STUDY OF THE ONTARIO ENVIRONMENTAL PROTECTION INDUSTRY

JUNE 1992

Ontario
Environment
Environnement

ISBN 0-7729-9932-5

STUDY OF THE ONTARIO ENVIRONMENTAL PROTECTION INDUSTRY

Report Prepared By:

Ernst and Young

Report Prepared For:

Ontario Ministry of the Environment

JUNE 1992

PRINTED ON RECYCLED PAPER
IMPRIMÉ SUR DU PAPIER RECYCLÉ

Cette publication technique
n'est disponible qu'en anglais.

PIBS 1966E

ACKNOWLEDGEMENT AND DISCLAIMER

This report was prepared for the Ontario Ministry of the Environment as part of a Ministry funded project. The views and ideas expressed in this report are those of the author and do not necessarily reflect the views and policies of the Ministry of the Environment, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

Citation of this report is requested.

TABLE OF CONTENTS

Executive Summary

- This report presents an extensive examination of the Ontario environmental protection industry, including a review of industry size, growth prospects, export market opportunities and competitiveness. A model for estimating the Ontario economic impact of selected environmental projects is also provided.

- The environmental protection industry includes firms that provide specialized goods and services used to prevent or clean-up damage to terrestrial, aquatic and atmospheric environments. Major elements of the industry include manufacturing and on-site construction and assembly of environmental equipment, consulting engineering, solid and hazardous waste management and recycling services, and laboratory and other consulting services.

- The 470 firms that responded to our mail survey reported revenues from Ontario operations of over $1 billion in 1990.

- In total, using survey results, interviews and other sources of data, we estimate that the Ontario environmental protection industry had annual revenues of roughly $2.5 billion in 1990 and about 30,000 employees, in 1,500 to 2,000 firms across the province.

- An earlier Ernst & Young (Woods Gordon) study conducted in 1988-89 estimated that the industry had annual revenues of about $2 billion in 1987. The changes since 1987 reflect both industry growth and new information sources that have enabled us to refine the estimate of industry size. Areas of growth over the 1987-90 period included municipal water and sewage treatment plants, laboratory services, recycling, and hazardous waste treatment.

- Future demand growth will be generated by regulations and the increasing environmental consciousness of businesses and consumers.

- Both the Canadian and Ontario governments continue to tighten regulations on environmental discharges. The Ontario government has undertaken major initiatives aimed at toxic discharges and waste management. Current policy themes include the principle of pollution prevention, a multi-media approach to environmental reguiation, a target of virtual elimination of toxic discharges, and the potential use of economic instruments for environmental protection.

- Air pollution control firms expect annual growth of 9-13% over the next five years, although a major surge in spending may occur later in the upcoming five years. Steel mills, metal platers, and chemical firms will be involved in process change measures to control emissions. Air pollution control problems targetted for abatement measures include Ontario Hydro sulphur dioxide control, and adoption of low NOx burners, solvent substitution and other measures to control ground level ozone.

- Water pollution control firms expect a more rapid growth of 10-15% per year, triggered by the demands posed by tighter regulations in Canada and abroad. Closed-loop systems, process enhancement in water separation systems, and methods of reducing water usage will be active markets in view of the emphasis on pollution prevention and virtual elimination of toxins. The pulp and paper, mining and chemicals industries, municipal sewage treatment, and Great Lakes site clean-up will be among the areas of increased activity according to purchasers in this market. Spending by metal platers, food processors and other industries discharging into municipal sewers will also be on the increase.

- Ontario solid and hazardous waste firms expect a very rapid growth of 15%-21% per annum, with waste reduction and recycling consulting, material recovery facilities, site decommissioning and hazardous waste destruction expected to be the areas of growth. The forecast growth rate of individual respondents could also include their expectations for mergers, gains in market share, or shifts from public to private sector hauling. Several industries report efforts at process change to reduce their landfill costs and hazardous waste generation. Some municipalities expect to expand blue-box programs recycling to new materials. The provincial government is placing greater emphasis on waste reduction efforts.

- Changes in the environmental protection industry and market since our 1988-89 study include: a stronger emphasis on waste reduction, a delay in some air pollution control spending relative to what had been previously anticipated, the emergence of new markets in eastern Europe, and examination of closed-loop systems for wastewaters. Governments have also responded to some of the problems reported in our previous study, with significant new federal and provincial initiatives in support of technological development in the environmental protection industry. Worldwide, the industry continues to consolidate slowly, with mergers, technology licenses and other linkages between firms growing over time.

- Ontario environmental protection firms responding to our survey forecast an annual average growth rate of 14% over the next five years. Solid and hazardous waste management firms predict the fastest growth, focussed on such areas as materials recovery, hazardous waste destruction and site decommissioning.

- Future demand for environmental products and services is examined in three foreign markets: the U.S., Europe (including emerging markets in Eastern Europe) and Mexico. The U.S. environmental market is worth about $130 billion annually. Eastern Europe and Mexico have major environmental problems, but future demand will be restrained by the availability of funding.

- The Ontario environmental protection industry is quite competitive in domestic and foreign markets. For projects in Ontario, in-province suppliers (including branches of foreign-owned firms) reap most of the services demand (engineering and on-site construction) and about three-quarters of the purchases of materials and equipment. A number of key environmental equipment components have a significant import content, ranging as high as 100%. Ontario firms are also quite active in export markets and in other provinces, accounting for in the order of one-quarter of goods producers' sales. Many environmental services firms are also very active outside the province, primarily using branch office personnel.

- The environmental protection industry is reasonably well-served by educational institutions in the province. However, there are shortages of certain specialists, such as hydrogeologists. Canadian engineering graduation rates may not keep pace with future demand, and there is still a need to encourage more women to enter the environmental professions. In order to meet the human resource needs of the environmental protection industry, there will need to be closer linkages between the industry, regulators, and universities and colleges. In-house training will also remain important for key scientific and technical skills.

- The report reviews a number of suggestions made by industry participants for future government policies to improve industry competitiveness. Two major themes in these comments are the need for consistency and stringency in regulatory policies and their enforcement, and general concerns regarding the economic and business climate in Ontario and the rest of Canada.

Ontario Environmental Protection Industry 1990
Summary Statistics

Revenues:	$2.5 billion
Expected growth rate:	14% per annum for next 5 years
Employment:	30,000
Number of firms:	1,500 to 2,000
Exports from Ont.:	25% of products sales*
	10-15% of services sales*
Imports into Ont.:	less than 10% of Ontario market for services
	about 1/4 of Ontario market for goods

*Excluding sales by out-of-province branch offices. Includes exports and out-of-province Canadian sales. We caution that these figures are approximations based on limited data.

1. Introduction

1.1 Background

The market for environmental protection products and services is in the midst of a considerable period of change, both in Canada and around the world. In Ontario, major new legislative initiatives will require billions of dollars in expenditures in such areas as municipal and industrial wastewater treatment, solid and hazardous waste management, recycling, remedial action plans on the Great Lakes, flue-gas desulphurization and the control of ground-level ozone.

While these expenditures will impose costs for industries, municipalities and utilities, they will also represent enormous business opportunities for well-placed suppliers of equipment and services. At the same time, Ontario firms face a tough competitive challenge from equipment imports in their home market, but are also increasingly showing interest in opportunities for exports of both products and services related to environmental protection.

The Province of Ontario has an interest in fostering the further development of the environmental protection industry, to ensure that it can effectively meet the needs of Ontario industries and municipalities, and to enable Ontario residents to benefit from employment opportunities generated in and outside the province as a result of environmental protection spending.

1.2 Purpose of this Study

A 1988-89 study (largely conducted in 1988) by Ernst & Young (then known as Woods Gordon) estimated that environmental protection represented a $2 billion industry in Ontario. Due to the scale and diversity of this industry, and the lack of information that existed at the time, our 1988-89 study was only able to scratch the surface of some important issues relating to the prospects for environmental protection firms in the province.

This report, prepared for the Ministry of the Environment with the cooperation of the Ministry of Industry, Trade and Technology, is aimed at meeting four, broad objectives:

- to update our 1988-89 Study *of the Ontario Environmental Protection Industry* (hereafter referred to as the 1989 study)[1]. This included developing a user-friendly, computer database on nearly 550 firms in the Ontario industry, their exports and used equipment sales, categorized by product/service and the nature of technologies employed;

- to develop an understanding of the present trends and future outlook for the Ontario environmental protection industry;

- to investigate the effects of various international trade developments in North America and Europe on the environmental protection industry including the Canada-U.S. Free Trade Agreement and the EC 1992 process. This also includes an analysis of the current competitive position of the Ontario industry and the measures that governments can take to improve this position;

- to develop a model that would allow the Ministry to assess the effects of various environmental control programs and policies on the Ontario environmental protection industry and its contribution to the provincial economy.

1.3 Organization of this Report

Including this Introduction, this report comprises nine Chapters and and Executive Summary. Chapter 2 reviews the methodology followed by the study team. Chapter 3 presents a description of the current structure and scale of the environmental protection industry in Ontario. Trends in legislation and the market demand for environmental products in Canada and selected foreign markets are reviewed in the subsequent two chapters, while Chapter 6 incorporates our findings on government policy impacts on the environmental protection industry. Our economic impact model comprises Chapter 7. Details on the environmental protection impact

1 The study was prepared in 1988, and subsquently released by the Ministry in 1989.

model and the derivation of coefficients used in the model (by M.M. Dillon) are appended.

2. Methodology

2.1 Overview

This study is based upon a multi-faceted workplan that drew upon previous research, interviews, mail surveys and engineering analysis to reach the findings reported herein. The following seven study elements made up the core of our workplan:

1. A review of relevant Canadian, U.S. and European literature on trends in environmental protection markets, including drawing upon the findings of other recent studies undertaken by Ernst & Young;

2. An extensive mail survey (with telephone follow-up) sent to all firms identified as participants in the Ontario environmental protection industry, and the production of a computer database on the industry;

3. Interviews with a sample of 50 firms in a diverse range of segments of the environmental protection industry;

4. Interviews with representatives from a sample of manufacturing industries, utilities, and municipalities that purchase environmental products and services in Ontario;

5. Research by environmental engineers at M.M. Dillon on the nature of inputs into a sample of typical environmental projects in water pollution control, air pollution control, solid waste management and hazardous waste management;

6. Interviews with educators, over 20 additional industry participants, and professional associations on the state of human resource skills in the province, and the requirements of the environmental protection industry[2];

2 Subsequent to the awarding of the contract for this study for the Ministry of the Environment, Ernst & Young was selected to conduct a major study on human resource needs for the environmental industries on behalf of Employment and Immigration Canada. This report incorporates some of the results of this additional reserarch into this issue.

7. Development of an economic impact model, using data from Statistics Canada and the engineering work conducted by M.M. Dillon.

In the next sections, we provide further details on the methodology used in our mail survey of the environmental protection industry, and the breakdown of our interview respondents. Details on the methodology for developing the impact model are in Chapter 7 and related appendixes.

2.2 Mail Survey

Our mail survey used a two-part, detailed questionnaire designed to expand upon the survey used in our 1989 study. The questionnaire was developed in July and August of 1991 following extensive consultation with Ernst & Young and the Ministries of the Environment and Industry, Trade and Technology.

Part A of the questionnaire was designed to elicit company specific data in order to build a directory of Ontario environmental protection firms. Part B was intended to aggregate confidential business data on a non company-specific basis to allow insights into the size, markets, employment, sales, technology, and other aspects of the industry.

Candidate mailing lists for this survey were assembled from several sources, including: a list from the Canadian Environmental Industries Association (CEIA) that had been assembled by Corporation House; the Department of Industry, Science and Technology; the Canadian Environmental Almanac; various MITT lists; and those supplied by trade associations such as the Association of Consulting Engineers of Ontario. In addition, national associations in the mining, electrical, chemical and petroleum industries were contacted to determine which members would likely be in the environmental protection business, and those identified in this manner were added to our mailing list.

A mail-out to 2,133 firms was completed between the months of September and November of 1991 after a delay due to postal strikes. The mailing indicated that they survey was being completed on behalf of the Ontario government by Corporation House with the participation of the Canadian Environmental Industries Association. Included in the mailing were Parts A and B of the questionnaire and two return envelopes for each Part to ensure maximum confidentiality on sensitive business information.

This mail-out generated 400 completed Part A questionnaires, 327 completed Part B's, and 118 responses from firms which are not in the environmental protection industry for a total 518 completed questionnaires. The response rate for Part B was lower than for Part A because it was considerably longer and more complex, as well as containing highly sensitive data which many firms were unwilling to divulge under any circumstances. A further 85 survey forms with incorrect addresses were returned.

If 118 out of 518 completed questionnaires were from firms not in the environmental business, it is assumed that the same proportion (23%) of the total 2,133 were also not in the environmental business. This suggests that the original list of 2,133 should have been reduced by about one quarter to 1,650. Furthermore, if some of the 85 wrong addresses are interpreted to mean that those firms are no longer in the business, then the universe would be further reduced to perhaps 1,600. On this basis, the completed questionnaire response rate for the initial mailing of Part A was about 25% (400/1600).

A telephone follow-up, reaching all non-respondents for which telephone numbers were available from the original source lists, was undertaken in December, 1991, by the Institute for Social Research at York University and by the Statistical Consulting Centre at Carleton University to encourage additional responses. Of the 1,530 questionnaires not returned (for Part A, where the name of the firm was identified), telephone calls were made to 1,187 or 77% of the eligible firms across Ontario. In each case, two calls were made and messages left at each number in the event that the appropriate individual was unavailable.

A second partial mail-out to 512 firms was undertaken following the telephone campaign between late December, 1991 and early January, 1992 to reach firms that reported that they no longer had the form available from the first mailing or had failed to receive it due to an address change. Finally, faxes or couriered surveys were sent to about 50 important firms that had not responded by the end of February, and 12 of the largest of these firms were telephoned in a final effort to obtain responses to the survey.

The telephone follow-ups, second mail-out and faxed surveys resulted in a combined total of 549 completed Part A questionnaires, 470 completed Part B's, and 154 responses from firms which are not in the environmental protection industry, from both waves of the survey.

Thus, the response to Part B was roughly 30% of the estimated 1,600 environmental protection industry firms on our original list, and the response rate to part A was roughly 34%.

The responses to the non-confidential part of the survey were used to develop a computer database of Ontario environmental protection industry participants. The database provides the government with the ability to collect, retrieve and assess the data.

2.3 Interview Program

Three sets of formal interviews were conducted for this study, in addition to discussions on individual issues with environmental market participants and observers.

The first set of interviews included personal and telephone discussions with a sample of 50 firms in the Ontario environmental protection industry. The following was the breakdown of respondents by sector:

Air pollution control equipment	7
Water and wastewater treatment equipment	8
Solid/hazardous waste and recycling equipment	6
Sampling and monitoring equipment	6
Laboratory services	5
Engineering, waste management, other services	18
TOTAL	50

Additional, shorter interviews were conducted with other firms in the environmental protection industry on human resource issues and various other issues discussed in this report.

A second interview program involved discussions, largely by telephone, with a sample of 40 purchasers of environmental products and services. The following is a breakdown of these interviews by sector:

Industrial minerals	4
Inorganic chemicals	2
Iron and steel	4
Metal casting	2
Metal mining and refining	3
Metal plating	2
Municipalities	4
Organic chemicals	2
Petroleum refining	2
Pulp and paper	3
Utilities (Ont. Hydro)	8
Other	4
TOTAL	40

3. Ontario's Environmental Protection Industry: Structure and Size

3.1 Industry Definition

Firms in the environmental protection industry, unlike those in traditionally-defined industries, produce a very wide array of products and services, serve different types of customers, and often are not in competition with each other. The firms in this sector are linked only in the sense that their activities are generated by purchasers' efforts to clean-up or prevent damage to the environment.

We define the environmental protection industry as including suppliers of specialized products and services used in avoiding or clean-up damage to land, water and air. The following major segments are included in this definition: 1) suppliers of equipment, instruments and supplies for pollution abatement, clean-up and resource preservation 2) construction and assembly of environmental systems on site; 3) suppliers of environmental engineering and consulting services; 4) suppliers of laboratory services; 5) suppliers of solid and hazardous waste management services, including recycling and 6) suppliers of sampling and monitoring equipment and instrumentation. Potable water treatment systems are included in our definition. As in our 1988-89 study, various equipment and services relating to indoor air quality (including asbestos removal), nuclear waste, and noise control are not included.

The various studies that have examined the environmental protection industry in Canada, the U.S. or Europe have adopted quite different definitions of the range of activities that constitute this sector. Our view is that an appropriate definition is one that includes firms that would generally view themselves as being environmental businesses, and one that avoids double counting where possible. For example, suppliers of intermediate goods such as pipes, structural steel and concrete used in a sewage treatment plant would not be included in the environmental protection industry. The value of these firms' output will likely be captured in the revenues of the final equipment supplier, and these intermediate suppliers would not generally perceive themselves as parts of the environmental protection industry. These firms would find it difficult to segment their output into that destined for environmental projects and other general industrial uses.

A second distinction that we draw is one between *expenditures* for environmental improvements and the output of the environmental protection industry. Many expenditures that yield environmental benefits do not generate demand for a well-defined environmental protection industry. For example, energy conservation may be an important element of addressing such problems as the greenhouse effect. However, spending on energy efficient motors or building insulation for this purpose generates demand for the motor and building materials sectors rather than the environmental protection industry. Indeed, some environmental expenditures (e.g. a redesign of a package that reduces its size) actually *reduce* the demand for the environmental clean-up or waste management products and services supplied by the environmental protection industry.

Many firms appear to have entered the industry since our previous study in 1988-89, reflecting the changing nature of the industry and the immature stage of its evolution. Many firms specialize in providing goods and services to one of three subsectors identified in the study, namely air pollution prevention, control and monitoring; water pollution prevention, control and monitoring; and solid waste reduction, disposal, treatment and site remediation. A significant number of firms are in two or more of these subsectors.

3.2 Numbers of Firms by Product / Service

Our mail survey[3] enabled us to obtain a picture of the range of environmental products and services. Firms were asked to indicate their type or types of environmental products or services by checking off individual items from an attached list.[4]

Seven product classifications were provided: natural resource conservation; air pollution control; water pollution control; waste management; chemicals for pollution control; measuring, monitoring, instrumentation and controls; and scientific, research and laboratory. Each of these classifications included an average of nine sub-categories from which to choose.

3 A review of the methodology and response rate is provided in Chapter 2.

4 The classifications used were developed in consultation with MOE and MITT, making use of the CIS Services Database Questionnaire and MITT's environmental products classification.

Many of the mail survey respondents are diversified in their environmental activities (see Chart 3.1). Approximately one-third of the surveyed firms, are multi-market firms, operating in more than one environmental business subsector (e.g. in both air and water pollution control), and one-quarter of the firms supply both products and services. Not surprisingly, these combined products-services firms, are larger than the average, and employ almost half (46%) of the people in our total survey sample.

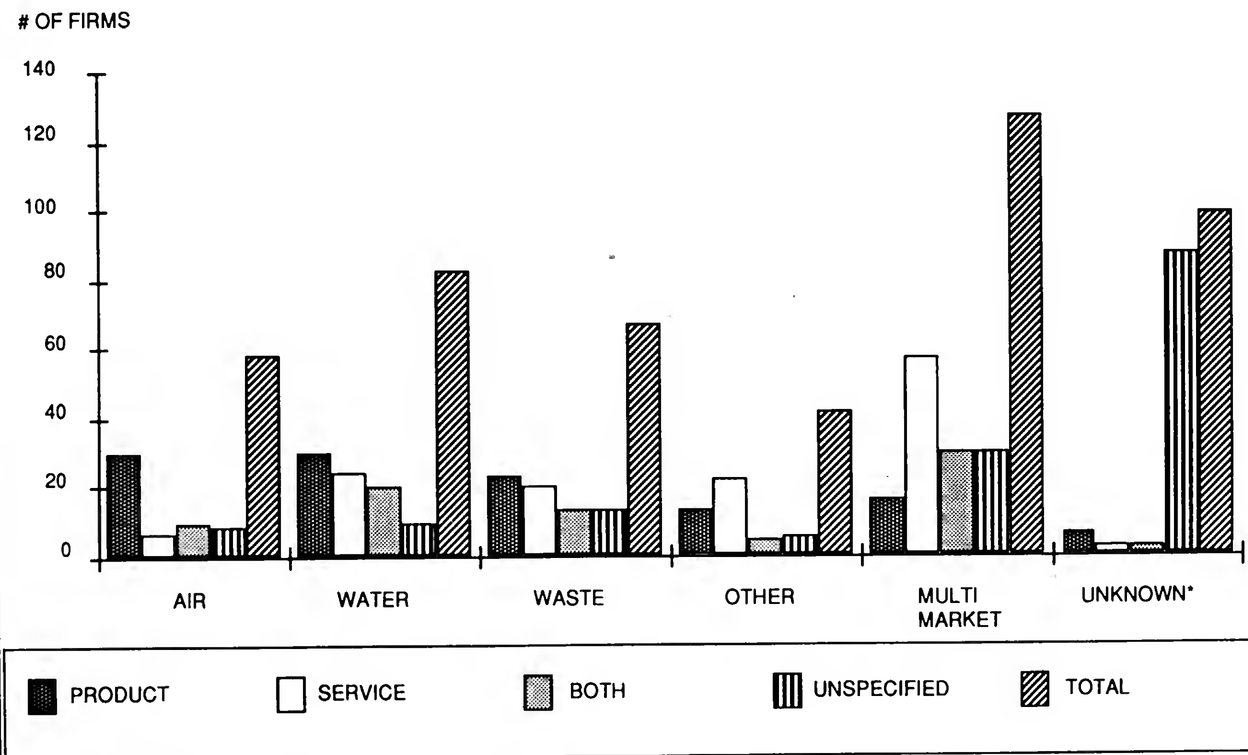
The data also indicate that, at least in terms of the numbers of firms (if not necessarily in terms of market shares), the various segments of the environmental protection industry in Ontario are still quite fragmented, with 10 or more suppliers in nearly all of the product or service categories. This indicates that there is a healthy degree of competition in the industry at present. As we discuss below, there is evidence that, internationally, some consolidation has been taking place, with mergers and entry by large firms leading to greater concentration in output. Even so, studies of other countries, including the U.S., continue to show that there are a large number of environmental protection firms competing in most market niches.

Table 3.1 indicates the number of responding firms that supply **products** in each category. The product area where the most firms in our industry sample (169) are active is the *water pollution control market*. Some 50 to 59 firms supply products to each of the water purification, sewage treatment, oil/water separation, filters and potable water treatment markets.

Although waste management is generally thought of as a *service* business, solid waste management *products* also accounted for a large number of responding firms, and the second most responses overall in terms of products. Within this category, the greatest number of survey respondents is in recycling products, where 60 firms are active. We suspect that firms selecting this category include both suppliers of equipment for recycling as well as firms involved in the wholesaling of scrap and waste materials. This product category was followed in terms of the numbers of firms by waste handling, waste separation, waste disposal products and control systems.

CHART 3.1
CATEGORIES OF FIRMS

ONTARIO ENVIRONMENTAL INDUSTRY, SURVEY RESPONDENTS



*Note: Includes firms that did not allocate their sales by environment category.

TABLE 3.1

FIRMS BY PRODUCT CATEGORY

	NUMBER OF FIRMS	
NATURAL RESOURCE CONSERVATION		51
AGRICULTURE	16	
FISHERIES	11	
FORESTRY	12	
WATER/COASTAL AREAS	18	
PARKS/WILDLIFE	8	
OCEANOGRAPHY/HYDROLOGY	16	
METEREOROLOGY/CLIMATOLOGY	10	
MAPPING/GEO INFOR SYSTEMS	16	
OTHER	10	
AIR POLLUTION CONTROL		126
ABSORPTION/ADSORPTION	30	
AIR HANDLING	53	
CATALYTIC CONVERTERS	11	
CHEMICAL RECOVERY	17	
DUST COLLECTORS	46	
ELECTROSTATIC PRECIPITATORS	20	
FABRIC FILTERS/MEDIA	37	
FILTER ACCESSORIES	28	
INCINERATORS	21	
SCRUBBERS--DRY	18	
SCRUBBERS--WET	33	
CONTROL SYSTEMS	60	
WATER POLLUTION CONTROL		169
AERATION SYSTEMS	29	
BIOLOGICAL TREATMENT	30	
CENTRIFUGES	13	
CHEMICAL FEEDING/MIXING	42	
CHEMICAL RECOVERY	28	
FILTERS	50	
GRAVITY SEDIMENTATION SYS	23	
ION EXCHANGE	21	
OIL/WATER SEPARATION	55	
POTABLE WATER TREATMENT	51	
SCREENS/STRAINERS	20	
SEWAGE TREATMENT	59	
WATER HANDLING	33	
WATER PURIFICATION	57	
WATER POLLUTION CONTROL SYS	169	
WASTE MANAGEMENT		142
INCINERATION	24	
RECYCLING	60	
WASTE COLLECTION-LIQUID	41	
WASTE COLLECTION-SOLID	26	
WASTE DISPOSAL	36	
WASTE HANDLING	45	
WASTE SEPARATION	44	
CONTROL SYSTEMS	36	
CHEMICALS FOR POLLUTION CONTROL		74
ABSORBENTS/ADSORBENTS	26	
AGGLOMERATION/PELLETIZING	10	
BACTERIA/ENZYMES	14	

CLEANING	19	
CORROSION/SCALE CONTROL	19	
DUST CONTROL	15	
WATER TREATMENT	39	
MEASURING, MONITORING, INSTRUMENTATION		119
INSTRUMENTS	89	
SAMPLING EQUIPMENT	41	
CONTROL EQUIPMENT	57	
DATA ACQUISITION EQUIPMENT	57	
ELECTRICAL DRIVE & CONTROL EQUIP	25	
SCIENTIFIC, RESEARCH AND LABORATORY		69
ANALYTICAL INSTURMENTS	41	
BACTERIOLOGICAL SUPPLIES	8	
CALIBRATION EQUIPMENT	18	
LABORATORY CHEMICALS	16	
LABORATORY DATA ACQUISITION SYS	13	
LABORATORY EQUPMENT--OTHER	27	
TOTAL NUMBER OF REPORTING FIRMS		*335*

The third largest number of products firms (126) in our sample are in the *air pollution control* market. The greatest number of respondents are in control systems, air handling equipment and dust collectors (46 to 60 each), followed by fabric filters/media, wet scrubbers and absorption/adsorption products.

A significant number of firms (119) in our sample offer *measuring, monitoring and instrumentation products* , mainly in the instrument market, followed by control equipment and data acquisition equipment. Relatively fewer companies supply *chemicals for pollution control, scientific research and laboratory products*, or *natural resource equipment* .

Table 3.2 provides an overview of the **services** categories. Eight classifications were offered in the questionnaire: natural resources, conservation and protection; consulting engineering services; environmental consulting services; waste management consulting services; pollution assessment and control; construction; waste handling operations; and laboratory/field services. Each classification included an average of six sub-categories from which to choose.

The two most popular service areas are closely inter-related: *environmental consulting* and *consulting engineering* services. There were large numbers of competitors in each of the major consulting and engineering service categories. Most of the firms in this sector, particularly the large engineering firms, offer a wide range of environmental services (often in addition to other engineering consulting work).

There were also a large number of *waste management consulting* services firms among the survey responses. Two emerging service areas, recycling and energy-from-waste, showed a surprisingly large number of responses.

There were 160 respondents that were active in the *pollution assessment and control services* market. Water pollution control and water quality assessment services are the most active markets in terms of the number of respondents. This sector also includes firms in waste management pollution control, waste surveys and characterization, and firms in the air sector, namely air pollution control and air quality assessments.

TABLE 3.2

FIRMS BY SERVICE CATEGORY

CATEGORY	*NUMBER OF FIRMS*	
NATURAL RESOURCE CONSERVATION		100
AGRICULTURE/SOIL/WATER	46	
FISHERIES	34	
FORESTRY	29	
WATER/COASTAL	41	
PARKS/WILDLIFE	25	
METEOROLOGY/CLIMATOLOGY	16	
OCEANOGRAPHY/HYDROLOGY	33	
MAPPING/GEO INFO SYSTEMS	40	
OTHER	21	
CONSULTING ENGINEERING		210
PROCESS EVALUATION	122	
PROJECT MANAGEMENT	141	
SITE RECLAMATION/REMEDIATION	105	
ENVIRONMENTAL STANDARDS	86	
COMPUTER SYSTEMS	69	
FINANCIAL/MARKET ANALYSES	55	
SOCIO-ECONOMIC STUDIES	55	
TRAINING	73	
ENVIRONMENTAL CONSULTING		213
ENVIRONMENTAL AUDITS	129	
ENVIRONMENTAL MONITORING	131	
ENVIRONMENTAL PERMITTING	79	
IMPACT ASSESSMENTS	108	
RISK MANAGEMENT	71	
SPILLS CLEAN-UP	84	
OTHER	53	
WASTE MANAGEMENT CONSULTING		163
MUNICIPAL SOLID WASTE	82	
SEWAGE	69	
HAZARDOUS/TOXIC WASTE	82	
RADIOACTIVE WASTE	33	
ENERGY FROM WASTE	64	
RECYCLING	78	
OTHER	32	
POLLUTION ASSESSMENT & CONTROL		160
ATMOSPHERIC MODELING	29	
AIR QUALITY ASSESSMENT	68	
WATER QUALITY ASSESSMENT	81	
WASTE SURVEYS/CHARACTERIZATION	67	
AIR POLLUTION CONTROL	67	
WATER POLLUTION CONTROL	93	
WASTE MANAGEMENT CONTROL	80	
CONSTRUCTION		59
WASTE HANDLING OPERATIONS		146
WASTE COLLECTION	43	
WASTE HANDLING/SORTING/TRANSPORT	49	
COMPOSTING	35	
WASTE TREATMENT PLANTS	54	
LANDFILLS	44	

INCINERATORS	38	
SEWAGE TREATMENT PLANTS	52	
SEPTIC TANK SERVICES	38	
POTABLE WATER	38	
RECYCLING	59	
LABORATORY/FIELD SERVICES		138
ANALYTICAL SERVICES	73	
SAMPLING, MONITORING, MEASUREMENT	112	
ENVIRONMENTAL RESEARCH	86	
TOTAL NUMBER OF REPORTING FIRMS		*346*

Waste handling operations generated responses from 146 firms, including waste treatment plants, sewage treatment plants, recycling, waste handling, sorting, transport and collecting. Based on interviews with industry participants, we suspect that our original survey list understated the number of small waste haulers in the province. Despite the presence of a few large firms, the greatest number of competitors in the environmental protection industry is likely to be found in the waste hauling industry, although water pollution control firms were more numerous in our survey sample.

There were 138 firms offering *laboratory and field services*, primarily sampling, monitoring and measurement services. These included both independent labs and branches of engineering firms that offer laboratory services. A smaller number of firms offer *natural resource and conservation services* and *construction services* , although we expect that many small construction firms have some activities relating to environmental projects.

3.3 Markets for Ontario EP Firms

Geographic Markets

Nearly all environmental protection firms with operations in Ontario sell their products and services in the Ontario market (see Chart 3.2). Over half of the surveyed firms also sell to the rest of Canada, with the most common markets being Quebec and the West.

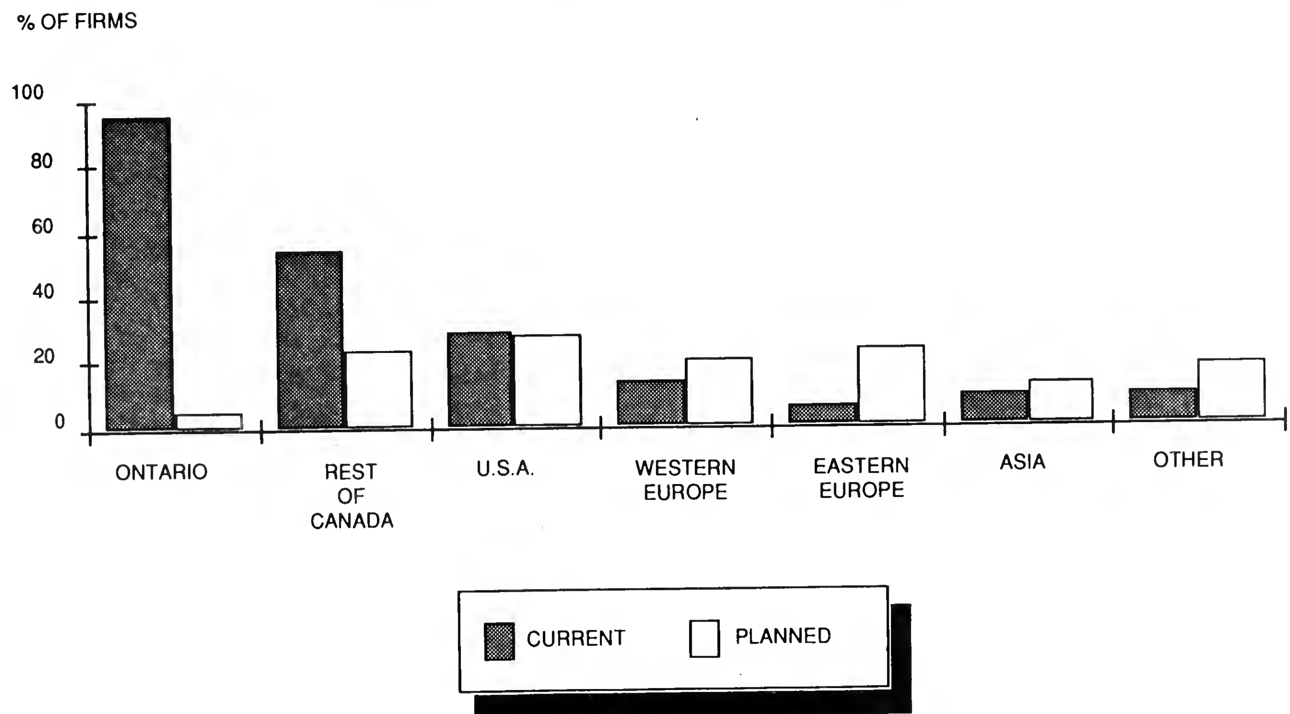
A substantial number of Ontario firms export at least some of their goods and services. The most commonly tapped export market is the United States, particularly the Northeast. A relatively small percentage (generally less than one in ten) of the firms sell beyond North America. The most popular overseas markets for our survey sample are in Western Europe.

Respondents were also asked to estimate the percentage of their *Ontario-produced* products and services sold to Ontario, rest-of-Canada, and export markets. Our knowledge of the industry, based on our previous study in 1988-89 as well as on interviews for this study, suggests that the responses received to this question significantly overstate actual exports from Ontario, with firms

CHART 3.2

GEOGRAPHIC MARKETS SERVED

ONTARIO ENVIRONMENTAL INDUSTRY, SURVEY RESPONDENTS



apparently including activities of branch offices elsewhere.[5] Our interview responses and other information suggest that about one-quarter of equipment sales are outside the province, and that 85-90% of services sales using Ontario-based personnel are within the province[6]. Within the equipment category, exports are more important for suppliers of instruments and specialized environmental equipment than for larger scale treatment systems that are largely constructed on-site. In instruments and smaller equipment items, some firms export the vast majority of their Ontario production.

Sectoral Markets

The largest market for Ontario surveyed firms is the manufacturing sector, to which nearly two-thirds (62%) of our survey sell (see Chart 3.3). Within the manufacturing sector, the chemical sector is the most frequently served market, followed by the petroleum refining and iron and steel industries.

Over half of the respondents sell to each of the local or federal/provincial governments (51%). Large numbers of firms also compete for the demand from utilities and resource industries.

Planned Markets

Our survey also asked respondents about their future market plans.[7] Many firms now active in Ontario expect to expand into the rest of Canada or the U.S. Although few firms currently export to Eastern Europe, almost one-quarter of firms report an interest in expanding into this region in the future.

---

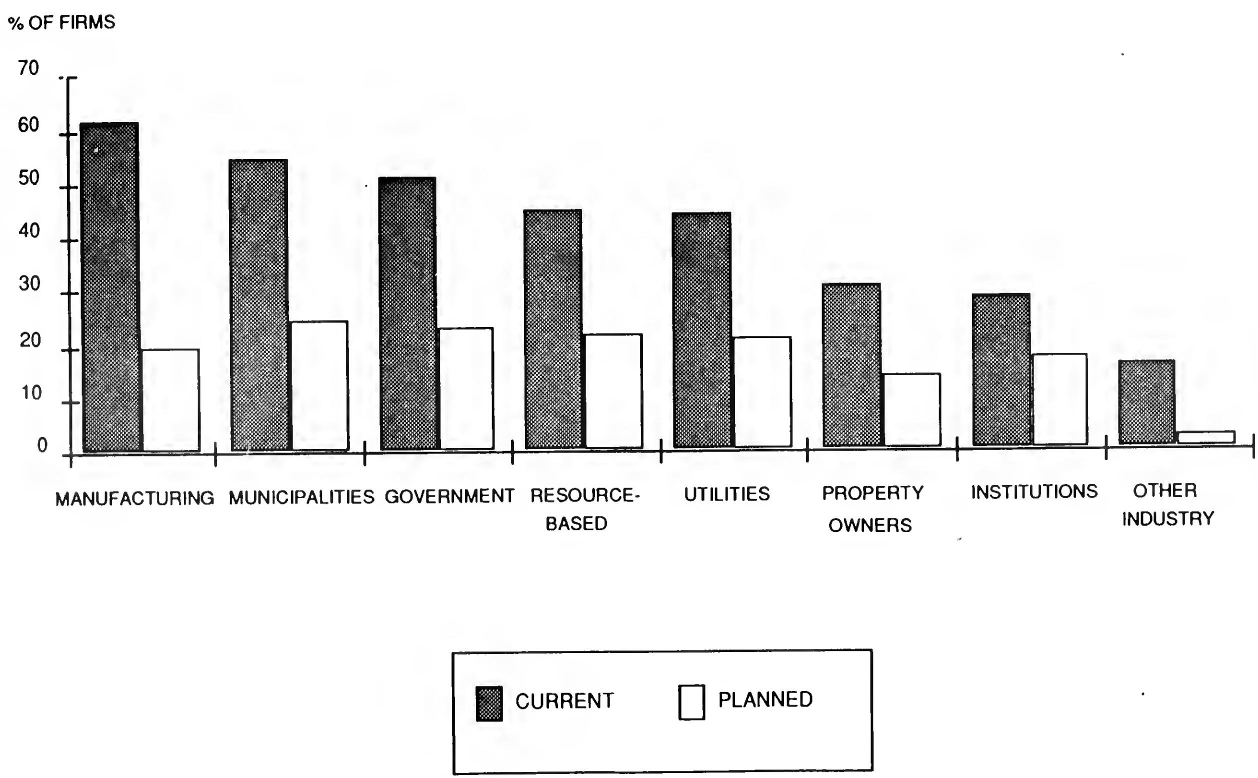
5 The responses suggest that only half of the Ontario-produced products and services remain in the province.

6 Our 1989 study, with a differently worded question, found that exports to other countries from Ontario were only 13.5% of sales. Statistics Canada data on engineering consulting firms in Ontario report that exports from Canada account for less than 5% of their revenues.

7 The intent of the survey question on planned markets was to elicit plans for entry into markets not currently served by the firm. A small share of respondents appeared to have interpreted "planned" markets as indicating those that they either planned to enter or that they planned to continue to sell in.

CHART 3.3
SECTOR MARKETS

ONTARIO ENVIRONMENTAL INDUSTRY, SURVEY RESPONDENTS



In contrast to new geographic markets where there were wide variations between current and planned sales, the ratio between current participants and planned entrants was relatively constant in terms of sectoral markets served. The institutional sector is one area where the number of firms interested in entering the market significantly exceeds the typical ratio.

