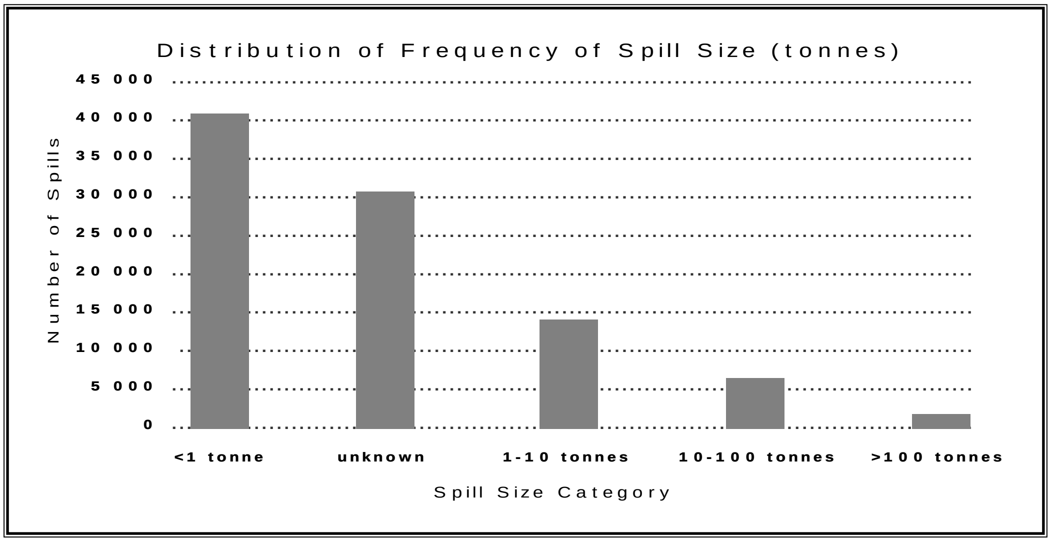
There are 11% fewer reported spills in the 1-10 tonne category for the 1990-1995 period than for the six preceding years (Fig. 2.1.6b). The number of spills of this size appears to decrease over the last four years. The 10-100 tonne category decreases 20% for the years 1990-1995, compared with the 1984-1989 period. This is good news as spills of this magnitude can have a significant impact on the environment.

In the >100 tonne category, there has been a gradual increase in the number of spills exceeding 100 tonnes since 1984. Examination of the two six-year periods indicates an increase of 59% in the number of reported spills >100 tonnes. Sewage spills account for 842 (65%) of the total 1 295 spills in this category. If sewage is removed from the >100 tonne category (data not shown), there is still a 17% increase in these large spills in the latter six-year period (1990-1995).

Table 2.1.6

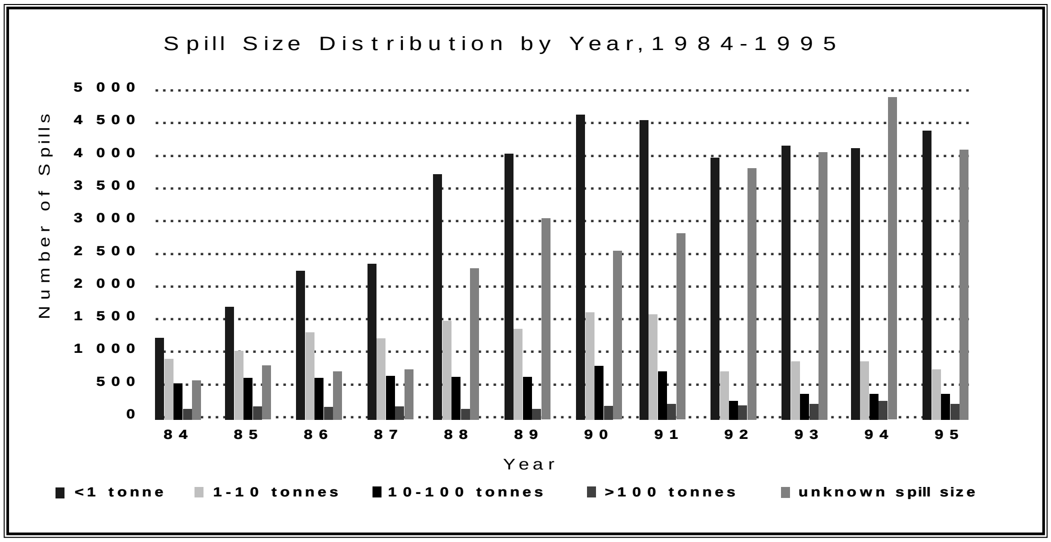
Spill Size Distribution					
	Number of Reported Spills				
Year	< 1 tonne	1-10 tonnes	10-100 tonnes	>100 tonnes	unknown spill size
1984	1 224	912	513	116	596
1985	1 721	1 056	619	122	790
1986	2 256	1 290	602	147	702
1987	2 339	1 238	650	171	716
1988	3 704	1 507	656	134	2 259
1989	4 034	1 358	677	136	3 041
1990	4 608	1 631	730	200	2 595
1991	4 547	1 571	781	216	2 823
1992	3 995	709	301	269	3 746
1993	4 145	881	383	217	4 085
1994	4 106	918	400	229	4 925
1995	4 368	826	377	180	4 160
Total	**41 047**	**13 897**	**6 689**	**2 137**	**30 438**

Figure 2.1.6a



NATIONAL SPILL STATISTICS AND TRENDS

Figure 2.1.6b



Notes for Sections 2.2 to 2.4

General

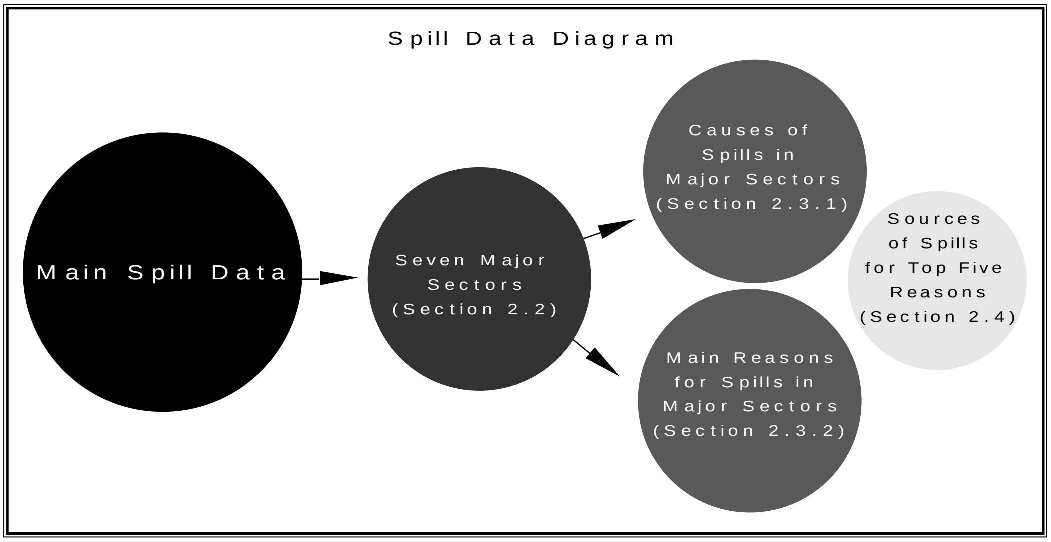
Sections 2.2 through 2.4 focus on seven major sectors: chemical, government (including federal, provincial, territorial and municipal governments and their holdings), metallurgy, mining, petroleum, pulp and paper, and the service industries. These seven sectors represent 65% of the total spills reported and 93% of the total volume reported spilled from 1984 to 1995.

The transportation sector has not been included in this analysis. Spills of hazardous materials (or dangerous goods as they are known in Canada) occurring in the transportation sector — such as spills from tank trucks and rail cars, particularly in quantities normally involved in a major derailment — are closely tracked by Transport Canada. As well, spill information related to the transportation of hazardous materials is available from Statistics Canada.

Figure 2.2.1 shows the outline of the sequence in which the results of the data analysis are presented in the report. The data for seven major sectors were extracted from the main database. Section 2.3.1 presents the causes of spills for the seven sectors, and Section 2.3.2 provides the main reasons for spills in those sectors. The results found in Section 2.4 use a subset of the data presented in 2.3.2 in order to determine the sources of spills for the top five reasons.

The ‘other’ category in Sections 2.3 and 2.4 combines the categories showing small percentages into one single group.

Figure 2.2.1



Median as an Indicator of Spill-Reporting Quality

Medians are used in this report as a means of analyzing spill data. To obtain the median, the spill-size values are ranked in either descending or ascending order. The median is the value in the middle of the list. Medians are a good measure of the central tendency of data sets that have very large or small values that are exceptions to the general situation.

In this section spill reporting quality is defined as the tendency to *report* a higher proportion of smaller incidents.

The median is used as an indicator of the quality of spill reporting. If the median spill size is decreasing over time, a conclusion may be drawn that spill reporting is improving.*

2.2 Summary Findings of Reported Spills in Seven Major Sectors

- The seven chosen sectors represent 65% of the total spills reported and 93% of the total volume reported over the 12-year period.
- The petroleum and government sectors incur the greatest number of reported spills among the sectors examined.
- The chemical sector shows an obvious reduction in the quantity spilled annually during the 12 years examined, although the number of spills in this sector increases over the period.
- Spill quantity either decreases or remains constant for six of the seven sectors examined. The government sector displays a steady increase over the period studied.
- Analysis of the median spill size for the period 1984-1995 indicates an overall improvement in spill reporting.

* Other variables which can result in decreasing spill size include improved prevention and mitigation measures.

2.2.1 Number of Reported Spills and Quantity Spilled in Seven Major Sectors

The number of reported spills in the seven sectors are presented in Table 2.2.1a. The total quantity of reported spills are presented in Table 2.2.1b.

The seven sectors vary greatly in size, therefore reasonable comparisons among sectors are not possible. The points to focus on are the number of spills being reported in each sector and that there is a considerable amount of material released to the environment, even in those industries that have committed significant resources towards spill prevention and pollution abatement over the years. There is potential for improvement in all sectors to reduce both the number of spills and the total quantity spilled.

All sectors show a jump between 1987 and 1988. This is attributable to changes in reporting requirements. Three key variables are examined in the next sections: the number of spills, quantity spilled, and median spill size for 1984-1995.

Table 2.2.1a

Number of Reported Spills in Seven Sectors

Year	Chemical	Government	Metallurgy	Mining	Petroleum	Pulp & Paper	Service Industry
1984	70	223	31	153	1 831	38	94
1985	130	200	58	83	2 053	44	104
1986	206	206	181	118	2 398	73	157
1987	179	228	139	124	2 512	63	208
1988	405	981	360	172	3 021	148	281
1989	582	1 080	392	172	2 971	224	346
1990	588	1 320	361	191	3 157	312	408
1991	552	1 487	508	195	3 139	291	434
1992	667	1 991	703	194	1 144	340	427
1993	754	1 957	618	186	1 531	371	456
1994	784	2 165	599	199	1 577	458	464
1995	534	2 204	431	184	1 642	353	484
Total	**5 451**	**14 042**	**4 381**	**1 971**	**26 976**	**2 715**	**3 863**

Table 2.2.1b

Total Quantity of Reported Spills in Seven Sectors (tonnes)							
Year	Chemical	Government	Metallurgy	Mining	Petroleum	Pulp & Paper	Service Industry
1984	1 783	142 556	4 860	113 078	72 121	2 948	433
1985	12 399	140 820	314	16 105	46 029	35 447	211
1986	16 160	11 267	23 923	29 972	62 232	28 138	431 886
1987	17 128	133 863	87 665	126 939	89 773	90 608	616 308
1988	5 498	58 480	23 497	6 752	29 444	26 933	1 115
1989	7 194	189 169	51 266	42 899	120 765	16 322	228
1990	6 629	84 194	79 178	35 247	50 284	35 845	310
1991	1 619	185 449	32 449	26 172	43 963	46 491	5 106
1992	827	1 386 991	193 435	58 667	11 164	25 494	5 625
1993	1 519	677 529	1 425 753	12 094	62 725	35 612	190
1994	178	678 622	27 489	7 262	18 174	19 751	197
1995	325	1 576 576	11 791	4 783	18 176	49 224	763
Total	**71 259**	**5 265 518**	**1 961 620**	**479 969**	**624 852**	**412 814**	**1 062 374**

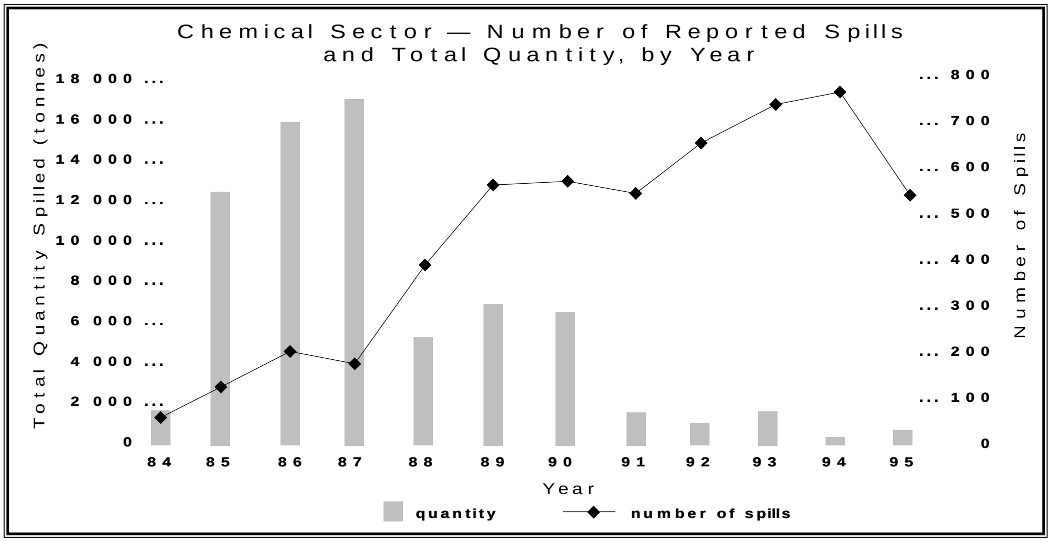
The following charts (Fig. 2.2.2 to 2.2.8) display analyses for each of the seven major sectors over a 12-year period. The graphs show the total reported quantity spilled (tonnes) and the number of reported spills for each of the sectors. (Please note that different scales are used in order to plot both on the same graph.)

2.2.2 Spills in the Chemical Sector

The chemical sector shows an increase in the number of reported incidents, from a low of 70 in 1984 to a high of 784 in 1994 (Fig. 2.2.2). In 1995, there was a 33% decrease from the previous year in the number of spills reported. The quantity spilled generally declines after 1989. The median quantity spilled decreases from 0.4 tonnes in 1984 to 0.1 tonnes in 1995. This suggests that more small spills are being reported, indicating improved reporting.

The Canadian Chemical Producers Association, an industry association which includes most of the major chemical producers in Canada, has implemented widespread programs to improve prevention, preparedness and response to incidents involving product handled by their members. These programs may have contributed to the reduction in total quantity spilled over the period examined.

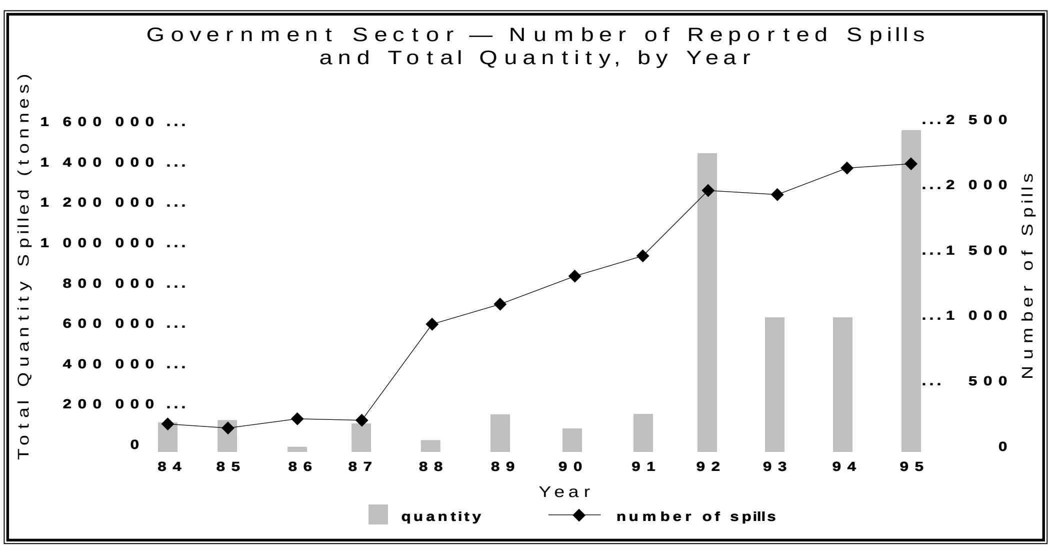
Figure 2.2.2



2.2.3 Spills in the Government Sector

This sector includes federal, provincial and municipal levels of government and their operations and holdings. Spills by the government sector also include municipal sewage releases which result from flooding or overflow. The number of spills reported in the government sector increases steadily after 1987 (Fig. 2.2.3). The quantity of material spilled remained relatively constant over the years 1984 to 1991. For the 1992-1995 time period, over 96% of the total spill quantities are composed of sewage spills greater than 1 000 tonnes. The median spill size for 1984-1987 is 0.6 tonnes.
In 1988, the median drops suddenly to 0.09 tonnes, followed by a gradual increase to 0.14 tonnes in 1995.

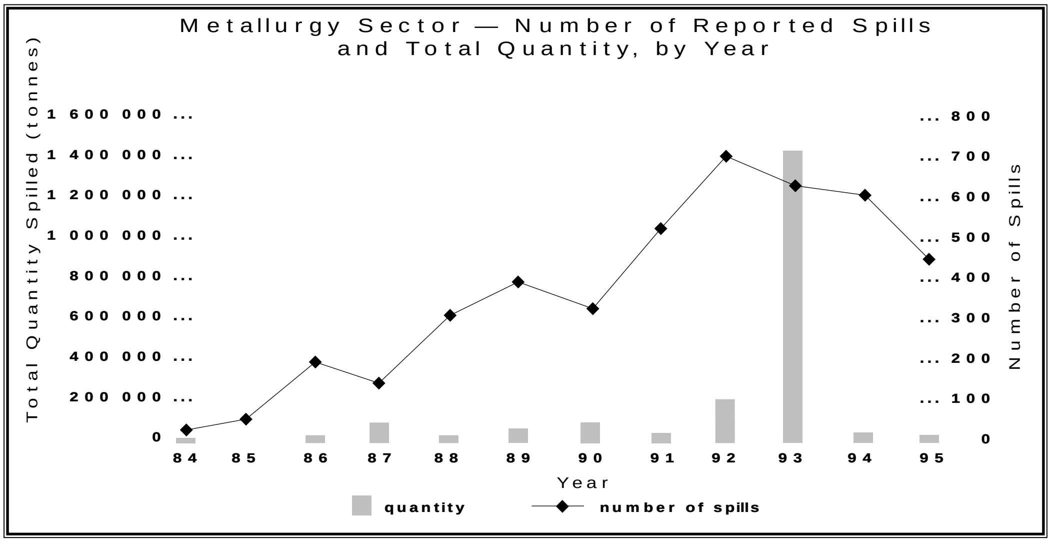
Figure 2.2.3



2.2.4 Spills in the Metallurgy Sector

The number of spills reported in this sector gradually increases from 31 spills reported in 1984 to a high of 703 spills in 1992, followed by a decrease to 431 spills in 1995 (Fig. 2.2.4). A large number of spills in this sector are large-quantity ‘mill water’ or ‘dirty water’ spills that are ten to a hundred times larger than other spills. Roughly 70% of the total quantity spilled in 1993 can be attributed to one ‘dirty water’ spill. Overall, the median spill size decreases from 4.5 tonnes in 1984 to 0.8 tonnes in 1995, indicating that reporting has improved over time.

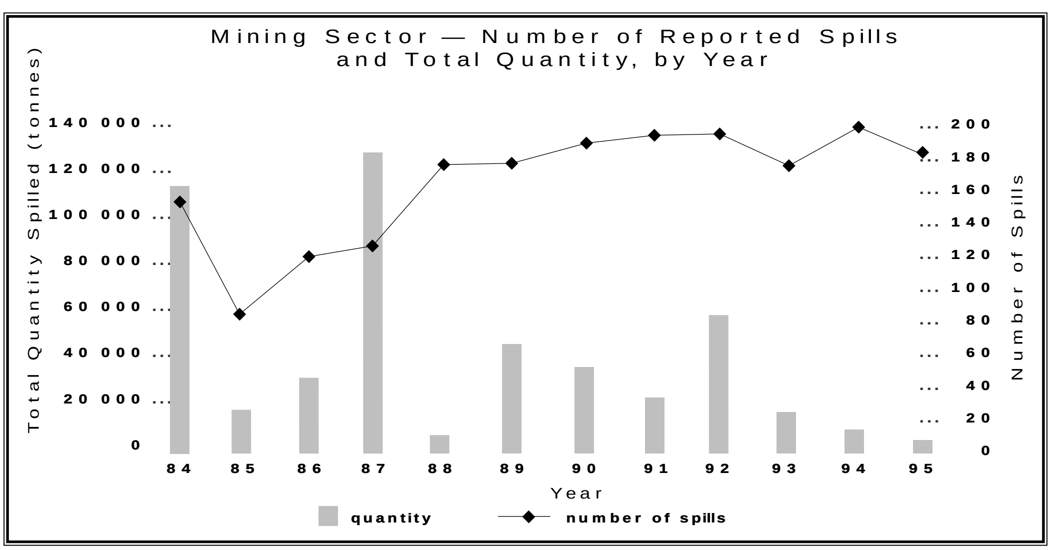
Figure 2.2.4



2.2.5 Spills in the Mining Sector

From 1988, the annual number of spills in the mining sector remains in the range of 172 to 199 spills per year (Fig. 2.2.5). From 1992 to 1995, the spill quantity declines. The peak in 1984 and 1987 are caused by a single large spill in each year, 87 000 tonnes of mining mill effluent and 100 000 tonnes of mine tailings respectively. The median spill size is 3.3 tonnes in 1984 and 0.5 tonnes in 1995, indicating that reporting has improved over time.

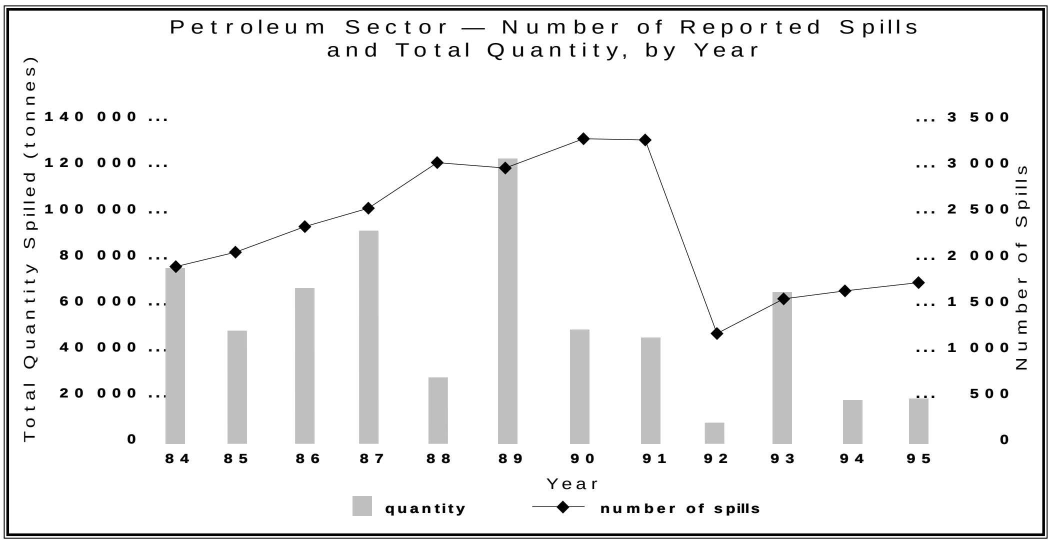
Figure 2.2.5



2.2.6 Spills in the Petroleum Sector

The petroleum sector shows two periods of slow increase in the number of spills: the first from 1984 to 1990, and the second from 1992 to 1995 (Fig. 2.2.6). Between these two periods there is a 64% drop. This may be largely due to the fact that data for Alberta was unavailable beyond 1991. Taking into account the drop in 1992, the quantity of spills in the petroleum sector reported over the 12-year period varies with no apparent trend. The median spill size in 1984 is 2.2 tonnes, decreasing steadily to 1.0 tonne in 1991. For the 1992-1995 period, the median is relatively constant at 0.4 tonnes for each of the four years. Based on the median spill size indicator, it can be concluded that spill reporting improved through the first eight years and has remained qualitatively constant in the last four years examined.

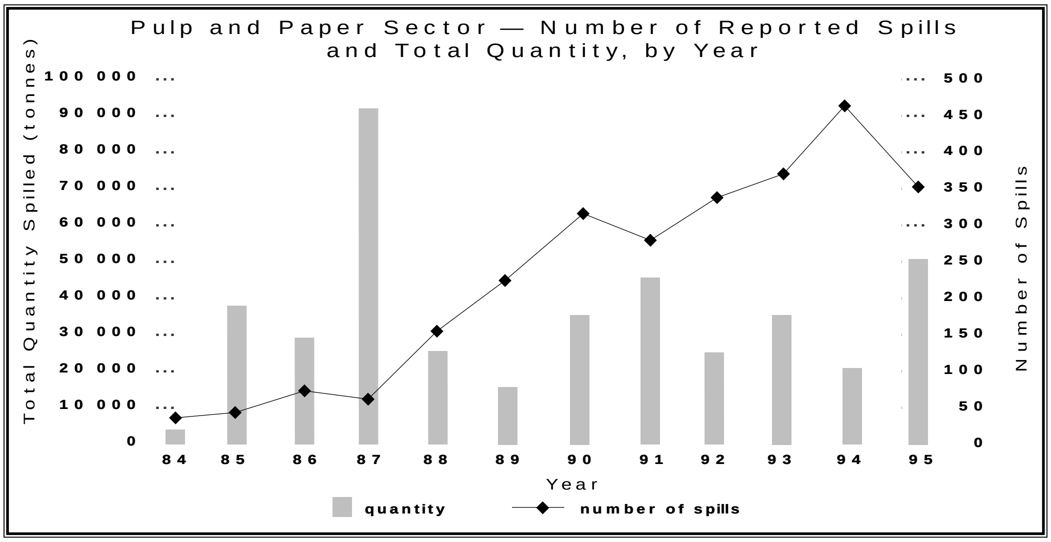
Figure 2.2.6



2.2.7 Spills in the Pulp and Paper Sector

The number of spills reported for this sector rises steadily throughout the period, from an average of 98 spills per year during 1984-1989 to an average of 354 spills per year during the 1990-1995 time frame. With the exception of 1987, the quantity spilled remains relatively consistent.
The peak in 1987 is caused by one spill of 65 000 tonnes of white water. The median spill size increases slightly, from 1.6 tonnes in 1984 to 1.8 tonnes in 1995. This indicates no real improvement in spill reporting.

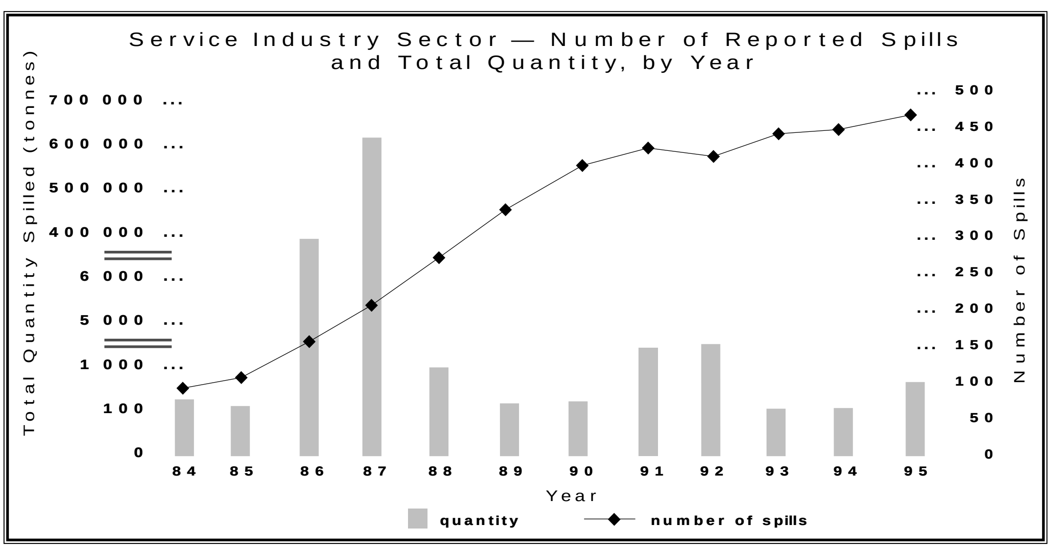
Figure 2.2.7



2.2.8 Spills in the Service Industry Sector

In this report, the service industry sector includes all types of services, including maintenance contractors, specialized industrial services and dry cleaning services. The number of spills in the service industry sector increases almost fivefold from 1984 to 1995 (Fig. 2.2.8). There is no discernible trend in the quantity spilled, as the quantity fluctuates greatly from year to year. The anomalies in quantity spilled in 1986 and 1987 are caused by single, large spills in each of those two years. The median spill size decreases from 0.6 tonnes in 1984 to 0.1 tonnes in 1995, indicating that reporting has improved.

Figure 2.2.8



2.3 Summary Findings for Causes and Reasons for Spills in Seven Major Sectors

- The 'cause' of a spill is 'what went wrong' while the 'reason' for a spill is 'why it went wrong'. Examination of the seven sectors together indicates that pipe leaks account for the majority of causes (22%), followed by discharge (11%), process upset (11%) and overflow (9%).

- Unknown causes account for 13% and unknown reasons 17% of all reported causes and reasons for spills.

- Equipment failure (25%) and human error (16%) are included in the top three reasons for spills among all seven sectors. Corrosion accounts for 12% of all reasons given.

- Spills in the production field are one of the top sources for four of the top five reasons: equipment failure, corrosion, material failure, human error, and storm or flood.

- Seventy-one percent of spills attributable to a storm or flood are sewage spills from either a sewage treatment plant or from a sewer. Run-off during periods of major precipitation, particularly from storm and sanitary sewers, constitutes one of the major reasons for sewage spills.

2.3.1 Causes of Spills in Seven Major Sectors

This section explores the causes of spills for the seven selected sectors. The cause of a spill relates to how a spill happened. Industry sometimes refers to cause as the source of the spill, however, for consistency, standard NATES field names have been maintained. Examination of these causes by persons working in the various sectors can assist in preventing similar events from happening in the future. Upon examination of the seven sectors data, it is interesting to note that 13% of causes fall into the 'unknown' category, making it the second largest category. This indicates a need for better follow-up, as the cause and reason are often not known until after the spill is first reported. This would provide more accurate data for analysis and a better focus for spill prevention programs. In the figures that follow, the unknowns are included in the total number of spills.

Pipe leaks are the most common cause of spills in the seven sectors, representing 22% of total causes.

Table 2.3.1 plots the spill cause against the seven chosen sectors, demonstrating that the leading causes of spills vary greatly from sector to sector. Process upset is the leading cause of spills in the chemical and metallurgical sectors, accounting for 39% and 25% of spills in those sectors, respectively.

Discharge is the most frequent cause of spills in the government and pulp and paper sectors, representing 28% and 15%, respectively, of all causes reported. Pipe leaks are the primary cause of spills in the mining sector (25%) as well as in the petroleum sector (33%). The most important cause of spills in the service industry is container leaks, accounting for 18% of the reported causes of spills in this sector.

Figure 2.3.1

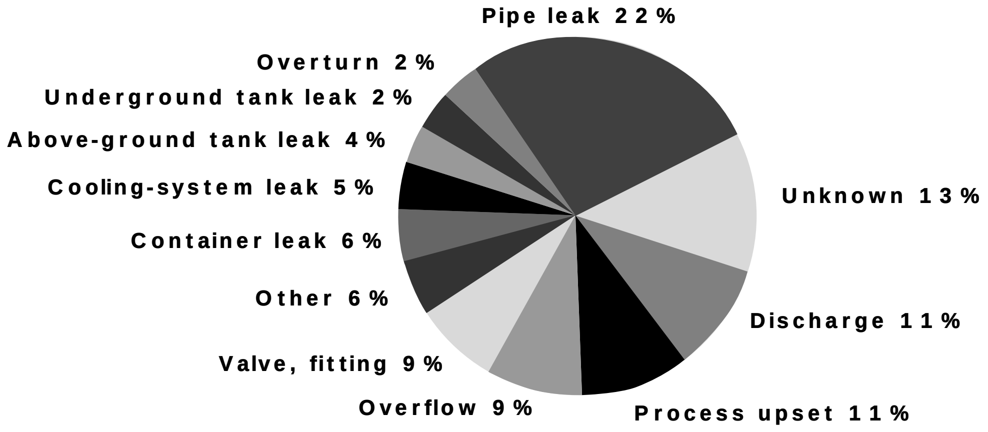


Table 2.3.1

Causes of Spills in Seven Major Sectors

Cause	Chemical	Government	Metallurgy	Mining	Petroleum	Pulp & Paper	Service Industry	Total
Pipe leak	553	1 939	668	485	8 854	368	601	13 468
Discharge	299	3 886	763	137	1 065	412	208	6 770
Process upset	2 145	405	1 079	71	2 408	355	223	6 686
Overflow	491	664	595	255	2 685	388	214	5 292
Valve, fitting	644	555	398	168	3 144	233	173	5 315
Other	306	790	224	217	1 165	137	506	3 345
Container leak	519	932	267	163	585	154	707	3 327
Cooling-system leak	29	2 912	60	15	25	6	29	3 076
Above-ground tank leak	134	387	73	74	1 283	83	256	2 290
Underground tank leak	16	227	12	12	719	10	148	1 144
Overturn	38	103	9	29	608	13	150	950
Unknown	267	1 222	231	331	4 395	546	646	7 638
Total	**5 441**	**14 022**	**4 379**	**1 957**	**26 936**	**2 705**	**3 861**	**59 301**

2.3.2 Reasons for Spills in Seven Major Sectors

This section presents the main reasons (sometimes referred to as 'root causes') for spills in the seven selected sectors. In some cases the 'unknown' category is quite large, totalling almost 17% of all spills in the seven selected sectors. The percentages that follow are derived with the unknowns included in the total number of spills.

As stated previously, the selected sectors are of different sizes and report differently. Each sector is therefore examined independently. There are, however, some apparent trends visible when reasons for spills in the various sectors are compared. Equipment failure and human error are among the top three reasons for all seven sectors. Focused prevention efforts in these two areas may contribute significantly to a reduction in the number of reported spills in these sectors.

Thirty percent of all spills in the chemical sector are due to equipment failure, while 15% are attributed to human error and 13% to intentional discharge. Equipment failure refers to the failure of systems and machinery, not to failure of the actual containment material or from corrosion of containment materials in piping and tanks (Fig. 2.3.2a).

In the government sector, the main reasons for spills are: storm, flood (25%), equipment failure (22%), and human error (10%). From a search of the database (not shown), the most frequent source of government-sector spills are waste water treatment plants, leading to the conclusion that ‘storm, flood’ is an important reason for sewage spills. This type of spill is often the result of overflow that occurs when rainfall exceeds the capacity of the treatment plant or sewer system.

Equipment failure accounts for 32% of the reasons for spills in the metallurgy sector, and human error for 11%. Similar percentages were determined for the mining sector, with 31% of the reasons for spills attributed to equipment failure and 14% to human error. Material failure and corrosion accounted for an additional 9% of reasons for spills in the mining sector.

Equipment failure (24%), corrosion (24%), and human error (18%) collectively account for two thirds of the reasons for spills in the petroleum sector.

Equipment failure is the reason for over one-third (37%) of reported spills in the pulp and paper sector. Human error accounted for 15% and power failure for 6%.

The service-industry sector, including businesses such as dry cleaning, construction and janitorial services, reported human error as the reason for 23% of all spills, with equipment failure accounting for another 15%.

In summary, the most commonly reported reason for spills in the seven sectors is equipment failure (25%), followed by human error (16%) and corrosion (12%). In all seven sectors, equipment failure and human error are included among the top three reasons for spills.