3.4 Employment

The 470 firms that responded to a question on Ontario employment reported a total of 11,730 employees in their environmental protection operations. As Chart 3.4 indicates, the water subsector employed the largest proportion of Ontarians in our sample, followed by waste management. As in the case of the number of firms, we suspect that the relative share in waste management is somewhat understated.

Growth in employment in our sample firms in the environmental protection industry in the latter 1980s was brisk (see Chart 3.5). The majority of firms (62%) and most of the jobs (85%) are in firms that have been in business since 1986 or earlier. Their employment increased by an average of 8% annually over 1986-90. Firms that started up after 1986 have generated much higher employment growth rates, although the number of surveyed firms falling into this category is statistically too small to provide a reliable sample.

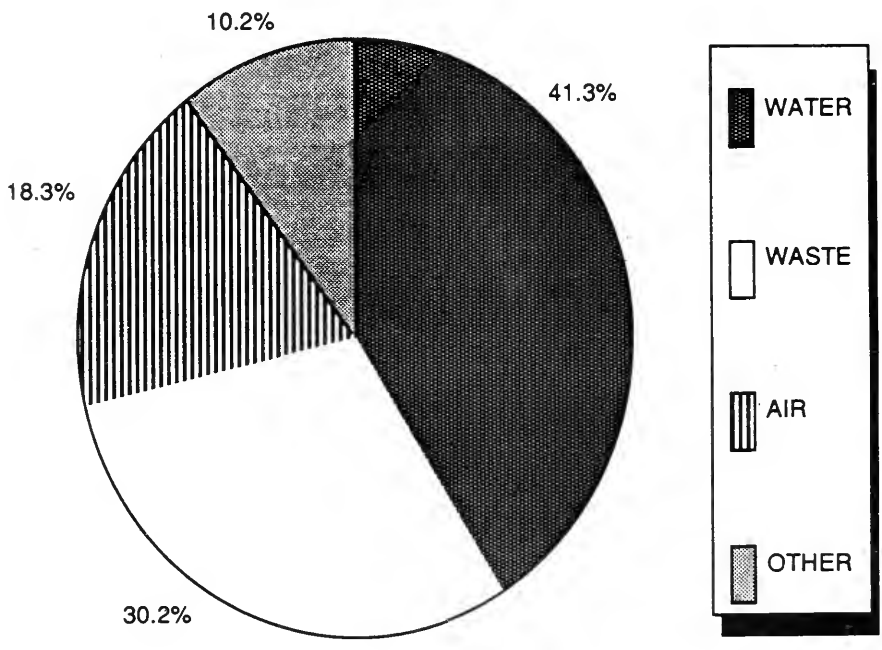
By far the fastest growth in employment in our sample was registered in the waste management subsector (25% per annum) followed by multi-sector firms (9%), water (6%) and virtually no increases in air or "other". We believe that some of the growth in the waste management field is attributable to the consolidation of sales through acquisitions by respondents rather than to market demand growth, since the reported growth appears to be far in excess with the likely growth in waste generation.[8] Some firms may also have included growth in sales by operations acquired abroad.

8 While waste management respondents may have gained market share through merger or growth, we are not in position to assess the extent to which this has resulted in an overall consolidation in the industry.

CHART 3.4

EMPLOYMENT BY SECTOR

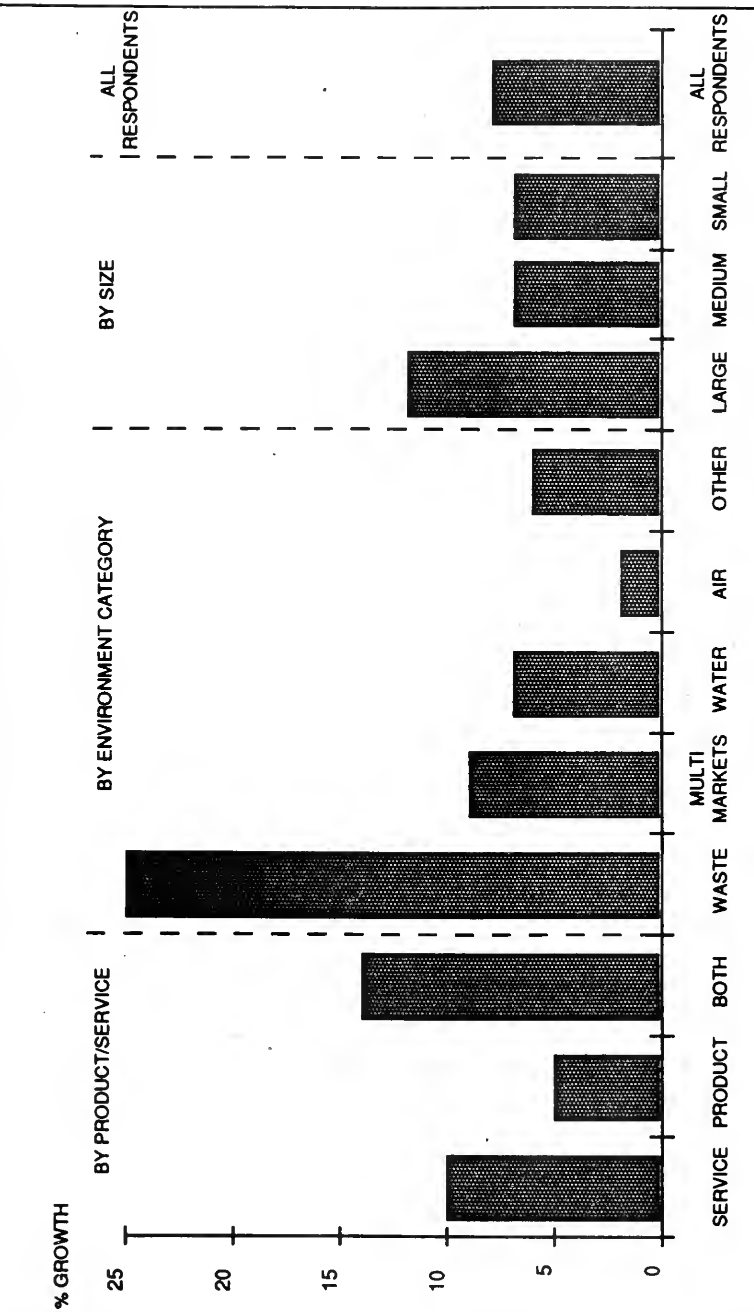
ONTARIO ENVIRONMENTAL INDUSTRY, SURVEY RESPONDENTS



*Note: Excludes firms that failed to specify industry segment.

CHART 3.5
AVERAGE ANNUAL GROWTH IN EMPLOYMENT, 1986-90

ONTARIO ENVIRONMENTAL INDUSTRY, SURVEY RESPONDENTS*



* Note: Excludes firms entering industry after 1986.

The larger firms (i.e., those with annual worldwide sales over $2 million) provided 60% of the employment in our sample of the environmental protection industry even though they only represented 25% of the survey. Moreover, their employment grew at twice the rate reported by small and medium sized firms (with less than $2 million in sales).

3.5 Sales Revenues

The 450 firms that provided responses to the sales question in our survey reported combined 1990 revenues of $1,068 million from Ontario environmental operations (see Table 3.3). As shown in Chart 3.6, the largest grouping of companies were those in the waste management subsector at $502 million (47%), followed by water at $302 million (28%).

Three-quarters of the sales revenues in our survey sample are from services and one-quarter are from the sale of products, a split nearly identical to that estimated in our 1988-89 study for 1987. Within the products segment, water-related products is the largest segment in our sample, followed by air pollution products. Within the services segment, however, waste management is by far the largest area of activity in our sample.

Table 3.3
1990 Sales by Environmental Subsector: Survey Results
(thousands of dollars)

Product	**Value**
Air	90,894
Water	113,708
Waste	55,635
Other	15,770
Unspecified	6,929
Total Products	282,936
Service	**Value**
Air	68,565
Water	188,580
Waste	446,152
Other	66,923
Unspecified	14,934
Total Services	785,153
Total	**$1,068,089**

The sales growth rates for responding firms that have been in business since 1986 or before grew at a compound average rate of 32% per year over 1986-1990 (see Chart 3.7).[9] We strongly suspect that this exceeds the growth in total industry sales, perhaps due to the impacts of mergers and acquisitions on reported sales, or to some understatement in estimates of 1986 sales that were not made by the respondent through examination of actual company data. For firms starting up after 1986, the annual growth rates are significantly higher, although these results should again be used with considerable caution because of the statistically small sample. Services firms tended to outpace others in annual sales growth.

Within the environmental subsectors, the highest annual sales growth rates were reported by firms in the waste management business, followed closely by multi-sector firms. This may again reflect the impact of mergers, the growth in such areas as recycling and hazardous waste management, and perhaps the continuation of the trend to shift waste haulage from the public to the private sector.

9 All growth rates in this section are based on calculating a compound annual growth rate for the sum of all firms' sales over the period. Thus, the growth of larger firms would be given more weight in this sample growth rate.

CHART 3.6

1990 SALES REVENUES

ONTARIO ENVIRONMENTAL INDUSTRY, SURVEY RESPONDENTS

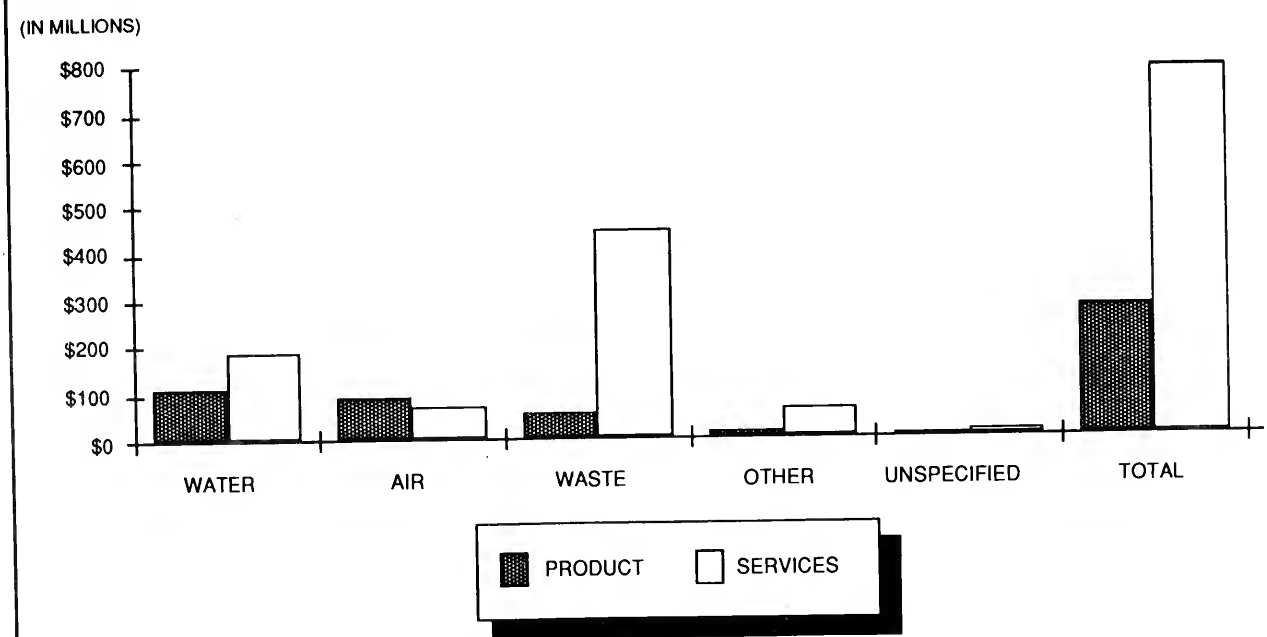
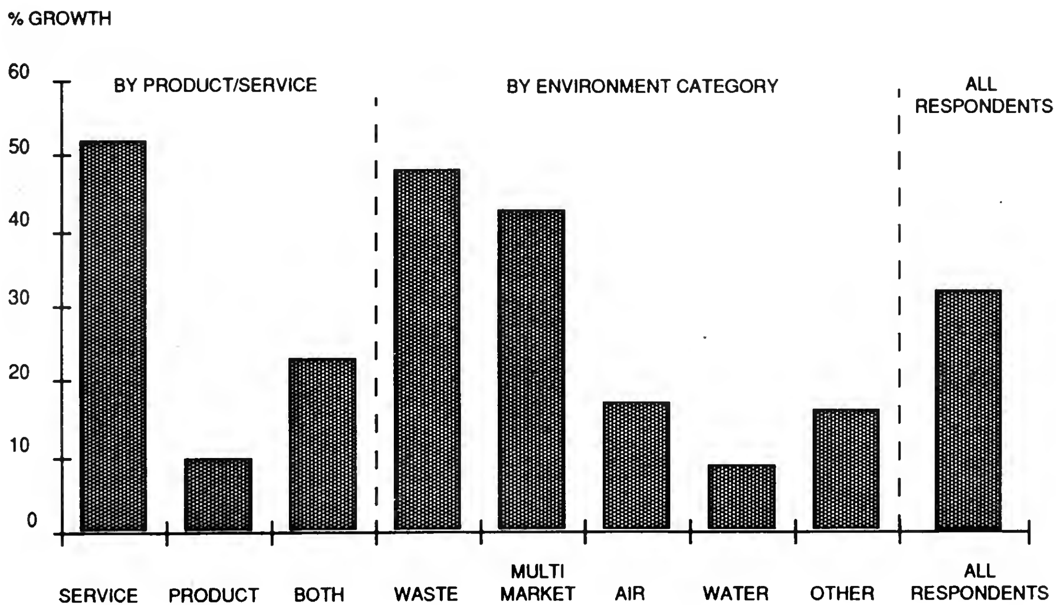


CHART 3.7
AVERAGE ANNUAL GROWTH IN SALES REVENUES, 1986-90

ONTARIO ENVIRONMENTAL INDUSTRY, SURVEY RESPONDENTS



The environmental protection industry has a very large number of small firms, and a much smaller number of major players that hold a significant share of the market (see Table 3.4). Only 25% of the firms in our sample reported annual worldwide sales of $2 million or more, but they accounted for 87% of total sales. In contrast, 29% of the firms reported annual sales of between $500,000 - $2 million, but they accounted for 10% of sales. Some 46% of firms reported annual sales of less than $500,000, but they accounted for only 3% of total reported sales. These firms likely include larger firms for whom environmental sales represent a modest portion of their total output, as well as a number of small consulting and service operations. The large firms also reported faster growth rates than the smaller firms in our sample.

Table 3.4
Distribution of Environment Protection Industry Firms by Size
(Mail Survey Respondents)

1990 Sales (Worldwide)	% of Firms	% of Sales from Ont.
$2 million or more	25%	87%
$500,000 to $2 million	29%	10%
Less than $500,000	46%	3%

The surveyed firms forecast an annual average growth rate of 14% over the next five years, which is considerably more modest than over the past five years, perhaps reflecting an expected continuation of the recent economic slowdown. Products manufacturers forecast an annual average 21% growth rate compared to 12% for services firms. We discuss responses to growth rates by sector (air, water, etc.) in Chapter 4.

Approximately 1% of respondents stated that they planned to leave the environmental business. Major reasons cited for leaving included: "Technology to produce our product not available in Canada", and high levels of frustration with current government policies. However, a further 10% of firms suggested that their commitment to Ontario was either under active reconsideration or wavering. A variety of sharp criticisms of current government policies toward business were made, along with expressions of concern about high costs of doing business in Ontario compared to the United States.

3.6 Technology

The majority of surveyed firms (60%) use "standard" technologies or equipment, which were defined in the questionnaire as items such as pipes and valves and commodity chemicals. This compares to those which use "advanced" technologies (40%) geared specifically to environmental prevention, treatment, clean-up or remediation. Among the industry's subsectors, 71% of air and waste management firms use standard technologies compared to 50 - 60% in other subsectors. Among the technological developments in use by respondents are: the development of more efficient backyard composters; a microwave process for disposing of used tires; increased use of microprocessors in environmental monitoring; ultraviolet disinfection; computer modelling; chemiluminescence-based air monitors; and tunable diode laser spectroscopy.

The technologies used by the majority of firms (58%) are applied to remedial problems compared to those geared toward preventing problems (42%). The most pronounced user of remedial technologies (83%) is the solid waste subsector.

A small proportion of firms, approximately 15%, sell or lease used environmental equipment, but our interviews with suppliers suggest that such sales likely account for a small share of these firms' total revenues. Indeed, purchasers interviewed for this study reported that used equipment accounted for none or a very small percentage of their environmental assets.

With respect to technology development, firms invested an average of 11-12% of their sales in R&D. This ranged from a low of 8% for multi-sector firms and 9.5% for air pollution firms to a high of almost 21% for waste management firms. These high, unweighted averages are heavily influenced by the presence of small firms that are still in the product development stage. In some cases such firms are investing more than 100% of their sales revenues in R&D. Research activity appears to be relatively stable as a share of revenue; three-quarters of the surveyed firms reported no change in the percentage of sales allocated to R&D over the last five years.

3.7 Input Costs

Respondents reported that input cost increases roughly matched inflation over the past few years, rising at an annual rate of 5-6%. For over half (55%) of the surveyed firms, the spread between input costs, namely materials, labour and other components, and final sales prices has tended to narrow slightly, suggesting increasing competition in the environmental market. For 37% of the firms, the gap has remained constant whereas it has widened for only 8% of the surveyed firms. This trend is similar across all industry subsectors except for the water subsector where fewer (48%) of the firms experienced a closing of the gap between costs and revenues.

3.8 Estimating the Size of the EP Industry

Our survey responses suggest that the environmental protection industry is a major contributor to the provincial economy, and that industry revenues run in the billions of dollars annually. Ernst & Young (1989), based on a less extensive sample of the industry and other available studies, estimated that the environmental protection industry in the province had revenues of $1.5 to $2.5 billion as of 1987. In this section, we use the results of our new survey, the reported growth rates of firms in this industry, and other studies of the market for environmental products and services, to update and refine our estimate of the size of the Ontario environmental sector.

As in our 1989 study, we caution that our estimates must be regarded as order-of-magnitude measures, as was clear from the wide range we quoted in the 1989 study. Even in the U.S., where extensive research has been conducted on the environmental protection industry, estimates of its size vary widely. The *Environmental Business Journal* (1991) produced a widely-cited estimate of $132 billion (U.S.) for the American environmental protection industry; the consulting firm Farkas and Berkowitz put EP industry revenues at only $60 billion (U.S.)[10].

There are several reasons for the high degree of uncertainty in such estimates:

10 As cited in Environmental Business Journal (1991)

- the absence of census data from official statistical agencies, due to the fact that environmental services and products are aggregated within several industry categories. Statistics Canada has made some efforts in recent years to remedy this difficulty, and some key results are expected to be released only later this spring;[11]

- the lack of a clear boundary line between the environmental protection industry and other sectors. Previous studies for Canada and the U.S. have differed on whether such activities as silviculture, asbestos removal, radioactive waste handling, indoor air quality, residential water filtering systems, water mains, and potable water treatment are included or excluded in the "environmental protection industry." There are also increasing difficulties in dealing with process change expenditures that are only partially for environmental purposes;

- the potential for double-counting revenues (e.g. equipment components being counted separately and as part of an overall system).

Because of these problems, we caution that differences between our estimates in this report for 1990 environmental protection industry activity and our previous estimates for 1987 cannot be strictly interpreted as measuring EP industry growth over the intervening period. Rather, these differences are due to both growth and refinements in our estimation procedure as new information has come to light.

In the following sections, we estimate activity in the Ontario environmental protection industry in the following segments:

- construction of environmental systems, undertaken by engineering construction firms as well as by equipment suppliers that assemble systems on site;

- materials, equipment, instruments and supplies;

11 These pertain to a survey of the waste management industry, which we understand may be released shortly, and a survey of municipal waste management practices, currently in the field. A recent analysis of pollution abatement and control costs (Statistics Canada 1992) does provide some valuable new insights into the Canadian market.

- environmental engineering and other environmental consulting services;
- laboratory and analytical services; and
- solid and hazardous waste management services, including recycling.

The results of this analysis are summarized in Table 3.5. In total, we estimate that the Ontario environmental protection industry had revenues of roughly $2.5 billion in 1990. Based on the employment to sales ratios reported by survey respondents, and the analysis of employment to sales incorporated in our 1989 study, we estimate industry employment at about 30,000 Ontarians.

Table 3.5
Estimated 1990 Revenues of the Ontario Environmental Protection Industry

Commodity	1990 Revenue
Construction of env. systems	$250 to 300 million
Materials, equipment, instr., supplies	$550-$600 million
Engineering and other consulting	$175-$200 million
Laboratory and analytical services	$50-$75 million
Solid, hazardous waste management (incl. recycling)	$1,300 to $1,500 million
TOTAL	$2,325 to $2,675 million

Note: Excludes services provided directly by governments. Does not include the finished values of products made from recycled materials.

Construction of Environmental Systems

Newly-developed surveys by Statistics Canada data provide fresh insights into Ontario spending on environmental goods and services.

We estimate that environmental construction is a **$250-$300 million** industry in Ontario, based on the following data.

Table 3.6 shows selected results from a survey of 1989 pollution abatement and control expenditures. These data exclude expenditures by municipal governments. The data also exclude expenditures on process changes that have environmental benefits.

Table 3.6
Ontario Expenditures on Pollution Abatement and Control 1989
($ Millions)

	Reported Expenditures	Adjusted for Non-response and Non-sampled Firms
Capital Expenditures by Type of Spending		
Construction	211.2	N.A.
Machinery and Equipment	117.0	N.A.
TOTAL CAPITAL EXP.	328.2	434.7
Capital Expenditures by Type of Pollutant		
Air pollutants	107.0	N.A.
Water pollutants	173.0	N.A.
Contained liquids	28.6	N.A.
Solid Wastes	19.7	N.A.
TOTAL CAPITAL EXP.	328.2	434.7
Operating Expenditures		
Materials & Supplies*	96.7	130**
Purchased Services	99.5	N.A.
TOTAL EXTERNAL OPERATING (excl. fuel, electricity)	196.2	N.A.
TOTAL SPENDING ON GOODS AND SERVICES	524.4	N.A.

Source: Statistics Canada (1992)
*Excludes fuel and electricity
** Estimated by Ernst & Young

Municipal capital spending for the environment is captured in the results of another Statistics Canada survey. As shown in Table 3.7, 1990 capital expenditures on such projects totalled close to $400 million in Ontario.

Table 3.7
Value of Selected Construction in Ontario 1989-91
($ Millions)

	1989	1990	1991
Sewage systems, disposal plants, and connections	225.7	274.1	339.1
Water pumping stations and filtration plants	93.4	115.6	144.6
Incinerators	0	0	0
TOTAL	319.1	389.7	483.7

Source: Statistics Canada (64-201)

Unfortunately, results from a survey of municipalities on solid waste issues are not yet available. Capital expenditures on solid waste management by municipalities are in the order of $50 million, according to interview respondents.

We therefore estimate that total 1990 capital expenditures on environmental protection in Ontario were in the order of $850 million, about equally split between municipalities and other purchasers.

Based on data provided by M.M. Dillon, we estimate that about $400 million of this $850 million was for construction and engineering and $450 million was for machinery, equipment and other materials.[12]

Of the roughly $400 million in construction and engineering, we judge that about $125 million was for engineering design and project management services, based on the typical fee to total project cost ratio reported by Dillon. Therefore the construction activity associated with environmental projects was about $275 million, or in the range of

12 Our 1989 study attributed a larger fraction to construction than we currently believe is warranted, based on new information from M.M. Dillon and a re-analysis of Statistics Canada construction data.

\$250-\$300 million. Exports and imports of such construction services are likely to be quite small, so this is also a reasonable estimate for the size of the environmental construction industry in the province. Note that these construction services are in part supplied by major environmental equipment and systems manufacturers, as well as by engineering construction contractors.

Materials, Equipment, Instruments and Supplies

Materials, equipment and supplies are used in both capital projects and in operating environmental protection systems. We estimate that Ontario environmental protection industry sales of such products total **\$550-\$600 million,** based on the following data.

As noted above, for capital projects, about \$450 million in expenditures are for environmental products (as opposed to construction and engineering). Our interviews and Dillon's estimates suggest that Ontario firms on average supply about 3/4 of the materials and equipment in environmental projects. This would suggest that the Ontario environmental protection industry supplies about \$300 to \$350 million in environmental equipment and related materials for Ontario capital projects.

Materials and supplies are also used for operating environmental systems. Unfortunately, very scanty data are available on this category of spending. Using Statistics Canada data, we estimate that such expenditures are about \$130 million after allowing for non-responses and non-surveyed firms. This estimate excludes spending by municipalities, which we judge adds about \$50 million in spending on materials and supplies for municipal sewage treatment plants.[13] No estimates are available for materials and supplies purchased for municipal solid waste and potable water treatment. Thus, in total, goods producers supply about \$180 million for the operations of environmental systems.[14] Assuming the same 75% share as allocated for capital costs, this would suggest a further Ontario output of \$135 million in goods for operating environmental facilities in the province.

13 A total of roughly \$100 million in goods and services is purchased for operating municipal sewage treatment facilities, based on a \$20 million estimate provided in Ernst & Young (1990b) for Metropolitan Toronto. We allocate half of this total to materials and supplies.

14 Excluding fuel and electricity.

Adding the goods production for capital projects and operations, the total Ontario production of equipment and materials for sales in the province is about $435-485 million.

Exports of environmental products to other provinces and abroad, conservatively estimated at 20-25% of goods producer's sales based on our interviews and 1989 study, would add at least a further $115 million, bringing our total estimate for Ontario environmental machinery, equipment, instrument and supplies to $550 to $600 million.

Engineering and scientific consulting services

Engineering and scientific consulting services are supplied in conjunction with capital projects, environmental impact assessments and other services. We estimate the annual sales of Ontario firms (excluding work performed by non-Ontario residents at branch offices) at **$175-$200 million**.

Statistics Canada has attempted to measure the environmental component of some service sector activities. 1988 revenues for Ontario consulting engineers were estimated at over $1.6 billion.[15] Of this total, 5.2% or $85.5 million, was for "environmental systems". A further 18.3%, or $300 million, was for "municipal systems", which includes both water and wastewater projects as well as municipal roads. We estimate that perhaps $40 million of this total was for water and sewage treatment plants based on the typical ratio of fees to project cost. This would suggest environmental engineering revenues of about $125 million in 1988, including exports. Using the average annual growth rate reported for environmental services in our mail survey (10% per annum), the 1990 revenues of this sector would be in the order of $150 million.[16]

As a check on this estimate, we noted in our estimates for construction that engineering and design fees associated with Ontario environmental capital projects would be in the order of $125 million.

15 In Statistics Canada publication no. 63-234.

16 Note that this estimate is significantly lower on a per capita basis than the 12.2 billion allocated by EBJ to U.S. "environmental engineering / consulting" firms. The U.S. estimate includes a significant component of what we have allocated to construction (e.g. in the nearly $1 billion attributed to the Bechtel Group, for example).

Ontario engineers would reap nearly all of this revenue, based on our interview responses. Export revenue, plus fees earned for services unrelated to capital projects, could account for the remaining $25 million in the estimate above. Thus, $150 million appears to be a reasonable estimate for the environmental revenues of Ontario consulting engineers.

A wide range of other types of firms are engaged in providing scientific consulting services for environmental purposes, including environmental audits, meteorological services, hydrogeological services and so on. Statistics Canada reports that 1988 revenues of the "scientific and technical services industry" in Ontario for environmental services were only $36 million. This was intended to include oceanography, meteorology, climatology, pollution and other research, and other environmental services, including laboratory services (which we estimate elsewhere at over $50 million). Only 23 firms were reported for Canada in this service category by Statistics Canada. We know this figure to significantly underestimate the size of this sector (which should include roughly 100 environmental labs alone), perhaps due to the exclusion of many small firms from the sample. In addition, we expect that environmental laboratories may be included in the $889.9 million reported for firms specializing in "laboratory testing and research services".

We conservatively estimate this subsector at $25-$50 million in 1990, including exports, based on interviews and some data on selected services (such as groundwater consulting), which, when added to our engineering estimate, accounts for our estimate of engineering and consulting services.

Laboratory and analytical services

Environmental labs have grown considerably in the last few years, although Ontario demand may have reached a peak in 1990 due to the MISA monitoring and testing program. We estimate that the Ontario environmental laboratory industry had 1990 revenues of roughly **$50-$75 million**. This estimate is based on interviews, estimates of the U.S. analytical sales per capita, and Statistics Canada data. We expect that export activity in this sector (in the sense of testing by Ontario labs of samples drawn elsewhere) would be very small.

Solid and hazardous waste management

The waste management sector, including recycling, includes several very large firms and many small waste haulers.

As noted above, the first Statistics Canada survey of this sector is still in process. Statistics Canada data suggest that total expenditures on purchased services for solid and contained liquid wastes was only $30-40 million in Ontario in 1989, an estimate that appears to be implausibly low, and which excludes the major segment associated with municipal spending on private sector solid waste services.

Based on industry interviews, we estimate that solid and hazardous waste management firms earn revenues of about $1.1 billion in Ontario, of which about 10% is for hazardous waste. A considerable fraction of the recycling industry is included in this figure, since hauling and sorting of materials for recycling and some materials recovery facilities are owned by waste management companies.

Little data is available on specialized materials recovery firms not linked to general waste management companies. In total, including their activities, we estimate the solid and hazardous waste management industry at about **$1.3 to $1.5 billion.** On a per capita basis, this is roughly half the size of the U.S. solid and hazardous waste and materials recovery sector as estimated by the *Environmental Business Journal* (1991), reflecting the greater role played by municipal governments in supplying municipal waste management services and the smaller market for hazardous waste treatment.

CH2M Hill (1991) data tend to provide some support for our estimate, at least in terms of its order of magnitude. They reported sales (presumably in 1989, although this is not clear in the report) of close to $700 million in Ontario recycling and waste hauling. Only very partial coverage of the sector was available in the data sources used, and materials recycling facilities and hazardous waste management revenues are not included.

While firms in the solid and hazardous waste field reported "export" activity in other jurisdictions in our mail survey, our interviews suggest that the vast majority of this activity is conducted by branch offices using resident employees in the applicable jurisdiction. We have therefore not included this activity as part of the Ontario industry.

Comparison of Estimates with Survey Results and U.S. Data

As a check on the reasonableness of our estimate of $2.5 billion in sales, we compare this figure with the results of our mail survey and with U.S. industry estimates.

Our survey results reported total revenues of more than $1 billion for 1990, with a roughly 25% response rate to the sales question. To understand the relationship between this sample result and the total industry size, we undertook a careful examination of the list of respondents and non-respondents.

We believe that the reported revenues are likely to be well in excess of 1/4 of the environmental sales of all firms on the original survey list, since it appears that about one-third of what we know to be large firms have responded. We also expect that the non-response rate from firms that are not in the environmental business was somewhat higher than the non-response rate for true environmental firms. On the other hand, the small firm response rate may be less than one in four. Assuming our response rate was 1/3 of the large firms (those with more than $2 million in sales) and 1/6 of smaller firms, we arrive at an estimate for sales of all firms on our original survey list of roughly $2.5 billion, with a total employment of 29,000.

This may overstate actual sales to the extent that respondents included some revenues in foreign and out-of-province markets not actually earned from Ontario operations. We note, however, that our original survey list cannot be assumed to be the universe of all environmental firms in the province. First, we likely excluded a large number of small waste management, recycling and consulting firms that were not included on the lists used to assemble our sample frame. Second, the rapid pace of entry of new equipment and services firms makes it unlikely that we captured all such firms on our list. Third, some firms present in 1990 have since ceased operation, and therefore could not be surveyed.

The best available U.S. estimates, scaled down for relative population size and for differences in environmental markets, provide an upper bound on activity in Ontario. *Environmental Business Journal* (1991) put the U.S. industry revenues at $132 billion (US) for 1990 (or $154 billion in Canadian dollars at 1990 exchange rates), as shown in Table 5.2, in Chapter 5. This appears to be reasonably consistent with an

EPA estimate of $115 billion (US) for American expenditures on protecting and restoring air, water and land.

There are three elements of the industry definition used by EBJ that we exclude from our definition for the Ontario industry. Our definition excludes asbestos removal and what EBJ terms "environmental energy sources" (i.e. geothermal, biomass, wind solar, cogeneration and small scale hydroelectric). Private sector U.S. water utilities are included in the EBJ study, but would not be a factor in Ontario. Deducting the revenues for these sectors yields an estimate for the U.S. of $133.6 billion in Canadian dollars. If the Ontario industry was similarly sized on a per capita basis, it would have revenues of about $5 billion.

This, however, is likely to be an upper bound on the size of the Ontario industry, and perhaps a considerable overestimate of its size in 1990. First, as we discuss in Chapter 6, Ontario imports a significant share (roughly 1/4 of in-province demand) of pollution control equipment and instruments, and the U.S. is probably a net exporter of such items. Second, the U.S. market for hazardous waste management, estimated at $13.3 billion, is likely to be significantly larger on a per capita basis than the comparable market in Canada, due to the large expenditures by the Superfund, the Defence Department, and other government agencies on site remediation. Third, some of EBJ's other categories include sales of products that we would not view as part of the environmental protection industry, such as gas masks and protective suits. Fourth, the U.S. data appear to include the worldwide activities of major environmental engineering construction firms, including the value of work performed by non-U.S. residents, while our estimates attempt to exclude such activities. Finally, our understanding is that private sector firms play a larger role in municipal solid waste management in the U.S. than would be the case in Ontario.

Comparison with 1987 Estimates

Our 1988-89 study used the much more limited data available at that time, and a smaller sample mail survey, to arrive at an estimate for the 1987 revenues of the Ontario environmental protection industry. At that time, we reached an order-of-magnitude estimate for industry revenues of $1.5-$2.5 billion.

We caution that one cannot simply compare the midpoint of our previous estimate for 1987 (i.e. $2 billion) with the new estimate for 1990 ($2.5 billion) to assess the growth in the industry over the 3 year period. The changes in our estimate reflect the combination of growth in the industry as well as refinements in our estimating procedure. Much more extensive data are currently available on business environmental spending than was previously the case, owing to very useful initial efforts by Statistics Canada to track environmental activity. In other areas, such as in the breakdown of overall project data into engineering, construction and materials and the import content in materials, we have benefitted from the new estimates on sample projects developed for this study by M.M Dillon. Finally, in both studies, there is still a considerable degree of uncertainty on the final estimates, particularly in the area of waste management and recycling which Statistics Canada is now in the process of investigating.

There are a number of indications that this sector has been growing over the period under study, if not quite at the growth rates reported in the sales of our survey respondents over 1986-90. First, Ontario construction expenditures on environmental municipal works (sewage systems, water filtration, disposal plants, etc.) grew from $195.5 million in 1987 to $389.6 million in 1990, or 25.8% per annum (including inflation). Second, there was a major upturn in laboratory and analysis work associated with the monitoring phase of the MISA program, and a significant growth in expenditures under the Countdown Acid Rain program took place over this period. Third, the Ontario economy grew at an average annual rate of 2.6% in real terms in the three year period 1987-90, and we would expect that industrial waste generation would have roughly tracked this growth.

Comparison with Other Industries

As shown in Table 3.8, the Ontario environmental protection industry is of similar scale to a number of other key industries in terms of its contribution to total employment in the province.

Table 3.8
Ontario Employment by Industry 1990

Industry	**1990 Average Employment**
Motor Vehicle Parts and Accessories	49,900
Motor Vehicle Assembly	34,500
Environmental Protection	**30,000**
Machinery	26,000
Chemicals	24,000
Iron and Steel	20,000
Pulp and Paper	14,400

Source: Statistics Canada, *Employment, Earnings and Hours*, Ernst & Young

4. Trends in Ontario and Canadian Demand for Environmental Protection

4.1 Highlights

In this Chapter we explore the outlook for environmental protection expenditures in Ontario and the rest of Canada, and its implications for the Ontario EP industry.

The outlook is presented in considerable detail, by market segment (air, water, solid waste), industry segment (products, services) and by consuming industry. Most readers will find only some of what follows to be relevant to their activities. For the general reader, we therefore begin with a brief summary of the most important trends documented in this Chapter.

Much of the future shape of the Ontario environmental protection industry will be determined by trends in federal and provincial regulations. The following are some of the highlights of these trends:

1. Increasing tightening of environmental standards. Among the areas being addressed in the near term are water pollution control, control of emissions contributing to ground-level ozone, solid waste reduction, and hazardous waste clean-up.

2. An emphasis on pollution prevention through process change rather than end-of-pipe controls.

3. Increased support for environmental technology development.

The environmental protection industry is expected to grow most rapidly where these regulations and other forces are having their greatest impact on industry and households.

Air pollution control firms expect annual growth of 9-13% over the next five years, although a major surge in spending in the market may be a few years off. Steel mills, metal platers, and chemical firms will be involved in process change measures to control emissions. Air pollution control problems targetted for abatement measures include Ontario Hydro sulphur dioxide control, and adoption of low NOx burners, solvent substitution and other measures to control ground level ozone.

Water pollution control firms expect a more rapid growth of 10-15% per year, triggered by the demands posed by tighter regulations in Canada and abroad. Closed-loop systems, process enhancement in water separation systems, and methods of reducing water usage will be active markets in view of the emphasis on pollution prevention and virtual elimination of toxins. The pulp and paper, mining and chemicals industries, municipal sewage treatment, and Great Lakes site clean-up will be among the areas of increased activity according to purchasers in this market. Spending by metal platers, food processors and other industries discharging into municipal sewers will also be on the increase.

Ontario solid and hazardous waste firms expect a very rapid growth of 15%-21% per annum, with waste reduction and recycling consulting, material recovery facilities, site decommissioning and hazardous waste destruction expected to be the areas of growth. The forecast growth rate of individual respondents could also include their expectations for mergers, gains in market share, or shifts from public to private sector hauling. Several industries report efforts at process change to reduce their landfill costs and hazardous waste generation. Some municipalities expect to expand blue-box programs recycling to new materials. The provincial government is placing greater emphasis on waste reduction efforts.

Monitoring and analysis spending is likely to decline as the peak of the MISA monitoring efforts is passed. Growing environmental service opportunities include environmental assessments, laboratory and analysis services relating to site decommissioning, and industrial water treatment engineering. Trends in instrument markets include growth in ground water monitoring, real-time monitoring, and remote sensing imaging.

4.2 Legislative Trends in Ontario and the Rest of Canada

4.2.1 Introduction

Several factors drive the demand for environmental products and services in Canada and internationally:

- economic growth, which creates the need for environmental products and services at new industrial facilities to ensure that these meet existing and proposed standards;
- population growth, which generates a one-time demand for the necessary environmental infrastructure (water and wastewater treatment and solid waste management facilities) as well as the ongoing services associated with household water and waste management;
- government legislation and regulations, enforced through standards or discharge taxes and fees, that have been growing more stringent over time;
- the increasing demand by consumers for environmentally-friendly "green" products, which in turn leads to demands placed by consumer product makers and distributors on *their* suppliers; and
- increased corporate environmental consciousness, linked to the growing public relations value of a strong record on environmental matters.

Most of the projections for rapid demand growth in the environmental protection industry are attributable to the need for additional pollution abatement expenditures by existing industrial and municipal facilities. These needs will be largely determined by the development and enforcement of tougher legislation and standards by federal, provincial and municipal governments. However, it is clear that the these legislative trends are influenced in turn by the environmental consciousness of both the general public and the business community.

4.2.2 Trends in Federal and Federal-Provincial Regulations and Other Policies

Major elements of existing federal environmental legislation include the following Acts[17]:

17 Drawn from Lawyers Weekly (1991).

- the Canadian Environmental Protection Act, which regulates the manufacture and use of a range of toxic substances. These include, among others, vinyl chloride, chlorinated dioxins and furans, ozone depleting substances, PCB waste storage, lead emissions from secondary lead smelters and chlor-alkali mercury emissions.

- the Environmental Assessment and Review Process order, which sets the criteria for evaluating certain private and public sector projects for their environmental impact, the result of which is a recommendation to Cabinet on whether the project should proceed. A recent Supreme Court of Canada[18] ruling established that EARP applies to projects that either require a federal permit (e.g. under the Navigable Waters Protection Act), or are located on federal land, or that receive federal funding or that are undertaken by the federal government.

- the Fisheries Act provisions relating to the protection of fish habitats;

- regulations relating to transportation in the Transportation of Dangerous Goods Act and the Canadian Shipping Act.

A number of national initiatives are expected to influence the demand for the output of the Ontario environmental protection industry in Ontario and other provinces. The following is a description of selected federal or federal-provincial programs enacted or under discussion. This is not intended to be an exhaustive listing of current environmental regulations in Canada. Rather, our focus is on areas of prominent change over the last two or three years, since it is changes in regulation that promote the greatest volume of expenditures.

The Green Plan

The federal government's Green Plan, released in December 1990, presents a phased action plan to address a wide range of

18 In Friends of the Oldman v. Canada. See Ross (1992) for a review of this decision.

environmental concerns, supported by $3 billion in federal funding. The following are the highlights of the planned initiatives:

- a clean-up of coastal and inland waterways, an Ocean Dumping Action Plan, and a Great Lakes Pollution Prevention Centre;

- a National Regulatory Action Plan aimed at virtual elimination of toxics (including new CEPA regulations for paper mills)

- progress on NOx-VOCs plans with the provinces; tighter emission controls on vehicles and transportation fuels, new air quality modelling, development of steps to meet air quality management obligations with the U.S. and other international agreements, and assessment of emissions trading options;

- a National Waste Reduction Plan that includes regulations on packaging (should the voluntary targets under the National Packaging Protocol be missed), standards and support for 3R activity, expanding the National Waste Exchange program, a new Office of Waste Management, and reductions in waste generation by the federal government.

- programs to clean up hazardous waste sites, including federal "orphan sites," and Great Lakes sediments, destruction of PCB wastes, establishment of mobile hazardous waste incinerators, regulations on transboundary waste shipments, and cooperation with the provinces on developing regulations for hazardous waste management.

- efforts at enhancing global environmental security, including extension of the Acid Rain Control Program to the year 2000, the phase-out of CFCs and other selected ozone depleting chemicals in advance of international agreements, and federal-provincial cooperation in promoting control of greenhouse gas emissions.

- cooperation with other countries and international organizations to foster demonstrations projects and technology transfer, as well as increased funding for environment research and technology development in Canada, including a $100 million Technologies for Solutions initiative announced in October 1991 and a $20 million Environmental Innovations Fund;

- measures directed at sustaining renewable resources, environmental management in government operations, emergency preparedness, parks and wildlife protection, and Arctic clean-up and protection.

Control of Pulp and Paper Mill Effluents

The federal government is moving to control certain organochlorine effluents from Canadian pulp and paper mills. The federal government recently confirmed that, at least in the near term, standards requiring the virtual elimination of effluents would apply only on the most toxic of these effluents - dioxins and furans - although they could be extended as other problems were identified. The federal government has also proposed changes to the Fisheries Act which would set new limits on effluent discharges and make all mills subject to regulations governing the discharge of suspended solids, oxygen-depleting substances, and acutely lethal effluents.

Management Plan for NOx and VOCs

The Canadian Council of Ministers of the Environment is in the process of developing a national Management Plan to address emissions of nitrogen oxides (NOx) and volatile organic compounds (VOCs) aimed at controlling ground level ozone problems. Canada is also a signatory to international agreements calling for the control of these emissions.

A three phase approach was outlined in CCME (1990) The plan, to be implemented over 1990-2005, will place particular emphasis on reducing emissions in three areas with high ozone concentrations: the Lower Fraser Valley in B.C., the Windsor-Quebec corridor, and the Southern Atlantic Region near Saint John.

At present, most of the specific regulatory steps to be taken are still under study. A Multi-stakeholder NOx/VOCs Science Program Management Group is directing a series of monitoring and modelling studies that will be used to set final emissions targets.

Most of the control expenditures may not occur until after 1994, in Phases II and III. The immediate demand for the environmental protection industry will be affected by the 31 initiatives included in the Phase I "National Prevention Program", and the modelling and consulting work that is included in the Phase I plan to develop further steps and targets for subsequent phases. Regulations may be supplemented by the use of an emissions trading system, which, if implemented, could result in the creation of opportunities for firms to provide brokerage services in emissions permits.

National Packaging Protocol

The Council of Ministers of the Environment adopted this protocol in April 1990, as a part of an earlier agreement to aim for a 50% reduction in waste generation by the year 2000. The agreement on packaging establishes a target of a 50% reduction in packaging wastes based on 1988 levels.

The Canadian Environmental Assessment Act (Bill C-13)

This Act would supplant the existing environmental assessment process, to clarify federal jurisdiction and process issues. According to Lawyers Weekly (1991), the result would be a reduction in the stringency of reviews provided to some projects (e.g. those of harbour commissions).

4.2.3 Trends in Ontario Regulations

Ontario has traditionally been a leader among Canadian provinces in promulgating environmental legislation and regulations. Thus, not only will Ontario policies influence the EP industry demand in the province, they will also tend to presage regulatory developments and EP industry demand in the rest of Canada.

The province's Environmental Protection Act is the primary source of authority for the Ministry of the Environment. It grants the Ministry with the power to issue approvals for processes that create discharges or emissions and for waste disposal operations. It allows the Ministry to issue clean-up orders, and makes it an offence to discharge contaminants into the environment unlawfully.

A number of key principles are currently guiding the development of regulatory policies and other measures by the Ministry of the

Environment. These principles will have an important influence on future demand for environmental protection products and services in the provinces:

- *Pollution Prevention.* The Ministry will be seeking to promote the prevention of pollution at its source, rather than end-of-pipe controls. This includes the use of process modifications, closed loop processes, substitute raw materials and product redesign to reduce or eliminate waste bi-products. This could actually reduce future demand for some segments of the environmental protection industry that are linked to the supply of end-of-pipe equipment.

- *Multi-Media Approach.* The Ministry will take a unified look at air, water and terrestrial consequences of activities in issuing permits and designing regulatory approaches. This will preclude the use of strategies to protect one medium that merely transfer problems to a second medium. It will therefore tend to add emphasis to the pollution prevention concept.

- *Promoting the Development of Green Industries.* The Ontario government will be using the promotion of clean technologies and innovations in pollution prevention and waste reduction to position Ontario as a leader in these areas.

- *Economic Instruments.* The Province, along with the federal government, is exploring the potential for the increased use of economic instruments (e.g., pollution taxes, tradeable discharge permits) as a supplement to command and control regulations. Among the areas where economic instruments are already being applied are in charges for sewer usage and increased tipping fees for solid waste dumping. Future applications could include tradeable permits for certain air emissions, such as nitrogen oxides.

Water Pollution Control

MISA

The Municipal Industrial Strategy for Abatement (MISA) is the cornerstone of the province's efforts to control discharges into Ontario waterways. MISA is arguably the most comprehensive environmental legislation in Canada. The objective of the legislation is the "...virtual elimination of toxic contaminants in municipal and industrial discharges into provincial waterways." Initially, the program has targeted direct dischargers including municipal sewage treatment plants and the following nine industrial sectors:

- petroleum refining;
- organic chemicals;
- pulp and paper;
- iron and steel;
- metal mining and refining;
- industrial minerals;
- electric power generation;
- inorganic chemicals; and
- metal castings.

In the first phase, completed in August 1991, individual companies monitored their effluent streams according to Ontario Ministry of the Environment regulations. In the second phase, the Ministry will determine the Best Available Technology Economically Achievable to limit discharges. In the third phase, the Ministry will promulgate regulations with specific limits for effluent discharge based on the data collected from this testing and the ability of available technology to remove toxics or other elements from water. The final regulations, which will set effluent limits on each sector or subsector, are expected to be implemented over the next few years.

Recent announcements by the Minister of the Environment[19] suggest that the final effluent limits will consider additional factors in addition to the availability of technology. The Ministry will be emphasizing the pollution prevention, process change, and multi-media considerations noted above. It will also stress the virtual elimination of persistent toxic chemicals, and the prohibition of effluents shown to be lethal to fish. The multi-media approach will tend to increase the market demand for systems and approaches that do not generate sludges that pose problems for land pollution.

19 Grier (1991)

Although the MISA program has been in place since 1985, its full impact on the demand for environmental products and services will not likely be felt until the regulations for each of these nine sectors are finalized some time over the next two years. It is expected that the Ministry will allow industry some time to meet the new standards, probably in the order of three to five years from the date when the regulations are finalized. Both of these factors will lessen the impact which MISA will have on spending in any one year.

Municipal Sewer Use By-Laws [20]

Municipalities in Ontario establish by-laws that set limits on industrial discharges into their sewer systems. The Ministry of the Environment has a model by-law, first set out in 1964 and then updated in August 1988, that it has recommended for adoption by municipalities. Collins and Dahme (1989) cite studies that showed that the earlier model by-law was not adopted by many municipalities, and that there were inconsistencies in its use by others.

The new by-law sets limits for a number of discharges into municipal sewers. The Sewer Use Control Program, as proposed in a 1990 discussion paper, would make the adoption of this by-law mandatory. Initially, the Ministry would target all municipalities with one sewage treatment plant and a minimum population of 10,000. A total of 22 industry sectors would be required to monitor and control their effluent discharges, comprising:

- the 9 MISA sectors listed above;
- textile mills;
- leather tanning and products;
- timber products, including wood preserving;
- industrial laundries, including dry cleaning;
- rubber and rubber products manufacturing;
- hospitals, clinics and funeral services;
- food processing;
- integrated automobile manufacturing facilities;
- equipment manufacturing and assembly;
- stone, clay and cement industry;

20 This section draws on Collins, S and H. Dahme (1989) and on Ernst & Young (1990).

- service industries (agricultural services, photographic processing, warehousing and disinfection and extermination services);
- printing and publications industry; and
- the transportation industry.

Under the proposed by-law, all industrial dischargers will be required to sample and test water emissions entering into municipal sewer systems. The cost of this testing to industry is estimated at some $100 million per year. This is based on an estimated municipal cost of $20 to $30 million annually to audit water emissions, and an EPA calculation that total industrial monitoring costs are 4 to 5 times total municipal auditing costs. The Ministry of the Environment estimates that between 3,000 and 5,000 industrial dischargers will be covered by this law, according to interviews conducted for Ernst & Young (1990b).

The 1988 by-law sets limits on discharges of contaminants into municipal sewers, based on maximum levels for temperature, alkalinity, acidity, and suspended solids, and restricts emissions that would alter the colour of the water or create a surface film or sheen. There are also specific limits on metals, fuels, oils, toxic materials and hazardous wastes. Fines for violations are also significantly increased.

Along with restrictions on emissions to sanitary sewers, the municipal by-law will increase the amount which municipalities charge to industry for sewage treatment. Based on a survey of 4 large municipalities by the Ministry of the Environment, it is estimated that the revenue from current surcharges to industry covers about 67% of the operating costs of sewage treatment plants associated with industry flows. The Ministry wishes to increase this amount to cover 100% of operating costs and a percentage of the capital costs equal to the cost of financing. The Ministry estimates that these additional costs would double the fees which industry is now paying to municipalities for sewage treatment. More importantly for the environmental protection industry, it will create an incentive for industry to recycle or re-use its water in order to reduce these fees, thereby creating a demand for both engineering services and technology.[21]

21 The three preceding paragraphs are based on interviews with Ministry officials conducted for Ernst & Young (1990b).

As part of the regulations, industry will be required to implement a *Best Management Practices* plan for contaminated surface runoff. The plan will address items such as materials storage, housekeeping practices, preventative maintenance procedures, safety programs and employee training.

Those companies with a reasonable potential for chemicals spills or batch discharges that could have adverse environmental impacts will also be required to implement an *Industrial Discharger Management Practices* plan. This plan will address items such as spill prevention methods, materials storage, preventative maintenance procedures, housekeeping practices, safety programs and employee training. Both of these programs will create significant opportunities for consulting services to design and implement these plans for individual companies. The largest segment to be covered by this legislation is the machinery manufacturing segment (e.g. aerospace, consumer durables, etc.). In addition, the new legislation will likely include industries such as service stations, transportation companies and warehouses. Most of the emissions from these companies are from cleaning water and runoff which may contain contaminants such as grease, oil and solvents.

Other Initiatives

Other initiatives in water and wastewater treatment include plans for legislation on safe drinking water standards and groundwater protection. This could further increase the pressures to address runoff emissions from industrial and agricultural activities in the province.

Remedial Action Plans are also being developed to address 17 previously contaminated sites along the Great Lakes, such as the Hamilton harbour area. The financing of these plans, expected to be very costly, remains under discussion.

Air Pollution Control

Clean Air Program

We understand that the Clean Air Program, announced by the previous Ontario government, is currently under review by the province. It is likely that the specifics of the original CAP program will be altered. However, we believe that the original draft proposal is indicative of some of the longer-term directions that air quality legislation will take in the province.

The Clean Air Program would regulate stationary air emissions in the province of Ontario. The program proposed that all significant air pollution sources be required to install appropriate control equipment and meet specific emissions limits.

It also stipulated that the level of pollution controls be matched to the degree to which the contaminant is hazardous, based on a division of substances into three "levels of concern". The most serious carcinogens or bioaccumulating contaminants would be subject to requirements for "virtual elimination". Other pollutants implicated in genetic changes, long-range transport and atmospheric impacts would be controlled using best available technologies. Emissions causing nuisance impacts would be regulated to an extent that reflected economic considerations as well as environmental impacts. The program also left open the possible use of economic instrument approaches to achieving its ambient quality objectives.

As with MISA, the first stages of the Clean Air Program were to have involved a major effort to monitor emissions. This would have included requirements for source testing, continuous monitoring of major source, ambient monitoring and visible emission monitoring. As with MISA, individual companies would be responsible for monitoring air emissions.

Even if CAP is extensively modified, we believe that the overall direction in air quality legislation will be to broaden the scope of existing air pollution control measures, and extend it to smaller point sources that had previously been treated more leniently.

Acid Rain Program

Ontario's Countdown Acid Rain program is designed to meet Ontario's commitment to Canada's overall target reductions in sulphur dioxide emissions.

Earlier regulations were successful in reducing ground level concentrations. Regulation 308 placed a prohibition on a source that contributed to an ambient concentration greater than 830 micrograms per cubic metre of air, a level chosen with reference to health effects above such levels. Inco was ordered to build a "superstack" in 1970, and a series of control orders were issued that by 1983 reduced its emissions by more than 60% from those allowed in 1972. Hydro took steps on its own to reduce the sulphur content of its coal, while Falconbridge had control orders postponed due to failures in the control methods installed.

In 1980, the federal government and the seven eastern provinces began the process of establishing reduction standards for sulphur dioxide in Canada using both scientific and economic rationale. The total level of reduction chosen was based on a calculation that the environment could withstand deposition rates equal to approximately half of those in 1980. Each province was asked to become responsible for achieving a share of the total required reduction tonnage and to reduce its emissions based upon total emissions in the province in 1980 (allowance was made for variances in annual production), with some consideration for the ability of the province to make reductions (for example, Nova Scotia's almost total reliance on coal fired generating stations was taken into account) and the impact on the province's economy. The model for reduction was based upon Ontario's model. The emission goals were set in 1984, and companies were given 10 years to comply. Countdown Acid Rain was announced at the end of 1985.

In Ontario, four companies (Inco, Ontario Hydro, Algoma, and Falconbridge) are expected to make all of the cuts required to meet the province's 1994 quota. Together these companies account for some 80% of sulphur dioxide emissions in the province. The metals companies have already taken many of the steps necessary to meet their control requirements. Algoma is controlling its emissions through controls on its level of production. Thus, most of the remaining expenditures are likely to be undertaken by Ontario Hydro.

Solid and Hazardous Waste Management

The major solid waste management problems facing the province are the decreasing capacity of existing landfill sites, the shortage of publicly acceptable locations for additional landfills, and the intention of the government to avoid incineration as an alternative to landfills. The Ministry has therefore focussed its efforts on supporting or requiring waste reduction, reuse and recycling (3R) activities.

OMMRI

Ontario Multi-Material Recycling Inc. (OMMRI) was originally established in 1986 as a cooperative effort by soft drink companies and suppliers of containers and container materials. The Ministry of the Environment, OMMRI, and municipalities participate on an equal cost-share basis to establish blue-box recycling programs in Ontario communities. This program and other support by MOE to municipalities has led to a rapid expansion of curbside pick-up and recycling in the province.

In February 1990 this concept was extended under an agreement between the Ministry and the following industry sectors[22]:

- newspaper publishers, printers and their suppliers;
- grocery products distributors, manufacturers and their suppliers;
- plastic products and packaging materials;
- other packaging materials; and
- soft drink manufacturers and their container suppliers.

According to Flemington (1990), OMMRI's new mandate encompasses four core elements:

1. Research, Development and Demonstration – OMMRI will support research into markets for recyclable materials; total waste management system needs, and

22 Flemington (1990),

demonstration projects in the areas of composting and commercial / institutional recycling;

2. Capital Grants – OMMRI will provide grants to help cover the capital costs associated with extending the blue box program to 80% of Ontario households and expanding the types and volumes of materials that are recycled;

3. Local Assistance – OMMRI will provide funds and expertise to municipalities starting or extending blue box programs;

4. Communications – OMMRI will fund a program to communicate waste management solutions in Ontario.

At present, the major difficulty facing OMMRI is the lack of economical markets for waste materials collected. Low prices for the materials (particularly newspaper and PET) has resulted in financial problems that could jeopardize the program in the long run. Municipalities are complaining that they are forced to finance an increasing cost of curbside programs, and additional resources have come from soft drink companies and the province to cover some of the escalation in costs.

Waste Reduction Action Plan

Ontario's Waste Reduction Action Plan is targeted at limiting the flow of wastes into the depleting supply of landfill sites. The Ministry aims to have at least 25% of such flows diverted from landfills and incineration through waste reduction, recycling and reuse by 1992, and 50% by the year 2000. Elements of this plan could include:

- regulations compelling source separation by industry of metals, glass, paper and other recyclable materials;
- the production of waste audits and workplans for waste reduction by solid waste generators and packaging users;
- expansion of the blue box program to apartment building and rural areas, including mandatory use of the program by large municipalities;

- establishment of central composting facilities; and
- a review of strategies to promote markets for secondary materials.

Bill 143, the Waste Management Act, was brought before the legislature in 1991. The bill would enhance the power of the Ministry of the Environment to issue regulations that require recycling and re-use. The Act is significant in its emphasis on voluntary compliance by industry as the first option in meeting objectives for waste minimization.

Extended Liability for Clean-up

Amendments to provisions of the Environmental Protection Act, through the enactment of Bill 220 in June 1990, enhanced the government's ability to order clean-ups (contaminated property, spills, discharges) expeditiously and efficiently. As part of these amendments, the scope and extent of liability for clean-up was broadened. Administrative orders can now be issued to a wider range of parties (including previous owners and lenders) regardless of whether they are responsible for the damage.

This direction is also reinforced by the recent ruling of the Alberta Court of Appeal in the "Northern Badger" case, which held that clean-up costs had priority over a secured creditor in the event of a bankruptcy.[23]

Environmental Bill of Rights

The Environmental Bill of Rights (EBR) is a proposed initiative of the provincial government that is intended to significantly expand the public's role in defining and enforcing environmental standards. This will likely serve to broaden the scope of activities coming under environmental regulations, tighten standards, and enhance enforcement efforts, particularly against smaller sources that previously were not the focus of government attention.

While the final draft of the legislation is not yet available, the elements of the EBR are likely to be similar in intent to those incorporated in a

23 Onyshko (1991)

proposal made by the current Minister of the Environment while she served as an opposition M.P.P. The proposal would allow for a variety of forms of public participation in protecting the environment, including:

- participation in the design of new standards and regulations, through written briefs and / or public hearings;
- legislated requirements on how the government responds to public complaints concerning suspected environmental contamination, including standards for investigations, response to the complainant, and possible use of public hearings;
- creation of a new cause of action for suits brought by citizen groups to protect the environment. Both governments and industry organizations could be defendants in such suits, which would not require that the plaintiffs demonstrate that they have been personally damaged by the actions of the defendant. This provision would be similar to the types of suits that are available in certain U.S. states and under U.S. federal environmental laws (e.g. the Clean Water Act).

Provincial Funding Programs

The Province of Ontario also provides support for environmental improvements through a number of funding programs. These include grant programs to support 3R initiatives, accelerated capital cost allowances for eligible investments in environmental protection assets, grants to municipalities for water and sewer investments, and support for research and development of environmental technologies. The government has also announced that the support of green industries will form an important part of its industrial development strategy for Ontario.

4.3 Trends in Canadian and Ontario Air Pollution Control

4.3.1 Introduction

Several segments of the Canadian market for air pollution control equipment have the potential for demand growth, with the timing being determined by the pace of regulatory development and enforcement. Some of the regulatory developments reviewed above have the potential for creating demand for air pollution control equipment, including:

- the steps still to be undertaken to control sulphur dioxide emissions from major point sources, particularly from power plant utilities;
- control of NOx and VOCs under the Management Plan, particularly in central Canada and B.C.;
- control of various toxic emissions under the Clean Air Program or a replacement initiative.

In Ontario, new air quality initiatives are likely to be phased-in over the next decade. With the CAP estimated to entail capital costs of over $2.5 billion in one scenario ("Scenario A" in Hickling, 1991), industries would likely be given a significant time period in which to phase in the required equipment and process changes. Furthermore, there would be considerable demands placed on Ministry of the Environment resources in developing the detailed control plans.

Thus, in the medium term, much of the demand increase attributable to a broadening and tightening of air quality regulations may be related to monitoring, testing and engineering design work, rather than the actual installation of equipment. Similarly, the phase-in of the NOx-VOCs control plan could leave major control expenditures several years away.

Table 4.1, drawn from Ernst & Young (1990b), shows the estimated annual expenditures on air pollution control for major industry sectors. These were rough, order-of-magnitude estimates based on a limited survey of major firms across Canada. Municipal spending on air pollution control at landfills and solid waste incinerators was included in solid waste management spending, while controls on sludge burning processes were incorporated into wastewater treatment costs. Note that these expenditure estimates represent the demand for all goods and services used in air pollution control, including basic industrial equipment (pumps, valves, pipes) and supplies. This would significantly exceed the demand for specialty products supplied by the environmental protection industry.

Table 4.1
Estimated 1990 Expenditures on Air Pollution Control in Canada
(Millions of 1990 Dollars)

Industry	Annual Expenditures
Pulp and Paper	$150-175
Chemical Mfg	$100-130
Utilities	$230-250
Mining	$80-125
Oil and Gas	$50-100
Other Mfct.	$10-20
Iron and Steel	$10-20
Industrial Minerals	$5-10
Other	$50-100
Total	**$685-980**

Source: Ernst & Young (1990b)

4.3.2 Supplier Outlook

Our mail survey air pollution control equipment suppliers expect to see a 13% annual growth rate in sales over the next five years, while suppliers of related services anticipate a 9% growth rate. Firms supplying a mix of air quality goods and services forecast a 12% growth rate for the next five years.

Equipment suppliers interviewed by by Ernst & Young generally expected relatively modest growth from domestic demand sources in the very near term. Their view is that major steps in NOx and VOCs control are still several years away, and some other areas of demand are viewed as having had their capital equipment needs met. For example, one firm felt that most of the demand for basic ash handling and gas movement equipment had been met. Another that supplied the mining industry noted that the slow growth in their client sector would impede their own equipment sales. Overall, equipment suppliers generally perceived greater demand growth in foreign markets, including the U.S., Mexico and South America.

4.3.3 Purchaser Outlook and Literature Review

In order to add to the perceptions of suppliers, we spoke with a sample of 40 purchasers of environmental products and services. These purchasers appeared to be better able to pin down the types of equipment and services that will be used to address future regulatory requirements. We also drew upon the results of two earlier studies on the environmental equipment market in Canada by Ernst & Young (1990b) and Dun & Bradstreet Canada (D&B) (1991).[24]

D&B (1991) surveyed 2,393 Canadian companies, of which 556 had more than 50 employees, on current and future environmental spending. Firms reported expenditures data only on an aggregated basis for air, water, solid waste and land management problems. However, some indications of future trends in air pollution control equipment is provided by respondents' projections for the types of equipment they intend to install.

The survey results suggest that large firms were better able to respond to questions on future equipment purchases. Just over half of the large (50+ employee) companies surveyed report that they deal with air pollution problems. Of these, close to half predicted some installations of air pollution control equipment over the next three years, and 57% expected installations in the next decade. As would be expected, the greatest number of installations will be of basic air handling, filtering and dust collecting equipment. Relative to the installed base, there are significant expansions projected for installations of incinerators, wet scrubbers and chemical recovery systems.

24 Where sources are not cited, the material in this section is based on interviews with purchasers.

Table 4.2
Current / Expected Installations of Air Pollution Control Equipment in Canada
(As a % of 295 Companies Currently Dealing with Air Pollution Control)

	Currently Installed	New Installation in Next 3 Years*	New Installation in 4-10 Years*
Ab / Adsorption Systems	14%	7%	4%
Air Handling Equipment	42	15	9
Chemical Recovery System	15	8	5
Computer soft / hardware	12	8	5
Dust Collectors	59	15	9
Electrostatic Precipitators	10	4	3
Fabric Filters	41	11	4
Incinerators	10	6	4
Scrubbers - dry	4	5	3
Scrubbers - wet	15	8	4

*Includes some firms with current installations that expect to install additional or replacement equipment.
Source: Adapted from D&B 1991.[25]

Sector Analysis

Iron and Steel Industry

Steel operations currently deal with a number of environmental protection issues related to air quality, including control of emissions of particulates, acid fumes, SO_2, fluoride, NOx, VOCs, and toxics. According to the two major firms surveyed for this study, particulates

25 D&B (1991) reported the results additively - they added the percentage of firms expecting an installation in the next 3 years to those with a current installation, and reported this as the percentage that will have an installation 3 years from now. This ignored the possibility that some of the expected installations were at firms with existing installations.

are dealt with using three main approaches: electrostatic precipitators; baghouses; and, wet scrubbers. Hydrochloric acid fumes are handled by a "packed" scrubber system. Scrubbers are also used to control SO_2 and fluoride emissions. Nitrous oxides (NOx) are minimized in the operations of one company by employing low NOx burners in boilers and soaking pits. Catalytic oxidation is also used in the industry to control NOx emissions. Volatile organic compounds are sometimes dealt with using catalytic incineration techniques. One surveyed firm noted two methods for control of toxics emissions, most notably benzene: proper maintenance to prevent door and lid leaks from coke ovens; and, a process known as 'gas blanketing', where an inert gas is placed into tanks to keep benzene from escaping.

Smaller mills that use electric arc furnaces generally have fewer air emissions to control, and the original systems installed in these newer plants may be able to meet future air quality requirements.

Ernst & Young (1990b) found that Canada's steel companies have already invested considerable amounts in the past on air quality management. In view of these accomplishments, the industry believes that it is reasonably well-prepared to meet some of the requirements from a future Clean Air Program.

Recovery of metals from dust collected from scrubbers, as well as from dry dust collected in the process area, is one aspect of air management at steel mills that will generate future expenditures. The Steel Council of Canada, representing the steel industry, has identified this as an area of future improvement by the industry. Fine particulates less than 10 microns are also likely to be addressed by the industry in the near future using either "absolute filters" (high efficiency fabric filters) or an improvement in the collection capabilities of dry scrubbers. Another source of improvement will be in dry gas cleaning for basic oxygen furnace and blast furnace emissions.

Meeting the anticipated guidelines of the Clean Air Program (CAP) was mentioned by both firms interviewed for this study as the most important factor for change in approaches to air protection. However, limited increases in air spending were anticipated because the Ontario steel industry is experiencing difficult business conditions. Once CAP or some alternative is implemented, the industry expects to face increased monitoring requirements as firms and the MOE investigate current emission levels.

In order to meet future air quality regulations, a number of changes were identified. One firm noted that end-of-pipe particulate control efforts are likely to move to greater use of baghouses rather than wet scrubbers, since its experience has been that the former offers superior performance in this application and eliminates the contamination of water that occurs in wet scrubbing systems. Process changes and shifting material usage were also noted by the firms to deal with some items, notably polycyclic aromatic hydrocarbons (PAHs). Several end-of-pipe technological approaches to PAH control were also identified, including scrubbers, catalytic incineration, and adsorption using carbon, activated alumina, or other substances.

Toxics may be dealt with by greater use of gas blanketing. One respondent indicated that toxics are not readily controlled at end-of-pipe, and process or raw material changes would also not be effective. However, two end-of-pipe techniques are in use in the United States: dry or wet scrubbers, for toxics in both gaseous and particulate forms; and, fabric filters (baghouses) for toxic particulates.

The CCME Management Plan for NOx-VOCs control includes a number of initiatives that will require expenditures - internal or external - by the iron and steel industry. In Phase I, the following measures will apply:

- development of energy efficiency performance standards and guidance documents for new iron and steel plants by December 1992;
- voluntary energy audits;
- new source performance standards for NOx from industrial boilers effective in 1994
- retrofit 50% of boilers in Lower Fraser Valley and Windsor-Quebec areas to these 1994 new source standards by 1997;
- new source performance standards (1995) and retrofit (1997) to meet these standards for emissions of NOx from sintering, coking and other iron and steel processes, aimed at reducing 2005 emissions by 50%.

Several options are available for the control of NOx emissions from the iron and steel sector. Industry participants interviewed by Ernst & Young cited substitution from bunker sea oil to natural gas, and altering the burning configuration within boilers. Flue gas emissions control systems , such as selective catalytic reduction, noncatalytic reduction, or staged air combustion, are among the options cited by CCME (1990) and McInnes and Van Wormer (1990).

Electric Power Utilities

Four utilities account for 80-90% of the generating capacity in Canada. The three utilities outside Ontario - Quebec Hydro, B.C. Hydro and Power, and Newfoundland and Labrador Hydro - rely extensively upon water as their main source of generating power. By contrast, Ontario Hydro uses a combination of water, nuclear power and fossil fuel generating stations. Since air quality problems are largely related to fossil fuel combustion, most of the demand for air management products and services in this sector is from Ontario Hydro.

Ernst & Young (1990b) reported that Ontario Hydro's environmental budget was targetted to increase from $125 million in 1990, to $220 million in 1991, $370 million in 1992 and $410 million in 1993, largely related to controlling air emissions. Total spending by Ontario Hydro to reduce air emissions over the next decade is estimated at some $2.8 billion.

Conventional fuel operations are currently trying to control three main substances – particulates, SO_2, and NOx. Particulates are addressed using precipitators. Hydro is currently upgrading their precipitators, and using lower sulphur fuels to improve precipitator efficiency. The lower sulphur fuels also reduce sulphur dioxide emissions. Additionally, the utility is "washing" fuel to eliminate some modest amounts of sulphur. Flue gas scrubbers are also being built at some facilities to reduce SO_2 in line with regulatory targets. NOx control is achieved with high-efficiency burners on boilers. As well, an engineering study commissioned by Hydro has suggested modifications to combustion that should produce some further reduction. A "selective catalytic reduction (SCR) unit" could be used as an end-of-pipe technique for NOx.

The nuclear plants are dealing with radioactive emissions through high-efficiency filters and intensive monitoring programs. The utility can afford to undertake most services needs internally, although limited amounts are spent on external servicing and design for new technologies.

Much of the planned spending over the next few years will be directed at meeting targets for the reduction of SO_2 emissions. For newer generation units, this will be achieved in part by the of use low sulphur fuel. Older facilities will have to rely on added end-of-pipe controls, with eight 500 MW units slated for flue gas desulphurization retrofits by the year 2000. According to a Hydro official, high-efficiency wet scrubbers – which use a lime spray dryer where lime(stone) and soda ash are mixed with water and then sprayed through flue gas – are likely to be used at Hydro facilities, since the technology has been shown to be effective. As well, injection of lime(stone) or other chemicals into boilers (sorbent furnace injection) may be used, although, according to Burnham (1989), it creates the need for special waste handling for high lime content wastes.

Power generation is a major source of NOx emissions, accounting for over 16% of emissions in the Windsor-Quebec corridor according to the CCME (1990).

Hydro has already installed low NOx burners at Nanticoke. Hydro views its purchases of other major technologies for NOx control as being at least 10 years away. Our Hydro interview respondent believed that further research was needed to develop flue gas emission control (such as SCR or selective noncatalytic reduction), which was also the Hydro view reported in Burnham (1989).

CCME (1990) argues that SCR has already been proven effective in Europe. The Management Plan for NOx-VOCs will require *new* coal, oil and gas power plants to meet NOx targets of 100 ng/J, 90 ng/J, and 40 ng/J (expressed in terms of NO2 per unit of heat input) respectively by the year 2000, a level that will require SCR or other flue gas clean up technologies. These new facilities are likely to be outside Ontario. The target for existing plants, at 200 ng/J for the plant as a whole by 1995, could be met with less costly methods (perhaps depending on whether or not it is set as an annual average with some peak-day shutdowns or a daily limit) or by installing SCR on some of the units of a multi-unit plant.

Despite being at about one percent of allowable limits of radioactive air emissions, Hydro believes that it is likely to expend some effort to assess the possibility of further reductions.

Metal Casting

Metal casting firms in Ontario currently use scrubbers, dust collectors, and baghouses to control particulates, which are their main air pollution problem. One firm also requires scrubbers to handle SO_2 produced from its mould-making process.

Few substantive changes in air protection needs are anticipated by metal casting respondents. The Clean Air Program (CAP) or its replacement may necessitate some increased monitoring efforts, which the firms tend to contract out. One firm conceded that this monitoring may uncover other contaminants requiring control. The firms were split on whether air spending will rise over the next five years – one operation had recently installed a costly scrubber system, and expected spending to fall as a result.

Non-ferrous Metal Mining and Smelting

Sulphur dioxide (SO_2) emissions are a significant concern for metals firms, including all three of the firms interviewed. The companies are required to meet sizeable targets for reductions in their emissions by 1994, and all the firms are involved in process changes to deal with SO_2. Inco, for example, was required to reduce its emissions from its 1990 level of 685,000 tons per year to 265,000 tons per year. For the most part, the company has developed its own solutions to the problem, based on a new milling technology and replacement of existing smelters with oxygen smelting furnaces. The cost of the changes is estimated at more than $400 million. The company will also have to make changes at its Thompson, Manitoba operation, although the cost there is expected to be significantly less than at Sudbury. Hudson Bay Mining and Smelting has announced spending plans of some $70 million to reduce its sulphur dioxide emissions.

Two companies surveyed also operate plants that turn sulphur dioxide gases into sulphuric acid which is subsequently sold to users. One firm sells most of the sulphuric acid produced on the export market. Additionally, end-of-pipe techniques are used to control SO_2 emissions, notably baghouses and electrostatic precipitators.

Particulates were the other main air issue mentioned by metals firms. Wet scrubbing of acid gases and electrostatic precipitators are used to control particulates. As well, a gold mining operation noted that electrostatic precipitators are used to deal with particulates from arsenic trioxide generated in their roaster.

Surveyed operations in Ontario were doubtful that any major changes in substances controlled, or technology used, are likely over the next five years due to the substantial recent and ongoing investments in air protection. The Clean Air Program (CAP) is anticipated to require only small efforts on the part of mining and smelting firms. Particulates may need to be controlled to a greater extent under CAP, although firms were uncertain as to what technology is likely to be used. One firm noted that dealing with NOx from underground equipment may involve the retrofitting of better catalytic converters. Surveyed firms also expected that new air quality regulations in Ontario will likely require increased monitoring efforts.

Metal Plating

Environmental protection purchases were discussed with two Ontario metal plating firms. The main air concern for metal plating companies is emissions of volatile organic compounds (VOCs) caused by solvent-based products used in spraying systems. Control of VOCs prompts purchases of filters and chemical coatings for stacks (which help to control emissions). Otherwise, goods and services purchases in the air segment are not currently a major expenditure for firms interviewed.

The environmental problem associated with solvent-based items is likely to decline in importance as the industry moves toward water-based spraying products. One firm surveyed is currently considering switching to these environmentally safer products. If difficulties are encountered, then the firm sees possible use of water scrubbers or incinerators to further deal with VOCs until water-based items become viable.

Chemical Industry

Organic chemical producers interviewed for this study currently use air-related control for several substances, including VOCs (such as benzene, toluene, xylene, and solvents), ammonia, and various other organic chemicals. Methods of end-of-pipe control mentioned by respondents are scrubbers, incineration, and absorbers. Scrubbers are often bought as "off-the-shelf" systems, although one large firm noted that it is able to design and build simpler types of scrubbers internally. Incineration is often used with combustible pollutants. Blowers, pipes, and flow meters are purchased to operate the incinerator. Adsorbers with activated charcoal are used by one firm to capture solvents from vapour streams.

The inorganic chemical industry faces a variety of air concerns, with wide variations depending on the product mix in a particular facility. The two firms interviewed for this study have concerns regarding a wide range of substances, including particulates, organic materials, mercury, SO_2, ammonia, chlorine, and hydrogen sulphide. Baghouses are employed to control particulates produced at one respondent facility. This same operation deals with some organic materials through incineration, and the remainder are handled by a thermal oxidizer stack that oxidizes the organics. Scrubbers are used to handle SO_2, chlorine, ammonia, and hydrogen sulphide at another respondent operation. Recovery of chlorine from its air streams also takes place at this second facility in order to maximize their production of saleable product.

The chemical industry will play an important role in new efforts to control emissions of NOx and VOCs as a part of the CCME Management Plan (1990). NOx emissions are created in combustion processes. Final standards for NOx emissions from industrial boilers will be set on new sources by 1994, and half of existing boilers in sensitive regions of Canada are to be retrofitted to these standards by 1997. Whether lower cost options, (such as low NOx burners, flue gas recirculation, or fuel reburning) or higher cost add-on approaches (SRC, SNR) will be required will depend upon the standards that are developed.

VOC control has been described as the chemical process industry's "single largest environmental challenge."[26] Controlling these emissions will involve reducing discharges from both point sources and fugitive sources, and will effect both the processes used, and the products manufactured, by the chemical industry.

26 McInnes, Jelinek and Putsche (1990)

Reformulations are likely in paints, varnishes, adhesives, and various household chemical products to reduce the VOCs emitted in their use. For processes, new source performance standards are to be implemented by 1994, and extended to existing plants in the lower Fraser valley and the Windsor-Quebec corridor by 1996. Fugitive emissions reductions programs are to be in place by 1993 at all new plants and existing plants in the lower Fraser valley and the Windsor-Quebec corridor.

VOC control methods for point sources could include thermal or catalytic incineration, carbon adsorption, condensation or absorption, with the appropriate technology being dependent on the properties of the waste stream.[27] Fugitive emission control is a very difficult process. Firms interviewed by Ernst & Young are using double seals, and continually tightening pipe connections to address some of these sources. Further steps will likely involve new monitoring efforts and equipment, enhanced maintenance programs, and the purchase of leak resistant pumps and valves.[28] Containment of leaks in an enclosure is another possibility in some cases.

Firms surveyed by Ernst & Young for this study expect a significant increase in their spending on air pollution control over the next five years. One firm noted that this increase might not take place until the mid-1990s depending on the timing of CAP and other regulatory developments, although it also suggested that the industry's own internal standards were having an impact. Changes will involve both end-of-pipe equipment and process improvement. Envisaged areas of expenditures include:

- monitoring equipment and services to meet new MOE requirements;

- process changes to increase output yield in order to save on materials costs, reduce waste, and meet tougher standards for mercury emissions;

- significant efforts to control fugitive emissions of VOCs and hydrogen sulphide. One respondent noted that they have a major opportunity for a cost-effective solution to

27 McInnes, Jelinek and Putsche (1990)

28 Suprenant (1990)

this problem, but would not elaborate. The other operation expects roughly 60% of air spending over the next five to seven years to be targeted toward fugitive emissions.