Figure 2.3.2a

Chemical Sector — Spills by Reason

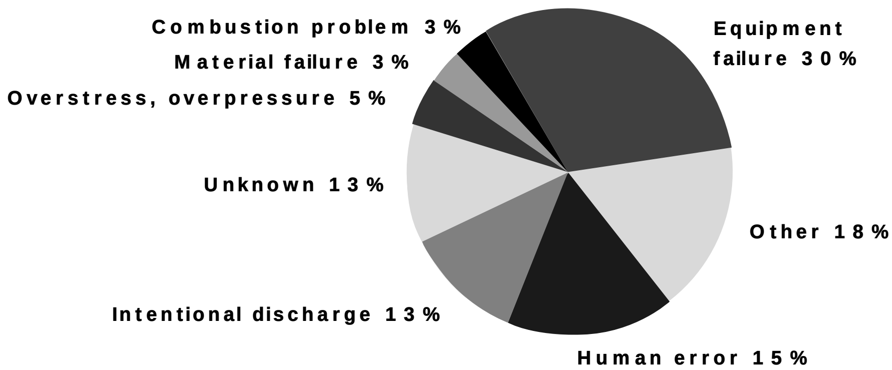


Table 2.3.2a

Number of Spills by Reason in Seven Sectors

Chemical Sector	No. of Spills
Equipment failure	1 600
Human error	835
Intentional discharge	726
Overstress, overpressure	282
Material failure	188
Combustion problem	187
Other	949
Unknown	684
Total	**5 451**

Figure 2.3.2b

Government Sector — Spills by Reason

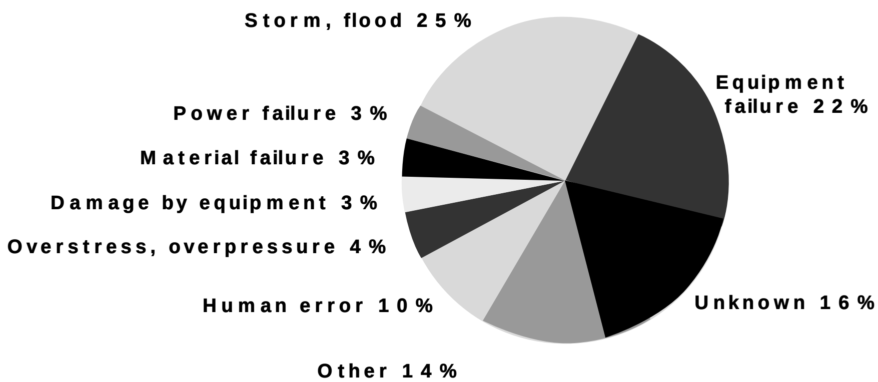


Table 2.3.2b

Number of Spills by Reason in Seven Sectors

Government Sector	No. of Spills
Storm, flood	3 339
Equipment failure	3 146
Human error	1 469
Overstress, overpressure	533
Damage by equipment	461
Material failure	460
Power failure	435
Other	1 958
Unknown	2 241
Total	**14 042**

Figure 2.3.2c

Metallurgy Sector — Spills by Reason

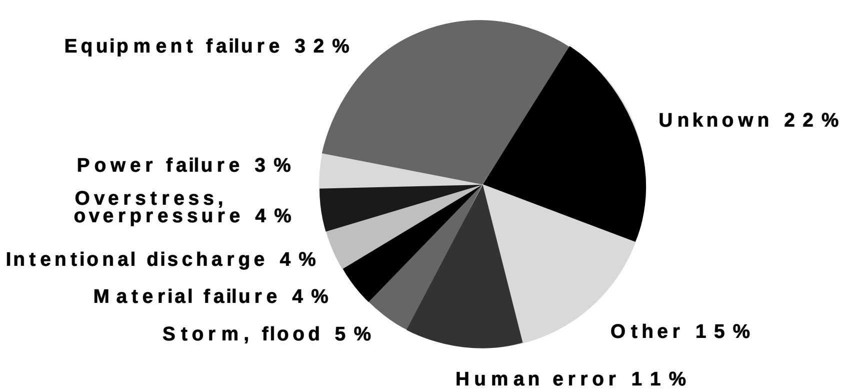


Table 2.3.2c

Number of Spills by Reason in Seven Sectors

Metallurgy Sector	No. of Spills
Equipment failure	1 394
Human error	498
Storm, flood	216
Material failure	193
Intentional discharge	163
Overstress, overpressure	162
Power failure	117
Other	654
Unknown	984
Total	**4 381**

Table 2.3.2d

Number of Spills by Reason in Seven Sectors

Mining Sector	No. of Spills
Equipment failure	613
Human error	268
Material failure	134
Storm, flood	78
Ice, frost	45
Corrosion	44
Gasket joint	42
Damage by equipment	41
Overstress, overpressure	40
Other	213
Unknown	453
Total	**1 971**

Figure 2.3.2d

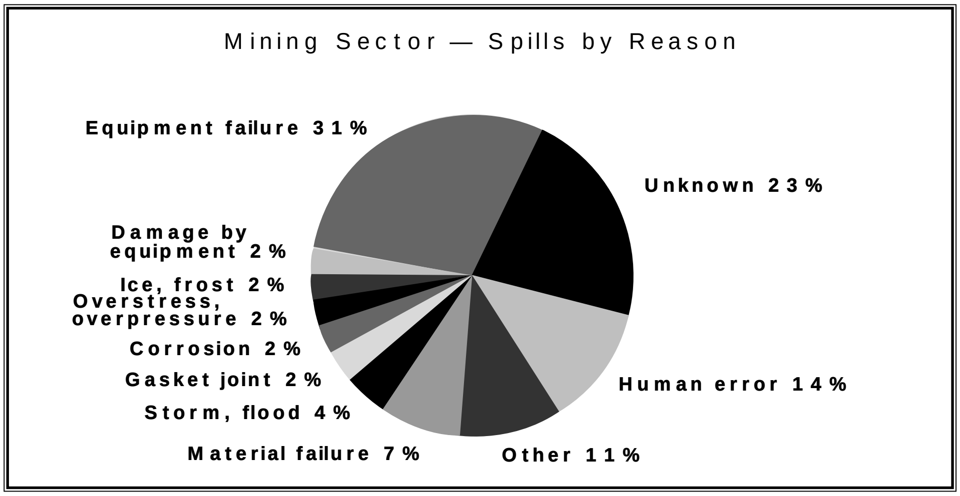


Table 2.3.2e

Number of Spills by Reason in Seven Sectors

Petroleum Sector	No. of Spills
Equipment failure	6 616
Corrosion	6 432
Human error	4 990
Material failure	856
Gasket joint	483
Damage by equipment	467
Other	3 445
Unknown	3 687
Total	**26 976**

Figure 2.3.2e

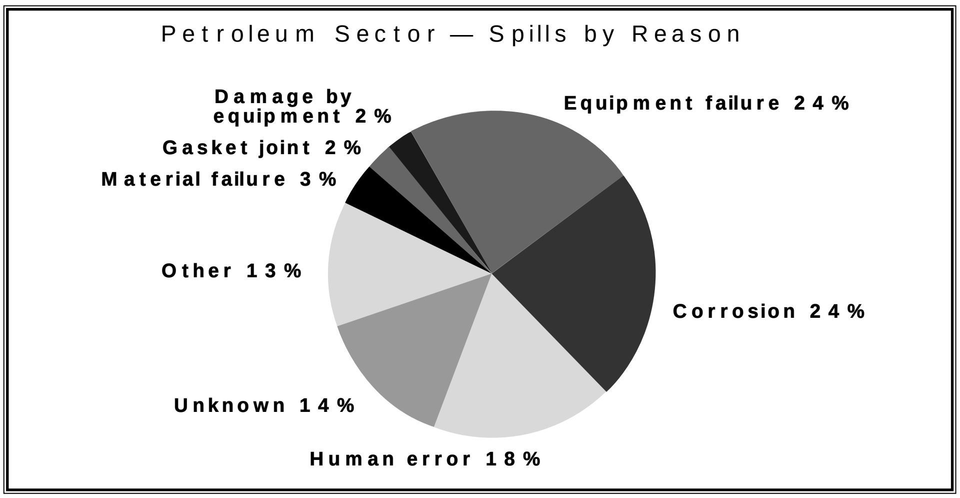


Table 2.3.2f

Number of Spills by Reason in Seven Sectors

Pulp & Paper Sector	No. of Spills
Equipment failure	977
Human error	404
Power failure	153
Intentional discharge	93
Overstress, overpressure	64
Material failure	62
Other	362
Unknown	600
Total	**2 715**

Figure 2.3.2f

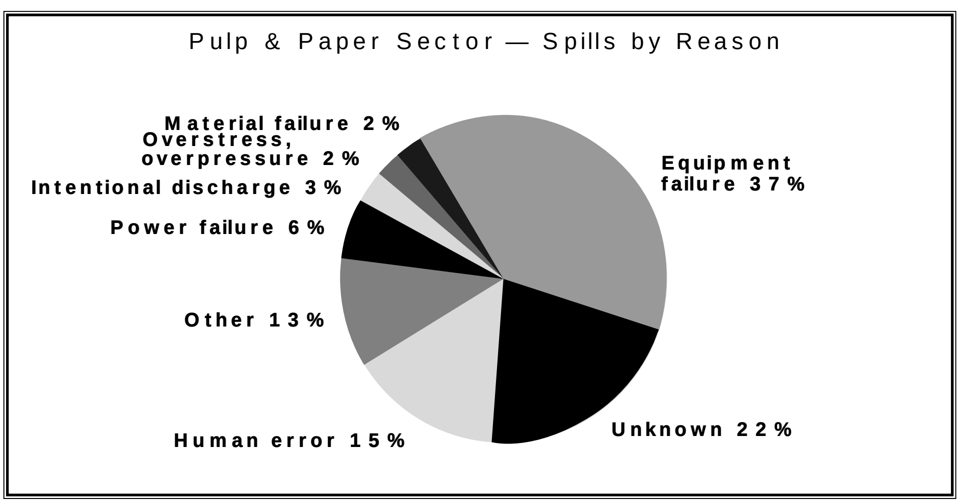


Figure 2.3.2g

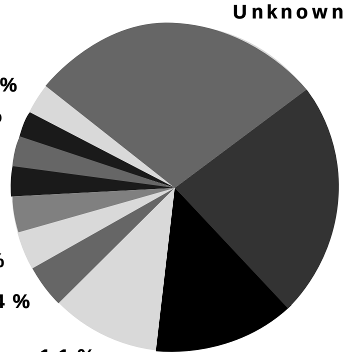


Table 2.3.2g

Number of Spills by Reason in Seven Sectors

Service Industry Sector	No. of Spills
Human error	882
Equipment failure	595
Intentional discharge	153
Material failure	131
Corrosion	116
Damage by equipment	109
Fire, explosion	102
Negligence	94
Vandalism	93
Other	429
Unknown	1 159
Total	**3 863**

2.4 Summary Findings for Sources of Spills for the Top Five Reasons

- The top five reasons for spills are equipment failure, corrosion, material failure, human error, and storm or flood.
- Twenty-five percent of spills in the production field are directly attributable to the top five reasons.
- Spills that result from equipment failure occur most frequently in the production field and in other industrial plants.
- Pipeline spills (45%) and spills occurring in the production field (42%) together account for 87% of the spills resulting from corrosion. This may be attributed to the extreme weather, moisture and pH conditions to which facilities in these sectors are exposed, all of which contribute significantly to corrosion.
- Material failure occurs frequently in the production field and in other industrial plants where containment materials are frequently subjected to overstress, overpressure, or incompatibilities between the containment material and the product being contained.
- Human error is a significant reason for spills in all of the sectors examined. This is consistent with occupational health and safety data identifying human error as a primary cause of industrial accidents.
- Events involving sewage account for 71% of the spills resulting directly from a storm or flood.

2.4.1 Source of Spills for the Top Five Reasons

An effective spill-prevention strategy focuses on the root causes of accidental releases. The *reason* refers to the 'why' of the spill. The *source* is the specific type of installation or vehicle that failed. By examining what sources were involved for each of the top five reasons, prevention efforts can be more precisely targeted.

This section details the top five reasons for spills and the sources of those spills for the seven chosen industrial sectors (chemical, government, metallurgy, mining, petroleum, pulp and paper, and service industry). Incidents falling within the top five reasons for spills in the seven sectors total 37 363 reported spills (Table 2.4.1a). These spills are broken down by source in Table 2.4.1b below.

Table 2.4.1a

Top Five Reasons	Total Number of Spills	% of Top Five Reasons
Equipment failure	14 941	40%
Human error	9 346	25%
Corrosion	7 048	19%
Storm, flood	4 004	11%
Material failure	2 024	5%
Total	**37 363**	**100%**

Top Five Reasons for Spills in Seven Sectors

Table 2.4.1b is helpful in interpreting the charts in sections 2.4.2 to 2.4.5 (which detail the sources of spills by individual reason) as it provides a view of the relative importance of each source.

Table 2.4.1b

Number of Spills by Source of the Top Five Reasons in Seven Sectors

Source	Total Number of Spills	% of Number of Spills
Production field	9 360	25%
Other industrial plants	6 149	16%
Sewage treatment and sewers	4 089	11%
Tank trucks and other motor vehicles	3 762	10%
Pipeline	3 945	11%
Storage (all types)	2 900	8%
Service station	1 316	4%
Other	5 842	15%
Total	**37 363**	**100%**

2.4.2 Source of Spills Where Reason is Equipment Failure

Equipment failure refers to failure of system components including anti-overflow devices or electronic controllers. Spills in the production field (29%) and in other industrial plants (26%) are the top two sources of spills resulting from equipment failure (Fig. 2.4.2). Tank trucks and other motor vehicles account for 9%, and storage for 7%. These two sources both contain extensive piping, handling, containment, and storage systems that are all subject to equipment failure. Regular equipment inspection and maintenance are of great value in reducing the frequency of spills due to equipment failure.

Figure 2.4.2

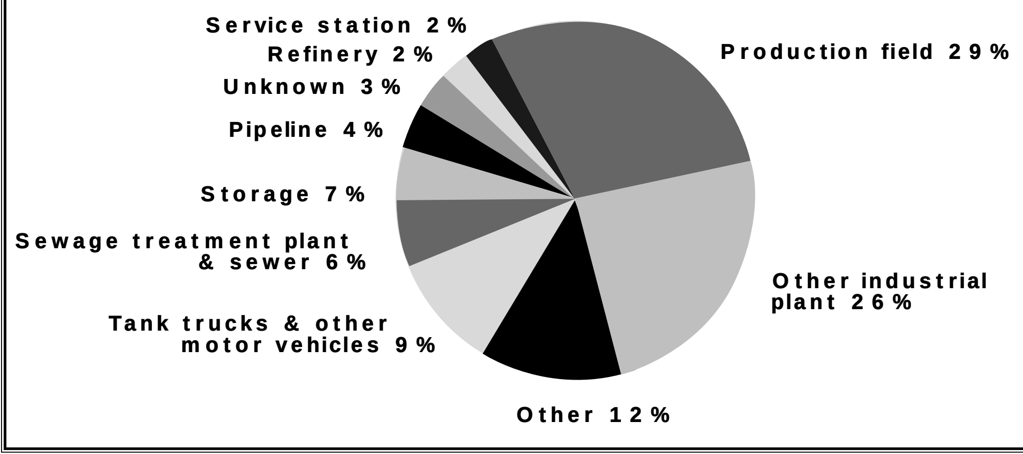


Table 2.4.2

Source of Spills Where Reason is Equipment Failure	
Source	**Number of Spills**
Production field	4 292
Other industrial plant	3 817
Other sources	1 725
Tank trucks and other motor vehicles	1 377
Storage	993
Sewage treatment plant and sewer	971
Pipeline	549
Unknown	521
Service station	357
Refinery	339
Total	**14 941**

2.4.3 Source of Spills Where Reason is Corrosion

Spills in the production field (which includes mines and oil wells) and from pipelines account for 42% and 45% of the spills attributed to corrosion respectively (Fig. 2.4.3). Table 2.4.1b indicates that pipeline spills account for 11% of the total spills in the seven sectors.

Equipment and piping used in these environments are exposed to extreme temperatures, weather conditions and moisture. The equipment is not normally housed in buildings and structures that would protect them. Pipelines are exposed to acidic soils and moisture. All of these factors contribute to corrosion.

Figure 2.4.3

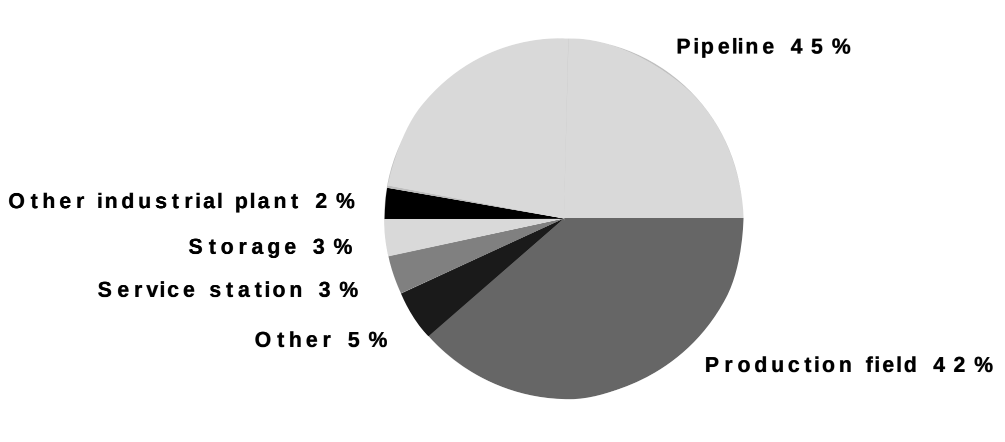


Table 2.4.3

Source of Spills Where Reason is Corrosion	
Source	Number of Spills
Pipeline	3 124
Production field	2 965
Service station	241
Storage	178
Other industrial plant	170
Other	370
Total	**7 048**

2.4.4 Source of Spills Where Reason is Material Failure

Material failure is defined as the failure of the containment material for any given system. Failure is usually the result of poor design, substandard containment materials, or incompatibility between the containment system and the product being contained. The two most common sources of spills attributable to material failure are the production field and other industrial plants (Fig. 2.4.4). Each accounts for 23% of the total spills caused by material failure. Tank trucks and other motor vehicles are the source of 14% of spills caused by material failure, while spills in storage facilities are the source of 10%.

Figure 2.4.4

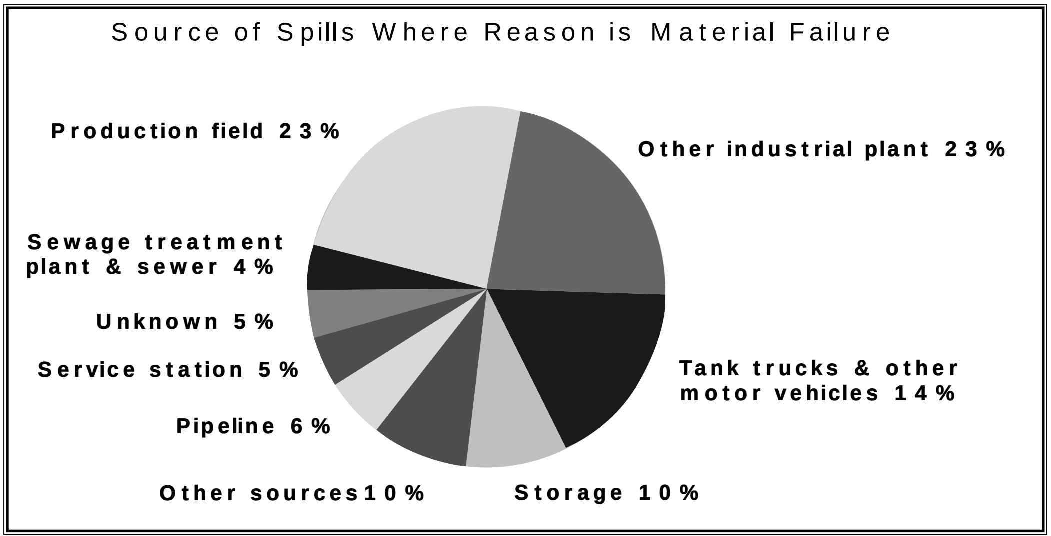


Table 2.4.4

Source of Spills Where Reason is Material Failure

Source	Number of Spills
Production field	477
Other industrial plant	464
Tank trucks and other motor vehicles	284
Storage	198
Other	204
Pipeline	113
Service station	102
Unknown	92
Sewage treatment plant and sewer	90
Total	**2 024**

2.4.5 Source of Spills Where Reason is Human Error

The most common source for spills where the reason is human error is ‘tank trucks and other motor vehicles’, at 22% of the total spills (Fig. 2.4.5). Spills in the production field and in other industrial plants each represent 16% of the total spills due to human error.

All of the major sources of spills where the reason is human error have fairly equal values. Personnel in all areas of work make errors. Human error may be reduced by altering workplace design, and also by determining and then eliminating the factors which contribute to human error. Training is often the recommended approach for reducing incidents related to human error.