- controls to be added for chlorides;
- additional baghouse capacity to control particulates;
- scrubbers for ammonia and for a thermal oxidizer stack ;
- phasing out systems that require the use of CFCs.

In the long term, the chemical industry, along with other sectors using combustion processes, may be required to seek methods of reducing CO_2 emissions as a part of efforts to control global warming. The chemical industry produces CO_2 from fuel combustion in furnaces and from 'crackers'. Ernst & Young (1990) found that in some cases the carbon can be collected and, when mixed with minerals such as lime, can be used to make calcium carbonate. If widely applied, however, this process would generate these byproducts in amounts that would far exceed the demand for them. As a result, there is a need to find methods to either reduce the CO_2 emissions from plants or to find alternative uses for the carbon.

Petroleum Refining

Refineries in Canada generally have well established processes installed for cleaning air emissions such as scrubbers, electrostatic precipitators, cyclones and sulphur recovery plants.

Petroleum refineries in Ontario interviewed for this study are currently dealing with several air pollution control problems, including SO_2, NOx, VOCs, and hydrocarbons. Some have sulphur plants that reduce SO_2 to elemental sulphur from refinery gases. One firm noted that it is able to sell this sulphur to fertilizer and explosives manufacturers. NOx is created in furnaces in refineries, and both respondent operations are converting to high-efficiency burners or newer furnaces. Hydrocarbons result from non-optimized combustion; one operation is trying to monitor the amount of oxygen put into the combustion area in order to maximize burning of hydrocarbons. Fugitive emissions of hydrocarbons and VOCs are also concerns for petroleum refineries. Surveyed firms are increasing maintenance efforts to try to reduce this pollution source, with mixed success. One firm reported particulate concerns generated by their catalytic cracker. "Cyclone" centrifuges are used to separate particulates from the rest of stack gases.

The Clean Air Program, even if amended, is expected by refiners to have a strong impact on the air protection efforts of this industry, causing total expenditures to increase strongly during the next five years as compared with the last five years. Tougher regulations under discussion in other provinces, including Alberta, and regulatory developments under the federal-provincial NOx-VOCs plan, will also contribute to demand growth. Respondents anticipate added controls on ground-level ozone, NOx, hydrocarbons, and benzene.

In the near term, respondents suggested that fugitive emission containment will be a major focus of their air quality efforts. Added controls, double seals, and internal floating roofs with vapour recovery are being considered for storage tanks. Vapour recovery in product loading facilities is also planned by one firm. Increased maintenance, new valves and pumps are likely approaches to address other sources of fugitive emissions.

In order to eliminate hydrocarbons, one firm may try to introduce more oxygen in its burners to permit complete combustion. Continuous stack analysis, increased user of air pollution modelling, and greater consulting requirements when designing major processes are also anticipated.

Pulp and Paper

Particulates and total reduced sulphur (typically linked to kraft pulp mills using sodium sulfide in the process) are the main air environmental control problems currently being dealt with by pulp and paper firms in Ontario. Particulates tend to be handled with scrubbers and electrostatic precipitators. The precipitators are the more effective of the two technologies in use. One firm noted that it would soon be moving from scrubbers to precipitators in anticipation of regulations requiring precipitators. Oxidizers are employed to reduce sulphur emissions. One respondent noted that the firm was planning to use pure oxygen rather than air in the oxidization process, which should result in greater efficiency.

The Clean Air Program (CAP) and federal initiatives on VOCs and NOx are likely to cause some changes for pulp and paper operations in Ontario. Particulates are anticipated to have a lower priority in terms of new regulatory measures, according to one firm. Total air spending is likely to rise moderately, if our sample is representative of the industry in the province. However, one respondent noted that CAP (or its replacement) will have a 10-year phase in period, so that the company would not be making any equipment purchases during the next five years. Expected changes as a result of new government regulations are:

- the aforementioned shift to precipitators from scrubbers due to water control problems resulting from droplets created in scrubbers;
- increased need for monitoring and analysis services to understand what substances are emitted and to monitor once new control equipment has been purchased;
- more efficient burners and better combustion temperature control in boilers.

Industrial Minerals

Dust is currently the main air concern in the industrial minerals industry with several methods of control being used:

- baghouses;
- electrostatic precipitators; and,
- chemical and water spraying of roadways, fuel piles, and raw material piles.

Another control issue facing some firms is flue gas containing fluoride which necessitates the use of scrubbers. One cement-making firm also noted that it has begun to analyze its stack gases, in advance of CAP monitoring requirements, in order to better understand the extent of their emissions, particularly of SO_2 and NOx. Another company noted that air modelling is currently done in advance of all new capital investments, while the lime-producing firm is also monitoring its stack emissions.

Discussions revealed that firms – except for the lime and aggregates company – expect significant additions over the next several years to the list of substances that they will have to control. Notable mentions included possible Ontario and federal regulations regarding SO_2, NOx, VOCs, and CO_2. According to cement firms, the production of CO_2 is inherent in the process of making cement, and no method presently exists to make cement in another fashion. Firms were generally not aware of which specific technologies are likely to be used to address these various emissions. At the very least, monitoring and analyzing requirements are expected to rise as a result of new government initiatives.

Municipalities

Surveyed municipalities indicated air pollution concerns originating from two sources – landfills and sewage treatment plants. Several air problems are created by landfills, including methane gas, odours caused by sulphur gas, and dust from access roads. One municipality handles methane and sulphur with underground trenches in the landfill containing perforated pipe. The pipes are connected to a vacuum fan that moves the gas to an incinerator. Dust control is usually achieved through watering and calcium chloride application on roadways, and grassing unused areas. Occasionally, polycide spray is applied to the edge of landfills or when trenches are being constructed. Monitoring instruments are required, and consulting services are used for landfill analysis and design as well as dust control.

Air problems may increase as a landfill site expands. An expansion of the aforementioned collection system for methane and sulphur gases in anticipated, and capping of the landfill with clay may occur.

Air quality concerns at sewage plants are generated by the incineration of sludge from the water treatment process. One municipality interviewed is looking at several alternatives to incineration. The sludge from water treatment could be used as fertilizer. However, toxic materials are currently left in the sludge, and additional equipment would be needed to further treat any sludge destined to become fertilizer. A second possibility is higher efficiency burning of sludge, which would permit sludge to be more fully burned. The city's sewage plant is investigating "fluidized bed incinerators" that may burn more efficiently. Lastly, the facility is evaluating the possibility of producing oil from sludge. The advantage of this approach is that no waste ash would remain to be hauled.

Other Industries

A number of other sectors will potentially require expenditures to address air pollution control issues over the next decade. Dry cleaners, paint sprayers, degreasing processes, gas stations, printers and plastics manufacturers will be involved in efforts to control VOC emissions, particularly in sensitive areas such as the Lower Fraser Valley and the Windsor-Quebec corridor. Efforts to control both NOx-VOCs and greenhouse gas emissions could ultimately involve a very wide range of energy-consuming industries. Finally, urban growth in some regions will place pressures on various industries to deal with difficult-to-control odour problems.

4.4 Trends in Canadian and Ontario Water and Wastewater Treatment

4.4.1 Introduction

Urban development (and the need for municipal water and sewage systems) and regulatory change will be the driving forces in the market for water and wastewater treatment goods and services. In the regulatory field, the following will be the most significant forces in determining the market demand:

- Ontario's MISA program targetted at municipal and industrial discharges into provincial waterways;
- Federal government measures to control dioxins and furans from pulp and paper mills;
- The federal St. Lawrence cleanup program;
- Adoption of the model municipal sewer use by-law by Ontario communities and the resulting requirements for industry to control discharges into municipal sewer systems;
- Remedial action plans to clean up Great Lakes sites;
- Efforts by other provinces to address water pollution problems, including Quebec's St. Lawrence Action Plan.

Table 4.3, drawn from Ernst & Young (1990b), shows order-of-magnitude estimates for annual expenditures on water and wastewater treatment in major Canadian industry sectors. These were rough, order-of-magnitude estimates based on a limited survey of major firms across Canada. These estimates include products supplied by the environmental protection industry as well as the pumps, valves, pipes and other basic products installed as a part of environmental control measures.

Table 4.3
Estimated Expenditures on Water Pollution Control in Canada
($ Millions)

Industry	Annual Expenditures
Municipalities	$1,700-1,900
Pulp and Paper	$500-600
Chemical Mfg.	$100-130
Utilities	$25-30
Mining	$80-125
Oil and Gas	$50-100
Other Manufacturing	$50-60
Iron and Steel	$30-60
Industrial Minerals	$5-10
Other	$50-150
Total	**$2,590-3,165**

Source: Ernst & Young (1990b)

4.4.2 Supplier Outlook

Our mail survey respondents in water pollution control equipment forecast an annual growth in sales of 15% over the next five years. Related service suppliers expect a growth rate of 10%, while firms supplying a mix of products and services for water and wastewater treatment predicted a 15% growth rate.

Firms interviewed by Ernst & Young noted a number of specific market areas expected to see significant growth in the next 5-10 years.

Responses to a question asking for anticipated areas of growth included:

- automated testing equipment that provides real-time computing power on-site;
- "closed loop systems" (as opposed to end of pipe solutions) motivated by cost saving and government emphasis on pollution prevention approaches;
- water separation technology will grow at a strong pace in the world market. There will be a demand for process enhancement in water separation systems in order to improve the costs for the end-user, and opportunities in the recycling of the effluent within the production process. This is linked to the new emphasis on pollution prevention strategies;
- water filtration systems for the petrochemical industry and municipalities;
- mobile systems that can pre-treat water before final disposal because of the cost of moving liquid waste;
- a broadening of applications of water treatment systems to other domains such as the treatment of run-off from mall parking lots;
- solvent reclaiming - on-site recovery of chemicals is very cost effective; and *spill remediation* - the treatment of small spills (under 50 gallons) by removing contaminant, treating the water and disposing of it into the municipal sewer system;
- UV treatment of water is expected to grow, largely outside Canada, as an alternative to chlorine - the growth markets for this technology are New Zealand, Australia, the UK, France and Germany. Ontario has proven to be competitive internationally in the supply of this equipment, but it has not yet gained wide acceptance in Canada;

- water treatment services and membrane treatment are expected to be strong growth areas, especially in the export arena.

Only a minority of firms mentioned any major impacts on their business as a result of the Ministry's announced emphasis on pollution prevention as opposed to end-of-pipe controls. This would appear to be surprising, since the shift could have significant impacts on equipment suppliers, and potentially reduce the demand for various end-of-pipe approaches and sludge management services. It may be that suppliers find it difficult to anticipate the impacts of the pollution prevention approach at present, since the final MISA regulations remain to be promulgated. VHB and CH2M Hill (1991) noted the lack of information on process changes that might be used as substitutes for end-of-pipe controls.[29]

4.4.3 Purchaser Outlook and Literature Review

As in air pollution control, we supplemented the perceptions of suppliers with purchasers of environmental products and services. We also drew upon the results of two earlier studies on the environmental equipment market in Canada by Ernst & Young (1990b) and Dun & Bradstreet Canada (1991) (hereafter cited as D&B), and on the review of MISA technologies by VHB and CH2M Hill (1991). In this section, where references are not provided, the views are those of our interview respondents.

D&B (1991) surveyed 2,393 Canadian companies, of which 556 had more than 50 employees, on current and future environmental spending. Firms reported expenditure data only on an aggregated basis for air, water, solid waste and land management problems. However, some indications of future trends in water pollution control equipment is provided by respondents' projections for the types of equipment they intend to install.

The survey results suggest that large firms were better able to respond to questions on future equipment purchases. Table 4.4 provides the responses of the 286 firms (just over half of the 50+ employee companies surveyed) that reported that they deal with water pollution problems.

29 VHB and CH2M Hill (1991) p 1-11.

The most commonly installed items of equipment are methods of physical separation such as filters, screens and strainers, and gravity sedimentation systems. Relative to the installed base, the most significant increases are expected in such areas as biological treatment systems, oil / water separation systems and water treatment systems.

Table 4.4
Current / Expected Installations of Water Pollution Control Equipment in Canada
(As a % of 286 Companies Currently Dealing with Water Pollution Control)

	Currently Installed	New Installation in Next 3 Years*	New Installation in 4-10 Years*
Aeration systems	9%	5%	4%
Biological treatment systems	10	6	3
Centrifuges	6	2	2
Chemical feed/mix equip.	24	10	4
Chemical recovery systems	20	6	4
Computer soft / hardware	10	6	3
Filters	33	8	5
Gravity sedimentation systems	37	7	5
Ion exchange systems	7	4	2
Oil / water separation equip	29	12	19
Potable water treatment	9	1	2
Screens / strainers	28	7	4
Sewage treatment systems	16	7	5
Water handling products	6	3	1
Water purification systems	9	8	6

*Includes some firms that have current installations who expect to install additional or replacement equipment.
Source: Adapted from D&B 1991.[30]

30 D&B (1991) reported the results additively - they added the percentage of firms expecting an installation in the next 3 years to those with a current installation, and reported this as the percentage that will have an installation 3 years from now. This ignored the possibility that some of the expected installations were at firms with existing installations.

Sector Analysis

Iron and Steel Industry

Steel companies interviewed for this study deal with a wide range of potential contaminants in their liquid effluents, including metals, suspended solids, phenolics, cyanide, ammonia, oil, and dissolved hydrochloric acid. MISA's development document for the iron and steel industry in Ontario indicates that all of the larger steel mills in the province have wastewater treatment systems installed. As a result, we would expect that the industry in Ontario is reasonably well prepared to meet any new standards under MISA. Firms interviewed for this study expected only moderate growth in environmental spending related to water pollution control.

Clarifiers, filters, and ion exchange systems are currently used to handle metals in wastewater. Suspended solids are settled out in sedimentation basins. Biological treatment in the plant or a settling basin is applied to water contaminated with phenols and cyanide, although one firm noted that the local municipality treats some of the firm's phenols and cyanide under a contract with this firm. Ammonia is controlled in stills using steam stripping and chemicals to split the ammonia into nitrogen and hydrogen. Oil contamination is approached with clarifiers, filters, and "dissolved air flotation" where pressurized air is injected into the water to separate the oil and water. Water containing hydrochloric acid is evaporated in order to separate out dirt and iron oxides; the acid is reabsorbed into water and reused.

A number of trends in water protection were noted in our discussions. Recirculating water in a closed-loop system is the primary change identified by respondents. This approach to water protection would involve minimizing chemical use in steel-making processes, greater use of pumps, tanks, cooling towers, ion exchangers to prevent settling, and evaporators, according to the surveyed firms. One company noted that a recently built process that recycled and reused water has only 10% of the water requirement of its other facilities. Apogee *et al* (1990) estimate that recycling blast furnace gas cleaning water at Stelco and Dofasco as part of the RAP plan for Hamilton Harbour would entail capital costs of over $14 million, and also suggest a further $25 million in costs to bring the two plants to BAT standards.

Several other technological changes were anticipated that would affect water protection. Dry gas cleaning involves direct removal of contaminants, rather than cleaning steel-making gases with water. One surveyed firm is currently using this method while another firm intends to adopt the technique in the near future. Non-recovery coke-making, being newly utilized in the United States, would not generate any wastewater but would instead result in gases that are fully combusted.

VHB and CH2M Hill (1991) cite several possible treatment technologies that could be added as a part of a response to MISA standards, depending on their stringency. These include primary (e.g. sedimentation with chemical addition), secondary (e.g. activated sludge with nitrification and denitrification) and tertiary (e.g. chemical oxidation, activated carbon adsorption, ion exchange) treatment systems. For a large, integrated steel mill with 1 million cubic metres per day of wastewater, the costs of alternative treatment system additions would range from $117 million (sedimentation with lime addition, nitrification and denitrification) to $645 million (all of the above plus chemical oxidation, granular media filtration and granular activated carbon adsorption).

Longer term changes mentioned by interview respondents included eliminating coke-making (currently done in South Africa) and perhaps even doing away with iron-making in the manufacturing of steel. However, other industry experts note that virgin iron will always be required in steel-making for quality reasons.

The Steel Council of Canada, representing the steel industry, has identified a number of areas of future improvements in water pollution control in the industry, including:

1) oxides in the wastewater stream;
2) storm water runoff from plant sites; and
3) treatment of chrome-based solutions for reuse.

Electric Power Utilities

Ontario Hydro has a wide range of water protection needs occurring at fossil fuel generation sites, nuclear generation operations, transformer stations, and hydraulic stations. While air pollution control is Hydro's primary area of concern, some additional expenditures will be required to meet tougher water pollution control regulations over the next few years.

Fossil fuel generation facilities currently treat water for chemicals used in operating and cleaning boilers, run-off from stored waste ash, flue gas scrubber discharges, and metals. Treatment to restore pH balance counteracts chemical imbalances. Ash water run-off is handled in lagoons, although a switch is presently underway to dry storage. Metals are controlled with ultra-fine filtration systems.

VHB and CH2M Hill (1991) cite a number of potential additions to existing treatment facilities at fossil fuel plants, including ammonia removal (e.g. through air stripping), neutralization and granular media filtration for effluents from water treatment neutralization sump, and lime sedimentation and filtration for other streams. For a typical thermal station (e.g. Lakeview) the costs for such systems would range from $9 million (for neutralization only) to $103 million (for neutralization, sedimentation with chemical addition, granular media filtration, air stripping, steam stripping, chemical oxidation and ion exchange).

Process changes cited in the same study could include changes in the chemicals used to control cooling system fouling, recirculating systems for bottom ash transport streams, separation of drains used for oily effluents from other effluent streams, and various methods of avoiding contamination in building and stormwater effluents.

With the exception of ash handling or coal drainage wastes, nuclear plants face similar water treatment issues as fossil fuel generating stations. Nuclear operations currently emit less than one percent of the regulatory limits of radioactivity, according to our respondent from Hydro. Dangerous levels of contamination are internally treated and retained. No chemicals are used in the nuclear power generating process, and no treatment for such pollutants is required.[31]

Transformer stations are primarily concerned with leaks of insulating materials due to transformer failure. Secondary containments such as liners and spray-on materials have been installed around equipment containing sizable amounts of insulating liquid. As well, detectors to

31 Nuclear plant waste management issues associated with spent fuel was not considered to be part of the environmental industry for the purpose of this study.

monitor for the presence of insulating liquids in both water and oil/water separators are purchased. Services used include soil removal and clean-up, and disposal for solid and liquid hazardous wastes. In the near future, transformer stations are likely to purchase new types of liners and spray-on materials. Total spending in the transformer station area is expected to rise over the next five years, in order to meet more demanding environmental regulations.

The hydraulic generating stations deal primarily with oil containment. Several programs are ongoing to ease this water pollution concern. Plastic bearings lubricated with water are replacing grease-lubricated bearings in turbines. Governor oil systems – which use oil pressure to control for water flow – are being phased out, and electrical actuators installed in their place. Transformers on the downstream side of dams have the potential for failure, which would release oil into the water course. Dyking and piping systems are being built to take any such escaped oil away to a reservoir. Lastly, the zebra mussel infestation threatens to clog pipes at hydroelectric plants. Chlorination injection equipment is being purchased to defend against this pest. The dilution of the chlorine is likely to keep the concentration in water courses at a safe level. However, monitoring equipment is being purchased to ensure that regulatory limits are respected.

Environmental impact assessments will remain a major area of activity for electric utilities in Ontario and other provinces. Major hydroelectric power projects will continue to be subject to close scrutiny for their impact on terrestrial and aquatic eco-systems.

Metal Casting

The metal casting firms interviewed for this study have differing needs and approaches with regard to water pollution control. The main concern of one company is water that is contaminated by particulates in their air scrubber. This water is put through two clarifiers. In the first, acid is added to precipitate iron oxides. In the second clarifier, polymer is added to bring out heavy metals, and alkaline substances are used to return the pH to proper levels. The water is then reused in the scrubber. Water from casting machine spills is also treated in these clarifiers.

The second company has a wastewater treatment plant that uses lime, sodium metobisulphate, and other neutralizing chemicals to deal with its water pollution problems.

The firms differed in their views regarding future water treatment expenditures. One operation foresees spending falling, with the only change being the use of ferrasulphate instead of acid to precipitate out iron oxides in their clarifiers. This change would not lower the pH as far, saving on costs of alkaline substances required to subsequently raise the pH level. The other firm anticipates a plant upgrade using neutralization, precipitation, filtration, and aeration to deal more fully with metals, phenols, fluorides, and sulphates.

VHB and CH2M Hill (1991) cite a number of process changes that could be used by firms in this sector to minimize contamination of storm and cooling water. As reflected in our interviews, future end-of-pipe treatment costs will vary widely in this sector, depending on existing process in place. Options include recycling of cooling water; additional primary treatment systems for TSS (sedimentation with or without lime addition) and oil/grease removal (dissolved air floatation and gravity separation); and tertiary treatment (e.g. chemical oxidation and granular media filtration) for phenols and to further reduce TSS. Capital costs for the various options examined ranged from less than $300,000 for a small primary treatment system to over $100 million for a large (90,000 M3 per day) primary and tertiary system.

Non-ferrous Metal Mining and Smelting

The waste streams from mines differ according to the metals produced and the processes used. A summary of 67 Ontario mines and their wastewater effluents, drawn from Ernst & Young (1990b), is presented in Table 4.5. MISA monitoring applied to only 58 mines due to the inclusion of only 27 active gold mines (VHB and CH2M Hill 1991).

Table 4.5

Ontario Mines and Wastewater Components

Mining Sector	# of Plants	Wastewater Contaminants
Copper, Nickel, Lead, Zinc Category	17	Effluents can be acid; neutralization commonly required. May contain organic mine-mill reagents. May contain metals such as copper, nickel and zinc.
Gold Category	36	Effluents contain cyanide and heavy metals. Several plants using cyanide destruction methods including natural degradation, hydrogen peroxide, chlorine or sulphur dioxide.
Salt Category	2	Wastewater contains sodium chloride.
Silver Category	2	Most waste flows contain arsenic in both suspended and dissolved forms. Effluent volumes are small.
Uranium Category	9	Acid Mine Drainage is a common problem due to pyrite found in the ore. Most effluents are weakly radio-active. Ammonia is a problem at certain plants in this category.
Iron Category	1	Acid drainage.

Source: Ontario Ministry of the Environment, The Development Document for the Effluent Monitoring Regulation for the Ontario Mineral Industry Sector: Group A.

The diversity of concerns is reflected in the wide range of measures currently adopted by firms interviewed for this study. Effluents from milling and other processes are often contaminated with heavy metals. Lime or other chemicals are generally used to assist precipitation of these metals in settling ponds. This process raises the pH of the effluent which must then be brought back down by the addition of carbon dioxide or sulphuric acid. Industry observers noted that nickel-copper mines also must control arsenic in their effluent. A gold firm's effluent contains small amounts of cyanide which are dealt with by natural degradation in their settling ponds.

In addition, rain or snow falling on tailings often becomes contaminated. Acid Mine Drainage is an important issue for the mining, and the industry currently invests substantial amounts to deal with this problem. As of 1988, about 18 mines in Canada had mechanical effluent treatment plants to treat mine water. The surveyed firms collect this water in the same facilities used to treat effluent, although one firm is spending a sizable amount of money to cover its tailings. Monitoring equipment is required to enable firms to properly deal with both effluent and mine drainage water. One firm noted that it makes extensive use of hydrogeological services to monitor effects on surrounding surface and underground water. Environment Canada estimates that about one-third of the mines in Canada produce acid mine water. Most acid mine water is treated with an alkaline reagent, usually lime.

Future changes in water pollution control will depend on the outcome of the MISA regulatory process. According to the Ontario Ministry of the Environment, future MISA regulations will call for much lower levels of arsenic and cyanide in mine wastewater. One firm noted that virtual elimination or zero discharge may be a goal of MISA. This company currently recycles 50% of its water, but any increase in this percentage would require major process changes which would be costly. However, this firm noted that it would prefer to alter its processes to meet this goal rather than add end-of-pipe technologies such as ion exchange. A gold firm mentioned that the process changes that it anticipated as a result of MISA would yield some cost benefits to the firm and also would likely reduce some air emissions as well.

Total spending on water protection goods and services could rise substantially as the mining industry moves to meet MISA guidelines. The proportion of spending aimed at services is likely to increase, according to the firms, due to increased monitoring and hydrogeological requirements as well as process design consulting needs. VHB and CH2M Hill, based only on data for generic or representative mines, estimated that the "minimum technically achievable loading strategy" for TSS would entail capital costs of close to $350 million.

The Mining Association of Canada Environment and Health Committee has also identified several technological needs for the mining industry:

- characterization of tailings ponds and mine water;
- cyanide recycling and control;
- control and recovery of thiosalts; and
- water recycling systems.

Metal Plating

Water protection is the greatest area of environmental spending and effort in the metal plating industry. Settling processes are used to deal with both of the main problems generated by the production process – suspended solids and dissolved heavy metals (e.g. chrome, lead, nickel, zinc, iron). Suspended solids are handled by a standard settling technique. Chemicals are added to the effluent containing dissolved metals which settles the metals into a sludge. However, the addition of the chemicals to precipitate out the metals changes the pH of the water. Firms must then readjust the pH level before discharging the water. Some firms also use other processes (oxidation, alkaline chlorination, hydroxide precipitation) to treat wastewaters contaminated with cyanide or chromium. Few services beyond a minor amount of consulting and installation of some equipment are used by the surveyed firms.

Several new items requiring control are foreseen by one company, most notably phosphorus and overall biochemical oxygen demand (BOD). The firm is currently not certain how these substances will be handled. Phosphorus might be dealt with by the addition of calcium chloride, although this company noted that it is difficult to monitor for the phosphorus content of water. One metal plater mentioned that the use of chromes and other metals may be reduced or eliminated in order to save on the costs of treatment.

Treatment system changes were also noted by interviewed firms. The final pH adjustment may require new end-of-pipe systems as metal platers are faced with tighter allowable pH ranges on discharges. Sand filtering or centrifugal processes could be added after the settling stage for suspended solids. Substitution of chemicals used to settle dissolved metals may occur in order to reduce the amount of sludge that water treatment produces. Firms also have installed atomic absorption spectrometers and other instruments to meet the requirements for the monitoring and control of effluents.[32]

Spending on water protection goods is likely to decline at surveyed firms since recent investments have been made, and since firms will be looking to reduce the amount of substances needing to be treated.

However, we expect that other firms will be facing significant costs if their communities adopt the model sewer-use by-law set out by the Ministry of the Environment. VHB and CH2M Hill (1991) estimated that there are 673 metal finishers discharging into public sewers in Ontario, and the total cost for a "minimum technically achievable loading strategy" for TSS was put at $9.7 million. According to the Canadian Association of Metal Finishers, one third of its members employ fewer than 10 people, and these small firms may find it difficult to comply with the by-law.

Chemical Industry

Water protection needs in the *inorganic chemicals* sector vary according to the types of chemicals produced by the facility. Respondent firms are dealing with several concerns, including nitrogen, mercury, organic chemicals, and pH imbalance.

Nitrogen is dealt with in three ways at one operation. The manufacturing process is being tightened to reduce losses. Some collection and reprocessing of nitrogen in wastewater streams is also being undertaken. As well, lined sludge ponds are used to settle out some of the nitrogen contained in the facility's effluent.

Another firm has a water treatment plant to deal with mercury, organic chemicals, and pH difficulties. Each environmental concern has a separate approach: 1) mercury treatment involves chemical reagents, precipitation, settling, and filtration through several mediums, including carbon, sand, and filter presses; 2) organic chemicals treatment employs settling, chemical addition to treat sulphide, and pH adjustment necessitated by the treatment process; and, 3) a separate need exists for pH adjustment (either up or down) of effluent received directly from the chemical plant.

32 Collins and Dahme (1989)

Suspended solids such as phosphorus, nitrogen, and carbon are key water protection concerns for organic chemicals firms, according to respondents. One firm uses microbiological methods for treating chemical laden effluents, with "bugs" being placed in the water, eating the chemicals, and subsequently dying. Another important group of substances, dissolved organics, are currently removed from effluent using carbon filters and by installing solvent removal equipment at the point of solvent use.

The MISA program should necessitate significant spending increases for water protection, according to respondents in both organic and inorganic chemicals. Chemical companies in Alberta expect to face a similar increase in spending due to the Alberta government's proposed regulations on clean air and clean water. In Quebec, 13 of the 50 companies targeted by the St. Lawrence Action Plan are chemical manufacturers.

Inorganic chemicals firms expect to respond to MISA requirements in part through a sharp reduction in water usage. The development of entirely "closed-loop" water processes is thought by firms in this sector to be extremely difficult to implement. VHB and CH2M Hill (1991) found no zero-discharge practices in this sector in the U.S. or Canada.

One firm noted that some relatively minor production process changes are planned to reduce contaminant loading in effluent water. Firms do not anticipate that any new substances will have to be controlled, but expected that treatment of all currently regulated items will have to be enhanced. VHB and CH2M Hill (1991) report on a range of alternative end-of-pipe approaches (e.g. chemical reduction, sedimentation, granular media filtration, activated carbon adsorption, chemical oxidation) with capital costs per plant ranging as high as $200 million. Monitoring and analysis expenditures are anticipated to rise moderately from current levels in the near term.

Substantial amounts have been spent by *organic chemicals* firms on testing and analysis under the MISA program recently. Organic chemical companies interviewed were uncertain as to what regulatory requirements would be put in place under MISA in the wake of this monitoring phase. One operation suggested that handling of suspended solids was unlikely to change a great deal, while the other company sees the "bugs and pools" approach to suspended solids to be a significant trend for both the firm and the industry. According to one respondent, as chemical industries try to reach zero discharge, process changes are likely to become unprofitable methods of environmental control, and firms will have to increase their end-of-pipe pollution control efforts.

One company plans a significant expenditure on control and containment of accidental spills. A gravity-fed system is planned with substantial purchases of pipe, analytical equipment, consulting, and construction services. Before the end of the decade, this firm also expects to install a tertiary water treatment system.

VHB and CH2M Hill (1991) examine a range of process change (e.g.water reuse, product substitution, best management practices for leaks) and in-plant treatment options (e.g. activated carbon adsorption metal removal, steam stripping), and present costs for various primary, secondary and tertiary end-of-pipe approaches. Treatment additions cited as potentially needed at various plants include granular activated carbon adsorption, chemical oxidation, granular media filtration, chemical reduction, and sedimentation with chemical addition. Capital costs range as high as $350 million for a large plant and tertiary treatment additions. For the sector as a whole, they estimate that the minimum technically achievable loading strategy for TSS could cost over $750 million., based on the limited information available.

Remedial Action Plan programs could potentially entail significant expenditures at certain organic chemicals firms if sport fisheries are to be restored. Apogee *et al* (1990) estimate that treatment programs at four organic chemical plants on the St. Clair River would entail a total capital cost of $143 million, and significant expenditures would may also be required at other sites, as shown in Table 4.6. These costs would not likely be in addition to the requirements under MISA, since Apogee *et al* (1990) note that the U.S. BAT costs used in their estimates are probably a lower bound on MISA compliance costs.

Table 4.6
Capital Costs for Organic Chemicals Firms to Restore Sport Fishery at RAP Sites

Site	$ Millions
Bay of Quinte	$1.1
Niagara River	7.7
St. Clair River	143.1
St. Lawrence River	2.2

Source: Apogee *et al* (1990)

Petroleum Refining

Refineries surveyed have wastewater treatment facilities which use physical, chemical, and biological methods of pollution control. Physical methods are usually separators (API separators) or settling ponds for suspended solids. Chemical adjustment of pH levels is required at one facility. An activated sludge system is used by one firm where micro-organisms are circulated in a closed system in order to destroy hydrocarbons. The dissolved organic materials are then removed before discharge.

Few water protection-related changes are anticipated during the next five years by surveyed firms, beyond the planned end-of-pipe installation of filtration by one operation. According to respondents in this sector, the Ontario Ministry of the Environment does not expect that MISA will have a significant impact upon expenditures in this sector. Petroleum refineries in Canada have been regulated by the federal government for some time and have, as a result, invested in the necessary technology to control wastewater streams. Firms interviewed for this study expected total water spending to stay roughly constant at current levels. In the longer term (over the next 10 years), one facility intends to minimize wastewater production both through process changes to reduce water use and through the recycling of water required in the refinery.

VHB and CH2M Hill (1991) confirm that most refineries are in compliance with current standards for TSS, ammonia and other contaminants. However, they present costs for a number of potential tertiary treatment additions (granular media filtration, granular activated carbon adsorption, powdered activated carbon adsorption) for process water, with costs per refinery ranging up to $42 million to as low as $630,000.

Pulp and Paper

Water pollution control is the primary environmental concern for pulp and paper corporations. Pollutants being controlled include suspended solids, biological oxygen demand (BOD), toxins (such as dioxins, furans and other and organochlorines), and chlorinated phenols. Treatment is broken into two stages. Settling ponds for solids constitutes "primary" treatment. Polymers are often added to assist settling. The remaining sludge is also generally de-watered. "Secondary" treatment introduces biological techniques and aeration to neutralize contaminants. One firm mentioned that it adds nutrients at this stage to help bugs break down certain materials.

Services for water protection are used frequently in the pulp and paper industry, including monitoring, testing, installation, hydrogeological studies, and maintenance. One firm also mentioned that it had contracted a consultant to model its operations' receiving water to understand the ecological impact of its treated effluent.

Requirements under MISA and the proposed federal regulations on dioxins and furans will be the major driving forces for water pollution control spending by the pulp and paper industry in Ontario. Water and Pollution Control (1990) notes that federal regulations have been in place for two decades, but the record of enforcement has been spotty. The new demand for water treatment systems will come as a result of the catch-up to previous regulatory requirements (generally relating to the need for secondary biological treatment), as well as the response to MISA and federal regulations on organochlorines.

The federal government commissioned a detailed *Background Study of Proposed Amendments to Pulp Industry Regulations on Organochlorines and Dioxins* to estimate the capital and operating costs of its proposed regulation to the pulp and paper industry.[33] Across Canada, the report estimates that the industry faces an investment of over $2 billion in water treatment equipment to meet the

33 N. McCubbin Consultants Inc., *Economic Impact of Proposed Regulation of Pulp and Paper Industry BOD TSM and Toxicity Organochlorines (AOX) Dioxins and Furans*, Environment Canada, June 1990.

proposed federal guidelines, while other estimates have ranged up to $3 billion. The costs may be reduced by the recent announcement that only dioxins and furans, rather than the full range of organochlorines, will be targetted in the first stages of the control program, with others being added only as evidence on their specific environmental impacts is obtained.

The cost estimates cover all costs of design and installation for the system, including engineering costs. The federal study assumed a variety of treatment systems would be installed, depending upon the mill site, including:

- primary clarifier;
- aerated stabilization basin;
- activated sludge;
- sludge dewatering by twin wire press; and
- anaerobic.

The high projected costs will not translate into billions of equipment sales in any one year. Ernst & Young (1990b) projected that the required investments will be made over a fairly extended period, perhaps extending beyond the 1994 deadline, due to the high cost to the industry and its current weak financial position.

In addition, according to the Council of Forest Industries, over half of B.C. portion of the costs has already been expended.[34] Alberta and B.C. have had provincial standards on dioxins and furans in place for some time, and nearly all mills have secondary treatment in these provinces. For example, in its 1989 annual information form filed with the Ontario Securities Commission, MacMillan Bloedel announced that it planned to spend $68 million at its Alberni Pulp and Paper, Harmac and Powell River mills to eliminate production of dioxins and furans (all three mills are in British Columbia). Spending will decline sharply once these investments have been made because the company will have completed all or most of the capital improvements necessary to meet government regulations.[35]

34 Ross (1991)

35 It is important to recognize that capital spending by individual companies will follow irregular patterns. A major investment in environmental equipment over one or two years does not necessarily mean that the company will continue to spend that amount every succeeding year. In fact, it is more likely that the opposite will occur and the company

Some firms expect to use process changes to either reduce or eliminate emissions affected by the new regulations. Donohue Inc. of Quebec City, for example, recently announced that it would build a $25 million chlorine dioxide production plant at its St.-Félicien pulp mill. The company indicated that the use of chlorine dioxide in the pulp-bleaching process would reduce the amount of dioxins and furans in the pulp and mill effluent to below detectable levels. We might also expect to see more recycling of water to lower effluent flow rates and, therefore, reduce the capital and operating costs of the water treatment system.

In addition to the capital costs of water treatment systems, pulp and paper mills in Canada will undergo a substantial increase in operating costs as a result of the installation of these systems. The most significant external cost would be for polymer, phosphoric acid and other chemicals for the systems. The federal government is also considering extensive monitoring requirements for the industry.

MISA guidelines will be the other important factor determining future needs of Ontario pulp and paper firms. Monitoring under MISA commenced in January 1990. MISA will impose requirements for the best available technology economically achievable for each discharger. Eric Hall of the Wastewater Technology Centre expects that many firms will meet new regulatory requirements by installing secondary treatment systems, such as an aerated lagoon.[36]

All three Ontario firms interviewed for this study expect to be required to add or to expand secondary treatment facilities at some of their Ontario operations. One company suggested that it would be changing its processes to reduce water use over the next 2-3 years. Another firm sees the need to either reduce chlorine use in its processes or add new end-of-pipe control technology for chlorine. Spill containment systems are also under investigation at one respondent operation.

According to Eric Hall, conventional primary and secondary biological treatment systems will handle BOD, suspended solids and acute

will reduce its spending in succeeding years. Therefore, for example, we would not necessarily expect MacMillan Bloedel to spend a large amount on air pollution control technology in 1990 or 1991 simply because it did so in 1989.

36 Water and Pollution Control (1990)

toxicity problems, but possibly not the full range of organochlorines that might ultimately be subject to regulation. Hall cites several approaches on both conventional methods and innovative approaches currently being tested in Canada, including: chemithermomechanical pulp mill designs able to achieve zero discharge; anaerobic pre-treatment, mixing and aerobic treatment for kraft mill wastewater to control chlorinated organics; membrane technologies coupled with biological treatment; and altered activated sludge treatment.

One Ontario firm mentioned that it is looking at several innovative control processes: reverse osmosis, (such systems exist for other industries, but are not yet available for pulp and paper) "freeze crystallization" utilized in the U.S., ultraviolet techniques, which the firm believes may or may not be applicable to pulp and paper; and biological systems other than activated sludge.

On balance, the three surveyed firms have quite differing expectations on future changes in water pollution control spending. One company believes that its recently purchased control technology is adequate and that the firm's water spending will fall as a result. The others expect significant increases in spending for water treatment.

Industrial Minerals

Testing and analysis under the MISA program has been the major area of water pollution control expenditure for surveyed industrial minerals firms over the last five years. Settling ponds and monitoring the impact of landfill sites on ground water were other areas of expenditure in this market segment.

The MISA program is expected to result in some increase in spending on water protection – primarily on goods – over the next five years, although two firms believed that they would not be affected to any great extent by new regulations. Several items are expected to require additional control such as alkalinity, total suspended solids (TSS), and perhaps lead, arsenic, and mercury. Firms tended to be uncertain as to how these items might be controlled, although filtering and settling tanks were noted as the likely approach to TSS. Additionally, one firm mentioned that their process currently involved cooling water that is discharged at high temperatures, but was unaware of any impending regulations to require cooling before discharge. The same company is investigating a closed-loop process, but the temperature reached by cooling water is presenting some difficulty.

Municipalities

Municipal water protection concerns are generated both at landfill sites and sewage treatment plants. Ground water protection is the main water-related problem at landfill sites. All municipalities interviewed were involved in monitoring groundwater (one landfill site interviewed analyzes 1200 samples per year) as well as conducting hydrogeological studies surrounding their landfill sites.

One municipality surveyed for this study provides an example of the techniques and purchases made across the province. The main landfill site has retained a consultant on a full-time basis to analyze groundwater. This landfill site has an engineered clay liner (other municipalities have sites with natural clay lining) to prevent leachate seeping into the aquifer. A consultant is retained during liner construction to ensure quality control, and monitoring equipment is also used to test the integrity of the liner on an ongoing basis. Water from the landfill site is collected in polyethylene pipe and pumped into the sanitary sewer system. This landfill site also has "purge wells" located between the site and populated areas. If found, contaminants are pumped out of the ground into the sanitary sewer.

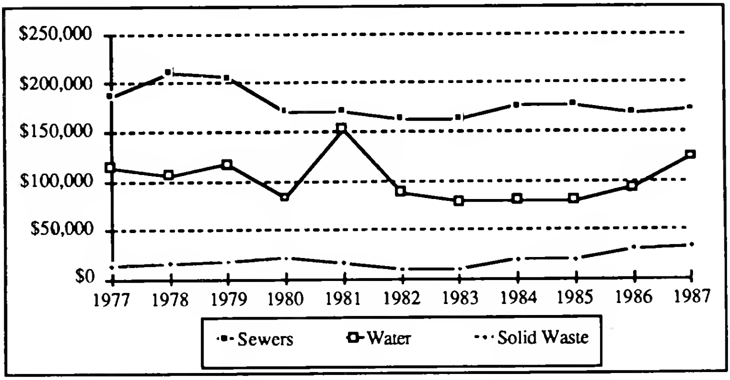
Sewage treatment facilities are a major investment in water pollution control for municipalities. Pollutants are accepted from all industries, although municipal by-laws limit certain substances. Key pollutants for one municipality interviewed are residential sewage, heavy metals, organic compounds, and wastes from paint and organic chemical manufacturing.

Total spending by municipalities in Ontario on areas such as water treatment and sewage treatment has not grown significantly in real terms over 1977-87, as shown in Chart 4.1.[37] However, more recent data cited in Chapter 3 for water and sewage treatement showed rapid growth over 1987-90.

37 The publication on which this data is based is no longer being produced.

Chart 4.1

Municipal Environmental Capital Spending in Ontario After Inflation (thousands of Canadian dollars)



Source: Ontario Ministry of Municipal Affairs, *Municipal Financing Information 1987.*

Based on Ontario statistics, municipal spending on sewage treatment represents about 41% of all municipal environmental capital expenditures. While all municipalities in Ontario have some form of sewage treatment, this ranges from very simple systems such as lagoons to more sophisticated systems employing extended aeration and sand filtration.

A wide range of environmental protection goods are required for sewage treatment plants. Monitoring and testing equipment as well as automatic samplers and flow meters are used to evaluate water quality. Other purchases include pumps, air blowers, tanks, and filters. One facility included on our interview list uses activator sludge to deal with soluble and solid BOD in water. Micro-organisms create solids that are subsequently settled in clarifiers. The settled sludge is shifted to digestors where bacteria are removed. Then, the sludge is dewatered and incinerated. Consulting services are often used to assist with treatment site selection, to recommend equipment, and to design process changes.

Sewage treatment spending grew rapidly in the late 1980s, due to growth in Metro Toronto and the surrounding regions. However, the recent economic slowdown is likely to affect sewage treatment spending, as housing and industrial development has slowed. Future growth will be affected by MISA which is designed to lessen the amount of industrial sewage being treated by municipal sewage treatment plants in the province. As such, it will counteract some of the growth in sewage treatment systems that will be linked to population growth in the province.

Several significant changes that will cause increases in sewage treatment spending were mentioned by Ontario municipalities or reported in Ernst & Young (1990b). Some 28 municipalities have primary treatment systems only. These will all be upgraded to include secondary treatment systems over several years (the time period has not yet been established) at an estimated cost of some $600 million.

Interview respondents expect that future regulations will require greater flow monitoring and sampling. As well, process changes are foreseen in order to begin to treat ammonia, and to remove chlorine used to disinfect effluent. Greater capacity would be required necessitating additional tanks, blowers, and pumps, but other specific equipment needs are not clear. Consulting assistance would undoubtedly be required to implement these process changes.

Remedial Action Plans for Great Lakes sites could entail over $1 billion in expenditures urban runoff control and improvements at sewage treatment plants. Table 4.7, based on Apogee *et al* (1990), provides capital cost estimates for steps to restore sport fishing at RAP sites. Sewage treatment plant improvements are largely upgrades to secondary treatment with nutrient and phosphorous removal. Urban runoff control includes the construction of retention basins; physical, chemical and biological treatment; and other measures.

Table 4.7
Capital Costs of Municipal Programs to Restore Sport Fishery in Remedial Action Plans
($ Millions)

Site	Urban Runoff Control	Sewage Treatment Plant Improvements
Detroit River	$81.7	$51.8
Hamilton Harbour	64.9	69.2
Jackfish Bay	0.4	0.0
Metro Toronto	543.8	0.0
Niagara River	23.7	35.3
Nipigon	0.5	1.7
Peninsula Harbour	0.0	0.2
St. Clair River	11.0	28.9
St. Lawrence River	9.1	22.6
St. Mary's River	11.9	20.9
Severn Sound	5.1	0.2
Spanish River	0.0	4.8
Thunder Bay	17.2	32.8
TOTAL	$769.3	$268.4

The Quebec government subsidizes all of the construction costs for sewage treatment facilities in that province, with the budget for next year likely to be near $500 million. Of these amounts, approximately 60% is for actual construction of the plants, 12-15% is for consulting studies and the balance is for sewage lines to link up municipalities to the sewage treatment plant.

Most municipalities in other parts of Canada either have some form of sewage treatment or are in the process of adding this capacity. In Nova Scotia, for example, 59% of the population lives in areas with sewage treatment facilities. Another 25% are in areas which are in the process of putting in capacity, while 9% are in the early planning phase. The remaining 7% have no sewage treatment facilities. There are still some major cities without complete sewage treatment facilities, including Halifax and Sydney.

In New Brunswick, 80 of 117 municipalities have sewage collection and treatment facilities. All of the three major communities

(Fredericton, Saint John and Moncton) are in the process of upgrading their facilities to provide sewage treatment capability for all the sewage generated. Saint John will have the largest investment as the current capacity treats only 40% of the raw sewage generated. It is expected that over a 5 year period another 15 communities will put in sewage treatment facilities.

On the west coast, Victoria and Vancouver will likely be undergoing major sewage treatment projects in the near future. Victoria currently has no sewage treatment other than screening. Vancouver, like other cities in Canada, has a problem with sanitary sewer overflow mixing with the storm sewers. The city will be adding a system to control this overflow. We understand that a technology has yet to be selected. The capital costs for these projects is estimated at $100 million per year over 5 years.

Operating costs for sewage treatment plants vary considerably by the type of plant. Metro Toronto estimates that annual operating expenditures for its 4 sewage treatment plants are about $20 million for outside goods and services. This expense would include items such as pumps, coagulants and chemicals, but not electricity or natural gas. These expenses would also include many 'non-environmental' products which are needed to operate and manage these facilities.

The Quebec government estimates that there are 300-400 municipalities drawing water from surface water sources without some form of water treatment. The government in that province is drawing up legislation to improve the quality of drinking water in these communities. We would expect that this program, if adopted, would be the largest increase in capital spending in Canada for drinking water treatment. Other than this, we are not aware of any major programs taking place in Canada to construct water treatment facilities, although we understand that Ontario is considering the development of new drinking water standards.

A longer term trend may be the use of disinfectant treatments to replace chlorine in the water treatment system in the future. We understand that some tests are taking place now in Ontario with other treatments such as ozonation or UV, the latter being an area where Ontario has been competitive in export markets. Because of the danger in handiing chlorine, and other considerations, there are some advantages to finding alternatives. As a result, markets for disinfection technologies could grow in the future. At the same time, we are aware that water treatment technology in Canada has not changed for many years, and that change comes slowly to this industry.

4.5 Trends in Canadian and Ontario Solid and Hazardous Waste Management

4.5.1 Supplier Views

Solid and hazardous waste management service firms expect a 15% annual growth in revenue over the next five years, based on our mail survey results. Producers of equipment for waste management forecast a 21% annual growth in sales for the same period, with firms supplying both products and services to this market project a 19% annual growth rate.

Firms interviewed by Ernst & Young expect that the solid and hazardous waste management sector will see strong growth in some areas, but weak growth elsewhere.

Process changes by industry, coupled with waste reduction initiatives in both consumer and industrial product markets, will keep the solid waste disposal industry growing at less than the growth in the economy. Higher tipping fees are already encouraging firms to reduce the volumes of waste they send to landfills, according to disposal companies. Municipal landfills also reported revenue declines associated with reductions in waste flows and diversions of Ontario waste to lower-cost U.S. dumps. Furthermore, some waste management firms are feeling the impact of declines in manufacturing activity in Ontario. Incinerator manufacturers and other manufacturers of waste management products see their primary markets of growth to be either the United States or overseas because of the solid waste disposal restrictions in Ontario.

Among the areas expected to see more promising growth in the future are:

- consulting on waste management planning for municipalities faced with a shortage of landfill sites and a moratorium on incinerators;

- consulting relating to litigation surrounding contaminated sites or waste management projects;

- sludge management;
- providing consulting services to existing waste disposal clients relating to waste reduction, recycling opportunities, and other waste management issues;
- chemical recovery and recycling;
- material recovery facilities;
- decommissioning of contaminated land sites;
- hazardous waste management / destruction;
- composting products and services, particularly in overseas markets;
- incinerators for VOCs in the U.S. market, particularly on the west coast (due to regulatory requirements there).

4.5.2 Purchaser Views and Literature Review

As in the case of air and water pollution control, we used interviews with purchasers as well as other reports on Canadian environmental markets to develop further insights into potential growth markets for solid and hazardous waste management. In this section, where references are not provided, the views are those of our interview respondents.

D&B (1990) found that the majority of large companies surveyed dealt with solid waste management issues. Of the 393 firms with 50 or more employees reporting equipment installations, the most common items of equipment were those relating to waste collection. Major expansions are seen in several types of equipment relative to the installed base, as shown in Table 4.8.

Table 4.8
Current / Expected Installations of Waste Management Equipment in Canada
(As a % of 393 Companies Currently Dealing with Waste Management)

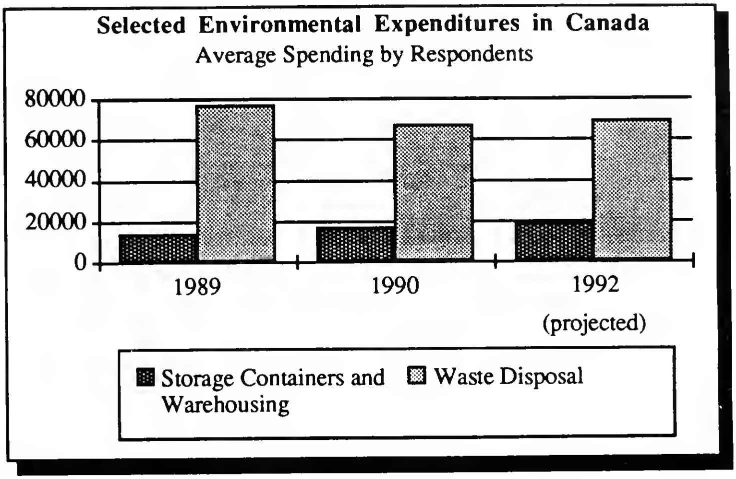
	Currently Installed	New Installation in Next 3 Years*	New Installation in 4-10 Years*
Computer soft / hardware	7%	5%	3%
Incineration	6	9	2
Recycling systems / equip.	41	18	11
Liquid waste collection	49	43	7
Solid waste collection	55	11	7
Waste disposal systems/equip	33	8	5
Waste handling systems/equip	27	9	6
Waste separation systems	20	10	6

*Includes some firms that have current installations who expect to install additional or replacement equipment.
Source: Adapted from D&B 1991.[38]

D&B (1990) also surveyed firms on current and projected expenditures for environmental purposes. As shown in Chart 4.2, firms expected to spend less on "waste disposal services" in 1990 or 1992 than in 1989, but increasing amounts for warehousing, shipping and storage. This would appear, in our view, to reflect a growing reliance on alternatives to disposal, such as recycling and re-use.

38 D&B (1991) reported the results additively - they added the percentage of firms expecting an installation in the next 3 years to those with a current installation, and reported this as the percentage that will have an installation 3 years from now. This ignored the possibility that some of the expected installations were at firms with existing installations.

Chart 4.2



Source: D&B (1990)

Table 4.9, drawn from CH2M Hill (1991), provides the best current estimate of the sources of solid wastes in the province as of 1989. The focus of these estimates is on non-hazardous wastes disposed at landfills and incinerators. Excluded from these estimates are the significant waste volumes generated by construction/demolition wastes not sent to public landfills, soil/spill decommissioning, road construction, dredging, as well as foundry sand, blast furnace slag, fly ash, bottom ash, compost and sewage sludge.

In contrast to air and water pollution control, heavy industries are not the dominant business sources of solid wastes in Ontario. As shown in Table 4.9, such sectors as construction, retailing, communications and other services, and food and beverage industries are among the larger sources of industrial wastes.

Table 4.9
Solid Waste Sources in Ontario, 1989

Source	Tonnes
Residential	**4,053,200**
Industrial, Commercial, Institutional (ICI)	
Agriculture	75,000
Mining	no data
Food and beverage industries	468,000
Rubber, plastic and leather industries	135,000
Textile, knitting mills and clothing industries	38,000
Wood industries	25,000
Furniture and fixtures industries	74,000
Paper and allied industries	80,000
Printing and publishing industries	42,000
Primary metal industries	139,000
Metal fabricating industries	171,000
Machinery industries	49,000
Transportation equipment industries	255,000
Electrical products industries	81,000
Non-metallic minerals industries	59,000
Chemical and chemical products industries	61,000
Miscellaneous manufacturing industries	34,000
Other manufacturing industries	no data
Wholesale trade	166,000
Construction	1,601,000
Transportation	134,000
Communications and services	1,155,000
Electrical power and gas	28,000
Retail trade	397,000
Other sources (incl. government)	94,000
TOTAL ICI	5,361,000
TOTAL RESIDENTIAL AND ICI	**9,414,200**

Source: CH2M Hill (1991)

Sector Analysis

Iron & Steel Industry

Acid, chrome, and caustic soda are important hazardous waste concerns for the Ontario iron and steel firms interviewed for this study. Hydrochloric acid is recovered from wastewater and is reused, avoiding the need for disposal. Chrome is recovered from wastewater in an ion exchange process but cannot currently be reused, which is a significant concern for the respondent firms. The Steel Council of Canada cited the need for methods of treating chrome-based solutions for reuse as an important item on the industries environmental agenda. One firm mentioned that caustic soda – used to clean steel – is neutralized with acid and hauled away by a waste disposal firm. This firm hopes to recycle and reuse its caustic soda in the future.

An important avenue to reduce hazardous waste will be the use of more environmentally-friendly raw materials, notably coated-free scrap, low-sulphur coal, and, new solvents. At the end of the pipe, one firm noted an effort to expand recycling technology for iron oxides. As well, byproducts such as blast furnace slag, currently sold to other users, will have to be upgraded in quality to retain customers such as cement plants and aggregates firms.

Solid waste management does not appear to represent an area of major concern or planned change for this industry, which is already one of the most active users of recycled materials. Some scrap is produced that contains lead and zinc. One firm noted that future needs to separate out the lead and zinc were foreseeable, a view echoed by the Steel Council of Canada. Waste from sintering plants is generally returned to the process. One firm believed that spending on solid waste would decline over the next five years compared to the last five years as their recycling efforts take greater hold.

Electric Power Utilities

Electric power plants deal with both hazardous waste and solid waste issues. Ontario Hydro generally has similar concerns with hazardous waste as many industries in the province, including substances such as PCBs, solvents, cleaning fluids, and lubricating oils and greases. Hydro is gradually taking PCB-using transformers and capacitors out of use, and the PCBs are usually collected and stored on site. Occasionally, a capacitor fails, and soil along transmission line routes is contaminated. This soil is put into barrels and stored. Hydro is involved in both internal and external research which is investigating PCB destruction technology. Other hazardous materials are collected by Hydro, and hauled away by waste disposal firms.

Radioactive wastes are produced by nuclear generating stations, and are classified as hazardous wastes. Spent fuel currently remains on site in pools. Some low- and intermediate-level wastes are stored centrally at the Bruce nuclear facility, including items such as paper products, cleaning materials, ion-exchange resins from water treatment at nuclear plants, and tools. Very low-level waste are incinerated at Bruce.

No change is seen in the storage of spent fuel, unless a federal depository is established. A new incinerator for low level radioactive wastes may be built at Bruce, which would greatly reduce the need for storage of low level waste materials. Compacting of remaining low-level materials could reduce storage further. As well, Hydro is involved in a project to design decontamination equipment for cleaning materials and tools.

Hydro's solid waste concerns are standard industrial wastes and ash from fossil fuel generating stations. Ash is wet stored in landfills, and the nuclear operations have a landfill for regular solid wastes at the Bruce facility. Solid waste spending is almost entirely on goods used to manage Hydro landfill sites.

Several solid waste management changes are planned by Ontario Hydro. Recycling of industrial wastes is underway, with a goal of 25-50% reduction in landfill usage. Scrubber sludge from new facilities being constructed at fossil fuel generating sites will be a concern in the future.

Engineering studies on ash utilization and landfilling are currently underway. Under MISA, ash is likely to be dry stored. This dry storage may permit the waste ash to be reused, which is not possible with wet storage. Several uses may be possible, including sales to the cement industry, backfill material for mines and quarries, and as material for road construction.

Metal Casting

Hazardous wastes are not a major difficulty for metal casting firms surveyed. All spending in this segment goes to hauling services. Waste oils are produced, most of which is hauled by reclaimers. One operation uses some old oils for lubrication on conveyor belts. In addition, one firm is currently storing PCBs on its production site. The other firm has chrome-laden sludges from its water treatment hauled away. Few changes in hazardous waste management are seen by either firm, other than one company's plans to reduce sludge wastes by adding filters in the water treatment plant.

The two surveyed firms differ in their relatively minor solid waste management needs. One operation intends to run its own landfill. They currently are using hydrogeological consulting services, and foresee continued use of such services. The other firm produces slag, core sand, and other wastes that are hauled by a waste disposal company. This respondent complained that such disposal firms had significant market power that hurt user industries such as metal casters. The firm further suggested that the government should take action to prevent disposal firms from pricing abuses since such actions may discourage industry from properly handling of solid and hazardous wastes that are increasingly costly to have hauled away.

Non-ferrous Metal Mining and Smelting

The mining industry is not a substantial producer of hazardous wastes. Used oils, greases, and solvents are generally collected in drums and then hauled by waste disposal firms. Two operations noted that they are storing PCBs. One of these firms has been able to reuse contaminated oil after having destroyed its low level PCBs. Another firm has a small amount of laboratory wastes that are taken away by haulers. Little change is expected in how firms deal with their hazardous wastes, although one company is looking at the possibility of using waste oils for fuel.

Tailings are the predominant solid waste produced by the surveyed mining operations. Specific areas are generally designed to handle tailings, and one firm noted that it uses waste lime to try to neutralize its tailings. Dams are often built to contain tailings, and these dams are tied into the treatment of drainage water. Waste rock from mine development is also a concern in this industry. This material is treated similarly to tailings by the surveyed companies. Sealing or capping tailings and waste rock is likely in the future. One firm noted that it is considering establishing wetlands that may deal with acid drainage naturally.

Increases in tipping fees at municipal dumps are encouraging mining firms to reduce waste sent there. One company is involved in pilot project with a municipality where the firm receives compostable materials from the dump to use as a covering on its tailings.

Metal Plating

The surveyed firms produce some hazardous waste such as solvents, greases, oils, and metal-laden sludges from their water treatment processes. The increasing cost of hauling away these materials is driving firms to consider how substances might be recycled, reduced, or even reused. One firm is currently recycling spent paint and solvents, and is investigating possible reuse of the metals contained in treatment sludge. A further change tied to water protection is the possibility for the elimination of chrome usage.

Total spending in the hazardous waste segment may not greatly change. While haulage costs are expected to rise, metal platers are seeking ways to reduce the volume of hazardous wastes that they produce. Thus, the overall trend is expected to be a decrease in the use of hazardous waste hauling services, and an increase in consulting services and equipment used in recycling and reuse.

Interviewed firms produce few solid wastes. Some of the few items generated are recycled, while the remainder is able to be sent to municipal dumps. No significant changes are anticipated in this area.

Chemical Industry

In addition to the oils and greases handled by most industries, hazardous chemical wastes are a concern for organic chemical manufacturers. At one operation, used oils and greases are collected, some are subsequently cleaned and reused in processes, while unrecoverable amounts are incinerated. Chemical wastes and sludges are generally collected by the companies, and hauled away by waste operators which receive almost all environmental protection spending on hazardous wastes.

Surveyed firms in the organic chemicals subsector see two key changes in the future for hazardous waste management. Process changes will be aimed at both better yields (with less waste produced) and reduction in the use of materials that generate hazardous wastes. As well, increased recovery and reuse of certain substances is likely. One firm is also considering installing an incinerator to burn waste sludges.

Several types of hazardous wastes are generated by inorganic chemical respondents, including mercury-contaminated sludges, oils, paints, solvents, cyanide, and "reactive" wastes such as sulphides and carbon tetrachloride. Most of these items are collected, and hauled by waste management firms. However, processes are used by companies to recover and reuse cyanide and mercury. One firm noted that its unrecoverable cyanide is rendered non-hazardous through either incineration of cyanide-laden dust, or chemical treatment that destroys waste cyanide.

Process changes aimed at reducing the volume of hazardous contaminants produced are expected to become more important in the next few years. Respondents believe that few further opportunities exist for recovery of hazardous substances from waste streams, except perhaps some additional recycling of waste oil. Efforts are planned to segregate waste more effectively in order to reduce total volumes of contaminated material to be hauled; carbon tetrachloride and sodium hydrosulphide were noted as examples of wastes intended to be separated. As well, one firm intends to find ways to render substances non-hazardous at the production facility, rather than incur higher disposal fees.

Total spending on hazardous waste management is expected to rise only slightly over the next five years. Haulage fees are anticipated to rise, pushing up total disposal costs, but this will largely be offset by declining volumes of hazardous waste.

Landfills, recycling, and haulage to municipal dumps are current methods of solid waste management used by organic chemicals firms. One firm noted that about half the material deposited in its landfill is non-hazardous aqueous sludges, while the other half are dry solids.

Inorganic chemicals firms generate modest volumes of solid wastes, from such items as office refuse, cardboard, and construction wastes. However, one inorganic chemical company operates a moderately sized, naturally lined landfill with at least 15 years of capacity remaining. Reusable or bulk containers are being used extensively in the industry for product shipping, and their use is expected to grow slightly in the future. Respondent solid waste spending goes mainly to municipal dump tipping fees.

Increased recycling is anticipated by chemical companies in order to reduce both the amount of solid waste generated and tipping fee payments. One organic chemicals firm is planning to de-water its sludges to reduce the volume of materials entering the landfill. Greater monitoring as well as the installation of a run-off water collection system are other solid waste management changes expected by this firm.

Total spending on solid waste management is likely to rise only moderately over the next five years, according to respondents. Greater recycling efforts will help to compensate for increases in tipping fees.

Petroleum Refining

Catalysts containing metals and storage tank residuals are the main hazardous wastes dealt with by refineries surveyed. Currently, all these wastes are hauled away by disposal firms. One firm mentioned some smaller concerns with caustic acid items and spills contaminated soil. Virtually all spending on hazardous waste management goes to hauling fees, which are expected to rise dramatically, pushing total spending up strongly over the next five years.

Refineries do not expect any change in the way their hazardous waste problems are handled. Firms suggested that the refinery process generates waste sludges that are unavoidable. However, one company thinks that recycling, reuse, or volume reduction of some wastes may be possible.

Other than the minor concerns of recycling office wastes with blue box programs and the shipping of other materials to municipal dumps, refineries do not have solid waste management problems. Surveyed operations expect to increase recycling to try to avoid growing tipping fees at civic landfills.

Decommissioning of sites used in the downstream industry, such as gasoline stations, will be a major concern of petroleum marketing firms. One respondent estimated that cleaning up sites formerly used as gas stations could entail hundreds of millions of dollars in Canada.

Pulp and Paper

The surveyed pulp and paper firms were not significant producers of hazardous wastes. Any wastes generated tend to be typical industrial concerns such as lubricating oils, old paints, solvents dyes, and laboratory waste. Most of these substances are hauled away by waste disposal companies. Respondents mentioned that they would like to burn recycled oil in their power boilers for energy, but regulations currently prohibit such practices.

PCBs are also an issue for pulp and paper operations. A number of mills in Ontario were built before PCBs were recognized as an environmental hazard. Surveyed firms are converting operating components that used PCBs and storing them. Overall, few changes are foreseen in the manner of handling hazardous wastes.

All surveyed firms operate landfill sites for bark and unusable wood waste. Two firms deposit water treatment sludges in their landfill, although one firm burned about half of their sludge for energy. Other than purchasing equipment to move the waste, pumps and liners are occasionally bought to use at the landfill sites. Most external spending is allocated to consultants for site preparation and expansion studies as well as hydrogeological testing.

Few changes are anticipated in solid waste management beyond searching for new sites. One firm is making a modest waste reduction effort to reduce cores and wrappers of paper rolls that are currently returned by customers. Another firm is investigating the possibility of grinding sludge otherwise destined for landfill to sell as mulch for home gardens, but is not hopeful of the prospects. One respondent did mention that a potential need exists for remediation at old landfill sites.

Industrial Minerals

The industrial minerals industry is not a significant producer of hazardous wastes. The main areas of concern are oil and grease products used to lubricate machinery as well as solvents. Currently, firms are recycling some items such as crankcase oils and lighter lubricants. Some items are stored and hauled away by waste disposal firms. One firm noted that it is beginning to demand that the suppliers of heavy greases and lubricating oils collect any containers that the firm cannot clean itself. The only trends revealed in our discussions are potential increases in recycling of crankcase oil, other petroleum products not now recycled, and ethylene glycol products (e.g., antifreeze).

Kiln dust from cement manufacturing is the main item of solid waste that firms in the industry deal with themselves. One firm reported that a small amount of their kiln dust is sold commercially as a soil stabilizer. However, the vast majority of kiln dust produced by surveyed cement makers is stored in piles or landfills owned by the firm.

Some companies run their own landfill sites for metal and lumber scraps. Occasional consulting services for hydrogeological testing are required for proper landfill management. Incidental solid waste is generally sent to municipal landfill sites. Few other external purchases of goods or services were mentioned by surveyed firms.

Two trends were identified in our discussions – storm water control and new sales possibilities for kiln dust produced by the cement manufacturers. One firm that stores the dust in piles on its production site noted that storm water runoff from the stockpiles may become a concern in the future. Generally, a hard crust forms on top of the piles quickly after deposition, but some areas may be exposed to rain water. Initially, this firm sees a need for monitoring. If a problem is found, settling ponds for the runoff are likely to be used. Another firm is investigating several possibilities for their kiln dust: reuse of some of the material for salable cement; sales to other companies that can use the dust; and further sales as a soil stabilizer. However, the extent of these possibilities was thought to be fairly limited.

Municipalities

Some cities in Ontario operate household hazardous waste programs, either picking up such wastes on an intermittent basis or operating permanent depots. One municipality interviewed collects hazardous wastes and turns it over to a disposal firm, while another city contracts out both collection and haulage. Total spending on hazardous wastes is expected to rise significantly due to increased hauling fees and expanded collection from residences and other small waste producers.

Municipalities handle solid waste produced by residential, commercial, and industrial ratepayers through landfill and recycling, while composting plans are in the works in some jurisdictions. Landfills may or may not require construction of a liner. Cities and towns with clay soils can rely on natural lining, while those with sandy soils must construct clay liners. Standard equipment such as trucks, compactors, earth scrapers, and bulldozers are required by to operate landfill sites. A number of municipalities in the province are searching for new landfill sites as existing facilities reach capacity. Hydrogeological and other site preparation studies are normally undertaken when investigating potential locations. Some municipalities contract-out garbage pickup and landfill operation.

In order to reduce the need for added landfill space, many municipalities have instituted "blue box" recycling programs. Cities are looking to expand their efforts to include more items in the recycling pickup such as cardboard, fine papers, mixed plastics, magazines, and boxboard. As well, a number of jurisdictions plan to expand service to handle recyclables produced by schools, institutions, and businesses.

The anticipated changes over the next five years in solid waste management generally involve expanded blue box programs. However, a few municipalities in the province are also beginning composting efforts. In particular, one southern Ontario city anticipates that once a planned expansion of the blue box system and a composting program are both in place, landfills will handle only 40% of total solid waste generated in the jurisdiction. (Currently, blue boxes are this municipality's sole waste diversion program, and only about 5% of total waste produced is shifted away from landfill.) Households in this city will be asked to separate all waste produced into three streams: organics for composting; recyclables; and other items. Some of these other items may be recoverable as scrap, while the remainder will be landfilled.

The municipality interviewed with the most advanced composting plans is in the midst of a major capital project to handle both compostables and recyclables. After considerable consulting design assistance, the city is constructing several major buildings and purchasing equipment such as turning machines to agitate composting material, bag breakers, shredders, screens, conveyors, and balers. The compost will eventually go to municipal landscaping uses. If the compost quality is high enough, the municipality thinks it may be able to sell some to nurseries and sod farms. Another city is subsidizing (along with the Ministry of the Environment) composters for home use.

Few other changes in solid waste management are foreseen, although one city intends to increase its emphasis on the collection of household hazardous waste. Total spending on solid waste management is expected to grow moderately over the next five years.

Other Sectors

In contrast to air and water quality management, solid waste management needs are not concentrated in a small number of industrial sectors. Virtually all businesses generate office refuse. A wide range of manufacturers have wastes associated with unused materials (e.g. lumber from furniture making, or textiles from clothing manufacturing), damaged goods, or packaging materials from their suppliers. Construction firms generate significant volumes of waste from construction sites.

While we have not conducted interviews in each of these sectors, it is likely that the general trends would be similar to those of the sectors covered. Wastes sent to traditional disposal sites are likely to grow less rapidly than the economy as a whole, while recycling and reuse activity will grow much more rapidly.

Several industries are also playing an increasing role as users of waste materials. The Ontario newsprint industry is increasingly under pressure to increase the content of recycled fibre, and fine paper consumers are also demanding products made from recycled paper. Dofasco and Stelco are the largest recyclers of steel metal cans, while Consumer's Glass is the largest recycler of used glass.

The market for innovative technologies for separating and recycling wastes is likely to grow rapidly in response to regulatory pressures and increased disposal costs. Resource Plastics Corp opened a pioneering plant for recycling and upgrading soiled plastics in 1990. Other initiatives are under examination or in process for such materials as construction wastes (lumber), Tetra-paks, and other materials. The LCBO recently undertook a study of options for the re-use of alcoholic beverage containers.

The health care industry is another sector with important waste management requirements. Pathological waste must be handled separately from other waste. There are several different methods for disposing of this waste including incineration, hammermilling and sterilization.

According to Ernst & Young (1990b), roughly half of Ontario hospitals (about 122 in total) operate their own incinerators, most of which use dated technologies that are no longer acceptable to the Ministry of the Environment and therefore in need of upgrading. These hospitals will be examining their options for solid waste disposal in the next few years. The Ministry is also reviewing applications from private companies to establish centralized incineration facilities in the province, similar to those operated by Decom in Quebec. The time frame for implementation of waste management changes for Ontario hospitals is anywhere from 3 to 10 years.

4.6 Trends in Canadian and Ontario Markets for Control, Sampling and Monitoring Instruments

4.6.1 Introduction

The demand for environmental instruments will in some cases be closely related to the changes in air, water and solid and hazardous waste management discussed above. Some of the demand for monitoring, testing and control instruments will be driven by the need to control new environmental protection processes and test their performance over time.

In other cases, specific regulatory requirements will influence the demand for monitoring equipment. The major monitoring program under MISA is already largely completed. Future demand may come from various future initiatives, such as: a revised Clean Air Program, monitoring efforts relating to refining our knowledge of NOx-VOC sources, or testing relating to the clean-up of contaminated sites under Remedial Action Plans in the Great Lakes.

4.6.2 Supplier Views

We also interviewed a sample of Ontario manufacturers of instruments for their views on potential areas of demand growth. Among the areas projected to have good growth opportunities are:

- robust field equipment to monitor ground water emissions;
- real-time monitoring technologies;
- monitoring applications for large, high profile facilities subject to tightening environmental enforcement;
- software and equipment for monitoring and analysis relating to emerging environmental concerns, including the determination of solid waste site locations, spill analysis, rehabilitation of mines and other contaminated sites.
- remote sensing imaging, as a part of the growth in demand for geographic information systems to monitor environmental activity.

4.6.3 Purchaser Views and Literature Review

As noted above, the results of our discussions on future air, water and solid waste management issues with purchasers also provide some indications of future needs for related instrumentation and monitoring equipment. For example, several respondents noted significant increases in monitoring requirements are likely in air pollution control, under the CAP or some amended program. The municipal sewer use bylaw could increase monitoring expenditures for industrial sources that currently discharge wastes into municipal sewer systems.

D&B (1991) survey of 556 firms with more than 50 employees found that many firms report current use of measuring, monitoring or laboratory equipment and supplies relating to environmental applications. As shown in Table 4.10, the most common items are sampling systems, followed closely by air and water quality instruments and sensors. Firms project a significant pace of acquisition of control, sampling and monitoring instruments and various laboratory equipment items over the next decade.

Table 4.10
Current / Expected Installations of Control, Sampling and Monitoring Instruments in Canada
(As a % of 556 Companies with 50+ Employees)

	Currently Installed	New Installation in Next 3 Years*	New Installation in 4-10 Years*
Air quality instruments	14%	8%	4%
Groundwater instruments	6	4	2
Water quality instruments	15	6	3
Sampling systems	21	7	4
Combustion controls	12	4	3
Computer controls	8	6	3
Process controls	15	5	3
Sensors	15	6	3
Data acquisition equipment	8	4	2
Electrical control equipment	13	5	2
Analytical instruments	15	5	3
Bacteriological supplies	3	0	1
Calibration equipment	10	3	2
Environmental chambers	3	1	1
Lab data acquisition equip.	5	2	1
Laboratory equipment	13	4	2
Lab reagents and supplies	11	3	2

*Includes some firms that have current installations who expect to install additional or replacement equipment.
Source: Adapted from D&B 1991.[39]

39 D&B (1991) reported the results additively - they added the percentage of firms expecting an installation in the next 3 years to those with a current installation, and reported this as the percentage that will have an installation 3 years from now. This ignored the possibility that some of the expected installations were at firms with existing installations.

4.7 Trends in Canadian and Ontario Markets for Engineering Consulting, Laboratory and other Services

4.7.1 Introduction

Similar to instrument demand, the demand for engineering and other services (excluding solid and hazardous waste management) will be closely linked to changes in the approaches to air, water and waste management discussed above. Engineering consulting demand for environmental projects is typically related to developing recommendations and designs for treatment of wastes or waste reduction initiatives, and supervision of their installation. Laboratory services are related to both ongoing testing requirements as well as the specific programs mandated under MISA, CAP or other regulations.

MISA demand, formerly focussed on monitoring and lab services, will increasingly be shifted to environmental engineering, as new control orders are developed. The demand for water quality lab services may grow faster outside Ontario, as other provinces adopt regulations similar to those in Ontario.

The other major factor in this area will be regulations that impose liabilities for environmental damage on creditors of bankrupt firms and acquirers of industrial lands. This will create a demand for auditing the environmental condition of numerous industrial properties on behalf of potential creditors and acquirers.

4.7.2 Supplier Views

Firms interviewed by Ernst & Young projected a number of areas in which growth in demand will occur:

- laboratory services related to air emission monitoring;
- laboratory services related to the decommissioning of contaminated sites, and testing on sites for creditors and acquirers of corporate assets;
- consulting firms using simulations models for environmental assessments;
- other work for environmental assessments

- consulting to municipalities to resolve solid waste management problems as landfill sites become more scarce;
- consulting to industry on waste management issues;
- consulting and other services relating to sludge management;
- expert testimony for an increasing number of environmental hearings and court cases;
- industrial wastewater treatment engineering.

4.7.3 Purchaser Views and Literature Review

The results of our interviews with purchasers reported under the air, water and solid / hazardous waste headings also provide insights into future consulting and laboratory requirements. Major initiatives relating to process changes or end-of-pipe controls will typically be linked to external service expenditures. However, some of the larger respondents indicated that, particularly where process change solutions are sought, in-house engineers play an increasingly important role, reducing the role played by the environmental protection industry.

Ernst & Young (1990b) noted that the trend in environmental regulations will be to increase the degree to which smaller sources are subject to regulation. This is the case, for example, in Ontario's MISA program and the related initiative aimed at firms currently discharging into municipal sewers. Future regulations in such areas as VOC control, waste reduction, and greenhouse gas emissions are also likely to increase significantly the number of firms seeking changes in their current environmental practices. This trend will be important to suppliers of environmental consulting services, since these smaller sources will generally not find it economical to employ in-house resources to meet their environmental planning needs. At the same time, our interviews with purchasers for this study suggest that larger industrial sources of environmental discharges have expanded their in-house environmental engineering skills.

D&B (1991) surveyed firms on their recent and projected use of environmental consultants. The results show that, in the near term, the number of firms that make use of environmental consultants is not expected to increase. Of the 1,837 small firms (less than 50 employees) surveyed across Canada, only 4% had hired environmental consultants in the past 2 years, and only 3% expected to do so in the next 2 years. Some 28% of the 556 larger firms surveyed used environmental consultants in the past two years, but only 26% said they will do so in the next two years. Ontario firms reported the greatest use of environmental consultants – 13% of firms of all sizes used them in the last two years; 11% project doing so in the next two year period.

5. International Environmental Protection Markets

5.1 Introduction

As noted in our survey results, many Ontario environmental protection firms are now active in international markets. There is considerable potential for future growth in this export activity. As in Canada, increasing regulatory demands and growing public and corporate consciousness on environmental matters will result in greater demand for environmental products and services. International trade liberalization will both ease market barriers and help to generate interest in export markets among Ontario firms.

In this Chapter, we review market developments in three potential export markets: the United States, Mexico and Europe. Since in each case other, very recent reports have examined these markets[40], we do not undertake a full study of these markets in this report. Rather, we report on the highlights of the findings of these previous studies, as well as on recent developments that may affect Ontario export demand.

In general, many of the same trends observed in Ontario are evident in foreign jurisdictions. These include:

- The adoption by regulatory authorities of the following key principles: sustainable development; economic instruments (including full-cost pricing, pollution taxes, liability for site damage; and in the U.S., emissions trading); pollution prevention (vs. end-of-pipe control);
- A slow consolidation of the currently diffuse environmental protection industry, with mergers of major international firms and the entry of major industrial firms (chemical companies, conglomerates);
- Increasing attention to 3R activities, and growth in materials recovery facilities and waste reduction initiatives;
- Tightening regulatory requirements on toxic discharges and municipal/industrial wastewater treatment;

40 Redma (1990), Ernst & Young (1990a) and Verut (1990).

- Where command and control regulations are in use, regulators are increasingly mandating either Best Available Technology or BAT subject to a reasonable cost constraint.[41]

- Efforts to address transboundary problems, including efforts aimed at acid precipitation and the phase-out of ozone depleting substances;

- Tighter controls on transboundary movements of hazardous wastes and more stringent disposal and treatment regulations; and

- Recognition of previously contaminated sites and efforts and site remediation.

The similarities in environmental problems and regulatory approaches will mean that solutions developed in Ontario will be highly relevant in other parts of the world. At the same time, countries that have moved ahead of Canada on some fronts are in position to develop products for export to Ontario.