Figure 2.4.5

Source of Spills Where Reason is Human Error

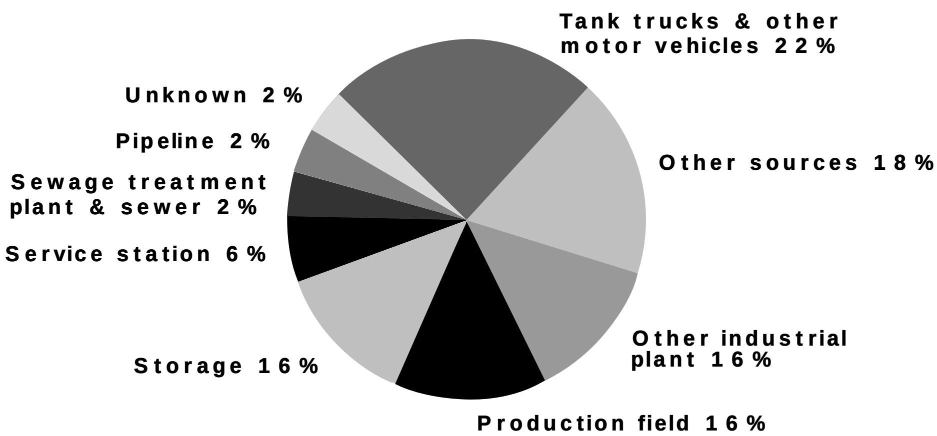


Table 2.4.5

Source of Spills Where Reason is Human Error

Source	Number of Spills
Tank trucks and other motor vehicles	1 981
Other	1 727
Other industrial plant	1 519
Production field	1 504
Storage	1 479
Service station	604
Unknown	223
Sewage treatment plant and sewer	163
Pipeline	146
Total	**9 346**

2.4.6 Source of Spills Where Reason is Storm or Flood

Seventy-one percent of spills attributable to a storm or flood are sewage spills from either a sewage treatment plant or a sewer (Fig. 2.4.6). Run-off causing overflows during periods of major precipitation, particularly from storm and sanitary sewers, constitutes one of the major reasons for sewage spills. Sewage treatment plants and sewers account for 11% of the total number of spills (Table 2.4.1b).

Figure 2.4.6

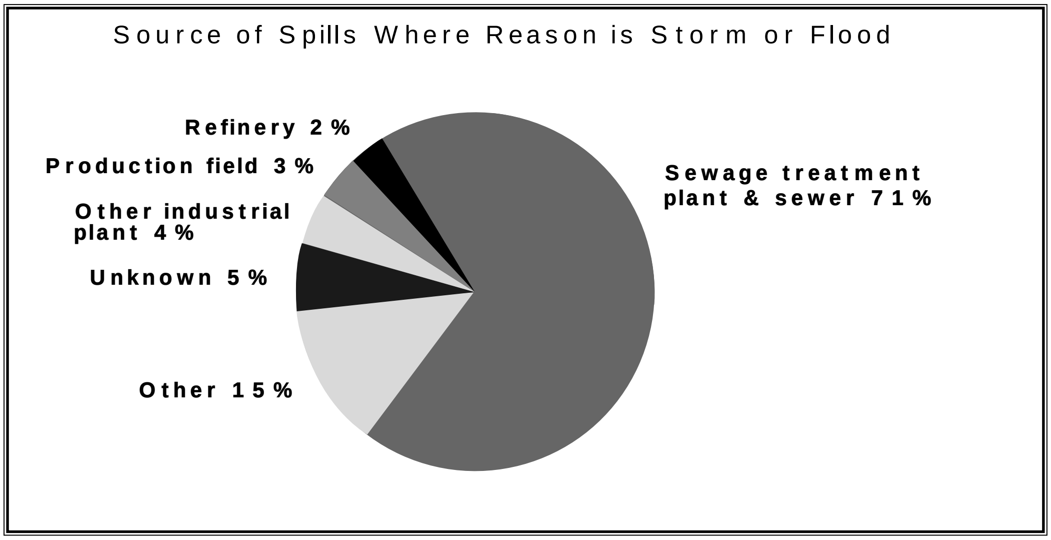


Table 2.4.6

Source of Spills Where Reason is Storm or Flood

Source	Number of Spills
Sewage treatment plant and sewer	2 832
Other	589
Unknown	212
Other industrial plant	179
Production field	122
Refinery	70
Total	**4 004**

2.5 Summary Findings for Federal Spills

The term 'federal facilities' refers to federal lands, works or undertakings as described in Part IV of the *Canadian Environmental Protection Act*. It does not refer to provincial, territorial or municipal lands, works or undertakings. The facilities of interest in this category include military bases, large laboratories, research facilities, airports, reserves, ports, marine vessels and all other holdings managed by the federal government. Stated simply, this category includes all federally managed resources. The key findings are:

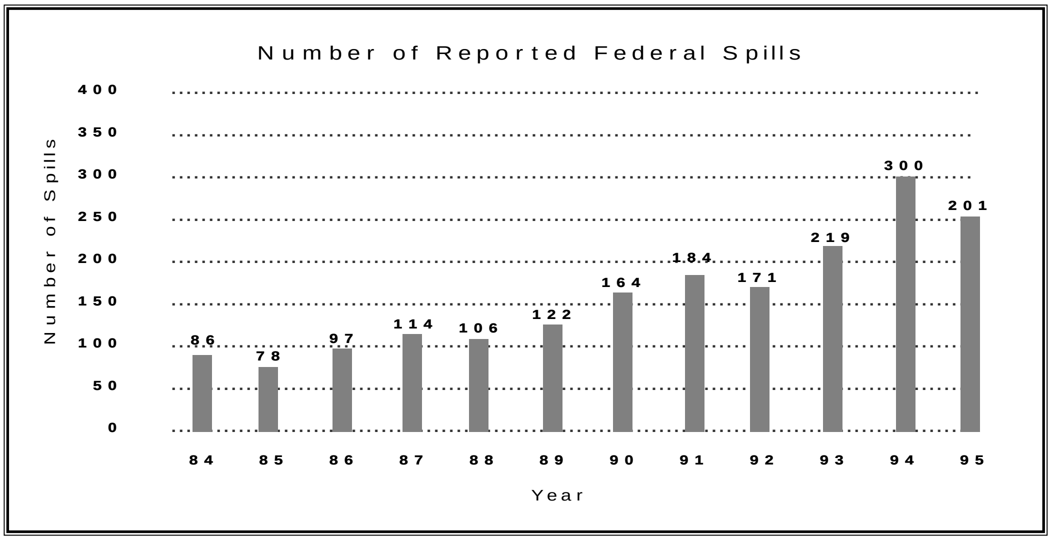
- Spills from the federal sector account for two percent of the total number of reported spills.
- The increase in the number of federal spills reported from 1984 to 1991 is proportional to the number of total spills reported over this period (Fig. 2.1.1).
- A single major spill can be very significant, as indicated in Figure 2.5.2 which shows a large sewage spill in 1987 and in 1994, and a fertilizer spill in 1987.
- Spills at federal facilities are most often the result of pipe, tank or container leaks. The frequency of tank and container leaks is higher in the federal sector than in the seven sectors examined in Section 2.3 combined (Fig. 2.3.1).

2.5.1 Number of Reported Federal Spills by Year

The number of reported federal spills by year increases as improved reporting criteria and tracking of spill incidents are widely applied (Fig. 2.5.1).

There is a steady increase in the number of reported spills until 1991. Between 1991 and 1995, with the exception of a jump in 1994, the number of reported spills remains relatively constant. There is a need for continued prevention, preparedness and response efforts in the federal sector.

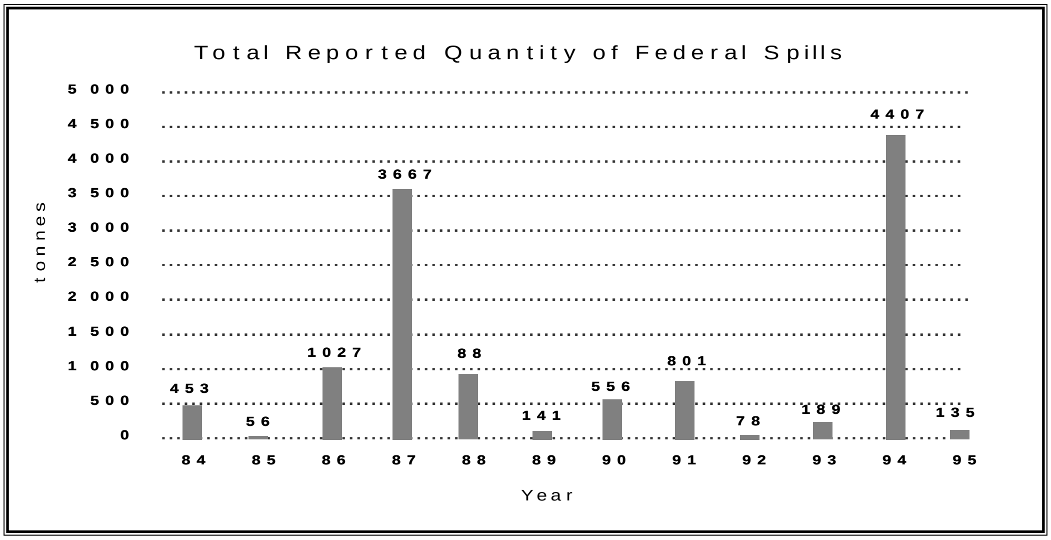
Figure 2.5.1



2.5.2 Quantity of Federal Spills by Year

A single major event can have a significant impact (Fig. 2.5.2). In 1987, a sewage treatment plant spilled 2 275 tonnes of sewage. In the same year, 1 220 tonnes of fertilizer were spilled into a river during a flood. These two incidents account for nearly 95% of the quantity of material spilled in that year. In 1994, another federally owned sewage treatment plant discharged 4 000 tonnes of sewage due to a power failure. This one spill accounts for over 90% of the total quantity of material spilled that year.

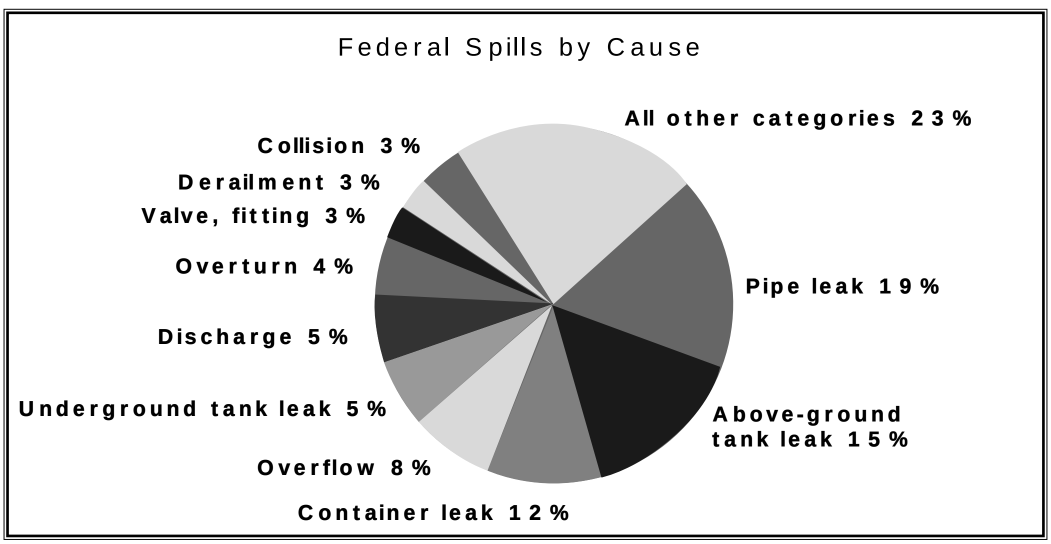
Figure 2.5.2



2.5.3 Federal Spills by Cause

The major causes of federal spills (Fig. 2.5.3) are pipe leaks, which account for 19% of spills, above-ground tank leaks 15%, and container leaks 12%. These top three causes together account for nearly half of all reported federal spills. Spills due to overflows and leaks from underground tanks account for 8% and 5% respectively. The combination of above-ground and underground tank leaks, container leaks and spills due to overflow — all of which are related to container use — account for 40% of federal spills. Material storage is an area in which to focus prevention efforts.

Figure 2.5.3



NATIONAL SPILL STATISTICS AND TRENDS

2.6 Summary Findings for Spills and Affected Environment

- Spills discharged to land occur more frequently than spills to any other environmental medium. A spill of a given product to a waterway may have a much more serious environmental impact than the same spill on land.

- The majority of spills impacting saltwater are oils.

- The main reported consequences of spills to land are property and vegetation damage.

- Better follow-up and reporting on spill impacts with regards to fish, birds and other wildlife are required.

2.6.1 Percentage Distribution of Environment Affected by Reported Spills

In this section, all the reported incidents are examined with regards to the medium into which the spill was discharged. More than one environmental medium may be affected by a single spill. Of all reported spills, 48% are discharged to land (Fig. 2.6.1).

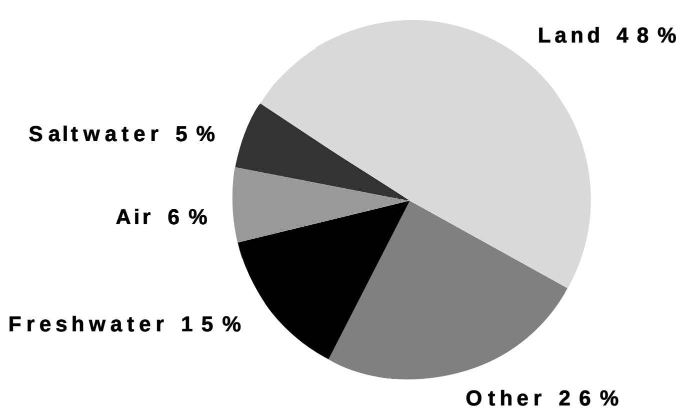
Releases to air account for only 6% of reported incidents. This low rate may be partly explained by the fact that releases to air are not always visible and may therefore be reported less often. Many land-based spills may also involve a release to air, but at the time of the initial report are described as land-based spills.

Waterways are second to land as the environmental medium most often affected. Groundwater may be impacted more frequently than statistics reveal (less than 1%); the existence or extent of groundwater contamination is often unknown at the time of the initial spill report and is rarely captured.

The ‘other’ category in this analysis refers to multi-media spills as well as spills that were held within some sort of containment area.

Figure 2.6.1

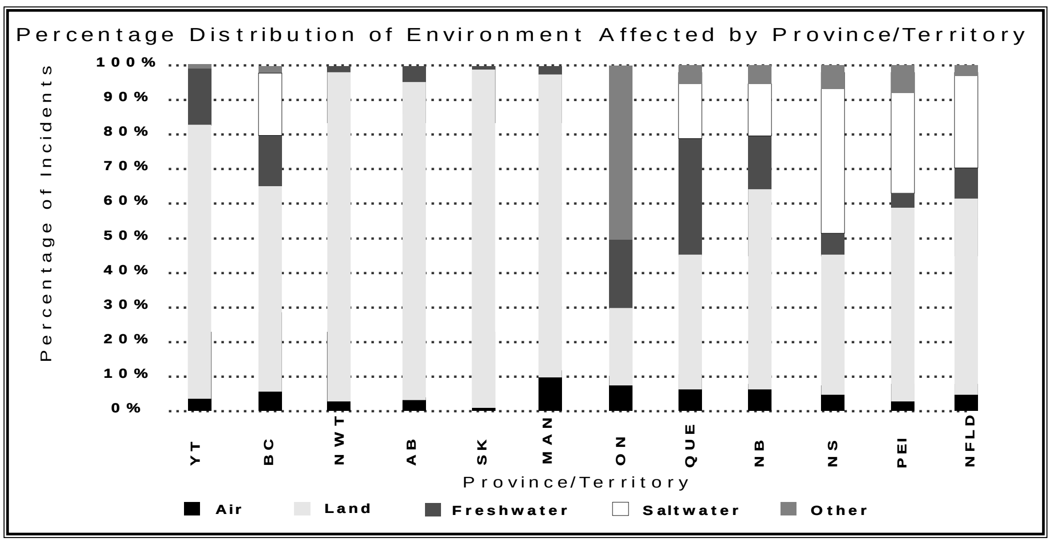
Percentage Distribution of Environment Affected by Reported Spills



2.6.2 Percentage Distribution of Environment Affected by Province and Territory

Upon closer examination of the environmental media affected, by province and territory, the largest number of spills to land are found to occur in Saskatchewan, Alberta, Manitoba, the Northwest Territories and the Yukon Territory (Fig. 2.6.2). There are a large proportion of facilities in the petroleum and mining industries located in these provinces, which in part accounts for the large number of spills affecting land. The Atlantic provinces (including Newfoundland) and British Columbia show high numbers of spills occurring in the saltwater environment, which is related to the marine activity on the east and west coasts. Quebec and Ontario have a higher number of spills affecting freshwater environments, which can be explained by the density of human population and activities adjacent to the St. Lawrence River, the Great Lakes and other fresh water bodies.

Figure 2.6.2



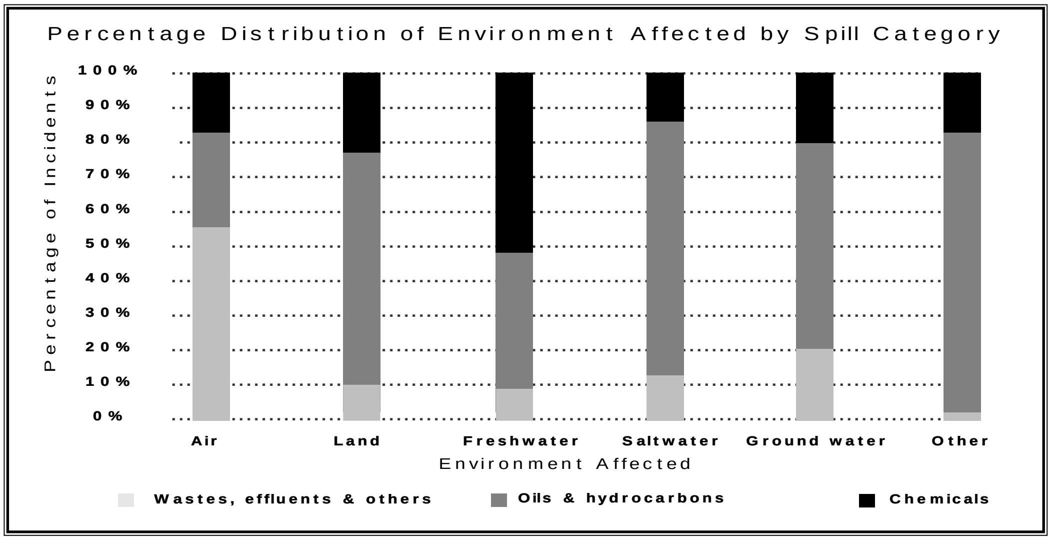
2.6.3 Percentage Distribution of Environment Affected by Spill Category (Oil, Non-Oil, Waste)

Every spill has the potential to affect one or more environmental media. The following chart (Fig. 2.6.3) shows how different types of spilled material — described as 'spill categories' — are distributed among the various media.

Nearly half of the incidents impacting air are from chemicals, with about 35% from oils and hydrocarbons.

Land is affected mostly by spills of oils and hydrocarbons (nearly 70%). The saltwater and groundwater environments are, in the majority of cases, also impacted by oils and hydrocarbons. The freshwater medium, on the other hand, is mostly impacted by wastes and effluents (52%).

Figure 2.6.3



2.6.4 Percentage Distribution of Reported Consequences of Spills

Figure 2.6.4 is a representation of reported consequences shown as a percentage of the total number of incidents, where data are available. The data available for this particular analysis are limited. However, the results are interesting and provide an indication of the most frequent consequences of spills.