5.2 The U.S. Market

5.2.1 Background

Trends in the U.S. market for environmental products and services will have a major impact on Ontario suppliers in the environmental protection industry. First, the U.S. market represents the most important export market for many Ontario firms. Geographic proximity, a common language, the ease of cross-border travel for business purposes are factors linking the environmental markets of the two countries.

Second, these links are further tightened by the presence of many multinational environmental firms operating on both sides of the border. For example, Laidlaw is one of the major players in the U.S. solid and hazardous waste management industry, while the U.S.-based WMI and BFI compete with Laidlaw in Ontario. Other multinationals present in both countries include ABB, Westinghouse,

41 This latter requirement has been termed Best Available Technology Economically Achievable (BATEA) in Ontario, Best Available Technology Not Entailing Excessive Costs (BATNEEC) in the European Framework Directive on air pollution, and Best Practicticable Control Technology (BPCT) in the U.S. Clean Water Act.

ENSR, Joy, Wheelabrator, Chemical Waste Management and Sevenson.

Third, U.S. regulatory policies may in many cases signal developments in Canadian jurisdictions. This is particularly the case where U.S. environmental problems have been more severe due to population density or other factors, leading to an earlier recognition of the problem in environmental regulations. Examples include the steps to address smog in Southern California and the efforts under the Superfund program to clean up heavily contaminated sites.

Fourth, technological solutions deployed by U.S. industries provide important indicators of potential demand in Canada. Canadian jurisdictions adopting Best Available Technology standards will often look at U.S. installations for evidence on the potential effectiveness of control technologies. Furthermore, U.S. multinationals operating in Canada may seek to duplicate solutions adopted by their parent companies.

Although export markets and Ontario competitiveness are an important element of this report, an examination of U.S. legislative and market trends was not included in the Terms of Reference for this study. This omission reflects the fact that the Ontario Ministry of Industry, Trade and Technology (MITT) recently commissioned a study on opportunities for Ontario exports of environmental products and services to the U.S.

In view of the importance of U.S. markets, we felt that our report would be incomplete without some reference to market trends south of the border. Thus, in this Chapter, we provide a few of the highlights from the recent study by Redma Consultants (1991) for MITT on U.S. market opportunities for Ontario environmental goods and services producers, and a report on environmental engineering markets by Ernst & Young (1992a). The reader is referred to these reports for more detailed reviews of these issues.

Our survey results showed that about one-quarter of Ontario firms responding were active in the U.S. environmental protection market. Firms were active in the U.S. market in a wide range of product and service areas.

5.2.2 Summary of U.S. Market Demand

Total expenditures on environmental protection in the U.S. are estimated by the U.S. EPA at $US 115 billion for 1991. W.A. Lorenz and Co., an American consultancy, puts 1991 spending at $130 billion, matching the estimate by NETAC (1992) for the size of the U.S. environmental protection industry. U.S. expenditures could significantly exceed Canadian spending in such areas as site remediation (heavily influenced by the clean-up of Department of Defence sites) and, in some states, wastewater treatment, where legislation has run ahead of most Canadian provinces. The private sector also plays a larger role in some aspects of municipal solid waste management. Future U.S. expenditures in the area of flue gas desulphurization will also reflect the greater reliance on high-sulphur coal. Table 5.1 shows a breakdown of projected U.S. expenditures for the year 2000.

Table 5.1
Projected U.S. Environmental Expenditures in 2000
(Billions of US$)

Air pollution control		
Stationary sources	$29.7	
Mobile sources	14.1	
Other	0.2	
TOTAL		$44.1
Water pollution control		
Point sources	56.6	
Drinking water	6.6	
Non-point sources	1.0	
TOTAL		64.1
Land pollution control		
Solid waste	22.1	
Hazardous waste	12.1	
Underground storage tanks	3.7	
Remediation	8.1	
TOTAL		46.1
TOTAL		$154.3

Source: Redma (1991)

As in Ontario, recent legislative developments will be key driving forces for future U.S. environmental market opportunities. Major elements of federal legislation include:

- the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) relating to waste management and site clean-up;
- the Clean Water Act; and
- the Clean Air Act, and recent amendments requiring significant expenditures to address acid gas emissions and expand the scope for emissions trading.

Redma (1991) also provides estimates of total U.S. demand for individual EP products and services, largely based on EPA reports or estimates derived by other consultants. Table 5.2 summarizes one estimate of the 1990 sales of the U.S. environmental protection industry.

Table 5.2
Estimated Size of the U.S. Environmental Protection Industry 1990

Industry	# of Public Companies	# of Private Companies	Sales (US$ Billions)
Analytical Services	7	1,600	1.8
Solid Waste Mgmt	15	4,200	28.6
Hazardous Waste Mgmt	35	2,400	13.3
Asbestos Abatement	14	3,000	4.0
Water Infrastructure	27	3,100	14.0
Water Utilities	13	24,000	11.5
Env. Consulting/Eng.	28	7,600	12.2
Resource Recovery	21	5,100	17.2
Instrument Mfg	12	500	1.8
Air Pollution Control Equip	16	1,600	5.4
Waste Mgmt Equip	17	5,000	9.2
Env. Energy Sources	10	800	1.8
Diversified co's	5	2,000	7.0
Conglomerates	17	500	4.0
TOTAL	237	61,400	131.8

Source: Environmental Business Journal (1991)

Redma (1991) concluded that the following types of U.S. market opportunities were most promising for Ontario EP firms:

- Those in water treatment where Ontario's reputation is strong;
- Markets in the Great Lakes region, particularly for new exporters;
- For air pollution control, the following industrial sectors: electrical power generation, chemicals, and pulp and paper;
- Supply air pollution control to small and medium sized firms that will be new to the market (dry cleaners, auto body shops, printers, bakeries)
- Alternative fueling systems;

- For water and wastewater treatment, the following industrial sectors: municipalities, electrical power, chemicals and pulp and paper;

- For water and wastewater treatment, the following products: potable water systems, in-process water treatment systems for chemicals firms (especially ion exchange systems), laboratory water quality testing services, and consulting engineering services.

- In solid/hazardous wastes, supplying state governments, medium sized municipalities and small to medium sized industry;

- In site remediation, sales through the U.S. Army Corps of Engineers.

Ernst & Young (1992) examined the opportunities for Canadian environmental engineering and consulting firms in the eastern U.S. market. Many of the areas highlighted in the Redma study, including spending associated with the revised Clean Air Act and hazardous waste management and site remediation, are featured in this report. The following is a sample of some of the additional areas of opportunities for environmental services firms:

- environmental audits or pre-acquisition site assessments;

- contracted operation and maintenance services;

- desalination;

- disposal of outdated weaponry;

- environmental engineering directed towards process improvements with environmental benefits; and

- the $656 million spent annually by the EPA, and $255 million spent by other U.S. federal government agencies, on environmental service contracts.

5.3 The Mexican Market

5.3.1 Introduction

The Mexican market for environmental protection products and services will present promising opportunities for selected Ontario environmental companies. There are several reasons why the Mexican market may be of particular interest in the coming years:

- geographic proximity relative to markets outside North America;
- the proposed North American Free Trade Agreement could both stimulate Mexican demand (by imposing environmental standards in the agreement) and improve access to the Mexican market for Ontario firms;
- economic and population growth in Mexico and their implications for increases in waste volumes;
- absence of strong, Mexican-based competitors in some segments (although competition from U.S.-based firms is likely).

A recent report for the Canadian Embassy in Mexico (See Verut 1990) provides an excellent overview of Mexican environmental opportunities for Canadian firms. In the remainder of this section, we present highlights from this report, supplemented by updates from more recent analyses (Fernandez, 1992) and our own recent experience in Mexico.

5.3.2 Environmental Conditions in Mexico

As in other developing countries with a significant degree of urbanization and industrialization, Mexico currently suffers from horrendous environmental problems. A combination of high population densities, lax environmental standards and inadequate enforcement has led to serious problems in terms of air, water and land quality.

Air Pollution

Air pollution problems are most severe in Mexico City, which is frequently cited on the list of the world's worst locations for air quality. The very high density of automobile operation, the use of poorly maintained vehicles with no pollution control devices, and the poor state of controls on industrial sources, have contributed to the current crisis situation in the capital city. Table 5.3 highlights the air conditions for some contaminants.

Table 5.3
Air Pollution in Mexico City

Pollutant	% due to mobile sources	% due to point sources	Average Levels	Maximum Levels
CO	100%		18.1 ppm	31.6 ppm
NOx	63%	27%	0.047 ppm	0.322 ppm
SO2	17%	83%	0.043 ppm	0.075 ppm

Source: Verut (1990)

Industrial sources of air pollution include 15,000 severe polluters, including electric power plants that burn heavy crude oil, metal smelters and foundries, pulp and paper mills, and other manufacturers.

Water Pollution

Water pollution in Mexico is another serious problem, with improper or nonexistent treatment of municipal sewage and industrial wastes in heavily populated areas being the source of the contamination. Industrial plants in Mexico city routinely discharge untreated wastewaters into a canal that flows through the city. Twenty rivers are classified as being the most severely polluted, including the Lerma, the Bravo and the Coatzacolcos.

Industrial sources of discharges include oil wells, petrochemical plants, and other heavy industries, as well as runoff from improperly dumped chemical wastes and agricultural pesticides. These sources account for 38% of discharges, with the remainder attributable to untreated municipal sewage. A total of 4,250 million cubic metres of wastewater is generated annually, most of which is currently untreated.

Solid and Hazardous Waste

Mexico has solid waste collection systems in major urban areas, but one-quarter of the 52,000 tons of garbage generated daily is left on streets or empty land. About two-thirds of the wastes that are collected are merely deposited in open air piles, with only just over a third going to landfills.

According to Fernandez (1992), Mexican industry produces some 12,000 tons of toxic wastes daily, with just under 10% being disposed of at the one licensed dump (in Neuvo Leon). The remainder is merely dumped in rivers, ravines, or empty land, a situatation that has left many rivers and lakes highly contaminated.

Of particular note is the extent of contamination originating from industrial operations located along the Mexico-U.S. border. Recent studies have found high rates of birth defects in U.S. border cities, which have been blamed on cross-border flows of hazardous wastes.

5.3.3 Regulatory Response and Market Opportunities

The Mexican government has been making some progress in addressing the problems of environmental management through the development of appropriate regulations. The following are some of the highlights of these efforts:

- A major 1989 initiative was aimed at the air pollution crisis in Mexico City. Steps included are measures restricting vehicle use, mandatory vehicle maintenance, catalytic converters for public vehicles, conversion to gas generated electricity and gas an industrial fuel, relocation of smelters, emission controls in industry, use of alternative fuels in vehicles, modernization/ installation of sulphur and HC recovery plants at PEMEX (the state oil company) facilities, and HC vapour recovery at fuel distribution facilities.

- A recently proposed program to address water pollution in the area bordering along the U.S., under an agreement reached with the Bush Administration;

- the 1988 Federal Law on Ecological Equilibrium, centralizing authority within SEDUE (Ministry of Urban Development and Ecology). It sets requirements for environmental assessments and permits for new facilities as well as providing overall authorization for the development and enforcement of environmental standards.

- A $2 million project to restore the Lerma River, Guadalupe lade and Laguna de Zumpango.

Despite the recent measures put in place by regulators, the Mexican environmental market is not large at present. Total equipment and instrument demand is estimated by Verut at $217.6 million (US) in 1989, a figure which may overstate the actual applications for environmental purposes.

Considerable growth in both goods and services demand is likely over the next decade. This will be driven by demands placed by the U.S. and Canada in the context of NAFTA, pressures from within Mexico for continued improvement in air quality, and industrial and population growth. American environmental groups have expressed considerable dissatisfaction with the weak border measures proposed recently by the U.S. and Mexico, and tougher measures may be required as a part of the political process leading to free trade.

Fernandez notes that several international companies are currently examining entry into the toxic waste field in Mexico. Chemical Waste Management, a leading American firm, recently opened a new incineration plant for toxic industrial oils, and has plans for four toxic waste centres. Chemical firms in Mexico, including major U.S.-based multinationals, are facing much more stringent requirements for proper disposal of toxic wastes.

The government is also encouraging industry to install proper wastewater treatment facilities, although progress is slow. SEDUE is in the process of treatment plants along the most heavily contaminated waterways. Overall, Fernandez forecasts a $10 billion market for "pollution control devices" by the end of this decade.

5.4 The European Market

5.4.1 Introduction

The European market is another potential source of export revenues for Ontario environmental protection companies. In addition, European firms are increasingly becoming active in North American markets, so developments in the European EP industry will ultimately affect Ontario firms in their home markets. Recent acquisitions, such as the purchase of FGD system producer Combustion Engineering by Asea Brown Bovari, and the purchase of ENSR by the Nukem (Germany), have signalled a gradual globalization of the environment industries.

A much smaller share of Ontario firms are involved in Western Europe than in U.S. environmental markets. Only 47 firms reported environmental goods exports to Western Europe, and 45 firms had service exports. These figures represent only one-third of the U.S. market participation rates. Distance, language barriers, and a lack of market knowledge are factors that may underlie the limited efforts by Ontario firms to expand into Western Europe.

Ernst & Young (1990a) presented an overview of opportunities in the EC environmental market, with some discussion of markets emerging in Eastern Europe. The reader is referred to this report, prepared for the Ontario Ministry of Industry, Trade and Technology, for details on European regulations, market trends and Ontario export opportunities. The following are a few of the highlights from our report:

- The European Community market for environmental protection goods and services is estimated to be in the order of US $50 billion in 1987. Other estimates range as high as putting the total market size at closer to US $100 billion in 1989.

- The German market is by far the largest in the EC, and is about 2-3 times as large as the EP markets in France or the U.K.

- Potable and wastewater treatment accounts for 1/3 to 1/2 of the total market for EP goods and services in the EC. Solid waste issues generate about 1/3 of the total. Air quality concerns attract 1/4 to 1/3 of total expenditures. Noise pollution control and energy conservation (included in some data sources) are modest contributors to the overall market totals.

- In Germany and the Netherlands, the current emphasis in industry is on changes in production processes that reduce waste generation. The markets for traditional end-of-pipe systems in these countries will be weakened by the new emphasis on integrated, clean technologies. The U.K. and France are thought to be 5-6 years behind in the use of this technology. Among these northern European countries, municipal water treatment projects frequently involve the introduction of tertiary treatments to precipitate nitrates and phosphates. Recycling and composting of wastes is most common in the EC in West Germany, Belgium, and France, although Spain is an exceptional case from Southern Europe in its high rate of recycling.

- In general, Southern Europe, where controls are only now being put in place, is still focussed on end-of-pipe solutions for industry and introducing primary treatment systems for municipal wastewater. Italy, Portugal and Greece have not gone far in recycling or composting. Overall, Southern Europe is thought to be about 15 years behind the rest of the EC in terms of its adoption of environmental protection technologies.

- The European Commission sets overall minimum guidelines for environmental regulations in member states. EC directives will promote spending in the following areas: flue gas desulphurization, monitoring for municipal incinerators, catalytic converters in vehicles, municipal wastewater treatment (especially in the Mediterranean area) environmental impact assessments, clean technology engineering, CFC substitutes, water quality monitoring and testing, and municipal solid waste management.

- Germany will remain the largest EC market. Italy and Spain will grow rapidly, but not pass the U.K. or France in total market size over the next decade.

- Direct export is a viable market entry strategy only for light, high value items such as some control equipment or instrumentation. Licensing or joint ventures may be favoured over greenhouse investment in manufacturing facilities for other abatement equipment.

- Aside from short-term contracts, services firms will have to look to either investment in an EC office or a joint venture with or acquisition of an established firm as an entry strategy. Germany (for market size and reputation) or the U.K. (for common language) are promising sources of partnerships or acquisitions. Branch offices or further alliances in individual EC countries still appear to be valuable despite the removal of trade barriers within Europe.

5.4.2 Recent Developments

Since the completion of Ernst & Young (1990), there have been two major developments in EC environmental policy that will shape future demand. First, the EEC's Council of Environment Ministers adopted a major Directive in the area of water treatment. Second, negotiations have commenced on the EC's fifth environmental Action Program.[42]

Water Treatment Directive

The water treatment directive, adopted on March 18, 1991, commits EC member states to significant actions to improve wastewater treatment. This is a pathbreaking move for the EC, in that it continues the movement beyond ambient standard setting into the prescription of remedial courses of action.

The directive will require all cities with a population in excess of 15,000 to have a wastewater treatment plant with secondary treatment (biological and secondary settlement) by the year 2000. Cities with 2,000 to 15,000 inhabitants will have a deadline of 2005 to comply with the same requirements.

Exceptions could be made for cities that discharge into less sensitive coastal areas have a population less than 150,000, in which case only a primary treatment system would be required. In some environmentally sensitive areas, treatment processes must also be installed to remove nutrients, such as nitrogen and phosphorous.

Other measures include a ban by 1999 on the current practice of releasing treated or untreated sludges into fresh or sea water.

Estimates of the cost of meeting this new directive vary quite widely. The EEC put the cost at some $60 billion (Cdn), while Germany estimated that total costs would be closer to $300 billion (Cdn).

Nitrates and phosphates in water are to be a major target in the EC and individual member states, according to Fouhy (1990). Beyond the legislation pertaining to municipalities, Fouhy predicts EC and member state legislation for nitrates from industrial wastewater treatment plants. This will place significant requirements on fertilizer

42 The four previous Action Programs were passed in 1973, 1977, 1983 and 1988.

and ammonia plants. Germany will also be moving to install dephosphatization equipment (most likely involving the use of anaerobic bacteria in sedimentation tanks to break down nitrates and phosphates) in municipal wastewater plants.

Fifth Action Program on the Environment

The discussions now under way within the Commission are aimed at the implementation of a fifth "Action Program" on environmental matters, that will form the framework for EC policy for the remainder of this decade.[43] The program is based on the following core principles:

- sustainable development;
- preventative and precautionary action (i.e. a Pollution Prevention approach);
- integration of environmental considerations into other policy areas.

Other broad themes, are also reflected in the program. First, the EC will make greater use of economic instruments as an approach to environmental protection, including charges, levies, taxes and subsidies.

Second, greater reliance will be placed on the role of the public in promoting environmental improvements. This will include environmentally-based labelling, and greater access to information flowing from environmental audits.

Third, the EC will increase enforcement of environmental laws across the Community. As we noted in Ernst & Young (1990a), the EC's issuance of directives have often run ahead of its ability to enforce them. The EC is now considering the establishment of a network of inspectors and inspection bodies, in addition to the planned European Environmental Agency.

The specific measures to be taken under the umbrella of the plan will not likely be implemented until later in this decade, according to Ernst

43 The following review is based on Ernst & Young (1992b) and O'Riordan (1989)

& Young (1992b). Five sectors are specifically targeted in the plan: manufacturing, energy, transport, agriculture and tourism.

Measures aimed at manufacturing will include eco-labelling, BAT requirements, and strict civil liability. Energy prices could rise considerably if a proposed carbon tax becomes the focus of efforts to promote conservation and forestall the greenhouse effect. Transport measures include improved fuel efficiency and the promotion of environmentally-friendly modes of transport. The agricultural measures will be aimed at soil conservation and surface and groundwater contamination. Containing the damage caused by tourism growth in the Mediterranean and other areas will include the creation of protected sites covering 15% of the EC's territory.

5.4.3 Eastern Europe

Our earlier report only touched on the market for environmental products and services in Eastern Europe. We noted that while the environmental problems faced by Eastern European nations were enormous, funding for addressing these problems would delay the growth in these markets, which were estimated at about $5-10 billion in total. Only 29 of our survey respondents reported involvement by their Ontario operations in Eastern European environmental services markets, and 33 firms reported exports of Ontario-made environmental products to this market.

In this section, drawing on Gilges et al (1991), Nichols (1989) and Ernst & Young work in Poland and Czechoslovakia, we explore some of the opportunities that are likely to emerge for environmental firms that position themselves to take advantage of Eastern European demand.

Economic pressures in the east bloc suggest that governments see immediate needs for economic infrastructure and capital investment, rather than spending on environmental matters. The director of the privatization agency in the former East Germany notes that "we must use our capital to build new factories on new sites, and then use the wealth created to clean the environment in a later generation."[44] Similarly, Nichols (1989) quotes several U.S. experts that have examined market prospects as having concerns about the ability of east

44 As quoted in Gilges et al, (1991)

bloc countries to generate sufficient hard currency to pay for environmental clean-ups.

These clean-ups would be extremely costly for the fragile economies of eastern Europe. Ernst & Young (1991) quoted an estimated cost of $188 billion to bring facilities in the former GDR to West German standards, but closures of plants could reduce this cost significantly. Gilges et al (1991) cite an estimated cost of $4 billion for environmental clean-ups in Leningrad alone. Furthermore, the extent of past environmental damage is only now coming to light in some countries.

Even if major clean-ups are several years away, there are areas of expenditure that will be active in the near term, with Levy (1990) citing an estimate of $16 billion in EP equipment alone in "the coming years". First, environmental protection investments will be included in plant upgrades undertaken as a part of modernization efforts in resource processing industries, either before or after privatization. This is especially the case where western investment is being sought, and in industries such as paper or petroleum refining where the east bloc firms earn hard currency.

Second, foreign aid coming from western Europe, the U.S. and Canada will in part be allocated to environmental projects. Aid from the European Bank for Reconstruction and Development, and from the PHARE (Poland and Hungary, Assistance to Restructing the Economies). Individual western countries are already providing funding for some environmental projects, particularly those that address transboundary air and water pollution control problems.

Third, some western environmental equipment firms may use low cost eastern European labour to manufacture products for western Europe and thereby generate hard currency to support other activities in eastern Europe.

Fourth, Poland, Czechoslovakia and Hungary are all looking at eventual membership in the EC, and would have to bring their environmental legislation into line if they are to be given serious consideration for membership.

Finally, there are signs that a number of eastern European countries are moving towards the establishment of environmental regulations, under pressure from the voting public. Environmental movements have been formed in several countries in the former east bloc. Levy (1990) notes that a poll in early 1990 showed that 83% of Czech and Slovac citizens felt that environmental improvements should be a top priority for the government. Both the Czech and Slovak Federal Republic and Poland have issued tougher emission standards and established fines for violators, but enforcement to date has been lax.

Environmental conditions across this region differ in the extent of the damage done. Hungary and Yugoslavia have a better record of environmental management than Poland, for example. Business International (1990) calls Poland "one of the the most ecologically devastated countries in the world." Overall, conditions generally are similar to those that existed in heavily industrialized areas in the west about two decades ago, although there are extreme cases of environmental hazards not seen in the past in the west, particularly those relating to toxic substances and radioactive wastes.

Air Pollution

Air pollution levels are extremely high in several countries that have made use of soft-brown coal (the former GDR and Czechoslovakia) or countries downwind from them (Poland). As shown in Table 5.4, emissions per capita have been several times the current experience of western countries.

Table 5.4
1988 Emissions of SO_2 and NOx
(Kilograms per Capita)

	SO_2	NOx
GDR	317	43
Czechoslovakia	179	61
Bulgaria	114	17
Romania	78	390
Hungary	115	259
Poland	110	41
USSR (European part)	35	15
U.K.	64	43
U.S.	84 (all SOx)	80
Sweden	25	46
France	22	29
West Germany	21	47

Source: Worldwatch Institute (as quoted in Gilges et al)
Note: Data for Romania are for 1980 (for sulphur dioxide) and 1985 (for NOx)

Health effects from high levels of SO_2 and lead are already known to be occuring in industrial areas of eastern Europe, such as in the Silesia area of Poland and in industrial areas of Romania and Bulgaria.

While the technological solutions to the existing problems are well known, funding remains the most serious constraint. Hungary's electric plants have a total modernization budget of $25 million (US), too little for a retrofit of even a single plant. In the former GDR, much of the problem from industrial sources will be addressed by shutting down some of the oldest coal burning industrial plants and using German capital and engineering expertise to retrofit others. Automotive emissions will be improved as the car industry in Germany and Czechoslovakia moves to western-designed cars.

The air pollution control market in some parts of eastern Europe will benefit from concerns in western Europe over transboundary pollution problems. For example, Scandinavian countries are providing financing for a $1 billion effort to revamp nickel smelting and a chemical plant in the former USSR in order to eliminate a threat to their forests from transboundary flows of acid gas.

Water and Wastewater Treatment

Water pollution is another serious environmental problem facing Eastern Europe. Nearly all major sources of water for the region are heavily contaminated from industrial discharges, leaching from dump sites, agricultural runoff and municipal sewage. Gilges et al (1991) cite the following examples of extreme contamination:

- Half of Polish cities, including Warsaw, have dumped raw wastewater into rivers. About 65% of Poland's surface water is unfit even for industrial use;

- Leningrad is responsible for discharging over 1.1 million m3/day of municipal sewage and industrial waste into the Neva River and the Bay of Finland;

- The Elbe is frequently named as the world's most polluted river, with discharges gathered from Czechoslovakia and the former GDR and extremely high levels of mercury, cadmium, and lead. A single German plant formerly discharged 20 kg/day of mercury;

- Salt and heavy metal levels in the Oder are so high that a planned investment in a desalination plant is expected to finance itself from the sale of recovered metals;

- 70% of Czech and Slovak rivers are heavily polluted and many are biologically dead. Half of the Baltic Sea floor and its two feeder rivers (the Wista and Oder) are unable of supporting life;

- The Black Sea and its feeder rivers, the Danube and Dnieper, are heavily contaminated with lead, nitrogen compounds and petroleum products;

- 90% of the Black Sea, along with the Caspian Sea, Aral Sea and Lake Lăgoda are dead.

Addressing these concerns will largely be linked to foreign capital inflows, both from sources of foreign aid and from investments in plant modernization. As in air pollution, priority may be placed in addressing transboundary problems of concern to western Europe. Sweden is funding the construction of wastewater treatment plants in Poland to address pollution in the Baltic, and a Swedish engineering firm is preparing plans to clean up Poland's paper industry.

Solid and Hazardous Waste

Eastern Europe has also been extremely lax in disposing of solid and hazardous waste. While large cities have municipal waste management systems in place, many smaller areas do not. Business International (1990) notes that only a small portion of the millions of cubic metres of Hungarian solid wastes are safely disposed or recycled, and over 2,000 Hungarian communities have no garbage collection.

Hazardous wastes and groundwater contamination from unregulated dumping is an even more pressing problem. Poland has been a major recipient of hazardous wastes from Western Europe, much of which has not been properly treated or disposed. Serious groundwater contamination has been detected in studies in northeastern Hungary and the former GDR. Cleaning up these chemical time bombs will cost billions of dollars that will ultimately have to wait for economic development in the east or foreign aid from the west.

6. Competitiveness of the Ontario Environmental Protection Industry and Government Policy

6.1 Introduction and Overview

As demonstrated in the preceding chapters, there will be considerable market opportunities in the next few years for environmental protection firms in North America and Europe. The share of these markets reaped by Ontario firms will in large part depend on their competitiveness vis-a-vis firms based in the U.S., Europe and the Far East.

Competitiveness can be defined as the ability of a firm to supply products or services to customers in a manner that meets or exceeds offerings of competitors while providing the firm with a sufficient return on investment. In terms of the environmental sector, there are several important elements of competitiveness:

- technological leadership - with many jurisdictions requiring the use of "best available technologies", it is imperative for a firm to be seen to be supplying products or services that meet currently achievable performance standards;
- price competitiveness - both goods and services firms must compete on price, particularly since many projects are subject to competitive tendering. Achieving price competitiveness while earning an acceptable profit margin rests on having high productivity, highly-skilled scientific and managerial staff and competitive wage rates;
- market identity - our previous work with firms in this sector suggests that success often rests on making buyers in the market aware of the skills and expertise that the firm can provide;
- local presence - related to the above, for both goods and services firms competing outside the home market, a local presence is often important to establishing credibility as a supplier to a particular geographic market, and to overcoming barriers to operating from a distance (licensing of professionals, tariffs and transport costs for equipment).

In this Chapter, we discuss a number of aspects of Ontario's competitiveness in supplying environmental products and services. First, we examine Ontario and Canadian trade performance in environmental products and services, a measure of the industry's ability to compete in the recent past in domestic and foreign markets. Second, we report on the views of industry participants on the factors that they see as helping or impeding their ability to compete. We then turn to a review of human resource skills, an important factor in determining competitiveness. Finally, we review suggestions made by industry participants for ways in which government policy can help engender a strong environmental sector in the province.

Our research suggests that Ontario firms are highly competitive in the supply of environmental services. Ontario is well served by major Canadian engineering consulting firms, laboratories, waste management companies and various other firms supplying meteorological, hydrogeological and other scientific services. These firms are generally perceived to be reasonably well-informed regarding technological options for environmental protection, and many have been quite active in foreign markets.

A number of foreign-based service firms have operations in Ontario, but these generally use Ontario residents for much of their work here. One engineering firm based in the province felt that profit margins had been eroded on environmental work due to increasing competition in the province from U.S. engineering firms.

A few purchasers, and some service firms, believe that Ontario firms have suffered somewhat from slow regulatory progress in the province. Some buyers feel that U.S. consultants are more experienced in dealing with contaminants where American regulations have preceded those in Ontario. Waste management companies in some cases suffer from an absence of dumping sites or approved incineration facilities in Ontario.

Purchasers of environmental equipment in Ontario are able to draw upon a wide range of suppliers with operations in the province, including both domestic Canadian companies and subsidiaries of foreign-owned multinationals. The Ontario content in major environmental projects within the province is quite high, reflecting the customized, on-site assembly of treatment systems and the high proportion of basic process equipment in such projects.

Ontario does have a number of leading edge designers and manufacturers of pollution abatement and control equipment and instruments. These include manufacturers of water filtration and purification equipment, air pollution control products, and various niches in monitors and instruments.

Nevertheless, it is clear that the environmental equipment sector is increasingly becoming a globalized industry, with major multinational equipment firms using research in their home country as a basis for expansion in other markets. U.S. and European equipment firms have a strong presence in Ontario. Although most report a significant Ontario content in their sales in the province, these firms do much of the key research and design work in their home countries.

As we emphasized in our 1989 study, the basis for competitiveness internationally appears to rest primarily on regulatory and enforcement policies in the home market. The major U.S, European and Japanese firms that are gradually consolidating the global equipment market have generally developed technologies in response to particular regulatory requirements in their home market. Ontario firms will be in the strongest position in those areas where future regulatory requirements in the province lead those of other countries.

As the equipment industry matures, most observers [see, for example, NETAC (1992), McIlvaine (1990)] expect to see a further consolidation, with larger firms supplying a greater share of the market. The signs of a gradual consolidation are already evident:

- large, multinational conglomerates are entering the market for environmental equipment (and services). Examples include several major Japanese (e.g. Mitsubishi Heavy Industries, Hitachi), and U.S. (Westinghouse, Corning, Exxon) industrial concerns, as well as many of the world's leading chemical companies.[45] Ernst & Young (1990a) chronicled the gradual consolidation of the European market under the control of large industrial concerns such as ABB, R.W.E. (Lahmeyer), Hoechst (Uhde), Deutsche Babcock, Siemens, Thyssen, and Metallgesellschaft (Lürgi) Kruger and Danisco Companie Générale des Eaux, Société Lyonnaise des Eaux, Bouygues and privatized British water boards.

45 See Gross (1992) for a discussion of Japanese entrants.

- Mergers and acquisitions, although slowing very recently, have linked a number of major players, often across international boundaries;

- Joint ventures and product licensing agreements are also leading to a further consolidation in technological offerings.

Ontario-based equipment firms will therefore succeed either by offering advanced, niche market equipment and services or by linking up with major international suppliers through joint venture, licensing or acquisition.

6.2 Canadian Trade Performance

Measuring trade in environmental products and services is extremely difficult. First, many instruments, process equipment, materials handling machinery, chemicals and other products are used for both environmental and non-environmental purposes. In some cases environmental applications are a small fraction of total usage. Second, some specialized environmental products are aggregated with other products in the commodity classifications used to report trade flows. Third, services trade is not well measured by type of service. Finally, trade data at the provincial level are not particularly reliable.

Table 6.1 reports 1990 Canadian trade with the U.S., Mexico and All Countries in commodity classes having significant environmental applications. The water filtration equipment category shows Canada with a modest trade surplus overall, with U.S. trade dominating our total trade picture. The air pollution control equipment categories and instrument categories all show significant trade deficits. Trade with Mexico has been at very low volumes.

Our view is that these data significantly overstate the current trade volumes in environmental products, since they include commodities that are heavily used outside the environmental protection industry. For example, it is likely that a significant (possibly majority) share of the data reported for the following categories are in use outside the environmental field:

(1) "industrial or lab furnaces, including incinerators"

(2) "centrifuges and "parts of centrifuges" which would include parts for clothes dryers and centrifuges used in various industrial processes;

(3) "filtering/purifying machinery or apparatus for gases" which would include furnace filters, filters for compressors, air conditioners, etc.;

(4) "parts of filtering...etc. for liquids or gases" which would include parts of automobile air or oil filters;

(5) each of the instrument categories would have non-environmental uses (medical and industrial labs, surveying equipment, etc.).

Table 6.1
Canadian Trade in Environmental Products 1990
($ 000)

Commodity	Exports	Re-exports	Imports
Industrial or lab furnaces, including incinerators (non-electric) and parts			
US	15,122	82	42,874
Mexico	25	0	0
All Countries	18,940	292	68,093
Centrifuges (excluding clothes dryers) and parts of centrifuges			
US	1,773	339	26,649
Mexico	0	0	0
All Countries	1,936	928	40,064
Filtering or purifying machinery / apparatus for water			
US	42,986	175	37,703
Mexico	5	0	0
All Countries	49,111	190	42,892
Filtering or purifying machinery / app. for liquid (excl. water, oil, bev.)			
US	26,113	1,096	22,289
Mexico	4	2	0
All Countries	29,333	1,603	29,598

Filtering or purifying mach / app for gases (excl. intake for int. comb. eng)			
US	37,704	343	239,497
Mexico	4,709	0	33,592
All Countries	102,536	702	283,270
Parts of filtering or purifying mach / app for liquids or gases			
US	28,904	2,475	110,811
Mexico	53	8	8
All Countries	36,655	3,752	136,725
Gas or smoke analysis apparatus			
US	3,838	228	20,463
Mexico	12	0	0
All Countries	5,524	311	27,621
Chromatographs and electrophoresis instruments			
US	6,449	212	17,632
Mexico	0	0	0
All Countries	8,100	236	19,811
Instruments for physical / chemical analysis n.e.s.			
US	11,790	1,283	66,463
Mexico	112	0	0
All Countries	18,913	2,040	91,880
Surveying, hydrographic, oceanographic, meteorological or geophysical instr. nes			
US	6,039	1,205	70,155
Mexico	105	15	1
All Countries	18,277	2,601	81,580

Source: Statistics Canada

Another estimate of Canada's trade position was included in Market Facts of Canada (1988). For 1990, the study projected total pollution control equipment exports of only $24 million, and imports of $747 million, for a deficit of $723 million. The report does not provide a description of the methodology used, but we believe that the export estimate significantly understates actual exports.

6.3 Performance in the Ontario Market

Ontario Purchaser Survey

More specific information on the Ontario market was obtained in our interviews with 50 Ontario purchasers of environmental products and services. Respondents were asked to identify the country/province of origin for equipment and service purchases. Our interviews suggest that Ontario firms (including branches of foreign companies that manufacture goods or provide services from an Ontario base) are quite competitive in their home market, particularly in services.

These interview responses must be treated with some caution. Firms may incorrectly perceive some Ontario-made items supplied by foreign-owned subsidiaries as imports. Others may consider an item to be supplied from Ontario when in fact the item was imported by their local equipment dealer.

As summarized below, respondents purchased a very high proportion of their environmental services from Ontario firms. In the case of waste management services, a firm has to be Ontario based at least in terms of waste pickups, although some wastes are sent to U.S. landfills. Ontario consulting and engineering firms also do well in their home market, with licensing requirements providing a degree of protection for engineers.

Some respondents were unable to identify the country or province of origin for their goods purchases, since the items were purchased from an equipment dealer or were purchased by an external project manager (engineering contractor). Those that were able to provide information felt that a high proportion of their purchases were from Ontario firms, although there were some exceptions.

A few noted that a significant share of their equipment purchases in Ontario were from foreign subsidiaries or Ontario firms that manufacture foreign-designed products under license. Thus, while Ontario has a high share of final assembly or manufacturing, its share of product engineering is lower.

The following is a summary of the responses by industry:

- *Industrial minerals* firms purchased about 90% of the air pollution control services from Ontario firms. One mentioned that U.S. consulting firms are a growing presence due to aggressive marketing and wider experience with innovative approaches gained in the more flexible U.S. regulatory system. Water pollution control goods and services were nearly all Ontario purchases, except for monitoring equipment (due to a price edge of a U.S. firm). Waste disposal services are all spent with Ontario firms.

- *Metal casting* firms reported that 90% of their air pollution control equipment was sourced in Canada, but Ontario firms only had half of this total. Dust collectors and SO_2 scrubbers were items purchased in the U.S. Ontario averaged a 75% share of the two respondents water pollution control products. Services were primarily sourced in the province of operation, but one firm used a design for water treatment originally prepared for its U.S. parent company.

- *Metal mining* firms reported that Ontario air pollution control firms supplied half of their purchases. The remainder was allocated to purchases of blowers and process equipment to convert SO_2 to acid imported from the U.S. and Europe. Ontario supplied 90-95% of water pollution control equipment. The Ontario share of pollution control and waste management services was also in the order of 95%.

- *Metal plating* firms reported that over 85% of water pollution control equipment was sourced in Ontario, although many of these goods are U.S. designs manufactured under license in Ontario. One firm also constructs some of its own water pollution control equipment. Ontario firms supply nearly all of the pollution control services, but one firm is looking at U.S. disposal of hazardous wastes.

- *Municipalities* reported significant import purchases for air quality control at landfills, including U.S.-made methane/sulphur incinerators and monitoring instruments. Sewage treatment plants used about 60% Ontario-made equipment, including chemicals, piping, electrical panels, and fabricated metal products. U.S. firms supplied much of the remainder, including pumping equipment, and in one case, its sludge dewatering equipment. Europe is the source for perhaps 2% of goods purchases, for valves and pump parts. Ontario equipment accounts for about 75% of solid waste goods purchases. Ontario consultants and waste management firms have nearly all of the municipal environmental services market due to their local presence and established relationships with purchasers.

- *Organic chemicals* firms source about 90% of goods and services purchased for air pollution control from Ontario suppliers. The respondents also estimated Ontario's share in their water pollution control equipment purchases at 90%, and Ontario supplies about

75% of their solid waste equipment. Nearly all services purchases for water and solid wastes are sourced from Ontario firms.

- *Inorganic chemicals firms* estimated that Ontario firms receive 80% of their service spending for air pollution control, but less than 50% of their air protection equipment spending. Ontario firms supply their "lower-tech" items such as baghouses, while "higher-tech" items including incinerators, scrubbers, and thermal oxidizers are often purchased in the U.S. or overseas. Some of this imported equipment spending may be linked to the experience that these multinationals have had with equipment suppliers to their parent companies, and to the very specialized nature of their air pollution control needs. Ontario firms receive between 70-80% of respondents' water pollution control equipment expenditures, and virtually all of their related services spending. Monitoring equipment, chemical settlers, pumps, and filters are all purchased in Ontario. Some specialized treatment products and equipment are sourced outside the province. Ontario firms receive a small proportion of hazardous waste goods spending, perhaps less than 25%. Respondent firms purchased major items outside Ontario, including an incinerator in the U.S., and a mercury recovery process in Europe. Services firms in the province appear to earn a somewhat greater share of respondent spending, roughly 40-60%. However, one firm noted that most of its hauling and disposal contracts have gone to firms in other provinces.

- *Petroleum refineries* were unable to estimate their Ontario content for goods purchases, but noted that Ontario firms were used for nearly all of their services requirements.