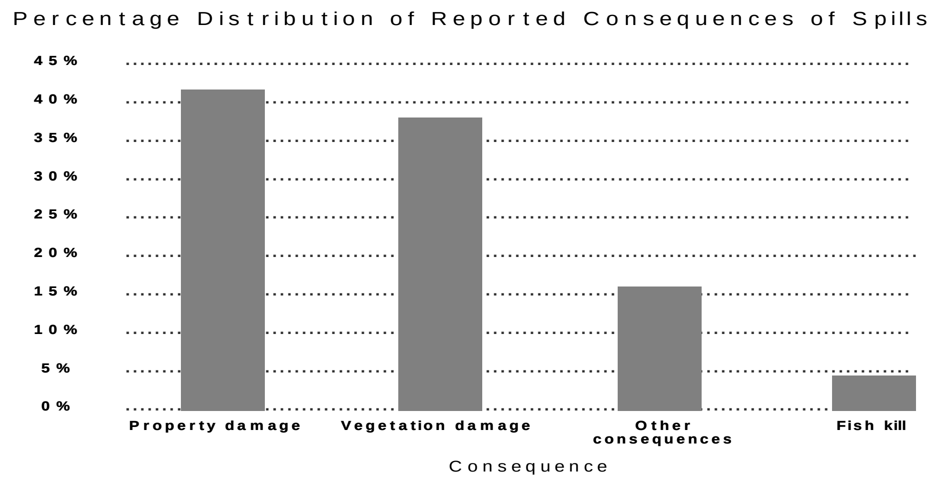
Property damage is the most frequently listed consequence (41%), followed by vegetation damage (38%). The fact that leaking pipes result in a large number of spills helps to explain the high percentage of reported consequences in these two categories.

Data for specific consequences such as oiled birds (<1%), contaminated drinking water (<1%) and income loss (<2%) are very limited and are therefore shown grouped in the 'other consequences' category. This category also includes the consequences not already indicated (approximately 14%) for a combined total of 16% of all reported consequences.

The number of reported fish kills is also quite low. There are several reasons that may contribute to an explanation. The evidence of a consequence of this type may not always be visible at the time of the initial report. Evidence of an impact may only become obvious days or weeks later.

As large number of spills affect both freshwater and saltwater, more complete reporting is required in this area in order to ensure that incident reports are updated if additional follow-up data become available. This would result in a more accurate representation of the impact of spills on fish, bird and other wildlife populations.

Figure 2.6.4



2.7 Summary Findings for Spills of MIACC List 1 Substances

Spill incidents involving the top five MIACC List 1 substances (both in number of spills and quantity spilled) are analyzed in this section. The five substances are anhydrous ammonia, chlorine, hydrochloric acid, gasoline and propane.

- Of all the MIACC List 1 substances, gasoline is spilled the most frequently (86%) and in the greatest quantity (83%). However, after 1989, the overall number of gasoline spills decreases as does the quantity spilled.
- The annual number of spills of ammonia and hydrochloric acid generally declines after 1989.
- The frequency of chlorine spills have increased gradually from 1984 to 1993 and declined somewhat from 1993 to 1995.
- The frequency of propane spills increases gradually over the period examined (1984-1995).
- A single spill event with a significant quantity spilled can impact the overall trend.

2.7.1 Introduction to MIACC and MIACC List 1 Substances

The Major Industrial Accidents Council of Canada (MIACC) was created in 1987. MIACC is a non-profit, multi-stakeholder organization dedicated to reducing the frequency and severity of major industrial accidents involving hazardous substances. The focus of MIACC is on emergencies prevention, preparedness and response (PPR) activities dealing with the manufacture, storage, transportation, distribution, handling, use and disposal of hazardous substances. MIACC also promotes harmonization in the implementation of PPR measures in Canada.

MIACC partners have developed lists of hazardous substances that have a potential for causing harm to people and the environment if released in an industrial accident. 'List 1' is the short list of high priority substances which are commonly found in Canada, in facilities and transport. The list includes substances that are considered to be highly hazardous (flammable, reactive, explosive, toxic) and that have a history of spill events.

Since 1991, Environment Canada has sponsored or participated in a series of life-cycle accident prevention workshops for specific MIACC List 1 substances. The life-cycle approach has been successfully applied in workshops for four substances: hydrofluoric acid (1990), chlorine (1993), propane (1995) and ammonia (1996). The reasons for selecting these specific substances range from amounts in commerce to a focus on a particular life-cycle stage. In future years, industry programs developed as a result of the workshops will likely show improvements for these substances, in both the number of spills and the quantity spilled.

2.7.2 Spills Involving the Top Five MIACC List 1 Substances

The following analysis examines the five List 1 substances involved in the highest number of spills. These are ammonia, chlorine, hydrochloric acid, propane and gasoline. Overall, the spill frequency for all five substances increases from 1987 to 1988 (Fig. 2.7.2), following the same trend as the overall number of spills reported in Canada (Fig. 2.1.1).

Gasoline is the most frequently spilled of the MIACC List 1 substances. The number of gasoline spills decreases substantially in 1992 and remains close to this value for the following three years. Gasoline is also the List 1 product spilled in the largest quantity with a total of 19 730 tonnes reported spilled between 1984 and 1995. One single incident, a pipeline leak in 1992, accounts for 6 200 tonnes (96% of the total for 1992). The second largest spill occurred in a storage depot in 1984 and accounts for 1 575 tonnes (28% of the total for 1984). Apart from these two peaks, the quantity reported per year decreases gradually throughout the period.

Anhydrous ammonia (including solutions >35%) and hydrochloric acid follow gasoline on the most frequently spilled list. Both reached a high of nearly 60 reported spills in the late 1980s. The frequency of ammonia spills has leveled off to approximately 40 per year, while hydrochloric acid spills have generally declined to levels close to 30 per year. The quantity of both ammonia and hydrochloric acid releases varies over the years studied, with no discernible trend.

Chlorine spills number in the order of 20 to 30 spills per year from 1988 to 1995. The number of spills gradually increases between 1984 and 1993, and declines slightly from 1993 to 1995 (Fig. 2.7.2). Apart from one large incident in 1986 (which involved a release of 408 tonnes due to a pipe leak in a storage area), the quantity of chlorine reported spilled per year does not change significantly, except for an increase in the last two years (Table 2.7.2).

The spill frequency of propane since 1988 increases from about 20 spills per year to about 30 spills. There is no discernible trend in spill quantities for propane.

Figure 2.7.2

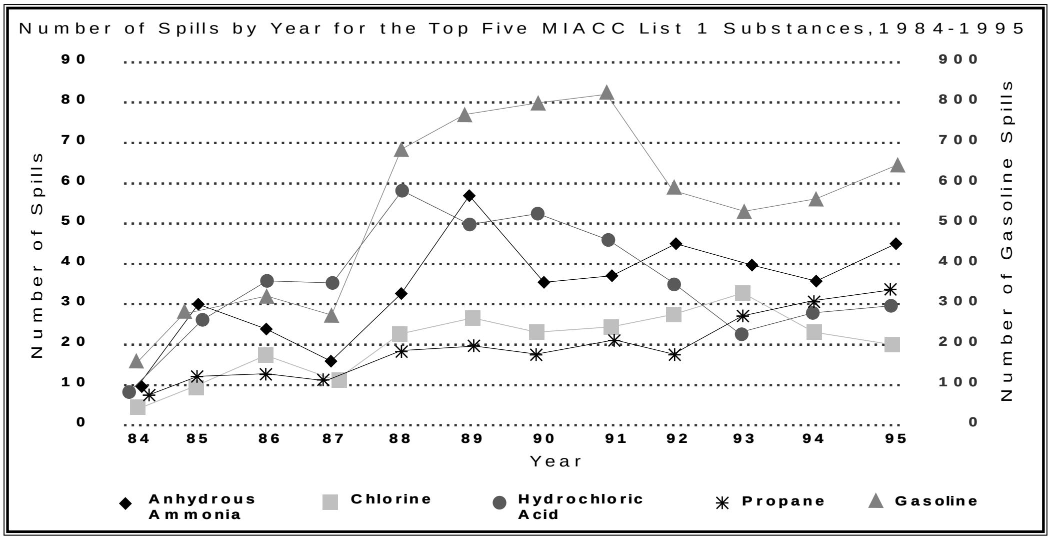


Table 2.7.2

Quantity Spilled Annually for the Top Five MIACC List 1 Substances

tonnes

Year	Anhydrous Ammonia	Chlorine	Gasoline	Hydrochloric Acid	Propane	Total
1984	27	2.9	5 632	36	19	5 716
1985	25	0.2	1 746	57	1 591	3 418
1986	33	409.1	909	53	25	1 430
1987	7	0.3	837	189	1	1 035
1988	17	9.2	1 096	51	1	1 174
1989	27	1.1	746	250	11	1 035
1990	86	0.1	675	106	64	930
1991	4	0.2	508	55	137	704
1992	28	0.5	6 439	346	15	6 829
1993	70	0.4	689	37	57	853
1994	13	8.2	206	72	43	343
1995	18	16.3	247	25	2	308
Total	**355**	**448.4**	**19 730**	**1 276**	**1 965**	**23 775**

2.8 Summary Findings for Spills by Material Categories

Analysis of the data for this section was carried out by grouping substances into three broad categories: oils, non-oils and wastes / effluents.

The key findings are:

- Oils account for 58% of the total number of spills reported, non-oils 24% and wastes 18%.
- Wastes and effluents account for 89% of the total quantity reported, non-oils account for 8% and oils 3%.
- The number of spills in the three material categories increases in 1988 and remains elevated since that time.
- Fuel oils and gasoline, subsets of the broad 'oil' category, account for 30% of the spill events reported.

The following charts and observations refer to all spills, regardless of the sector or source. Broad material categories are examined first, and more specific categories follow.

2.8.1 Reported Number of Spills by Material Category

The distribution of spill events by the broad types of materials spilled is presented in figure 2.8.1a. A distinction between oils and non-oils is used throughout the report, in an effort to maintain consistency with the previous spill trends report (Environment Canada, 1987). This distinction between oils and non-oils was first used in the initial years of spill management in Canada. Oil spills, particularly from large tankers, were at the forefront of public and political concern at that time. Through the years, chemical spills have gained equal importance in spill-prevention efforts.

Oil spills make up 58% of reported spills. The prevalent use of fossil fuels for powering vehicles, heating buildings, generating energy, and a myriad of industrial uses underlines the importance of oils as an independent category. Spill frequency is directly proportional to material usage. It is therefore not surprising to find that the highest spill rate is in the oils category.

Twenty-four percent of the remaining spills are composed of non-oils, and 18% are wastes and effluents.

Figure 2.8.1b looks at the spill quantities for the three categories. The tonnage spilled is dominated by the wastes and effluents category. A survey of the largest spills reported (Section 2.9) indicates that the majority of the largest spills are in this category. Most of these spills are municipal sewage releases, often due to storm or floods that result in the overflow or bypass of storm and sanitary sewage systems. Some incidents in this category are spills of industrial effluents; releases of 'mine water', 'mill water', 'white water', mine tailings, and other dilute solutions.*

Oils, including the range from bunker fuel to natural gas, and crude oil to gasoline, comprise 3% of the quantity reported, while all other substances, the 'non-oils' comprise 8% of the total tonnage of spills.

* As the concentration values of diluted effluents are usually not available when a spill is reported, the actual quantity of contaminant being discharged is often not known. In those cases where the concentration is known, the values are usually in the parts per million range. This means that the quantity spilled, in terms of contaminant release, may be smaller than it first appears.

Figure 2.8.1c shows the year by year progression of the breakdown of oils, non-oils, and wastes and effluents by number of spills reported. From 1984 to 1987, the proportion of waste spills ranges from 5% to 7%, while from 1988 on, the proportion of waste spills steadily increases to reach a plateau of about 25% of spills. The percentage of oil spills for the first six years (1984-1989) is 69%; for the last six years (1990-1995) it is 55%. Similarly, for 'non-oils', the proportion of reported spills remain fairly steady, going from 24% to 22%.

Figure 2.8.1a

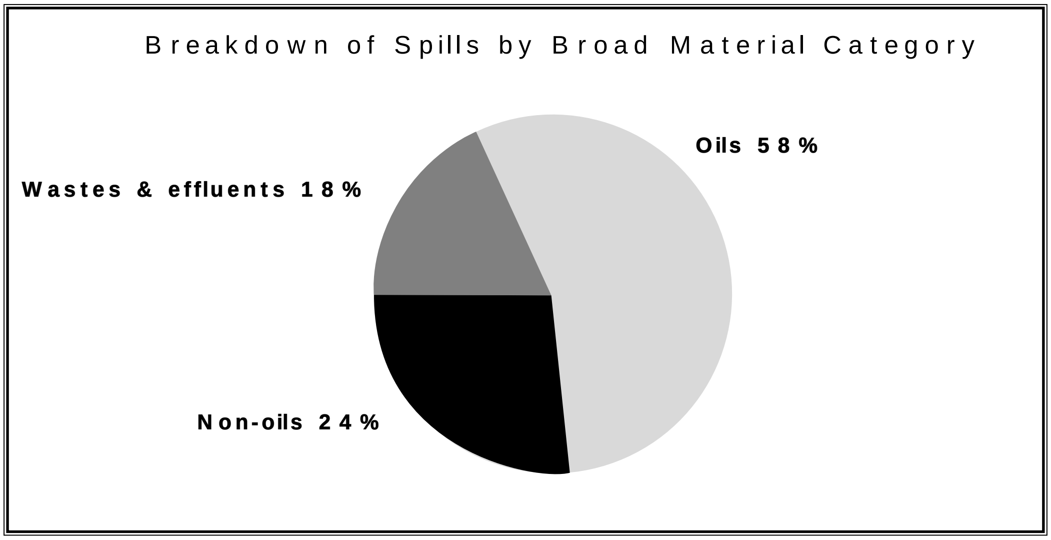


Figure 2.8.1b

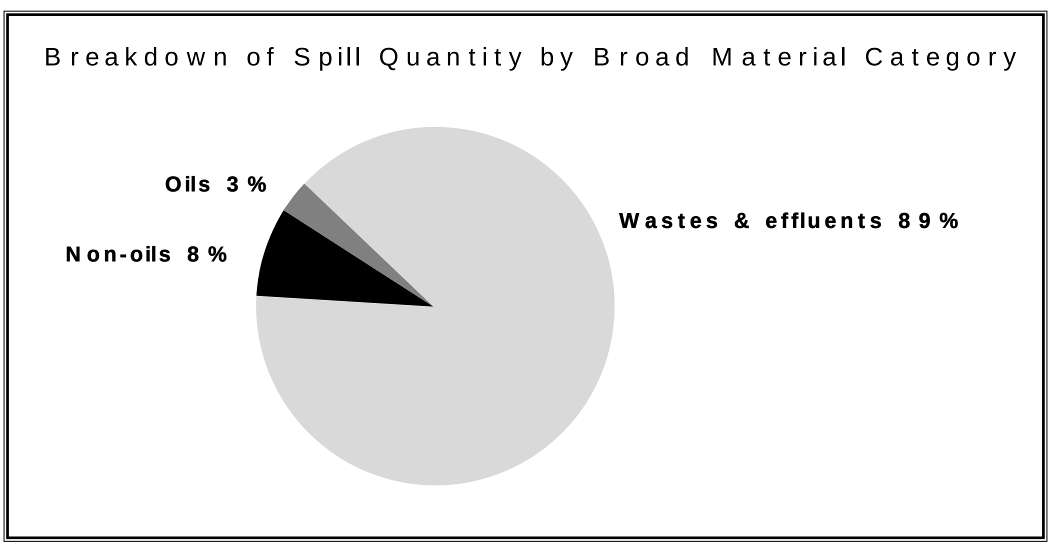
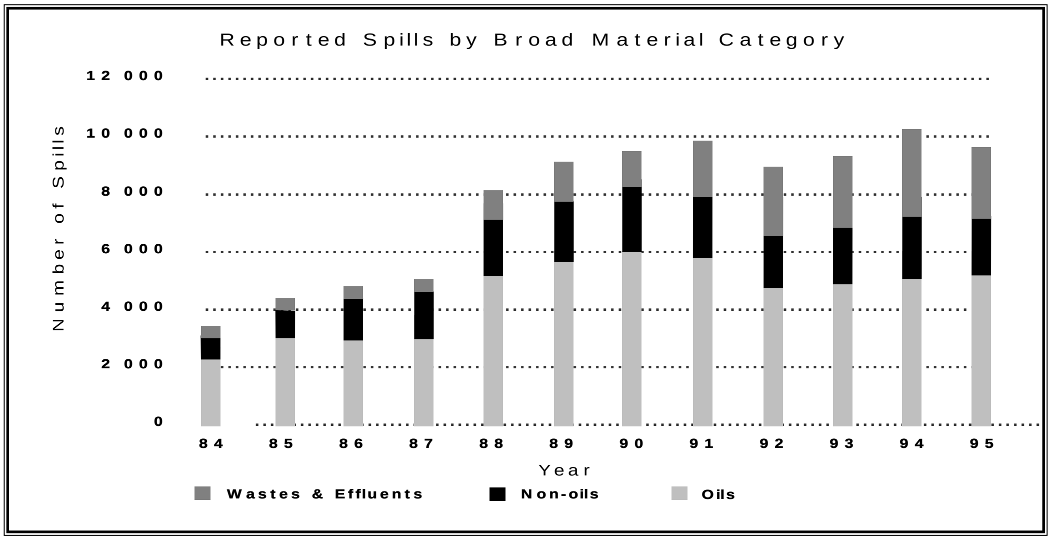


Figure 2.8.1c

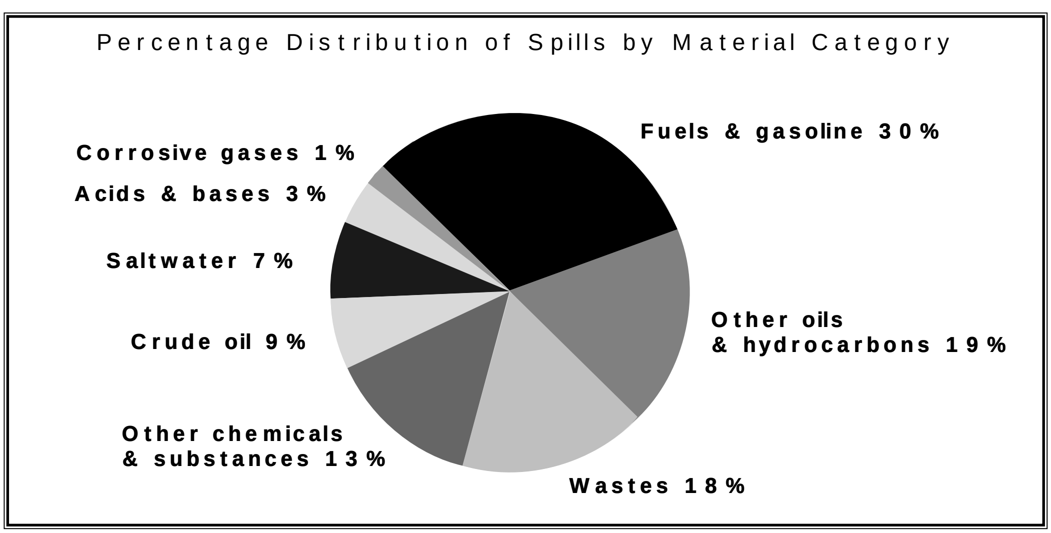


2.8.2 Percent of Spills by Material Category

Figure 2.8.2 shows a more detailed view of material categories, looking at the distribution by number of spills.

Fuel oils and gasoline, the most common fossil fuels currently used in Canada, account for 30% of the spill events in Canada. Crude oil, the source of these fuels, accounts for only 9% of the spills; with other oils and other hydrocarbons accounting for another 19%. Saltwater, a component of the mixture that comes out of the oil well, mixed with the crude, has always been reported as a separate substance (e.g. a two-tonne spill might be registered as one tonne of crude oil and one tonne of saltwater); it accounts for 7% of the spills. This indicates that the majority of crude oil spills occur at the stage where the crude is still in a mixture with saltwater. Acids and bases (among the most common in use in Canada are sulphuric acid and sodium hydroxide) comprise 3% of spills in the country. Corrosive gases (the most common being chlorine and ammonia) account for 1% of the total. The category called ‘other chemicals and substances’, which includes pesticides, plastic precursors, paints, salts, and a myriad of industrial chemicals, comprises 13% of spills.

Figure 2.8.2



2.9 Summary Findings for Major Spills in Canada (1984-1995)

- Sewage and effluents are spilled in high quantities nation-wide.
- The largest reported spills involve either sewage or effluents.
- There are a number of large saltwater spills occurring in the petroleum industry.
- Spills involving fuel oil and crude oil are the largest of the non-sewage / effluent spills.
- The number of spills exceeding 100 tonnes in Canada increases from 1984 to1992; the frequency decreases after 1992.
- The industry base and industrial activity in each of Environment Canada's five regions correlates to the nature of the major spills occurring in these regions.

2.9.1 Distribution of Major Spills in Canada

This section provides information on major spills in Canada by Environment Canada regions for the years 1984 to 1995 (Tables 2.9.1 through 2.9.5). Environment Canada's five regions are Pacific and Yukon (includes British Columbia and Yukon Territory), Prairie and Northern (includes Alberta, Saskatchewan, Manitoba and the Northwest Territories), Ontario, Quebec, and Atlantic (includes New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland). The tables presented in this section provide information on the types and quantities of major spills occurring in Canada in various sectors, and the sources and causes of these spills.

The sectors reporting large spills include chemical, government, metallurgy, mining, petroleum, pulp and paper, and service industry. These are the sectors examined most closely in this report. The transportation sector, although recognized as an important sector and prone to major releases, has not been included for reasons discussed previously in this report (see 'Notes for Sections 2.2-2.4)

The range of major spills and the types of substances spilled vary from region to region. High-quantity sewage spills are prevalent across the country.

A large number of major spills in the Pacific and Yukon and Atlantic regions are discharges to water. Most major spills occurring in the Prairie and Northern Region are either from pipelines or the production field. Ontario has multiple large spills in the metallurgy sector. Quebec shows spills in a variety of industries, including the transportation sector, petroleum refineries, and the chemical sector. The sources of the major spills reflect the industry base and activity in each region.

Table 2.9.1

Pacific and Yukon Region, Top Spills			
Material	**Sector**	**Quantity (tonnes)**	**Remarks**
Raw sewage	Municipal government	100 000	Pipeline leak, discharged into a river
Effluent	Pulp and paper	27 000	Discharge from pulp and paper mill into a lake due to equipment failure
Raw sewage	Municipal government	21 300	Spill to a river due to equipment failure
Raw sewage	Municipal government	13 500	Overflow discharged into river
Raw sewage	Municipal government	11 000	Discharge into marine environment due to equipment failure
Effluent	Pulp and paper	4 800	Discharge from pulp and paper mill on land due to equipment failure
Chlorinated water	Municipal government	4 550	Pipeline leak, discharged into a harbour
Raw sewage	Municipal government	4 500	Discharge into a river due to equipment failure
Gypsum rock	Transportation	3 200	Shipping accident in marine environment
Chlorine dioxide solution	Pulp and paper	815	Tank rupture, discharge into river/marine environment
Crude oil	Petroleum	750	Pipeline spill on land
Coal	Transportation	400	Train derailment
Chloramine	Municipal government	225	Pipeline failure
Crude oil	Petroleum	190	Pipeline failure, spilled on land
Sodium chlorate	Pulp and paper	150	Human error

Table 2.9.2

Prairie and Northern Region, Top Spills			
Material	**Sector**	**Quantity (tonnes)**	**Remarks**
Sewage	Municipal government	84 000	Spill from municipal sewage treatment plant
Mine tailings	Mining	39 000	Dyke failure as a result of material failure
Crude oil	Petroleum	13 075	Spill in production field, overflow due to human error
Saltwater	Petroleum	8 200	Pipeline failure due to corrosion
Saltwater	Petroleum	8 000	Spill in production field due to equipment failure
Gasoline	Petroleum	6 200	Pipeline spill due to equipment failure
Mine tailings	Mining	4 000	Dyke failure of storage pond
Mine tailings	Mining	3 300	Cause unknown
Crude oil	Petroleum	2 150	Pipeline leak due to material failure
Coal	Transportation	2 100	Train derailment
Crude	Petroleum	1 045	Pipeline spill due to corrosion

Table 2.9.3

Ontario Region, Top Spills			
Material	Sector	Quantity (tonnes)	Remarks
Effluent	Metallurgy	980 000	Dirty water discharge from a steel mill to harbour via storm sewer
Sewage	Provincial government	875 000	By-pass of chlorinated sewage due to storm
Sewage	Municipal government	300 000	Sewage by-pass due to rain
Sewage	Municipal government	250 000	Sewage by-pass due to rain
Sewage	Municipal government	160 000	Sewage by-pass due to rain
Effluent	Metallurgy	145 000	Discharge of dirty water from steel mill filtration plant into a lake
Sewage	Municipal government	100 000	Sewage by-pass due to rain
Sewage	Municipal government	80 000	Sewage by-pass due to rain
Sewage	Municipal government	72 000	Sewage by-pass due to rain
Sewage	Municipal government	65 000	Sewage by-pass due to melting of snow
Petroleum	Petroleum	4 050	Dyke failure
Ammonia solution	Chemical	3 650	Solution discharged to a river
Alcohol beverages	Food processing	3 500	Discharge of liquid into a sanitary sewer
Petroleum oil	Metallurgy	3 475	Discharge of oil and water mixture from steel mill into a lake
Petroleum oil	Metallurgy	3 060	Discharge of oil and water mixture from steel mill into a lake
Phosphate	Metallurgy	2 880	Discharged from steel mill into a storm sewer
Ammonia solution	Metallurgy	2 000	Discharge of cooling water mixture into a lake

Table 2.9.4

Quebec Region, Top Spills			
Material	Sector	Quantity (tonnes)	Remarks
Heavy oil	Petroleum	5 580	Above-ground tank failure in a refinery due to overstressed material
Sodium hydroxide	Chemical	1 640	Pipeline/equipment failure at industrial plant
Bunker C	Petroleum	715	Ship collision
Crude oil	Petroleum	400	Ship collision due to human error
Gasoline	Mining	395	Failed valve fitting due to vandalism
Fuel oil	Petroleum	295	Above-ground tank spill due to human error
Fuel oil	Petroleum	250	Pipeline spill due to human error
Bunker	Petroleum	235	Ship grounding due to storm floods
Fuel oil	Metallurgy	205	Equipment failure in metallurgy plant
Light fuel oil	Petroleum	180	Overflow due to equipment failure from storage
Bunker	Transportation	155	Valve failure due to human error in rail transport

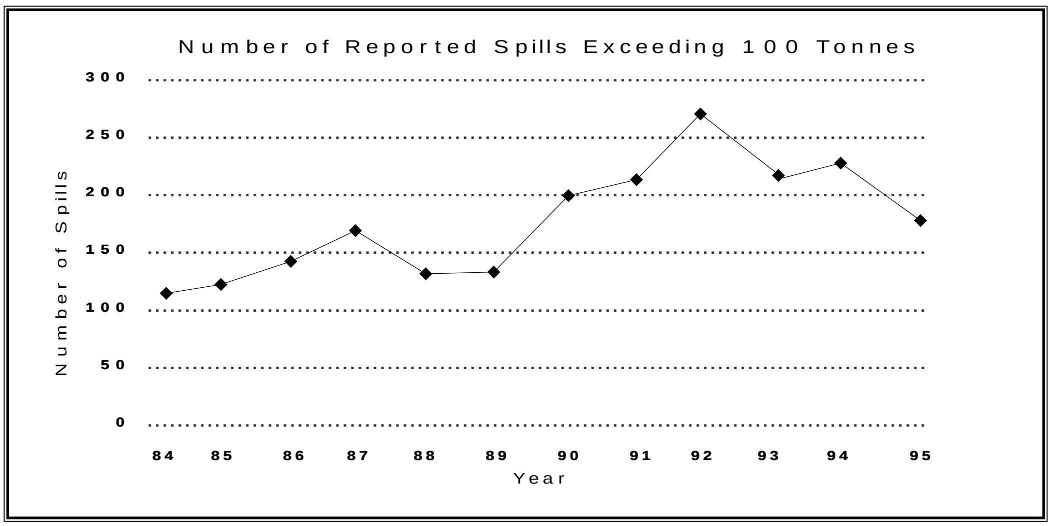
Table 2.9.5

Atlantic Region, Top Spills			
Material	Sector	Quantity (tonnes)	Remarks
Sewage	Municipal government	132 000	Discharge into harbour from sewage treatment plant
Crude oil	Petroleum	17 200	Shipping accident due to severe storm
Pig Manure	Agriculture	4 550	Dyke failure from a private sector farming operation
Sewage	Construction	4 550	Intentional dumping of sewage into a river from a construction site
Sewage	Municipal government	3 200	Discharge into a river from a sewage treatment plant
Sewage	Federal government	2 300	Sewage escaped to a National Park from hole in lagoon
Industrial waste	General food processing	2 300	Discharge due to lagoon wall failure
Fertilizer	Transportation	1 200	Train derailment due to flood
Mine tailings	Mining	1 000	Brine spilled into brook
Bunker oil	Petroleum	910	Ship collision
Bunker oil	Petroleum	440	Ship grounding
Bunker oil	Petroleum	410	Ship grounding
Lube oil	Federal government	400	Pipeline leak to a lagoon

2.9.2 Number of Major Reported Spills

The number of spills exceeding 100 tonnes rises steadily between 1984 and 1992 (Fig. 2.9.2). Since that time the number of large spills appears to decrease. This may be explained by industry's management in the area of hazardous materials; with an increased focus on the elements of prevention and preparedness, the result is fewer major spills from 1992 to 1995.

Figure 2.9.2



ENVIRONMENT CANADA'S ROLE IN ENVIRONMENTAL EMERGENCIES

3

3.1 The Environmental Emergencies Program of Environment Canada

The main objective of Environment Canada's Environmental Emergencies Program is to prevent and reduce the frequency and severity of impacts on the environment. This is achieved by promoting better prevention and preparedness measures, providing response advice, improving science and technology, and by relying on sound planning and partnerships. Environment Canada has entered into a range of bilateral and multilateral inter-governmental agreements, at the regional, national and international levels. These are designed to enhance Environment Canada's ability and the ability of others, to prevent, prepare for and respond to a variety of emergency situations.

The key components of the Environmental Emergencies Program are prevention, preparedness, response advice and science and technology. The Environmental Emergencies Program promotes these elements domestically and also does so through a variety of international activities.

This section briefly describes the components of the Environmental Emergencies Program. In addition, four case histories are presented which profile the role Environment Canada plays in an emergency and describe how a variety of environmental emergencies are handled through inter-agency co-operation.

3.1.1 Prevention

The preferred approach for dealing with environmental emergencies is to anticipate incidents and prevent them from happening, rather than engaging in a reactive approach after they occur. This approach is more cost effective for industry and for society as a whole. Environment Canada has developed an action plan to assist federal agencies to identify and manage the risks associated with the handling, storage, use and disposal of hazardous substances.

Environment Canada was a lead player in creating the Major Industrial Accidents Council of Canada (MIACC), formed in 1987. MIACC provides a national multi-stakeholder forum for industry, emergency response organizations, all levels of government, labour, academia and other interested parties to co-ordinate activities in all aspects of prevention, preparedness and response to major industrial accidents. The Department maintains a leadership role in areas such as risk assessment, process safety, life-cycle management of hazardous substances, and spills on federal lands.

3.1.2 Preparedness

Effective preparedness is built on trust and co-operation among government, industry and communities. Potential risks are identified and contingency plans are developed to deal with them, including training of personnel and periodic exercising of contingency plans. The Department works closely with other federal and provincial resource agencies, industry, and various international agencies to promote domestic and international preparedness measures for environmental emergencies. The detailed list of preparedness activities is presented in Environment Canada's *National Contingency Plan* (Environment Canada, to be published).

3.1.3 Response Advice

Environment Canada provides technical and scientific advice during emergency events, particularly those that fall within federal jurisdiction. Properties under federal responsibility include native lands, military bases, national parks and most airports. This responsibility also extends to federally managed resources, such as fish and wildlife, that come under the jurisdiction of the *Fisheries Act* and the *Migratory Bird Convention Act*. Sensitivity mapping is an important tool because it can provide up-to-date information on environmentally sensitive areas. It is useful for identifying resources at risk and determining protection and clean up strategies during an incident. The Department may also participate in joint-response operations if assistance is requested by other agencies. Effective emergency response requires teamwork among all levels of government, industry, communities, and local organizations.

Environment Canada conceived the Regional Environmental Emergency Team (REET) concept in the early 1970s. REETs are made up of federal, provincial and municipal government agencies, as well as industry and non-government associations that have expertise in dealing with environmental emergencies. During an emergency, the team's multi-disciplinary composition provides responders with 'one-window' for accessing scientific information and assessment of environmental protection priorities.

3.1.4 Science and Technology

Environment Canada is a leader in the advancement of knowledge on the behaviour and fate of chemicals in the environment. The Department is also involved in the development of many new environmental techniques and technologies for spill site hazard-level monitoring, spill containment and clean up, site remediation, and the disposal of contaminated debris. A specific example is the Laser Environmental Airborne Fluorosensor (LEAF) which can identify oil from the air in ways no other instrument can. A useful tool in promoting technology is Environment Canada's *Spill Technology Newsletter* with 2 500 subscribers in 40 countries. The Department also sponsors two annual international seminars: the Technical Seminar on Chemical Spills and the Arctic and Marine Oil Spill Program Seminar. Environment Canada hosts international research and development committee meetings to influence future research into chemical and oil spill detection, behaviour and response.

3.1.5 International

Canada has commitments under international treaties to assist other nations in responding to environmental emergencies, and to ensure that Canadian environmental interests along the Canada-U.S. border and in Arctic areas are protected. Environment Canada participates in international fora such as the Organization for Economic Co-operation and Development (OECD), the United Nations Environment Programme (UNEP), the United Nations Economic Commission for Europe (UNECE), the International Maritime Organization (IMO), the

International Joint Commission (IJC), the American Society for Testing and Materials (ASTM), and the Arctic Environmental Protection Strategy (AEPS) for circumpolar countries.

3.2 Case Histories

This report deals mostly with statistical analyses based on the evaluation of spill incidents. The statistical analyses are a means for examining national trends in the environmental emergencies, and allow for observations on the types of incidents which occur most frequently and why they happen. Case histories, which examine particular incidents, have a different function. Focusing on a given incident allows for an examination of the challenges faced at the operational level during a major environmental incident, review of the role and contribution of the various agencies involved and determination of cause to aid prevention efforts. In some cases, single incidents have changed the way entire industries carry out their activities, and have stimulated major changes in legislation at all levels of government. For these reasons, it can be very useful to examine individual incidents as well as the trends that are revealed by analysis of data on a large number of occurrences.

Each of the four cases has contributed to either major legislative changes, changes in the approach to such incidents, or the advancement of the scientific component of environmental emergencies and the prevention, preparedness and response to events. Each study provides an overview of the incident, the human impact, the environmental damage incurred, Environment Canada's role, discussion of inter-agency co-ordination, and any legislative changes or changes to industrial practices that were implemented in direct response to these incidents.

3.2.1 Canning, Nova Scotia — Warehouse Fire, May 31, 1986

Incident Overview

At approximately 2:00 a.m. on May 31, 1986, a fire broke out at an agricultural-product warehouse owned by Maple Leaf Farm Supplies Ltd. in the Village of Canning, Nova Scotia. The warehouse contained a wide variety of chemicals including pesticides, herbicides, fumigants (notably methyl bromide gas), fertilizers (45 in total), and several propane cylinders. Roughly 12 000 kilograms of solid and liquid waste was generated as a result of the fire and clean up activities, and 62 chemicals were eventually identified from samples taken in the area.

Human Impact

Residents in the Village of Canning were evacuated and not permitted back into their homes for six days.

Twenty-three fire fighters and police officers were treated for symptoms such as dizziness and eye irritation. Other than this, no serious injuries were reported. A series of blood and urine tests were performed on 220 individuals who had been potentially exposed to toxic fumes. The test results indicated that no significant bioaccumulation of substances had occurred.

Environmental Damage

Local fire fighters used 266 000 gallons of water and fire-fighting foam to fight the blaze.
The majority of the contaminated water migrated off-site over private property, into a farmer's pond, finally reaching the Habitant River and Minas Basin. As a direct result of contamination from the runoff, some vegetation and a substantial number of fish, worms and other invertebrates were destroyed. Toxic vapours from the fire had an adverse environmental impact on local air quality and surrounding vegetation. Overall, analysis of samples from various media indicated only transient environmental contamination. No long-term environmental consequences were observed.

Actions Taken by Environment Canada at Time of Incident

Regional Environment Canada staff:

- developed a comprehensive inventory of all agricultural products stored in the warehouse. This was performed in conjunction with the warehouse owner and the Nova Scotia Department of the Environment (NS DOE);
- worked with product manufacturers to determine the safest and most appropriate containment, neutralization and cleanup procedures;
- monitored site clean up and contamination of surrounding areas;
- supplied a reverse osmosis unit for treatment of pesticide-contaminated water; and
- performed and co-ordinated laboratory analyses of water, soil, sediment, fish, shellfish, and co-ordinated analysis of beef and milk samples.

Inter-Agency Co-ordination

Agencies involved included NS DOE, the RCMP, local fire fighters, provincial and county health authorities, the Department of Fisheries and Oceans, Agriculture Canada, Health Canada, the National Research Council (NRC), the Department of National Defence, several chemical company representatives and the Canadian Agricultural Chemicals Association (now known as the Crop Protection Institute of Canada).

Initial response activities were enacted with speed. The local fire chief contacted volunteer departments in the area to assist. CANUTEC (the Canadian Transportation Emergency Centre) was also contacted early on and provided spill information to the Canadian Coast Guard (CCG) Vessel Traffic Centre, the focal point for emergency communications in the Atlantic Region. CCG, in turn, relayed the information to the NS DOE, Environment Canada, and other interested agencies. Environment Canada and NS DOE representatives were on the scene within 3.5 hours of the initial response by the fire department. The RCMP and local fire fighters carried out the evacuation of the 750 nearby residents immediately after being alerted of the incident.

Environment Canada assisted NS DOE in the sampling and analysis of soil, sediment, water, vegetation, beef, and milk in the affected area. Some of the samples taken were provided to the NRC, Agriculture Canada, and Health Canada for analysis. Environment Canada's analyses were performed in Conservation & Protection labs in Dartmouth and Ottawa.

Options for remediation were also discussed at length among the various agencies. The following clean up strategy, which unfolded over a one-month period, was implemented:

1. All remaining warehouse substances were contained on site.
2. Structural building debris was decontaminated and removed for appropriate disposal or storage.
3. On-site and off-site contaminants and wastes were recovered and either disposed of or recycled.
4. Impacted areas were decontaminated and restoration activities initiated.

There was some discussion as to whether some materials should be disposed of or recycled. Some of the regulations which now govern the transportation and disposal of hazardous substances were not yet in effect. One hundred and sixty drums (over 30 000 litres) of chemical waste from the fire were slated for disposal at an Ontario landfill, but were turned back at the Quebec border for lack of proper transport authorization. As a result, the drums were stored on a local farmer's property for nearly a year following the initial clean up until all proper documentation was in order and the shipment could be sent to its destination.

Impact of Incident on Subsequent Spill Prevention, Preparedness, and Response Activities

As a result of the fire and numerous other similar incidents, new pesticide-storage regulations were enacted by NS DOE and industry warehouse standards were developed by the Crop Protection Institute of Canada.