- *Steel companies* use internal staff for many air pollution control services tasks. For external purchases, about two-thirds of air pollution control equipment and 85% of services purchases go to Ontario-based firms. Most of the remaining spending is received by U.S. companies, and a small proportion is paid to Europeans. Roughly half of water pollution control goods purchases appear to be made from Ontario firms. Foreign purchased items noted by respondents include clarifiers, cooling tower equipment, both ordinary and chemical addition pumps, and instrumentation. Most of these goods have originated in the United States, but some pumps and instrumentation were sourced in Europe. About 90% of water pollution services purchases occur in Ontario; the remaining 10% usually accrues to manufacturers of the foreign-sourced goods. No estimates were available for Ontario content in solid and hazardous waste spending.

- *Pulp and paper* firms reported that Ontario firms supplied about three-quarters of their air pollution control equipment and services. One respondent noted the existence of competitive Ontario producers of scrubbers and precipitators but another respondent felt Ontario's share in air quality supplies could decline in the future. One firm used the same Quebec consultants for all its operations in Canada. Water pollution control equipment purchases by our respondents showed an usually high import share; only 40% of goods were purchased in Ontario, with 15% sourced in other provinces, 35-40% in the U.S. and 5-10% in Europe. Chemicals, valves, pumps, tanks and other basic equipment is sourced in Ontario. Packaged treatment systems were sourced from American or European firms, and the pulp and paper firms thought that these had only partial Ontario content. Currently water pollution consultants from Ontario are used, but one firm felt it may look to experienced U.S. firms in the future. Ontario-based solid and hazardous waste services and consultants are used for nearly all purchases.

Ontario Hydro intends to spend several hundred million dollars on flue gas scrubbers during the next decade. For the initial scrubbers being installed at the Lambton generating facility, roughly 75-80% of the purchases involved will accrue to Ontario-based manufacturers and services firms, 15% will flow to U.S. companies, while the remaining 5% will be spent in Europe.

The costs of the Lambton scrubbers will be split between equipment (50-55%), construction (30-35%), and engineering (10-15%). The scrubber technology is of German origin, but 60-80% of the manufacturing is to be done in Ontario, 20-35% in the United States, and less than 5% in Europe. The construction will be completed by an Ontario firm. Trades workers from Ontario will be used on the work, based on an agreement between Hydro and the construction unions. The basic engineering will be done by German firms, but the detailed design and installation work, worth 60-75% of the engineering spending, is to be handled by Ontario consulting engineers.

In more general terms, the thermal generation area of Hydro is able to buy most of the products necessary for environmental protection in

Ontario. Items mentioned by respondents as being well-made in Ontario, were shells, steel work, tanks, electrical control, pumps, and fans. However, any equipment involving specialized designs is frequently purchased outside Ontario. Since Hydro may be the only Ontario purchaser of specialized items, producers are often not located in Ontario, but rather in the U.S. or Europe. About 80% of water pollution control equipment spending is directed at Ontario manufacturers, with most of the rest sourced in the U.S.

Consulting services firms south of the border were believed to be more aware of how to meet specific Hydro needs, but knowledge in Ontario was said to be growing. Consultants based in the province and in the U.S. were noted as being quite proficient with industry and technological trends for dealing with water pollution control concerns. In contrast, American firms were believed to have greater expertise in specific applications of technologies to air pollution control problems, due to the large number of utilities in the U.S. However, Ontario firms are thought to be gaining experience.

M.M. Dillon Estimates

For the purposes of the economic impact model (described in the next chapter), Ernst & Young contracted with the engineering firm M.M. Dillon to estimate the Ontario content in typical environmental technologies. Dillon's pollution control engineering experts relied on their own project management experience and discussions with leading equipment suppliers to estimate the share of equipment and services purchases that would be initially sourced in Ontario, and the Ontario content of equipment sourced from Ontario suppliers.

Detailed results are provided in the appendix to this report, prepared by M.M. Dillon. The following general conclusions are reached:

- A very high share of major equipment purchases are initially sourced through Ontario firms. Most of the major Canadian and foreign equipment firms have their own offices or licensees in the province.

- Ontario also generally reaps a high share of overall project costs. Many air and water pollution control projects entail customized engineering and construction on the site, and the local content in engineering, labour and basic construction materials is high.

- Components and parts originating in other provinces or imports of finished equipment are a majority of the value of Ontario purchases of air diffuser equipment, blowers, heat exchangers, mixing systems, sludge waste pumps, some electronic and automation equipment, dosage pumps, filter presses, transfer pumps, lamella clarifiers, filter modules for sand filtration, tubejets, front-end loaders, and composters. For some projects, such as sludge dewatering systems, these imports result in a high share of non-Ontario content in the materials portion of the project cost.

6.4 Factors Affecting Ontario Environmental Protection Industry Competitiveness

Our 50 interview respondents in the Ontario environmental protection industry were also asked to suggest factors that promote or impede their competitive position in domestic and foreign markets, and to assess the influence of trade agreements in promoting exports and increasing import competition.

Air pollution control equipment suppliers felt that Ontario firms were quite competitive in the segments of the equipment market they served. The following factors were cited as providing a boost to their competitive position:

- acceptance by the Ontario government that the Ontario supplier meets standards for best available technology;

- Ontario technology is equal to or superior to foreign technology, particularly in the areas of monitoring equipment, environmental consulting, specialized laboratory work, transformers for precipitators, and incinerators

- in some cases, Ontario firms indicated that they are more customer-service oriented than their US competitors and this gives them an edge;

- openness on the part of buyers in other countries to meet with Canadian suppliers, based on a good reputation for environmental management.

- a European preference in dealing with Canadians rather than Americans

Factors cited by air pollution control firms as reducing their competitiveness included:

- lack of knowledge on the part of Ontario-based suppliers regarding the opportunities available to them in the international markets and the appropriate means of addressing them;

- lagging of environmental standards in Ontario relative to American regulations, particularly in California, which gives U.S. firms a lead in gaining experience in the field;

- a shortage of trained engineering talent for development and manufacturing;

- difficulties in finding good representatives or agents in foreign jurisdictions;

- cost disadvantage relative to equipment manufacturers in low-wage, non-union southern U.S. states;

- limited opportunities to develop a track record in Canada due to the small domestic market and slow pace of regulatory development;

- other general business climate factors, including taxes and the high value of the Canadian dollar.

As anticipated in our previous study of the industry, the Canada-U.S. Free Trade Agreement has had little impact to date in the air pollution control market. Duties prior to the trade agreements were generally not significant, and some non-tariff trade barriers (U.S. Buy-America provisions, licensing of professionals) were not really addressed. One firm complained about recurring problems with delays posed by border officials on the American side. The potential agreement with Mexico is not expected to have a major impact on either the domestic market or exports, although some firms felt that there would be pressure on Mexico to enhance environmental standards.

Water pollution control equipment firms also perceive themselves to be competitive in their market niches, although many firms expressed frustration at the slow progress in implementing tougher regulations in Ontario and the impact that this is having on their market opportunities.

Factors cited by suppliers as contributing to their competitiveness in water and wastewater treatment include:

- the reputation of Canadians as trustworthy businessmen, especially in Europe
- the quality of Ontario technologies - especially those that are niche oriented
- the assistance and financing provided by government trade offices in international business ventures.

Firms in this area cited the following factors as inhibiting their competitiveness

- delays or problems in completing transactions at the border, including an inability to get information from the US customs prior to bringing equipment to the border;
- increasing scrutiny by US customs officials at the border now that the FTA is in effect;
- the lack of confidence on the part of Ontario and Canadian buyers and standard-setters in Canadian technology of all kinds;
- various elements of the manufacturing environment in Ontario, including the high Canadian dollar, high wage rates, tax policies, a lack of worker initiative from Canadian-born workers;
- a lack of economies of scale compared to US competitors;
- restricted access to capital in Canada (resulting from lack of confidence in Canadian enterprise by financial institutions);
- problems in dealing with language and business customs in the Far East;
- lack of environmental standards in Ontario vis-a-vis American regulations;
- American reluctance to use Canadian suppliers and the preference of some European buyers for firms with a manufacturing operation in Europe (overcome by one firm by establishing a U.K. plant); and

- the high costs of conducting business offshore.

As in air pollution, water pollution firms feel that trade agreements with the the U.S. and Mexico will have little impact on their business. Duties on goods exports and imports have historically been low, and in the cases of service companies they rarely face competition from outside their jurisdiction because of the problems of offering services across borders.

Ontario *solid and hazardous waste equipment* firms have been active in export markets, but also face tough competition in Ontario. Factors cited as contributing to competitiveness of Ontario suppliers included:

- a Canadian reputation for concern with the environment, with Canada perceived as being leaders in environmental management;

- the quality of Ontario technology

- some of the foreign competitors (e.g. in incinerators) are using older vintage solutions

- trade offices in foreign jurisdictions are very helpful in establishing contacts;

Factors impeding competitiveness include:

- the inability of Canadians to exploit their good name in the environmental field due to a lack of initiative or marketing expertise in some firms;

- American preferences for American technology, regardless of the terms of the FTA;

- the fact that there is no market for incinerators in Ontario;

- the high cost of doing business in Ontario (high wages, high taxes, and so on)

- lack of environmental standards in Ontario relative to American regulations, and the large domestic market base created by Defence Department spending in the U.S. on hazardous waste clean-up;

- a shortage of capital to buy Canadian technology in some lower-income foreign markets

- the high cost of components (i.e. parts) in Canada as compared to in America.

The Canada-U.S. Free Trade Agreement has had little impact, although respondents indicated that they are meeting more competition from the US suppliers. There is little concern that the Mexicans will be able to compete because they do not have the technology behind them. Firms expressed some longer-term interest in the potential value of the Mexican market.

Environmental laboratories in Ontario are both sheltered from import competition and blocked from export activities, due to the limitations in providing their service across borders. A number of firms maintain branch offices in other provinces or countries where they provide lab services.

Factors contributing to competitiveness of Ontario lab services suppliers include:

- Canada's good name in the world community
- the ability of labs in Ontario to deal with short-run, complex work, since American firms prefer straightforward, longer runs;
- prices in Ontario are lower that the U.S. because of the exchange rate, and the strict requirements that the EPA puts on the labs in the U.S.;
- Ontario labs provide good service and good quality work using highly skilled people.

Factors reducing competitiveness in foreign markets include the cost of doing business across the border, administrative barriers established at the border, a preference in the U.S. for American technology and a Canadian aversion to Canadian technology, and the lack of accreditation procedures in Canada for labs. One Ontario firm complained that Ministry of the Environment purchasing standards stressed low-cost bidding and thereby promoted the survival of the lowest quality firms. As in other areas, firms also felt that Ontario environmental standards were lagging those in other countries and were therefore giving others a head start in gaining a track record in the market.

Since lab services are generally not exportable, trade agreements have and will have a limited impact. Ontario firms are continuing to look into setting up facilities outside the province to serve markets in other jurisdictions. Firms showed neither concern for potential competition from Mexico nor interest in the Mexican market.

Suppliers of *sampling and monitoring equipment* have had to compete with imports in Ontario and in export market for some time, and those that have been successful feel that they continue to be quite competitive in their market niche. They attributed their competitive strengths to the quality of their people and technology, and their track record in Ontario. One firm noted that references from the Ministry of the Environment were very useful in gaining international sales.

Monitoring equipment firms shared some of the same concerns about the Ontario business climate as other environmental goods firms, citing high taxes and the high value of the Canadian dollar. Other factors impeding competitiveness include:

- competing against well financed American corporations, or companies where governments are willing to finance the purchase of their technology;
- negative American attitudes to foreign technology;
- difficulties in establishing a reliable distribution channel in the United States;
- difficulty in commercializing the technology, and a need for long term government support during the commercialization process;
- not being able to get EPA accreditation;
- inability to fly US officials into Canada for demonstration of products (US government regulations stipulating that the representatives of the government are not allowed to be flown out of the country by suppliers);
- lack of market experience in the US on the part of smaller Ontario suppliers, and their limited resources to devote to marketing programs;
- a shortage of skilled manpower in both engineering and marketing;

- subsidization by countries (especially France) of their home manufacturers in export markets, and the Canadian government's reluctance to follow suit;

- high tariff barriers in Southeast Asia.

Firms expressed some disappointment with the impact of the Canada-U.S. FTA, largely related to Buy-America preferences and other barriers that remain at the regional level. A trade agreement with Mexico was not seen as a major market opportunity, and Mexicans do not have the expertise to compete in this area.

Ontario *consulting engineering and waste management services* firms view themselves as quite competitive in Ontario and foreign markets, although one firm cited declining margins in Ontario due to aggressive marketing by branches of foreign firms. These firms have been quite active in foreign markets, although in some cases Ontario employees play a modest role in foreign service operations. Factors contributing to the competitiveness and international success of Ontario suppliers include:

- integrity of Canadian suppliers;

- quality of Canadian work;

- quality of Canadian technology;

- demonstrated skills based on large projects done before;

- Canadian services are well priced;

- waste management services are restricted in shipping waste to Canada because of Canadian political restrictions, but we can ship our waste to U.S. sites;

- for the large consulting firms it is their ability to offer an integrated solution to the client, not just an environmental assessment;

- for the smaller consulting firms, they are successful when they have developed a niche expertise that does not compete directly with large integrated US firms, and they can partner with the US firm;

- mid-sized consulting firms will have to rely on partnering in many cases to compete, because there will be a preference for large US firms with economies of scale and experience in managing large projects.

Factors reducing competitiveness include:

- American preferences for their own technologies;
- inability of project developers (industrial construction contractors) to go out and pursue business - they expect consultants to bring in this business;
- lack of government support in pursuing export business - too much red tape associated with getting funds for market development;
- distance from markets;
- US regulations that are quite strict;
- experience, economies of scale, and Canadian preference for large U.S. firms;
- shortage of skilled environmental engineers in Canada (particularly engineers with 8 to 12 years of experience because so few engineers were hired during the last recession);
- interprovincial barriers regarding engineering consulting work, particularly in Quebec and Alberta.

Trade agreements will have little impact because of the fact that services generally are not really exported, but are provided in foreign markets using branch offices. One responded noted that U.S .firms have started to buy Canadian consulting firms in order to access the Ontario market.

6.5 Human Resources and the Ontario Environmental Protection Industry

The environmental protection industry employs a broad range of people encompassing a wide variety of skills and occupations. Many of those working in the industry are highly educated professionals with skills unique to environmental protection. At the same time, there are large numbers such as engineers and lab technicians whose skills are common to other industries as well.

Government regulations and environmental concerns have resulted in a large increase in the number of environmental specialists in recent years. Greater demand for environmental impact assessments, environmental modelling and audits has resulted in a requirement for larger numbers of environmental scientists and engineers capable of delivering these services.

At the same time, new regulations and technological innovation require existing personnel to upgrade their skills and knowledge.

It is difficult to estimate the number of people employed in the environmental protection industry for several reasons, including:

1) many of those who work in the environmental protection industry also work in other industries. For example, a civil engineer who designs sewage treatment plants may also work on other non-environmental structures; a technician in a laboratory may perform both environmental and non-environmental analyses;

2) there are many small companies in the environmental protection industry and it is difficult to account for employment among these businesses; and

3) many manufacturers in other industries also produce goods for the environmental protection industry and it is difficult to estimate the number of employees or person hours dedicated to production of environmental products.

Based upon our research, and other studies of the industry, we have estimated that the environmental protection industry in Ontario employs about 30,000 workers.

In the sections below we discuss the nature of employment within various sectors.

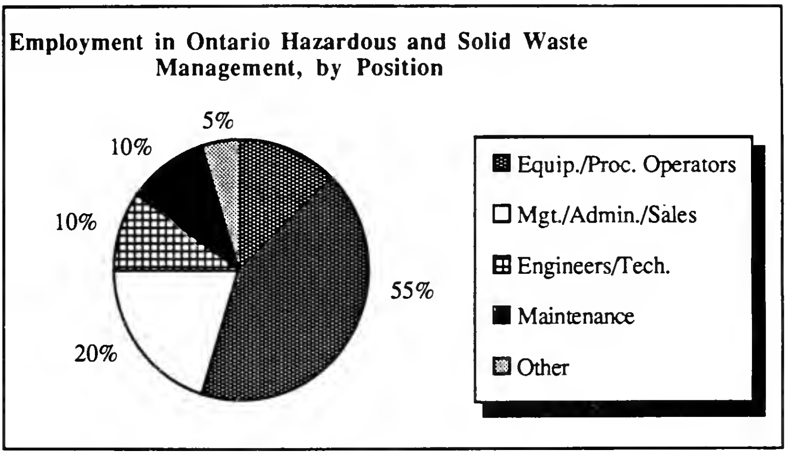
Services

The service sector may account for as much as 85% of total employment in the environmental protection industry. Within the service sector, the waste management industry is the largest employer. Consulting and laboratory services are two other areas using specialized environmental skills. The section below describes employment in each of these three industries.

Hazardous and Solid Waste Management

The hazardous (or "special') and solid waste management industry accounts for perhaps as much as 50% of total employment within the environmental protection industry. Employment in the hazardous and solid waste management industry is illustrated in Chart 6.1.

Chart 6.1



Source: Ernst & Young Industry Survey

More than half of the employment in hazardous and solid waste management consists of equipment and process operators. These include truck drivers, heavy equipment operators and process operators at landfill sites and waste processing sites. In small companies, the number of equipment operators as a percentage of total company employment is even higher.

Many of the workers in hazardous waste management, including equipment and process operators who are handling hazardous and toxic wastes, are graduates of chemical technology courses at colleges or may be chemistry graduates from a university. Consequently, this part of the industry has a very high level of technically skilled workers.

By contrast, equipment operators in the solid waste management sector are less likely to have specialized training in handling waste, other than that provided by their company.

Management and administration account for a further 20% of employment by this segment. Maintenance mechanics who are responsible for the repair and maintenance of equipment represent about 10% of employment.

This industry segment also employs engineers and technologists to perform various functions such as landfill site design and management, lab analyses, and process operation. These skilled workers constitute about 10% of the employment within this segment.

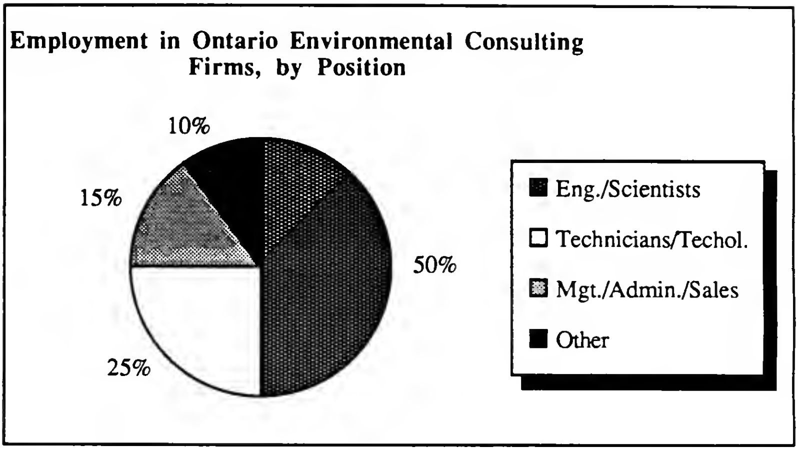
Those employed in the Other category include occupations such as dispatchers, security guards, and general labour.

Environmental Consulting

Environmental consultants provide a number of services to companies including monitoring of pollution, environmental assessments, environmental audits, engineering design of waste treatment plants, water treatment plants, landfill sites and other capital projects, and project management to construct and install environmental protection equipment and systems.

About half of those employed in this industry are either engineers or scientists with advanced technical education at the university level. A breakdown of employment by position is shown in Chart 6.2.

Chart 6.2



Source: Ernst & Young Industry Survey

After engineers and scientists, technicians and technologists represent about 25% of those employed. These include primarily chemical and engineering technologists, and lab technicians.

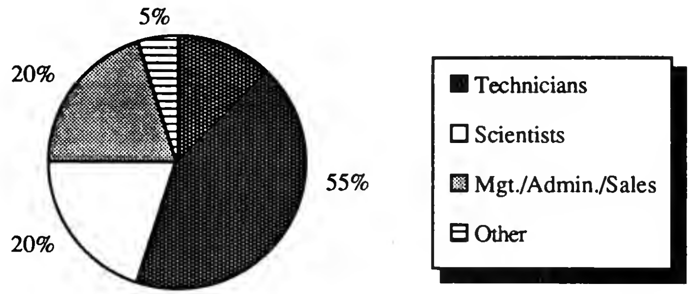
Management, administration and sales account for some 15% of those employed in the industry. Those in the Other category include draftsmen, planners, surveyors, and mechanics.

Environmental Laboratories

Environmental laboratories employ some 1,000 workers. About 55% of these are technicians and technologists who are responsible for tasks such as gathering samples, packaging samples and sample analysis. Chart 6.3 illustrates employment in this sector.

Chart 6.3

Employment in Ontario Environmental Laboratories, by Position



Source: Ernst & Young Industry Survey

Some 20% of employment in this sector consists of senior scientists who supervise testing, design testing procedures and provide consulting advice to customers, among other responsibilities. Most of these scientists hold doctorate degrees from universities.

Management, administration and sales represent about 20% of those employed by the industry, while the Other category, including occupations such as supervisors and maintenance staff, accounts for another 5%.

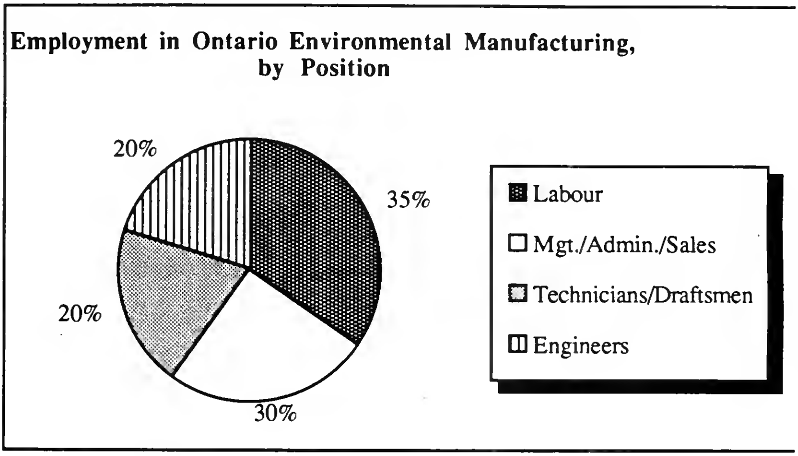
Manufacturing

About 35% of those employed in manufacturing environmental equipment are general labourers who assemble and manufacture equipment. Smaller companies in the industry often contract some or all of their manufacturing activities to outside companies, which reduces the percentage of general labour in this segment when compared with other manufacturing industries.

Management, administration and sales account for some 30% of employment by this sector. Technicians and draftsmen represent another 20%of employment. Engineers who design equipment and supervise installation also account for about 20% of employment by this sector.

Chart 6.4 illustrates the approximate employment by position in the manufacturing sector.

Chart 6.4



Source: Ernst & Young Industry Survey

Environmental Protection Industry Demographics

On average, employees in the environmental protection industry are younger than those in other industry sectors. There are significantly more employees in the 20 to 45 age group than for the province as a whole, and fewer workers over the age of 45. There are also very few workers under the age of 20 in the environmental protection industry.

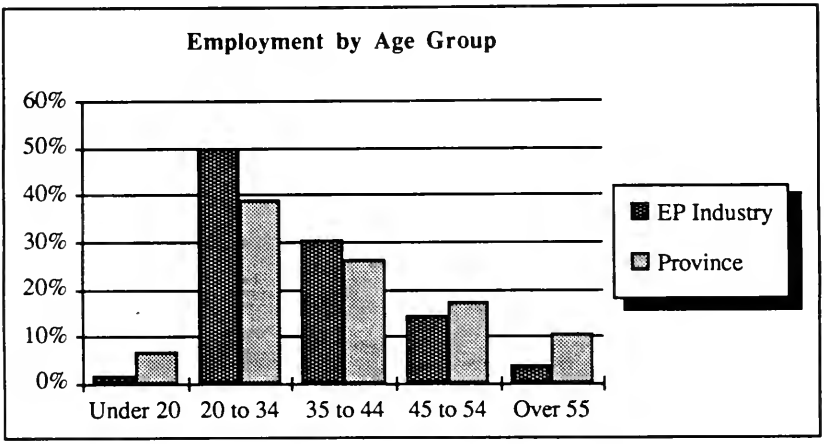
This age distribution is likely the result of two factors:

1) much of the employment growth in the industry has occurred in the past ten years, resulting in more workers in younger age groups; and

2) many of the positions in the industry require post secondary school education and there are relatively few openings for those under the age of 20.

The comparison of age groups in the environmental protection industry with the provincial average is illustrated in Chart 6.5.

Chart 6.5



Source: Statistics Canada, 71-220, Labour Force Annual Averages, 1991, and Ernst & Young survey.

The large number of relatively younger workers suggests that the industry will have a solid base of human resources for the future. As many of those in the 20 to 34 age group mature and gain industry experience, their knowledge and expertise will be valuable to the industry. They will also serve as mentors to those graduates entering the industry in future years.

At the same time, industry participants cited difficulties in recruiting individuals with ten or more years of environmental experience. The age profile provides some support to the notion that there is a shortage of such individuals in the industry. Some firms cited tough competition for such employees from government environmental departments and from the in-house environmental departments of major Canadian industrial firms.

Almost 90% of those employed in the environmental protection industry are males. This is not altogether surprising given the predominance of technical positions in the industry and the lack of female graduates in science and engineering. About 50% of the females employed in the industry work in administrative positions. Thus, encouraging women to enter the applied science fields that are key to the environmental protection industry will be one potential means of meeting future human resource requirements as the industry grows.

Education and Training

A significant percentage of the workers in the environmental protection industry require specific education and training to perform their jobs. Many workers have diplomas in environmental or chemical technology from community colleges, or degrees in science or engineering from universities. The effectiveness of the education system and its ability to produce qualified graduates to work in the environmental protection industry is important to the future growth of the industry.

In the section below, we review briefly the availability of education and training for the environmental protection industry.

Colleges and Universities

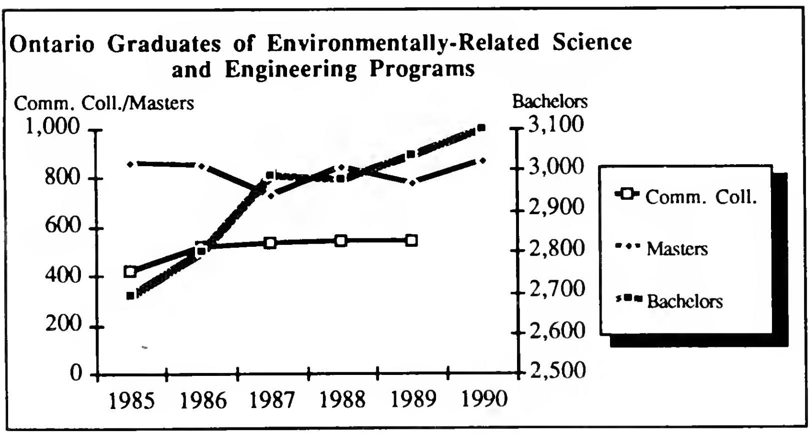
Education and training for workers in the environmental protection industry is available from colleges and universities throughout Ontario. Ontario, along with Alberta and B.C., is the leading jurisdiction in Canada in terms of the stage of development of such programs.

The types of programs available vary considerably from school to school. Many schools now offer undergraduate courses in environmental science or engineering as part of other degree programs. Students can also specialize in environmental science or engineering at the Master's level at several universities in Ontario. Several universities also offer co-op undergraduate programs which provide students with valuable work experience while getting their degree.

Community colleges in the province provide education for both technicians and technologists in several fields related to the environmental protection industry. These graduates fill a number of positions in the environmental protection industry including laboratory technicians and lab supervisors in the laboratory industry, equipment operators in the hazardous waste industry, and data gatherers or samplers in the consulting industry, among other jobs.

Our discussions with industry representatives and educators suggest that the industry is reasonably well served by Ontario's educational system. Enrollment in environmental science and engineering courses at the undergraduate level and community colleges has increased in recent years as has the number of graduates with an environmental specialization. There has been little growth in the number of masters degrees being earned in the science and engineering fields of interest to the environmental protection industry. Chart 6.6 illustrates the growth in environmental studies programs in community colleges and universities, at both the graduate and undergraduate levels.

Chart 6.6



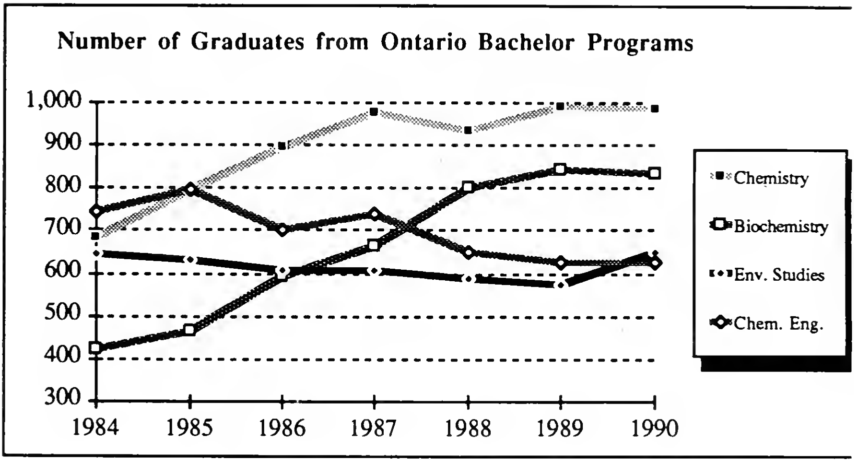
Source: Statistics Canada publications 81-204 and 81-222, various years. Data for community colleges were not available for the 1990 year.

The number of environmental technicians and technologists from Ontario community colleges has risen quite rapidly, from just under

150 per year in 1985 to over 220 per year in 1990. There are also over 200 graduates per year in environmental studies programs at community colleges.

There have been some shifts in the composition of undergraduate degrees issued in the science and engineering fields employed in the environmental protection industry. Chart 6.7 shows that the number of graduates from Ontario universities in fields related to environmental protection has increased in chemistry and biochemistry, but has been declining in chemical engineering, a key source of talent for the environmental protection industry.

Chart 6.7



Many employers prefer to hire graduates from co-op programs. These students, who have had a chance to work in industry while completing their studies, are much better able to adapt to industry upon graduation. The University of Waterloo has pioneered co-op programs at the university level in Ontario and has a very good reputation among employers for the quality of its graduates. With industry support, the University has also established a Centre for Groundwater Research which conducts research and educates future engineers and scientists for the environmental protection industry. Several of the employers we interviewed spoke highly of the

University's programs. Ontario universities and college administrators report a shortage of funds to develop new, innovative programs in the environmental field.

While there is a need for specific expertise to deal with environmental problems, most employers prefer graduates who have a general background in one of the core disciplines such as engineering, chemistry, geography or other science. This general knowledge is particularly useful later on in an employee's career when he or she is promoted to a management level. Even at an early stage, the employee may be required to work on projects outside of his or her specialization. Those who have specialized at an early stage in their academic career have more problems working outside of their field of study. As a result, employers often prefer a graduate of a core discipline who has specialized at the Master's level in university.

Internal Training

Many companies in the environmental protection industry rely heavily upon their own training programs to upgrade the skills of new employees. In environmental labs, for example, new employees are taught the specific analytical techniques used by that lab (in some cases, the lab methodology can be a source of competitive advantage for the lab). Hazardous waste management companies provide in-house training for their employees in areas such as occupational health and safety, customer service and safe driving techniques. Most environmental consultants are taught professional reporting techniques, a valuable part of the consultant's profession, by their employers since this type of training is usually not available in schools.

One difficulty with the heavy reliance on internal training is that firms are often put in a position of funding training costs for employees who subsequently move on to other firms or to the public sector. While this problem is not unique to the environmental sector, it does deter high cost training by firms.

Furthermore, more extensive training needs are difficult to meet while the employee is on the job. In the future, firms may make greater use of contracted training programs put on by educational institutions, particularly community colleges, on their behalf.

Human Resource Issues

The ability of Ontario's environment protection industry to grow will depend to a large extent upon the availability of technically skilled workers. The demand for employees will not affect all sectors equally. Industry segments such as hazardous waste management, air pollution abatement and control, and environmental assessment will likely experience a significant increase in demand for skilled personnel. More mature industries such as solid waste management, which accounts for a large percentage of employment, are not expected to experience any increase in employment in the future.

Some of the specific skills and occupations which will likely be needed in greater numbers include:

- Hydrogeologists: instrumental in the design and assessment of landfill sites, clean up of hazardous and toxic waste sites, groundwater contamination, and site decommissioning;
- Environmental Scientists: to perform environmental impact assessments and audits as well as manage site clean up projects; and
- Air Quality Chemists and Technicians: to gather and analyze air samples, as well as develop methodologies for air quality analysis.

The environmental protection industry also competes with many other sectors for engineers. Dalcor (1990) projected that the overall demand for engineers in Canada will grow much more rapidly than the supply of engineers in the 1990s, although the authors were perhaps a bit optimistic in terms of projected demand from major energy projects. The study concluded that the declining share of students selecting engineering as a profession will pose problems for Canadian industry by the end of this century, and recommended steps aimed at attracting students to engineering (particularly women) and considering expanded immigration for skilled engineers.

Because the environmental protection industry is growing and changing, there is a often a lag between technological and industry change and the skill levels and knowledge of those in the industry, including recent graduates. Although the education system will eventually adjust to changes in the industry, there is often a gap between industry demand for skilled employees and available supply which arises because of this lag. For example, recently the industry experienced a strong growth in demand for hydrogeologists to deal with issues of groundwater contamination and soil remediation. Although universities have responded with programs to meet this need, there is still a scarcity of experienced hydrogeologists largely because universities did not graduate significant numbers with this type of specialization 5 to 10 years earlier.

Industry participants with whom we spoke suggested that future environmental scientists and engineers will need both a strong general education as well as expertise in a specific environmental discipline. A greater number of those working in the industry will likely possess graduate degrees in an environmental field. While some of Ontario's universities have developed graduate level courses in environmental engineering and sciences, there is a concern on the part of industry that there will be insufficient numbers of environmental specialists to meet future demand.

Some employers would like to see the education system, particularly the universities, playing a greater role in upgrading the skills of engineers and scientists with bachelors degrees. University officials believe that there are limitations to what they can provide in terms of substituting for practical experience in the field, particularly in engineering.

Government legislation and regulation can have a significant impact on industry's demand for human resources. It is important for governments to recognize this impact and design their policies accordingly. Linkages between industry, government and academia should be enhanced to design educational programs to meet future environmental protection industry needs. Educational programs should be developed in conjunction with legislation to prepare graduates for work in the industry. All of these initiatives would help to address the human resource issues facing the environmental protection industry.

In the environmental products sector, other labour force issues are similar to those in other parts of the manufacturing industry in Ontario. These include the impact of exchange rate changes and wage rate increases on relative wages between Ontario and the U.S., particularly when compared to the lower-wage southern states.

6.6 Industry Views on the Role of Governments

Environmental protection industry participants in Ontario, particularly those in manufacturing equipment or instruments, share a number of concerns with other manufacturers in the province. As noted above, firms felt that current macroeconomic conditions, including the high Canadian dollar, the level of business and personal taxation, and wage rates in the province relative to those in the U.S., were making it difficult to compete from an Ontario base. Many of our mail survey respondents also used the "general comments" section of the survey to offer critical views on the current business climate in the province.

Other more specific concerns related to the pace and consistency of environmental regulation in Ontario and elsewhere in Canada, the availability of certain specialized skills in the labour force, and the barriers to trade across provinces and international boundaries.

Most of the firms interviewed for this study, and many of our mail survey respondents, had specific recommendations for measures that governments could take to improve the prospects of the Ontario environmental protection industry. The most frequently cited recommendation in our interviews was that Ontario should not lag behind U.S. jurisdictions in adopting and enforcing regulations, and that once announced, regulatory development be held to a strict schedule. One-quarter of our mail survey respondents also expressed similar views. Several firms in the water pollution control area expressed frustration with the slow pace of the MISA process, for example, and maintained that the delays they perceived in developing and enforcing new standards created uncertainties for their businesses.

In the area of marketing support, while there was praise from some firms for existing provincial efforts, several firms felt that the provincial industry ministry and federal trade officials placed an undue emphasis on some aspects of the environmental protection industry. Several firms felt that efforts to promote exports were not well-targetted, and that, as one respondent put it "too many taxpayer dollars are devoted to trade missions and trade fairs that do not generate results." In particular, one leading engineering firm noted that the potential for exporting environmental engineering services to other developed countries was quite limited, except where the developer of a project is also a Canadian firm, and that most such "exports" would ultimately involve the use of branch offices with foreign engineering staff. Another suggested that trade fairs for equipment manufacturers need to be more narrowly focussed, so that they bring together buyers and sellers of similar technologies.

Some firms offered suggestions for other ways that the government could assist firms in marketing and business planning. Several felt that the Ministry of the Environment could do a better job in disseminating information among potential suppliers, and in using its links to the EPA to provide information on American technological developments to Ontario firms. One respondent suggested that reports and publications, such as the directory of firms gathered in this study, should be sent to foreign trade offices promoting Ontario technology. Another suggested that those manufacturers that can export their services but do not know how need some type of education as to what avenues and assistance are open to them.

Many firms also offered suggestions relating to the role of governments as purchasers of environmental products and services. Preferences in other provinces for local suppliers are a major concern of Ontario firms in this sector, particularly those in consulting. They suggested that the provincial government should be placing more emphasis on negotiating an end to such interprovincial trade barriers. One felt that as a last resort the province should threaten to implement its own "Buy Ontario" program. A national accreditation program for laboratories was another suggestion to improve recognition of Ontario capabilities in other jurisdictions.

A number of interview and mail survey respondents were also critical of governments use of in-house laboratories and consultants which they felt was restraining the market for private sector firms and not necessarily providing a savings to the government if all employment overhead costs are taken into consideration.

As in our 1989 study, some equipment suppliers expressed frustration with what they perceived was a negative attitude regarding innovative Canadian technologies and a preference of government buyers for foreign technologies. One suggested that the government should be granting "best available technology" designations to Ontario technologies as a means of improving their marketability at home and abroad. Several mail survey respondents felt that the approvals process for technologies could be improved.

There were a number of suggestions relating to the role of governments in promoting technological development. Not surprisingly, there was a general call for more government assistance or tax relief to firms in this sector. One firm noted their need for assistance in the commercialization of the product, as opposed to the current emphasis on providing R&D funding. A mail survey respondent added that non-multinationals needed a greater share of such support. Another complained that the federal government will fund two or three suppliers in the development of the same technology, and then force them to compete against each other for a limited market Finally, most firms emphasized that technology leadership in the environmental field is most dependent on being in a jurisdiction that is committed to having the most demanding standards for environmental performance.

7. Environmental Protection Impact Model

7.1 Introduction

The Environmental Protection Impact Model (EPIM) has been designed for simplicity of use. An operator need only consult two areas of the model which are located at the top of the file. Exhibit 1 shows these two areas – labelled "Input Area" and "Summary Output Area". Data is entered in the appropriate shaded cell of the input area, and the user engages the calculation feature of the spreadsheet program. Then, EPIM estimates the economic impact, and displays it in the output area, with all dollar amount being in 1991 dollars.

Since capital expenditures associated with an environmental protection spending project are one-time in nature, the GDP, employment, and tax revenue created by the capital spending are also one-time occurrences. Economic and taxation impacts resulting from operating expenditures can be seen as recurring annually for the life of the project.