3.2.2 Hagersville, Ontario — Tire Fire, February 12-28, 1990

Incident Overview

On February 12th, 1990, a fire broke out at a tire dump in Hagersville, Ontario at a company called 'Tyre King'. The fire burned intensely for a total of seventeen days, consuming a total of 12.6 million tires. Canadian authorities implemented a 'controlled burn' strategy for the first seven days. The intervention at this stage was limited to building an access route downwind of the blaze and spraying the periphery with recycled firewater. For the second stage of the fire, when thermal radiation decreased significantly, construction equipment was used to break up burned tire piles and separate out the unburned tires to use as windbreaks.

Human Impact

No injuries were reported as a direct result of the fire. About 1 700 people living within a four kilometre radius of the dump were evacuated for the duration of the blaze, and 25 individuals were faced with the contamination of their water supply for a period of three months.

Environmental Damage

With no permanent fire system in place, a small artificial pond was the primary available source of water. The pond was located near the access road and 100 metres from the depot at the closest point and was frozen at the beginning of the incident. No sand or gravel quarry was in operation in the area.

The incident created 20 000 m^3 of solid waste and contaminated 4.5 hectares of land with fire water containing 12-50 m^3 of liquid residue (benzene, toluene, xylene, styrene, oils, etc.). Between 12 000 and 15 000 litres of oil were estimated to have reached the water table.

Inter-Agency Co-ordination

Agencies involved included: Environment Canada-Atmospheric Environment Service, the Ontario Ministry of the Environment and Energy, Health Canada, Emergency Preparedness Canada, Natural Resources Canada, Agriculture Canada, the U.S. Environmental Protection Agency, Public Health Services, Indian and Northern Affairs Canada, National Water Research Institute, Haldimand-Norfolk Fire Department, Canadian Coast Guard, Department of National Defence, and First Nations groups in the area.

Actions taken by Environment Canada at Time of Incident

Federal response to the fire was co-ordinated by Environment Canada's National Environmental Emergencies Centre. Environment Canada:

- acted in an advisory capacity to the lead provincial response agency to provide technical support as required;
- provided weather data and forecasts;
- performed surface-water-quality monitoring;
- performed air-quality monitoring;
- performed stream-flow monitoring; and
- conducted sample analyses.

Impact of Incident on Subsequent Spill Prevention, Preparedness, and Response Activities

1. Development of Tire Storage Guideline

   As a result of the Hagersville fire, a Canadian Council of Ministers of the Environment (CCME) Working Group on Used Tire Inventory and Management was established by the Ontario Ministry of Environment and Energy, and a *Proposed Guideline for the Outside Storage of Used Tires* was developed. This Guideline was also used as a basis for an amendment to the *Ontario Fire Marshals Act*: the fire service is now permitted to take pre-emptive action in response to a serious fire threat, and to take action in cases where human or environmental consequences from a tire fire would be severe, even where the likelihood of such a blaze is minimal.

2. Establishment of an Authorization Procedure for Facilities Storing Tires

   In July 1991, CCME guidelines set out an authorization procedure applicable to facilities storing a significant number of tires (greater than 1 000). Conditions for approval were proposed, many of which are variations of the tire storage guideline recommendations noted above.

3. Amendment to the *Ontario Environmental Protection Act*

   A legal technicality allowed Tyre King to avoid conforming to a 1987 environmental control order (calling for separation of the tire pile into hundreds of smaller piles with fire lanes, construction of a chain fence and a large water reservoir), by virtue of the fact that all such orders were halted while under appeal. This loophole has since been remedied: the Environmental Appeal Board now has the power to rule immediately on provincial court order appeals.

4. Recycling Initiatives

   Recycling initiatives have been spurred on by the incidents at Hagersville and Saint-Amable tire dumps. In Alberta, for example, scrap tires were formerly dumped at a rate of 2.2 million tires per year. Since the introduction of the tire-recycling strategy, tires have been used in a variety of innovative ways rather than being sent to tire dumps. Manitoba has also implemented a similar recycling program.

5. New Tire Tax Implemented

   A recycling fund was set up in July of 1991 in Alberta, based on revenue from a newly introduced $4-per-new-tire surcharge. In conjunction with the aforementioned recycling processes, this tire tax has cut into the 'backlog' of tires so substantially that all tire dumps across Alberta were expected to be cleared by 1998. A similar fund was setup in Manitoba in March 1995, whereby a "Waste Reduction and Prevention Levy" of $3.00 is added to all new tire purchases.

6. Amendment to the National Fire Code

The Fire Code was revised to include the concept of Isolated Storage Areas for tires and other materials with separation distances allowing access for fire fighting operations. The Fire Code was last published in 1995.

Lessons Learned

- Due to the toxicity of liquid residues that are released into the soil when tires ignite, tire dumps should always be established on impermeable surfaces.
- Intervention becomes feasible during the second stage of a typical tire fire. (Following the formation of a crust of ashes and steel and combustion within the main tire pile, thermal radiation is substantially reduced.)
- Radiation-impacted equipment and tires can be cooled more effectively when a low concentration of emulsifier (0.3%) is applied together with sprayed water.

3.2.3 Hervey Junction, Quebec — Train Derailment, January 21, 1995

Incident Overview

On January 21, 1995, a train travelling through central Quebec derailed from a broken section of track. Twenty-eight of the forty-four tank cars on the train went off the track and spilled a total of 255 000 gallons of concentrated sulphuric acid. The majority of the product entered Lake Masketsi and the Tawachiche River, northeast of Trois-Rivieres. In order to neutralize the acid, three truckloads (170 tonnes) of powdered limestone were poured into the lake. Due to residual contamination, Lake Masketsi has been closed for recreational use until the year 2003, and the Tawachiche River until the year 2000.

Agencies on site collectively agreed to the following strategy for recovery and subsequent remediation.

Recovery of tank cars

- Undamaged rail cars were lifted back onto the track and brought to Hervey Junction to be off-loaded. Several half-full cars were pumped out first, then returned to the track.
- Holes were drilled on the tops of several carriages in order to evacuate any hydrogen gas that might have accumulated within.

Neutralization of acid

- 170 tonnes of limestone were poured into the lake in an effort to neutralize the acid. This was unsuccessful.
- A slurry of limestone and sodium hydroxide was then used to accelerate neutralization of acid pockets in the lake.
- Soda ash (sodium carbonate) was applied to the ditch under the rail cars to neutralize the acid in the soil.
- Large limestone blocks were placed at the mouth of the river in order to neutralize any remaining acid in the waterway.

Follow-up activities

- Removal of lime build-up at spill site

- Monitoring of brook trout spawning habitat
- Replenishment of brook and lake trout populations

Human Impact

The spill occurred in a remote, sparsely populated region and no injuries were reported by response personnel.

Environmental Damage

The freshwater ecosystems affected by the spill were a spawning ground for certain species of protected fish, notably the gray trout and tommycod. As a result of the incident, these species may now be in danger of perishing in this area. The majority of aquatic populations along 13 km of the river were destroyed by the acid influx.

Actions Taken by Environment Canada at Time of Incident

Environment Canada:
- collected and analyzed soil samples;
- took aquatic pH readings;
- determined the sulphate and sulphuric acid content of samples;
- analyzed the acid concentration in tank cars;
- advised other agencies regarding physical / chemical properties of sulphuric acid;
- provided advice on site restoration options; and
- performed an environmental impact assessment.

Lessons Learned

- Bottom unloading tank cars are reliable during a derailment.
- Tank car weaknesses are mainly at dome level, at the unloading pipe, and with the safety disk set.
- Thorough emergency-response training for contractors should be provided.
- Vacuum truck usage for off-loading tank cars is safe as long as proper procedures are followed.
- Temperate water must be available for emergency showers for decontamination, particularly during the winter months.
- Further collaboration between carriers and shippers of dangerous goods needs to be established.
- An accurate definition of jurisdictions for the different intervening parties and organizations on the emergency site should be available from the onset of work.
- When establishing the clean-up action plan, multi-party co-ordination is essential.

3.2.4 Gray's Harbour, Washington — *Nestucca* Oil Spill, December 23, 1988

Incident Overview

On December 23, 1988, the tug *Ocean Services* rammed and holed its tow (the tanker barge *Nestucca*), off Gray's Harbour, Washington, as the result of an improperly maintained towline. Approximately 875 tonnes of Bunker C crude oil was estimated to have escaped. A significant amount of this oil eventually reached the west coast of Vancouver Island, causing coastal ecosystem destruction and seabird fatalities.

Human impacts

During clean up activities one member of the Canadian Coast Guard was killed in a boating accident. No other injuries were reported as a direct result of the spill.

Environmental Damage

Numerous beaches and shoreline ecosystems along the coast of Vancouver Island suffered oil damage. As many as fifty-six thousand seabirds were destroyed. Bald eagles and other raptors which fed upon oiled carcasses were injured; herring spawning areas and crab / shellfish populations were oiled; and traditional native seafood was impacted.

Actions Taken by Environment Canada at Time of Incident

Environment Canada's main role was to provide technical advice to clean up crews and assist with any spill-affected wildlife, where needed. Specifically, Environment Canada carried out the following actions:

- removed oiled and perished birds washing ashore (with local volunteer groups);
- chartered aircraft to provide infrared surveillance of the area in search of further oil slicks;
- engineered a beach rock incinerator for the purpose of dealing with oiled rocks at a sea otter colony;
- performed an impact assessment of oil-affected areas along the west coast of Vancouver Island and in parts of the central coast (in conjunction with Canadian Coast Guard and First Nations representatives);
- participated in the assessment and establishment of clean up priorities; and
- monitored the West Coast Trail and Pacific Rim National Park for any recontamination.

Inter-Agency Co-ordination

Environment Canada assembled a federal-provincial team of experts to establish clean up priorities and to assess the short- and long-term impacts of the spill. The Regional Environmental Emergencies Team (REET) included representatives from Environment Canada, Department of Fisheries and Oceans, Canadian Coast Guard, Natural Resources Canada, BC Ministry of the Environment, BC Ministry of Agriculture and Fisheries, and the Nuu-Chah-Nulth Tribal Council. At the operation's peak, over 350 individuals from Environment Canada, Department of Fisheries and Oceans, the Canadian Coast Guard, BC Ministry of the Environment, the Provincial Emergency Program, First Nations, the National Oceanic and Atmospheric Administration and volunteers were all working concurrently to clean up the oil and reduce environmental damage.

Impact of Incident on Subsequent Spill Prevention, Preparedness, and Response Activities

1. Development of the 'Shoreline Clean-up Assessment Team' (SCAT)

   The approach was created following the *Exxon Valdez* spill (several months after the *Nestucca* incident) as a means of dealing with shoreline pollution from a major oil spill. The SCAT technique provides a means of establishing priorities for shoreline protection and clean up. SCAT teams use existing information sources in conjunction with in-depth field evaluations of the shoreline to obtain data on area geomorphology, characteristics of oil on beaches, and the specific environmental resources at risk.

2. *Public Review Panel Report on Tanker Safety and Marine Spill Response Capability* ('Brander-Smith Report', September 1990)

   In June 1991, the federal government allocated resources for the improvement of Canada's spill prevention and response strategy. The funds were divided among Environment Canada, the Canadian Coast Guard, and the Department of Fisheries and Oceans, to be utilized over a six-year period in accordance with recommendations made by the Panel. One key goal set forth by the Panel was that Canada's regional response capability should be sufficient to address spill quantities up to 10 000 tonnes.

3. Amendments to the *Canada Shipping Act* (August 1995)

A series of regulations, penalties, and procedures for ships and oil-handling facilities aimed at heightened prevention and response capabilities were drawn up. Requirements were set forth for the establishment of emergency-response plans for vessels and oil-handling facilities. Most notably, oil-handling and shipping industries were required to enter into a contractual agreement with newly established, Canadian Coast Guard-certified, industry-funded Response Organizations.

4. Creation of the States / British Columbia Oil Spill Task Force

The States / British Columbia Oil Spill Task Force was formally created in 1989, in response to the *Nestucca* and *Exxon Valdez* oil spills. Its mission is to enhance the efforts of member agencies to prevent, prepare for and respond to marine oil spills on the west coast. This is achieved by reducing the costs associated with duplication of activities, sharing information and resources between agencies, co-ordinating development and initiation of spill risk-reducing policies and programs, and fostering regulatory consistency.

The main focus of the Canadian federal government following the *Nestucca* barge spill (1988) and the *Exxon Valdez* spill (1989) was to improve Canada's marine oil spill response capability.

5. BC Marine Oil Spill Contingency Plan

In 1992 the British Columbia Ministry of Environment, Lands, and Parks (the lead provincial agency for marine oil response) developed the BC *Marine Oil Spill Contingency Plan*, based on the international Incident Command System. The Plan defines the scope and structure of British Columbia's involvement in responding to a major oil spill.

6. Environmental Liability Proceeds Awarded

Environment Canada pursued the only Canadian environmental damages case for *Nestucca*, utilizing the 'contingent valuation' damage assessment methodology. Ultimately, $4.4 million CDN was collected from Sause Bros., the shipping-line owners. The funds have since been used for rehabilitation of a Langara Island bird-breeding colony. Additionally, the experience gained in assigning dollar values to the various spill activities led to creation of regional guidelines for recovering the costs of spills.

OBSERVATIONS AND CONCLUSIONS

4

The analysis of spill data and resulting trends helps to identify areas that need improvement through the development of appropriate strategies, processes and programs. The main purpose is to minimize the extent and impact of environmental releases.

This report examined eight key areas for the years 1984-1995 with respect to environmental incidents:

1. Spills in Canada and their distribution
2. Spills by industry sector
3. Causes, reasons and sources of spills in seven major sectors
4. Federal spills
5. Spills and environment affected
6. Spills of MIACC list 1 substances
7. Spills by material categories
8. Major spills in Canada

1. Spills Reported in Canada

The awareness and reporting of spills has increased through the mid-1980s and early 1990s as spill-reporting requirements were implemented through legislation in various provinces and territories all across Canada. Public awareness of the need for spill reporting has also increased. As a result, the number of spills reported annually increased steadily between 1984 and 1988 and has remained relatively constant since that time.

The analysis of months and seasons in which the greatest number of incidents occur yielded some interesting results. Environmental incidents are reported in the greatest numbers during the summer months, with almost equal numbers over June, July and August. The lowest number of spills are reported in December, January and February. This seasonal variation may be attributed to increased traffic volumes during the summer months.

Examination of spills by sector revealed that business (including industry) reports the greatest number of incidents, at 75% of all reported spills. This finding is in accordance with the fact that most of the products are manufactured, mined, handled and transported in Canada by the business sector.

The majority of spills reported are small-quantity spills of less than one tonne. The impact of a spill on the environment depends on the toxicity and concentration of the substance, on the volume spilled, and on the receiving environment. Therefore the size of the spill does not necessarily determine the environmental impact.

2. Spills by Sector

Data for seven major sectors were examined. The seven sectors are the chemical, government, metallurgy, mining, petroleum, pulp and paper, and service industry sectors. Spills from these seven sectors represent 63% of the total spills reported and 93% of the total quantity reported spilled. Overall there is better reporting (indicated by median spill volume) in the latter part of the 12 years of data examined in this report compared with the earlier years. Spill volumes in the seven sectors generally decrease or remain the same during the 12 year period studied. Over the last few years of data examined, the number of spills reported generally decreases.

3. Cause, Reason and Sources of Spills

The cause of a spill is 'what went wrong' while the reason for a spill is 'why it went wrong'. When the seven sectors are examined together, almost one quarter (22%) of the *causes* of a spill can be attributed to pipe leaks. Interestingly, equipment failure (25%) and human error (16%) are always present among the top three reasons for spills in each of the sectors.

The *sources for the top five reasons* for spills are examined for the various sectors. Spills in the production field are consistently one of the top sources for four of the top five reasons (equipment failure, corrosion, material failure and human error). Seventy-one percent of spills where the reason is identified as storm or flood occurred from a sewage treatment plant or sewer. This is largely the result of run-off or overflow during periods of significant precipitation.

The 'unknown' category accounts for 13% of all causes and 17% of the reasons reported for spills. These significant numbers indicate a need for better follow-up with the initial pollution incident report.

4. Federal Spills

The number of spills in the federal sector account for 2% of the total number of reported spills. The proportion of number of reported spills in the federal sector over the 12 year period is consistent with the number of reported spills nationally for the same period. It is perceived that increases in the numbers of spills reported over the data period are largely a result of legislated reporting requirements and increased awareness of the need to report spills.

Spills at federal facilities are most often a result of pipe, tank and container leaks.

5. Spills and Environment Affected

The extent of the impact of any given spill depends on many factors: the nature and concentration of the product, the environment affected, weather conditions and the quantity spilled. Most spills occur in small quantities, thus limiting the area of environmental impact. The environmental medium impacted for almost half of the reported spills is land. Environmental impacts to waterways occur in roughly one fifth of the incidents. While land-based spills can cause significant environmental impact and may migrate to groundwater, spills to waterways are generally more serious as they can impact entire habitats and disrupt food chains. The impact of a single marine spill can affect algae and plankton, fish, birds and marine life. In almost all land-based spills, there is damage to vegetation and property.

Some spills, due to the properties of product spilled, may persist in the environment for an extended period of time.

6. Spills of MIACC List 1 Substances

The Major Industrial Accidents Council of Canada (MIACC) is a non-profit, multi-stakeholder organization dedicated to reducing the frequency and severity of major industrial accidents involving hazardous substances. Workshops aimed at accident prevention and life-cycle management were held for four MIACC List 1 substances. Each substance was selected for specific reasons such as the quantity used in commerce or the ability to focus on a particular life-cycle stage of the substance.

The top five MIACC List 1 substances spilled, both in the number of spills and quantity spilled, are gasoline, chlorine, hydrochloric acid, propane and anhydrous ammonia. Of the List 1 substances, gasoline is spilled most frequently and in the greatest quantity. From 1992 to 1995, the number of gasoline spills decreases substantially. Anhydrous ammonia and hydrochloric acid are second and third among most-spilled List 1 substances. The quantities spilled of the top five List 1 substances show peaks in the late 1980s and decline thereafter. Chlorine spills decrease in 1994 and 1995, while the number of reported propane spills gradually increases from 1988 to 1995.

7. Spills by Material Categories

An analysis of materials spilled — grouping substances into the broad material categories of oils, non-oils and wastes / effluents — was performed. Spills involving oils occur 58% of the time. Wastes and effluents account for 18% of the total number of spills, but 89% of the total quantity reported; in other words, fewer spills but larger quantities. Most of these are sewage releases and some are spills of industrial effluents. Non-oils account for 24% of the total reported number of spills.

The number of reported spills in the three material categories of oils, non-oils and wastes and effluents increases in 1988 and remains elevated through to 1995.

A more detailed examination of material categories indicates that fuel oil and gasoline account for 30% of the spill events in Canada.

8. Major Spills in Canada

Major spills from each region were examined. The range in spill quantities and in the types of substances spilled varies from region to region. Sewage is spilled in very large quantities across the country. The sectors reporting large spills include the chemical, government, metallurgy, mining, petroleum, pulp and paper, service industry and transportation sectors.

Environment Canada's Role in Environmental Emergencies

Environment Canada's Environmental Emergencies Program aims to prevent and reduce the frequency and severity of impacts on the environment. Four case histories are described, which profile the role Environment Canada plays in an emergency and how agencies work together to achieve results. The incidents examined are:

- a fire at an agricultural product warehouse in Canning, Nova Scotia, 1986;
- a tire fire in Hagersville, Ontario, 1990;
- a train derailment in Hervey Junction, Quebec, 1995; and
- an oil spill from the tanker *Nestucca* in Gray's Harbour, Washington, 1988.

Several new changes and measures were introduced as a result of the *post mortem* of each of these incidents. These were in the areas of legislation and inter-agency roles and coordination during emergency incidents and in prevention, preparedness and response activities.

Observations

Several positive results were confirmed by this study. Better spill reporting over the study period demonstrates improved co-operation between industry and government. Efforts should continue to reduce the number of smaller spills and also to reduce the total volume spilled. Equipment failure, human error and corrosion are the key reasons for incidents where prevention efforts should be enhanced. Better preparedness is a proactive approach that ultimately saves money, time, energy, and the environment.

There are issues identified in this report which need to be addressed through government-industry discussions for various sectors. Environment Canada will initiate the dialogue with partners and clients to set priorities for future action.

The report has confirmed that the data on the reported consequences of spills are very limited. Many bird and fish kills occur every year as a result of marine oil spills. However, this information is rarely captured since it is often unknown during the initial stages of an incident. Better follow-up reporting in the area of environmental impact is warranted. Ongoing harmonization initiatives and better follow-up reporting strategies will be promoted in order to ensure better data capture for future reports.

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5

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G L O S S A R Y

Abbreviation or Word	Definition or Full Name
Above-Ground Tank Leak (cause)	Applies to tanks used for storage and transfer, that are not underground, and therefore includes fuel tanks and cargo tanks of ships, vehicles, and aircraft, etc. Leaks occurring at the weld points of pipes to tanks are included in this code
Agriculture (sector)	Includes the spillage of oils and non-oils used in the agriculture industry and includes co-operatives, farms and ranches
Aircraft (source)	Includes all vehicles that fly
Aircraft Crash (cause)	Only applies to aircraft accidents
Cause	Refers to the immediate cause of the accident or the equipment component that failed
Chemical (sector)	Applies to chemical process facilities which produce basic chemicals or feed stocks as well as facilities which produce end products from basic chemicals or feed stocks, and includes company bulk transport vehicles
Chemical Plant (source)	Industrial plants that manufacture, formulate and package chemicals. Includes petrochemical plants
Container Leak (cause)	Includes cartons, boxes, bottles, barrels, bags and any other type of container except tanks
Corrosion (reason)	Covers all forms of corrosion whether internal or external
Damage by Equipment (reason)	Applies to events such as: - a bulldozer or backhoe broke a pipe - a forklift damaged the container - an airport vehicle ran into an aircraft wing-tip tank
Derailment (cause)	Only applies to railway accidents in which one or more cars and / or engines left the rails

Abbreviation or Word	Definition or Full Name
Discharge (cause)	For all types of deliberate discharges, except those described in Bilge Pumping. Includes dumping of storage tank contents, acts of vandalism or sabotage, aircraft jettisoning fuel in flight, by-passing waste treatment systems, etc. Discharge may be used for leaks or spills caused by human error where none of the other cause categories apply
Dyke Failure (cause)	Storage pond and lagoon wall failures
Energy Generation (sector)	Applies to electrical power plants and distribution systems
Equipment Failure (reason)	Pertains to system components and includes: - malfunction of an anti-overflow device - vehicle brake or steering system break-down - controller failure - other similar reasons
Fertilizer	Covers all types of fertilizer: chemical (including anhydrous ammonia) and 'organic' (manure and sewage plant fertilizers)
Fire, Explosion (reason)	Only applies to spills or leaks that occurred because of a fire or explosion not those that resulted in a fire or explosion. For example, a leaking tank (due to material failure) that subsequently catches fire would not be coded as Fire, Explosion, but rather as material failure
Food Processing (sector)	Includes canneries, meat or fish packers, dairies, etc. and transportation vehicles owned by food processors
Forestry (sector)	All aspects of the forestry sector but excluding pulp and paper plants
Gasket, Joint (reason)	Refers to any form of connection (except weld), shaft seals or glands, cover gaskets, valve stem packing, etc.
General Manufacturing (sector)	Manufacturing establishments not covered by other codes. Examples: textiles, appliances, electronics, automotive assembly, etc.
Government (sector)	Applies to municipalities, provincial and federal parks, installations and vehicles serving the public; e.g. schools, post offices, hospitals
Human Error (reason)	Discharge due to mistake. For example: forgetfulness, wrong valve opened, wrong button pushed, driver or pilot error, etc.
Ice or Frost (reason)	Covers a range of occurrences resulting from low temperature (freezing)

Abbreviation or Word	Definition or Full Name
Industrial Plant (source)	This category encompasses power plants, heating plants and other manufacturing and processing facilities
Intent (reason)	Intentional discharge by owner, employer, or employee
Material Failure (reason)	Pertains to poor design or substandard material; material failure even though design stresses may not have been reached
Metallurgy (sector)	Includes the manufacturing of steel and other metals; excludes fabricating shops
Mining (sector)	Includes all mining operations and associated equipment and vehicles
NATES	National Analysis of Trends in Emergencies System
Other Industrial Plants (source)	Includes power plants, heating plants, potable water treatment plants, and all other manufacturing and processing facilities except production field, refineries, or chemical plants
Other Storage Facilities (source)	Includes private storage facilities such as those belonging to industrial heating plants, farms, private homes, etc. from which materials are used for on-site consumption, and includes lagoons, barrels and drums
Overflow (cause)	Refers to overfilling of tanks and containers, mobile or fixed
Overstress and Overpressure (reason)	Includes any form of overloading wherein the design strength of the hull, tank, pipe, container, gland, gasket, etc. was exceeded
Overturn (cause)	Only applies to vehicles that accidentally roll, upset, overturn, etc.
Petroleum (sector)	Includes all plants and services operated by the petroleum industry: gas stations and company bulk transport vehicles
Pipe Leak (cause)	Includes leaks from the pipe itself as well as leaks from some unidentified part of a piping system, and applies to any type or size of pipe, including flexible hoses, regardless of whether or not it is a ‘pipeline’ as defined by regulatory authorities or the oil industry
Pipeline (source)	Includes bulk transportation lines only; not local ‘in-plant’ piping. NB: large pipelines fall in the ‘Transportation’ sector (rather than in the ‘Petroleum’ sector)
Power Failure (reason)	Applies to discharges directly resulting either from a loss of power or during the ensuing start-up

Abbreviation or Word	Definition or Full Name
Process Upset (cause)	An upset in a process facility which results in an unusual release of a contaminant to the environment
Production Field (source)	Include oil-fields, gas-fields, mines, quarries and other such raw material sources
Pulp and Paper (sector)	Includes both spills of oil and / or non-oils in the process facilities of the pulp and paper industry
Quantity Spilled	The units used for amount spilled are always expressed as metric tonnes
Radioactive Material	Applies to any radioactive material even if it falls into one of the other material categories
Reason	Refers to the reason for the accident or why the spill occurred
Recreation (sector)	Applies to any facility which is established primarily to provide relaxation and enjoyment
Refinery (source)	Means oil refineries only, but includes all oil-refinery events, regardless of whether the material spilled was oil or non-oil
Residential (sector)	Includes private dwellings, cottages, apartment buildings, house trailers on private property
Road Conditions (reason)	Applies to on-road vehicle accidents attributed to wet, muddy or other adverse road conditions, except an icy road surface
Saline Water	Pertains primarily to the brine solution found in oil and natural gas fields
Sector	The economic or industrial sector
Service Industry (sector)	Includes all types of services, e.g. dry cleaning, maintenance contractors, specialized industrial services; does not include waste management
Service Station (source)	Includes retail fuel outlets that serve the public, e.g. airport and marine fixed dispensing installations, 'gas-bars', fleet shops, self-service gas stations, and garages that sell fuel and lube oil
Sewer, Sewage Treatment Plant (source)	All types of sewage treatment plants, sewage waste, industrial water treatment plants should be coded as 'Refinery', 'Chemical Plant', 'Other Industrial Plant' depending on the location
Source	The type of conveyance involved if the event happened in transit; otherwise, the type of facility at which the spill occurred

Abbreviation or Word	Definition or Full Name
Spill	An uncontrolled or unexpected release of a substance caused or allowed either, intentionally or unintentionally, into air, water or land, that may negatively impact human health or the environment
Storm, Flood (reason)	Events that occurred because of a natural precipitation and associated phenomenon, e.g. lightning, hail, wind
Storage Depot (source)	Includes chemical as well as oil storage facilities used for bulk storage from which materials are used for distribution. Does not include private oil storage facilities such as those belonging to industrial heating plants, farms, private homes, etc.
Tank Truck (source)	Includes all road vehicles carrying liquid or gaseous cargo in bulk
Train (source)	Includes all vehicles that run on rails
Transportation (sector)	Applies only to the transportation industry, e.g. the commercial carriers whose only business is transporting materials for their customers. It does not include transportation services operated by industries such as the petroleum, mining, food retail, and service industries
Underground Tank Leak (cause)	Applies to underground tanks used for storage and transfer. Includes leaks occurring at the welds between the piping and the tanks
Valve, Fitting Leak (cause)	The material escaped through a valve, gauge, filter, pump, joint, cover gasket, or other similar accessory / component of a piping system, tank, or other container
Vandalism (reason)	Intentional discharge usually constituting acts of sabotage or trespassing
Waste Management (sector)	All aspects of the waste-management industry: household garbage, biomedical waste, hazardous waste; includes operations such as pickup, transportation, treatment, and disposal

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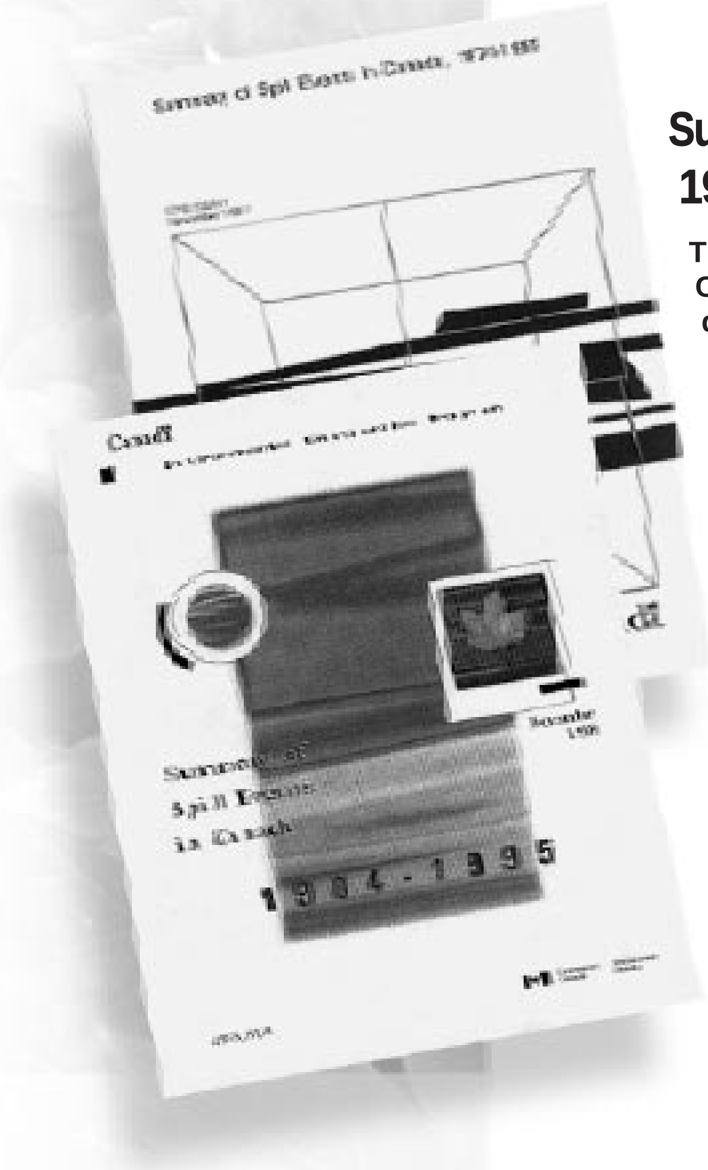

Summary of Spill Events in Canada, 1984–1995

Through a voluntary reporting system, Environment Canada's Environmental Emergencies Program receives data on spill events in Canada. Data are captured in a database called the National Analysis of Trends in Emergencies System (NATES).

This report provides a summary and trends for the 12-year period reviewed. Findings are presented on the number and quantity of spills, data on seven major sectors that incur spills, the causes and reasons for these spills, and impacts on the receiving environment. In addition, case histories of four significant environmental incidents are profiled.

The information in this report can be used to target specific problem areas, which could assist both the government and the private sector in developing and implementing appropriate spill prevention strategies. The report can thus be a valuable tool in efforts to protect Canadians and the environment from the adverse impacts of spills.

Also available: Summary of Spill Events in Canada, 1974-1983.

Hard copy: $20.00 for either report, or $34.00 for the two together, plus shipping, handling and applicable taxes. Please call for an all-inclusive price.

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Environmental Assessments of Priority Substances Under the *Canadian Environmental Protection Act*

Guidance Manual Version 1.0, March 1997

Environmental assessments can be very complex, requiring analysis of a substance's direct and indirect effects at many levels of biological organization. This manual provides detailed guidance for conducting assessments of priority substances in Canada.

Beginning with the collection and generation of data, the manual goes on to cover problem formulation and the characterization of entry, exposure, effects and risk. A final chapter deals with complex substances.

The manual is intended primarily for use by people leading environmental assessments of priority substances, and the groups of experts who will assist them. It will also be of interest to other organizations and individuals wishing to understand how Environment Canada conducts such assessments.

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Pollution Prevention: A federal strategy for action
Progress in Pollution Prevention: 1996–1997

The federal government defines pollution prevention as *"the use of processes, practices, materials, products or energy that avoid or minimize the creation of pollutants and waste, and reduce the overall risk to human health or the environment."*

Pollution prevention seeks to eliminate the causes of pollution rather than treating the symptoms. It promotes continuous improvement through operational and behavioral changes.

Pollution Prevention: A federal strategy for action, released in 1995, presents the federal action plan for pollution prevention. It emphasizes the need for individuals, companies, communities and governments to make pollution prevention a part of our everyday activities and decisions.

For more information, visit Environment Canada's Green Lane at *http://www.ec.gc.ca/pollution/strategy/plt_pl_e.htm*

Progress in Pollution Prevention 1996–1997

This report provides an update on progress made in pollution prevention for the fiscal year ending March 31,1997.

For more information, visit Environment Canada's Green Lane at http://www.ec.gc.ca/p2progress

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Toxic Substances Management Policy

The federal *Toxic Substances Management Policy* sets out a preventive and precautionary approach to dealing with substances that enter the environment and could harm the environment or human health.

The policy provides decision makers with direction and sets out a science-based management framework to ensure that federal programs are consistent with the policy's objectives. It also serves as the centre-piece of the federal government's position on the management of toxic substances in discussions with other governments.

The key management objectives are:

- virtual elimination from the environment of toxic substances that result predominantly from human activity and that are persistent and bioaccumulative; and
- management of other toxic substances and substances of concern, throughout their entire life cycles, to prevent or minimize their release into the environment.

For more information, visit Environment Canada's Green Lane at *http://www.ec.gc.ca/toxics/toxic1_e.html*

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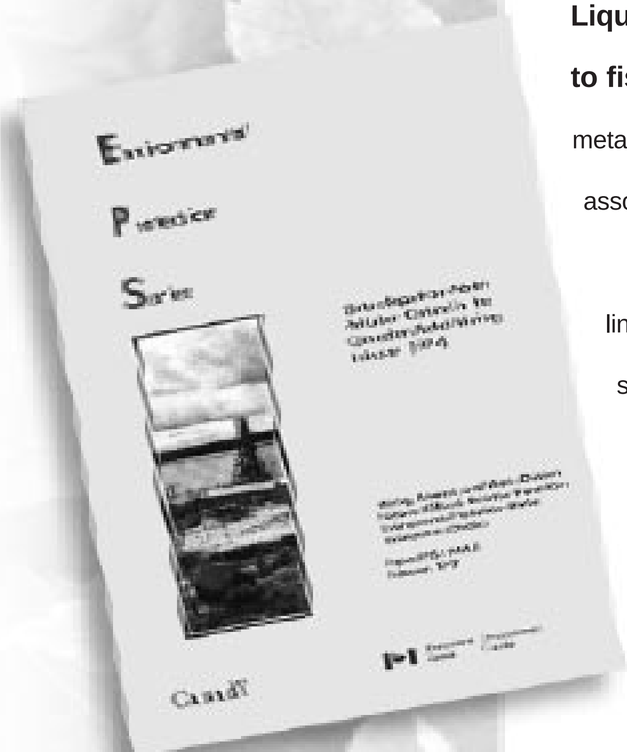
Status Report on Water Pollution Control in the Canadian Metal Mining Industry (1994)



Liquid effluents from metal mines can be harmful, even lethal, to fish and other aquatic life. This report assesses compliance by metal mines with the federal Metal Mining Liquid Effluent Regulations and associated guidelines during 1994.

The first section of the report describes the regulations and guidelines, and the requirements for monitoring and reporting. The second section presents data on compliance for each of 35 metal mines subject to the regulations and 38 metal mines subject to the guidelines. The report also reviews the principal pollution control technologies used at Canadian metal mining and milling operations.

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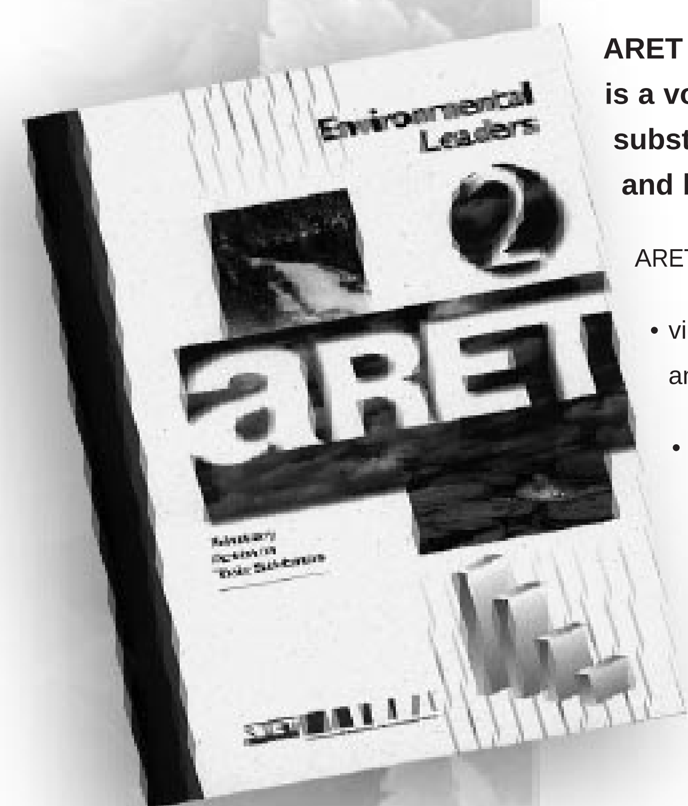

ARET — Accelerated Reduction/Elimination of Toxics — is a voluntary, nonregulatory program that targets 117 toxic substances, including 30 which persist in the environment and bioaccumulate in living organisms.

ARET aims to achieve:

- virtual elimination of emissions of 30 persistent, bioaccumulative and toxic substances
- reduced emissions of another 87 toxic substances to levels insufficient to cause harm.

Participants in this voluntary initiative include companies from eight major industrial sectors and organizations from government departments and agencies.

This report details the pollution prevention activities of 278 facilities that have responded to the ARET challenge launched in March 1994.

For more information, visit Environment Canada's Green Lane at *http://www.ec.gc.ca/aret/homee.html*

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Science and the Environment Bulletin
Science and the Environment: Issues

Two new Environment Canada periodicals help to ensure Canadians know about environmental priorities and the science behind them.

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