The economic impact of environmental protection spending on eleven specific technologies can be calculated. These technologies are:

Primary Clarifier

Aeration Basin and Secondary Clarifier

Anaerobic Sludge Digestion

Sludge Dewatering

Oil/Water Separator

Chemical Oxidation/Reduction and Final Clarifier

pH Control System

Sand Filtration

Baghouse (air)

Wet Scrubber (air)

Solid Waste Composter

In addition, if the specific technology involved in an environmental spending program is not known, the model has a generic category

EXHIBIT 1

INPUT AREA	*Capital Expenditure (1991 $)*	*Flow Rate*
Water Treatment		
Primary Clarifier		
Aeration Basin and Secondary Clarifier		
Anaerobic Sludge Digestion		
Sludge Dewatering		
Oil/Water Separator		
hemical Oxidation/Reduction and Final Clarifier		
pH Control System		
Sand Filtration		
Generic Water Treatment		
Air Treatment		
Baghouse		
Wet Scrubber		
Generic Air Treatment		
Solid Waste Composter		

SUMMARY OUTPUT AREA (All $ amounts in 1991 $)	One-Time Capital	Annual Operating
Project Cost (000's)	$0	$0
Employment (person yrs)	0	0
Ontario GDP (000's)	$0	$0
Ontario Expenditures by EPI (000's)	$0	$0
Total Ontario Taxes (000's)	$0	$0
Total Federal Taxes (000's)	$0	$0

Explanatory Note:
The economic impacts of capital spending projects generally occur durin the life of the construction project, while the economic impacts of the operating spending recur each year for the life of the treatment process.

for both air and water protection that will enable the user to estimate the order of magnitude of the economic impact.

The model estimates a number of variables of interest – for both the capital spending and the ongoing operating requirements – which are displayed in the output area[46], including:

- project cost;
- persons years of employment created by the spending program;
- gross domestic product (GDP) generated in the province of Ontario by the project;
- the expenditures made by the environmental protection industry in Ontario as it designs, builds, and installs the equipment; and,
- and the associated tax collections in Ontario by both the federal and provincial governments.

7.2 Using The Model

Entering Capital Expenditure Information

To estimate the economic impact of an environmental spending program, model users may enter either the total capital expenditure involved in a project or the flow rate that the technology will have to treat. *However, users should not enter both the amount of capital expenditure and the flow rate for a particular technology.*

Exhibit 2 provides an example where the value of a project is known. In this instance, the impact of a $1,500,000 purchase of an aeration basin and, secondary clarifier is investigated. The user enters "1500000" (no commas are necessary) in the appropriate row and in the "capital expenditure" column. *Note that any dollar values entered into the model must be in 1991 dollars.*

46 Note that the output area displays all dollar figures in thousands.

Entering Waste Stream Flow Rate Information

Exhibit 3 provides an example where the flow rate of the waste stream to be handled is known. Here, a wet scrubber process is proposed that will handle a flow rate of 500 cubic metres per hour.[47] The user enters "500" in the appropriate row and in the "flow rate" column. Again, once the model has calculated the results, the output area displays the economic impacts of the spending program.

Using the Model When the Specific Technology is Unknown

Often, a model user will know what environmental media that a spending program is designed to protect, but will not know the specific technology to be used. In this case, the generic treatment categories can be used. The calculations are based on the averages of the specific technologies for that media in the model. Exhibit 4 shows how the model can be used in this situation. If the user knew that $600,000 was to be spent on water protection, then one would enter "600000" in the capital expenditure column of "generic water treatment". The output area displays the economic impact estimates. *Note that it is not possible to enter a flow rate figure when the specific technology is not known.*

47 With most of the technologies handled by this model, flow rate input should be in cubic metres per hour. However, there are some exceptions. Please see Exhibit 6 where the proper flow rate variable for each technology is listed.

EXHIBIT 2

INPUT AREA	*Capital Expenditure (1991 $)*	*Flow Rate*
Water Treatment		
Primary Clarifier		
Aeration Basin and Secondary Clarifier	$1,500,000	
Anaerobic Sludge Digestion		
Sludge Dewatering		
Oil/Water Separator		
hemical Oxidation/Reduction and Final Clarifier		
pH Control System		
Sand Filtration		
Generic Water Treatment		
Air Treatment		
Baghouse		
Wet Scrubber		
Generic Air Treatment		
Solid Waste Composter		

SUMMARY OUTPUT AREA (All $ amounts in 1991 $)	One-Time Capital	Annual Operating
Project Cost (000's)	$1,500	$353
Employment (person yrs)	29	5
Ontario GDP (000's)	$1,160	$314
Ontario Expenditures by EPI (000's)	$1,329	$0
Total Ontario Taxes (000's)	$158	$43
Total Federal Taxes (000's)	$208	$56

Explanatory Note:
The economic impacts of capital spending projects generally occur durin the life of the construction project, while the economic impacts of the operating spending recur each year for the life of the treatment process.

EXHIBIT 3

INPUT AREA	Capital Expenditure (1991 $)	Flow Rate
Water Treatment		
Primary Clarifier		
Aeration Basin and Secondary Clarifier		
Anaerobic Sludge Digestion		
Sludge Dewatering		
Oil/Water Separator		
hemical Oxidation/Reduction and Final Clarifier		
pH Control System		
Sand Filtration		
Generic Water Treatment		
Air Treatment		
Baghouse		
Wet Scrubber		500.0
Generic Air Treatment		
Solid Waste Composter		

SUMMARY OUTPUT AREA (All $ amounts in 1991 $)	One-Time Capital	Annual Operating
Project Cost (000's)	$61	$30
Employment (person yrs)	1	0
Ontario GDP (000's)	$44	$26
Ontario Expenditures by EPI (000's)	$56	$0
Total Ontario Taxes (000's)	$6	$4
Total Federal Taxes (000's)	$8	$5

Explanatory Note:
The economic impacts of capital spending projects generally occur durin the life of the construction project, while the economic impacts of the operating spending recur each year for the life of the treatment process.

EXHIBIT 4

INPUT AREA	*Capital Expenditure (1991 $)*	*Flow Rate*
Water Treatment		
Primary Clarifier		
Aeration Basin and Secondary Clarifier		
Anaerobic Sludge Digestion		
Sludge Dewatering		
Oil/Water Separator		
hemical Oxidation/Reduction and Final Clarifier		
pH Control System		
Sand Filtration		
Generic Water Treatment	$600,000	
Air Treatment		
Baghouse		
Wet Scrubber		
Generic Air Treatment		
Solid Waste Composter		

SUMMARY OUTPUT AREA (All $ amounts in 1991 $)	One-Time Capital	Annual Operating
Project Cost (000's)	$600	$108
Employment (person yrs)	10	2
Ontario GDP (000's)	$393	$97
Ontario Expenditures by EPI (000's)	$444	$0
Total Ontario Taxes (000's)	$54	$13
Total Federal Taxes (000's)	$71	$17

Explanatory Note:
The economic impacts of capital spending projects generally occur durin the life of the construction project, while the economic impacts of the operating spending recur each year for the life of the treatment process.

Modelling Several Projects Simultaneously

The impact of several projects, or one project using several technologies, can also be modelled. Exhibit 5 shows an analysis involving a primary clarifier, anaerobic sludge digestion, and sludge dewatering. *Note that it is possible to input both flow rate and capital expenditure data, as long as each input applies to a different technology.* In this instance, the user knows that the primary clarifier will involve a capital outlay of $300,000, and is not aware of the cost for the other two elements, knowing only that they will need to handle 420 cubic metres of waste water per hour.

Ranges of Estimation

The calculations made by the model rely in part on cost functions for various flow rates for each technology. The cost functions have been estimated within a certain range of both dollars and flow rates. Within these ranges, the economic impact calculations should be good estimates (see Exhibit 6 for the cost and flow rate ranges for each technology). However, if the cost or flow of a project falls outside these ranges, the accuracy of the cost estimates will be reduced.

7.3 Adapting the Model

The model makes its calculations based on average relationships between industries, and the average market share for environmental protection supplies held by Ontario firms. However, users may sometimes be aware of the place of origin for the elements of a particular project. In such a case, one may wish to override the proportions assigned to the market share of Ontario-based manufacturers.

For example, a user may know that the belt filter press to be used in a sludge dewatering project is going to be manufactured in Ontario. As the model stands, a 0% share of the Ontario market is assigned to Ontario-based firms (see the figure "0.00" in the "Materials" column labelled "Ont. Assembly" in Exhibit 7. Although this exhibit reproduces the relevant portion of the model only for sludge dewatering, the following adjustment of the model can be used with any of the technologies.) If the user knows that an Ontario firm will be making the belt filter press for this sludge dewatering project, the user could input "1.00" in place of the model's entry. When the model is run, the economic impact calculation will be made with the assumption that the filter press is made in Ontario. *Users should be careful not to save the model after any such changes have been made, because the original parameter will be lost.*

EXHIBIT 5

INPUT AREA	*Capital Expenditure (1991 $)*	*Flow Rate*
Water Treatment		
Primary Clarifier	$300,000	
Aeration Basin and Secondary Clarifier		
Anaerobic Sludge Digestion		420.0
Sludge Dewatering		420.0
Oil/Water Separator		
hemical Oxidation/Reduction and Final Clarifier		
pH Control System		
Sand Filtration		
Generic Water Treatment		
Air Treatment		
Baghouse		
Wet Scrubber		
Generic Air Treatment		
Solid Waste Composter		

SUMMARY OUTPUT AREA (All $ amounts in 1991 $)	One-Time Capital	Annual Operating
Project Cost (000's)	$3,029	$446
Employment (person yrs)	46	9
Ontario GDP (000's)	$1,852	$413
Ontario Expenditures by EPI (000's)	$2,235	$0
Total Ontario Taxes (000's)	$253	$56
Total Federal Taxes (000's)	$332	$74

Explanatory Note:
The economic impacts of capital spending projects generally occur durin the life of the construction project, while the economic impacts of the operating spending recur each year for the life of the treatment process.

EXHIBIT 6

Technology		Cost Estimation Ranges	
	Flow Rate Units	***Flow Rate***	***Dollars***
Primary Clarifier	m^3/hour	250 - 1,000	227,355 - 486,450
Aeration Basin and Secondary Clarifier	kg/day	1,200 - 6,000	1,059,495 - 2,360,835
Anaerobic Sludge	m^3/hour	250 - 1,000	1,288,920 - 2,537,590
Sludge Dewatering	m^3/hour	250 - 1,000	842,605 - 1,596,085
Oil/Water Separator	litres/second	5 - 110	53,760 - 171,360
Chemical Oxidation, etc.	m^3/hour	5 - 25	233,220 - 572,240
pH Control System	m^3/hour	10 - 100	43,440 - 129,120
Sand Filtration	m^3/hour	250 - 1,000	352,015 - 1,055,700
Baghouse	m^3/hour	280 - 840	55,080 - 119,640
Wet Scrubber	m^3/hour	280 - 840	41,280 - 86,280
Composter	tonnes/day	75-375	1,728,100 - 6,657,200

EXHIBIT 7

Sludge Dewatering

	Entries	Calculations
Flow Rate (m3/hr)	0.0	0.0
Expenditure	$0	$0

Scale-Up Coefficients Sludge Dewatering	
Equipment	0.45
Construction	0.44
Piping	0.38
Elect/Instrument'n	0.38
Labour	0.45
Total Capital	0.45
Total Operating	0.60
Indirect Gross-Up	0.15

Direct Capital Cost - Base Case ***Sludge Dewatering***

	Materials			Labour		
	Ont. Assembly	EPI Ont. Spending	Cost	Ont. Assembly	EPI Ont. Spending	Cost
m3 Tanks	1.00	1.00	$4,000	1.00	1.00	$500
Dosage Pumps	1.00	0.40	$5,000	1.00	1.00	$1,000
Mixers	1.00	0.40	$12,000	1.00	1.00	$3,000
Transfer Pumps	1.00	0.50	$2,000	1.00	1.00	$1,000
Belt Filter Press	0.00	0.05	$378,000	1.00	1.00	$10,000
Sludge Pumps	1.00	0.60	$6,000	1.00	1.00	$1,200
Storage Tanks	1.00	1.00	$7,000	1.00	1.00	$1,000
Building	1.00	1.00	$45,000	1.00	1.00	$45,000
Construction	1.00	1.00	$45,000	1.00	1.00	$50,000
Piping	1.00	1.00	$27,000	1.00	1.00	$27,000
Elect/Instr	0.80	0.60	$31,000	1.00	1.00	$31,000
Subtotal			$562,000			$170,700

Flow Rate (m3/hour)	250.0

Direct Capital Cost	$732,700
Indirect Capital Cost	$109,905
Total Capital Cost	$842,605

7.4 Construction of the Model

The discussion of the Environmental Protection Impact Model's construction follows the diagrammatic presentation of Exhibit 8.

Input and Cost Functions

Two types of input are possible – dollars of capital expenditure or flow rate of waste stream to be handled. If the flow rate (Q) is entered, the model proceeds directly to the cost function to calculate both the capital and operating costs. The cost functions for all technologies have been estimated by M.M. Dillon, and begin with a cost structure for a base case flow rate. The cost of each element of the technology is scaled up using a particular functional form and various "scale up coefficients". The form used for all cost functions is:

$$C_Q = C_q * (Q / q)^s$$

where:

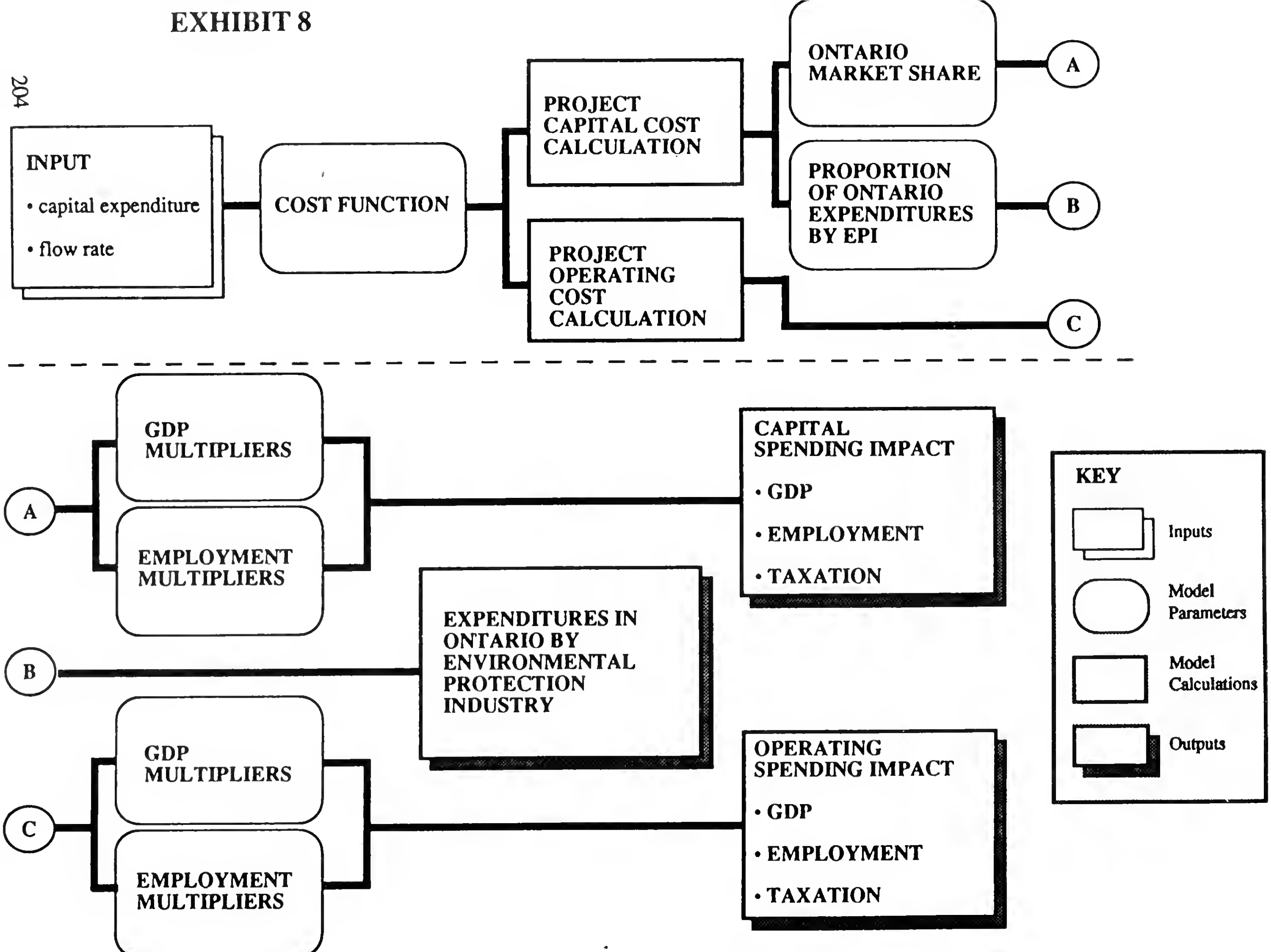
C_Q	–	cost for flow rate of Q which is under analysis
C_q	–	cost of base case flow rate of q
Q	–	flow rate of Q which is under analysis
q	–	base case flow rate of q
s	–	scale up coefficient

Each of the main elements of the technology's capital and operating costs has a scale up coefficient (s), base case cost (C_q), and base case flow rate (q) embodied as parameters in the model. Since the user has entered a value for the variable Q, the model uses this equation and the parameter values to calculate the cost of each element of the project being analyzed (C_Q).

Alternatively, the user may enter the project capital cost value (C_Q). *Note that all dollar values should be in 1991 dollars.* In this case, the model uses the equation and the parameter values to calculate the flow rate (Q) of the technology in question. This calculated flow rate is then used by the model to estimate the cost of the individual elements of the technology.

If the project cost value was the variable entered by the user, then an additional adjustment is made by the model. Because of the

EXHIBIT 8


INPUT
• capital expenditure
• flow rate
COST FUNCTION
PROJECT CAPITAL COST CALCULATION
PROJECT OPERATING COST CALCULATION
ONTARIO MARKET SHARE
PROPORTION OF ONTARIO EXPENDITURES BY EPI
A
B
C
GDP MULTIPLIERS
EMPLOYMENT MULTIPLIERS
EXPENDITURES IN ONTARIO BY ENVIRONMENTAL PROTECTION INDUSTRY
CAPITAL SPENDING IMPACT
• GDP
• EMPLOYMENT
• TAXATION
OPERATING SPENDING IMPACT
• GDP
• EMPLOYMENT
• TAXATION
KEY
Inputs
Model Parameters
Model Calculations
Outputs

approximate nature of the cost functions, the sum of the costs calculated by the model for the individual elements may differ from the total capital cost entered by the user. Thus, the model has a second stage which adjusts the costs of each element by any percentage difference between the initial calculation of total project cost and the entered value of the project cost.

Market Share of Ontario Suppliers

The model contains estimates of the Ontario market share held by Ontario-based environmental protection firms for the components of the various technologies. These proportions are used by the model to calculate the probability-weighted value of the project that is supplied by Ontario firms. As described in Section 1.4, these proportions can be changed temporarily by the user.

Multipliers and Model Outputs

The model provides analysis of the economic benefits to Ontario created by an environmental protection spending project. Users are able to estimate the employment generated in Ontario by a project, and the gross domestic product (GDP) resulting from projects is also estimated.

The revenue from the sale of the components of the various technologies is allocated by the model to the industries[48] that produce each of the components. Each of these industries has associated two multipliers obtained from the Statistics Canada Input-Output model . GDP multipliers convert total dollars of revenue in a particular industry into total dollars of GDP directly and indirectly created. Employment multipliers convert dollars of activity into the number of jobs created. (The employment multipliers produced by Statistics Canada measure jobs per 1984 dollars of activity. As a result, EPIM uses industry price indices to convert 1991 dollars of activity into 1984 dollars, before the employment calculation is made.) After the

48 Industries have been selected from the least aggregated definitions used in the Interprovincial Input-Output model. See: Statistics Canada, System of National Accounts, *The input-output structure of the Canadian economy*, Catalogue 15-510, pgs. 104-106. The components were assigned to these industries based on the list of products produced contained in: Statistics Canada, *Standard industrial classification*, 1980, Catalogue 12-501E.

GDP and employment impacts for each individual component are estimated, the total impact of the environmental protection project(s) is displayed in the output area.

Finally, to estimate tax receipts received by the federal and provincial governments, the model multiplies the GDP estimations by the share of Ontario GDP received in income, sales, and other taxes by each level of government.

APPENDIX 1

DETAILED DESCRIPTION OF ENVIRONMENTAL PROTECTION IMPACT MODEL

A1.1 Introduction

This appendix describes in detail how the Environmental Protection Impact Model (EPIM) operates, the assumptions embodied in the model, and the sources of the data used in the model. Readers interested in a summary description of the model's construction should see Section 1.4. For instructions on how to operate the model, see Sections 1.2 and 1.3.

A1.2 Model Construction

EPIM has three distinct sections: the Input area, the Summary Output area, and the cost/economic impact areas for the thirteen technologies.

Reading Entered Data

The model user enters either a capital expenditure figure in 1991 dollars or a flow rate figure in the Input area (Exhibit A1, Cells D4-D19, E4-E19). While flow rates and capital expenditure information can be entered at the same time for different technologies, only one or the other can be entered for a particular technology. The model then reproduces the entered data in the "Entries" column of the technology(ies) under consideration (see Exhibit A2, Cells B25, B26).[49]

The adjacent cells labelled "Calculations" in Exhibit A2, Cells C25-C26) show calculated flow rates and capital expenditures. Since users can only enter one of these items, the model calculates the other.

49 Primary Clarifier technology will be used for demonstration purposes throughout this appendix. However, the model is based on the same principles for each technology. Therefore, the description here applies to each technology.

EXHIBIT A1

INPUT AREA	*Capital Expenditure (1991 $)*	*Flow Rate*
Water Treatment		
Primary Clarifier	$350,000	
Aeration Basin and Secondary Clarifier		
Anaerobic Sludge Digestion		
Sludge Dewatering		
Oil/Water Separator		
Chem. Oxidat'n/Reduct'n and Final Clarifier		
pH Control System		
Sand Filtration		
Generic Water Treatment		
Air Treatment		
Baghouse		
Wet Scrubber		
Generic Air Treatment		
Solid Waste Composter		

SUMMARY OUTPUT AREA (All $ amounts in 1991 $)	One-Time Capital	Annual Operating	Share of Ont. GDP
Project Cost (000's)	$350	$49	
Employment (person yrs)	7	1	
Ontario GDP (000's)	$269	$49	
Ont. Expenditures by EPI (000's)	$329	$0	
Total Ontario Taxes (000's)	$37	$7	13.64%
Total Federal Taxes (000's)	$48	$9	17.95%

Explanatory Note:
The economic impacts of capital spending projects generally occur during the life of the construction project, while the economic impacts of the operating spending recur each year for the life of the treatment process.

EXHIBIT A2

	A	B	C	D	E	F	G	H	I	J
22	**Primary Clarifier**			***Direct Capital Cost - Base Case***				***Primary Clarifier***		
23					Materials			Labour		
24		Entries	Calculations		Ont.	EPI Ont.		Ont.	EPI Ont.	
25	Flow Rate (m3/hr)	0.0	573.1		Assembly	Spending	Cost	Assembly	Spending	Cost
26	Expenditure	$350,000	$350,000	Sludge Collector	1.00	0.75	$63,800	1.00	1.00	$4,500
27				Pump	1.00	0.60	$2,900	1.00	1.00	$600
28	**Scale-Up Coefficients**			Construction	1.00	1.00	$45,100	1.00	1.00	$61,400
29	**Primary Clarifier**			Piping	1.00	1.00	$1,800	1.00	1.00	$2,600
30	Equipment	0.29		Elect/Instr	1.00	1.00	$7,500	1.00	1.00	$7,500
31	Construction	0.60		Subtotal			$121,100			$76,600
32	Piping	0.75								
33	Elect/Instrument'n	0.75		Flow Rate	250.0			Direct Capital Cost		$197,700
34	Labour	0.64		(m3/hour)						
35	Total Capital	0.52						Indirect Capital Cost		$29,655
36	Total Operating	0.60								
37	Indirect Gross-Up	0.15						Total Capital Cost		$227,355

Capital Costs

The estimation of the capital cost of a particular flow rate for a technology, or conversely the flow rate for a particular value of project, relies on a cost function formulation devised by M.M. Dillon.

The form of this cost function is:

$$C_Q = C_q * (Q / q)^s$$

where:

C_Q	–	cost for flow rate of Q which is under analysis
C_q	–	cost of base case flow rate of q
Q	–	flow rate of Q which is under analysis
q	–	base case flow rate of q
s	–	scale up coefficient

The cost/flow rate estimation for each technology uses this functional form, although the parameter values differ.

A cost for a base case size of each technology as calculated by M.M. Dillon,[50] are shown in two places. For the Primary Clarifier, see Exhibit A2, Cells G26-G30 for the costs of the various components of the clarifier, and Exhibit A2, Cells J26-J30 for the labour costs of installing the components.[51] The base case flow rate is shown in Cell E33. The scale-up coefficient values are found in Exhibit A2, Cells B30-B35.

If a flow rate is entered by the user, EPIM applies the cost function and scale-up coefficients to calculate the capital cost of each component, and the total project capital cost. Conversely, if the user entered a capital expenditure figure, the cost function calculates an approximate flow rate for the project.

50 For details of the base case cost breakdowns and a discussion of the cost function estimations, see M.M. Dillon's report.

51 Note that the labour cost of installation of a particular component is on the same row as the cost of the component itself.

a) Flow Rate Information Entered By User

In this instance, the cost function will ultimately estimate the total capital cost for the project. The model uses the cost functional form, the values of the scale-up coefficients, and the base case material and labour costs to yield an estimate of the material and labour costs of each component of the project under consideration. The results are displayed in Exhibit A3, Cells M26-M30 for the component costs and Exhibit A3, Cells N26-N30 for the labour installation costs.[52] The total of the material and labour costs is labelled "Direct Capital Costs", and is displayed in Exhibit A3, Cell N33.

Engineering design and site supervision must also be considered as part of the capital cost of a project. M.M. Dillon has estimated these costs as a percentage of the direct capital cost for each technology. This percentage varies depending on the technology under consideration. The percentage for Primary Clarifiers is displayed in Exhibit A2, Cell B37. The calculated value of the indirect capital cost is shown in Exhibit A3, Cell N35, and the total capital cost of the project is found in Exhibit A3, Cell N37.

b) Capital Expenditure Figure Entered By User

In this instance, the cost function will ultimately estimate the flow rate of the project under consideration. The model will also use the cost function, the values of the scale-up coefficients, and the base case material and labour costs to allocate the total capital costs among the various material components, installation labour, and indirect capital costs.

52 This area of the model is labelled "Initial Calculation" but is equivalent to the "Final Calculation" when a flow rate is entered by the user. The "Final Calculation" figures differ from "Initial Calculation" only when a capital expenditure is entered by the user, and is described below.

EXHIBIT A3

	L	M	N	O	P	Q	R	S	T
22	*Direct Capital Cost - Analyzed Case*					*Direct Capital Cost - Analyzed Case*			
23	*Initial Calculation*		*Primary Clarifier*			*Final Calculation*		*Primary Clarifier*	
24									
25		Materials	Labour	Sub-Total			Materials	Labour	Sub-Total
26	Sludge Collector	$81,154	$7,653	$88,807		Sludge Collector	$80,869	$7,626	$88,495
27	Pump	$2,900	$600	$3,500		Pump	$2,900	$600	$3,500
28	Construction	$74,193	$104,417	$178,610		Construction	$73,933	$104,050	$177,983
29	Piping	$3,354	$4,422	$7,775		Piping	$3,342	$4,406	$7,748
30	Elect/Instr	$13,973	$12,754	$26,728		Elect/Instr	$13,924	$12,710	$26,634
31	Subtotal	$175,575	$129,845	*$305,420*		Subtotal	$174,968	$129,392	*$304,360*
32									
33	*Direct Capital Cost*		*$305,420*				*Direct Capital Cost*	*$304,360*	
34									
35	*Indirect Capital Cost*		*$45,813*				*Indirect Capital Cost*	*$45,654*	
36									
37	*Total Capital Cost*		*$351,233*				*Total Capital Cost*	*$350,014*	

After the initial calculation of the capital costs, an additional adjustment is made by EPIM. Because the parameters of the cost functions for individual components are estimates, the sum of the costs calculated by the model for the individual components, the installation labour, and the engineering and supervision work may differ slightly from the total capital cost entered by the user. EPIMreconciles the detailed estimates to the total by a relatively straight-forward adjustment which involves multiplying the cost of each component, the installation labour, and the indirect capital cost by the ratio of the "Initial Calculation" of total capital cost to the actual capital cost entered (Exhibit A3, Cell N37 divided by Exhibit A2, Cell B26). The adjusted component (Exhibit A3, Cells R26-R30), labour (Exhibit A3, S26-S30), and indirect capital costs (Exhibit A3, Cell S35) appear in the area labelled "Final Calculation". The total "final" capital cost (Exhibit A3, Cell S37) should equal the amount entered by the user.[53]

Operating Costs

The same functional form is used to estimate the annual operating costs for a project under consideration. The base case operating costs are shown in Exhibit A4, Cells W26-W29, while the scale-up coefficient for operating costs is displayed in Exhibit A2, Cell B26. The "Analyzed Case" column (Exhibit A4, Cells X26-X29) uses the cost function and the scale-up coefficient to calculate the annual operating costs for the project.

53 This adjustment rule is not followed for certain components of several technologies. The cost of these components does not change as the project size increases. However, they are usually small items such as the pump for the Primary Clarifier. As a result, the "Final Calculation" capital cost may vary slightly from the capital cost input by the user, as it does in Exhibit A3.

EXHIBIT A4

	V	W	X
22	***Operating Cost***		***Primary Clarifier***
23			
24		***Base***	***Analyzed***
25		***Case***	***Case***
26	Labour	$18,000	$29,612
27	Maintenance	$10,000	$16,451
28	Power	$2,000	$3,290
29	*Total*	*$30,000*	*$49,353*
30			
31	***Ontario EPI Expenditures***		
32			
33	Equipment	$62,392	
34	Construction	$73,933	
35	Piping	$3,342	
36	Elect/Instr	$13,924	
37	Installation	$129,392	
38	Engineering	$45,654	
39	*Total*	*$328,637*	

Expenditures in Ontario by the Environmental Protection Industry

EPIM also estimates the amount spent in Ontario by environmental protection firms in the course of completing the project under consideration, based on information gathered from firms by M.M. Dillon regarding EPI firms' purchases in Ontario. The proportion of the value of each component bought in Ontario is displayed in Exhibit A2, Cells F26-F30. These proportions are multiplied by the estimated cost of each component in Exhibit A3, Cells R26-R30, and the Ontario component spending is displayed in Exhibit A4, Cells W33-W36. As well, the installation labour costs in Exhibit A3, Cells S26-S30 are multiplied by the Ontario-purchase proportions in Exhibit A2, Cells I26-I30,[54] and the results are totalled in Exhibit A4, Cell W37. Lastly, the indirect capital costs for engineering are re-shown in Exhibit A4, Cell W38 as Ontario "Engineering" purchases.[55]

GDP and Employment Impacts

In order to estimate the economic impact of a particular environmental protection project, the elements of the capital and operating costs must be allocated to the industry that produces them.[56]

For capital expenditures, these allocations are displayed in Exhibit A5, Cells AC24-AC37 – the column labelled "Shipments (Capital)". In the case of the Primary Clarifier, the following allocations have been made:

Component	*Industry*	
Sludge Collector	98 -	Miscellaneous Machinery
Pump	96 -	Compressor and Turbine

54 For all technologies, the installation labour is assumed to be Ontario workers. Thus, these proportions are always 1.00.

55 For all technologies, the model assumes that the engineering design and site supervision is conducted by the Ontario-based operations of engineering firms.

56 Industries have been selected from the worksheet level of the Interprovincial Input-Output model. See: Statistics Canada, System of National Accounts, *The input-output structure of the Canadian economy*, Catalogue 15-510, pgs. 104-106. The components were assigned to industries based on the list of goods produced contained in: Statistics Canada, *Standard industrial classification*, 1980, Catalogue 12-501E.

Construction	160 -	Other Engineering Construction
Piping[57]	37 -	Plastic Pipe & Fittings (50%)
	78 -	Steel Pipe and Tube (50%)
Electrical/Instrumentation	144 -	Indicating/Recording Instruments
Installation Labour	599 -	Wages & Salaries (commodity)
Indirect Capital Cost	192 -	Professional Business Services

57 According to M.M. Dillon, either plastic or steel piping could be used in all water treatment technologies. The assumption of a 50-50 split of the pipe shipments between plastic and steel is made.

EXHIBIT A5

	Z	AA	AB	AC	AD	AE	AF	AG	AH
22	GDP AND EMPLOYMENT	*GDP*	*Empl.*	*Shipments*	*Shipments*	*GDP*	*GDP*	*Empl.*	*Empl.*
23	*Industry*	*Factors*	*Factors*	*(Capital)*	*(Oper.)*	*(Capital)*	*(Oper.)*	*(Capital)*	*(Oper.)*
24	37 - Plastic Pipe & Pipe Fittings	0.53134	0.13166	1,671		888	0	0.0	0.0
25	40 - Other Plastic Products	0.53134	0.13166			0	0	0.0	0.0
26	78 - Steel Pipe & Tube	0.53134	0.13166	1,671		888	0	0.0	0.0
27	84 - Power Boiler & Heat Exchanger	0.53134	0.13166			0	0	0.0	0.0
28	86 - Fabricated Structural Metal Pdts	0.53134	0.13166			0	0	0.0	0.0
29	96 - Compressor & Turbine	0.53134	0.13166	2,900		1,541	0	0.0	0.0
30	97 - Construction & Mining Machinery	0.53134	0.13166			0	0	0.0	0.0
31	98 - Miscellaneous Machinery	0.53134	0.13166	80,869		42,969	0	0.8	0.0
32	97 (L) - Industrial Chemicals	0.53134	0.13166			0	0	0.0	0.0
33	144 - Indicating/Recording Instruments	0.53134	0.13166	13,924		7,398	0	0.2	0.0
34	155 - Non-Residential Building Constr	0.64215	0.19694			0	0	0.0	0.0
35	160 - Other Engineering Construction	0.64215	0.19694	73,933		47,476	0	1.2	0.0
36	179 - Electric Power Systems	0.77939	0.07922		3,290	0	2,564	0.0	0.0
37	192 - Professional Business Services	0.84726	0.34729	45,654		38,681	0	1.2	0.0
38	599 (commod) - Wages and Salaries	1.00	39,106	129,392	46,062	129,392	46,062	3.3	1.2
39			39,391	*350,014*	*49,353*	*269,233*	*48,627*	*6.8*	*1.2*

Factors that indicate the GDP created in Ontario per dollar of industry shipments are shown in Exhibit A5, Cells AA24-AA37.[58] Industry shipments generated by the capital spending are multiplied by these factors to yield the GDP that results in Ontario, which is displayed in Exhibit A5, Cells AE24-AE37.[59]

The approach to the estimation of employment created by a project is slightly more complicated. Exhibit A5, Cells AB24-AB37 contains factors that indicate the employment created for every $10,000 of industry activity as measured in 1984 dollars. However, the model must adjust the shipments figures from 1991 dollars to 1984 dollars in order to use the employment factors properly. To this end, product price deflators for 1984 and 1991 for each industry are displayed in Exhibit A6, Cells AA3-AA15 and Exhibit A6, AB3-AB15.[60] The ratio of these two deflators is calculated and shown in Exhibit A6, Cells AC3-AC15. Industry shipments are multiplied by these factors to yield 1984 dollar value of shipments. Finally, these adjusted shipment figures are multiplied by the employment factors to arrive at the final estimate for employment created by the project.

The installation labour employment created is determined in a different fashion. Total labour cost (Exhibit A5, Cell AC38) is divided by an average cost of labour in the Ontario construction industry (Exhibit A5, Cell AB38) to yield person years of installation labour employment (Exhibit A5, Cell AG38). The average cost of Ontario construction labour is annual average earnings in the industry, plus benefits.[61]

58 These factors are "Total GDP per Dollar of Activity By Industry (In-Province Effects Only)", provided by the Input/Output Division of Statistics Canada.

59 The factor applicable to labour income paid to installation labour is 1.00, and is shown in Exhibit A5, Cell AA38.

60 Source: Statistics Canada, Industry price indexes, 62-011.

61 Annual average earnings in 1991 were $35,486, according to Statistics Canada, *Employment, earnings and hours*, 72-002. Supplementary labour income as a share of wages and salaries in construction in Canada in 1990 (the most recent year available) was used as an estimate of an additional percentage of cost due to benefits to workers. This percentage was 10.2%, according to Statistics Canada, Income and Expenditure Accounts Division.

EXHIBIT A6

	Z	AA	AB	AC
1	**Deflators for Employment Data**	**1984**	**1991**	**Ratio**
2				
3	Plastic Pipe and Pipe Fittings	95.6	121.9	0.785
4	Other Plastic Products	93.3	117.6	0.793
5	Steel Pipe and Tube	98.8	101.8	0.970
6	Power Boiler and Heat Exchanger	87.8	129.8	0.677
7	Fabricated Structural Metal Pdts	93.9	112.1	0.838
8	Compressor & Turbine	92.7	120.0	0.772
9	Construction & Mining Machinery	93.6	110.4	0.848
10	Miscellaneous Machinery	93.6	122.3	0.765
11	Industrial Chemicals	102.9	109.7	0.938
12	Indicating/Recording Instruments	95.8	112.8	0.850
13	Non-Residential Construction	95.7	117.9	0.812
14	Electricity	89.1	136.6	0.653
15	Professional Business Services	95.2	121.6	0.783

The items of operating costs are allocated to industries (Exhibit A5, Cells AD24-AD38) as follows:

Item	*Industry*	
Power	179	Electric Power Systems
Chemicals[62]	97 (L)	Industrial Chemicals
Maintenance/Labour		Labour Costs

The GDP and employment effects of operating spending are then calculated in a similar fashion to the capital expenditure impacts (Exhibit A5, Cells AF24-AF38, Cells AH24-AH38). For the employment created by operating labour costs, the labour cost is divided by an average Ontario manufacturing labour cost.[63]

Model Outputs

The final results of applying the model are displayed in the "Summary Output Area" (See Exhibit A1). The economic impacts of both the one-time capital spending and the annual operating expenditures are portrayed in Exhibit A1, Columns J and K, respectively. The figures for project cost, person years of employment, GDP, and Ontario EPI expenditures are the sums of the impacts of the project(s) under consideration.

The taxation figures are calculated as proportions of the GDP created. The share of GDP accounted for by Ontario and federal taxes in Fiscal 1990-91 are displayed in Exhibit A1, Cells L12- L13[64]. The Ontario GDP created by the project(s) are multiplied by these proportions to estimate the Ontario and federal taxes generated, and these tax revenue estimates are presented in Exhibit A1, Cells J12-J13 and K12-K13.

62 While chemical addition is not used in the Primary Clarifier technology, several other treatment processes do require chemicals.

63 Average annual manufacturing earnings in Ontario in 1991 were $34,584. Supplementary labour income as a share of manufacturing wages and salaries in Canada in 1990 was 13.9%. Sources are the same as for construction earnings and supplementary labnour income.

64 Sources: GDP – Statistics Canada, Income and Expenditure Accounts Division, *National Income and Expenditure Accounts*; Ontario Ministry of Treasury and Economics, Office of Economic Policy, *Ontario Economic Accounts*. Taxation – Federal and Provinical Budgets.

APPENDIX 2

UTILIZING THE STATISTICS CANADA INPUT/OUTPUT MODEL

A2.1 Introduction

When the Ministry of the Environment is assessing the economic impact of an environmental protection project, and when relatively detailed information on costs is available, it would be possible to use the Statistics Canada Interprovincial Input/Output Model (I/O model) to conduct an analysis. This appendix outlines how the Ministry can make use of the I/O model. Exhibit A7 illustrates the process for utilizing the I/O model.

A2.2 Assembling the Data for Submission to the Model

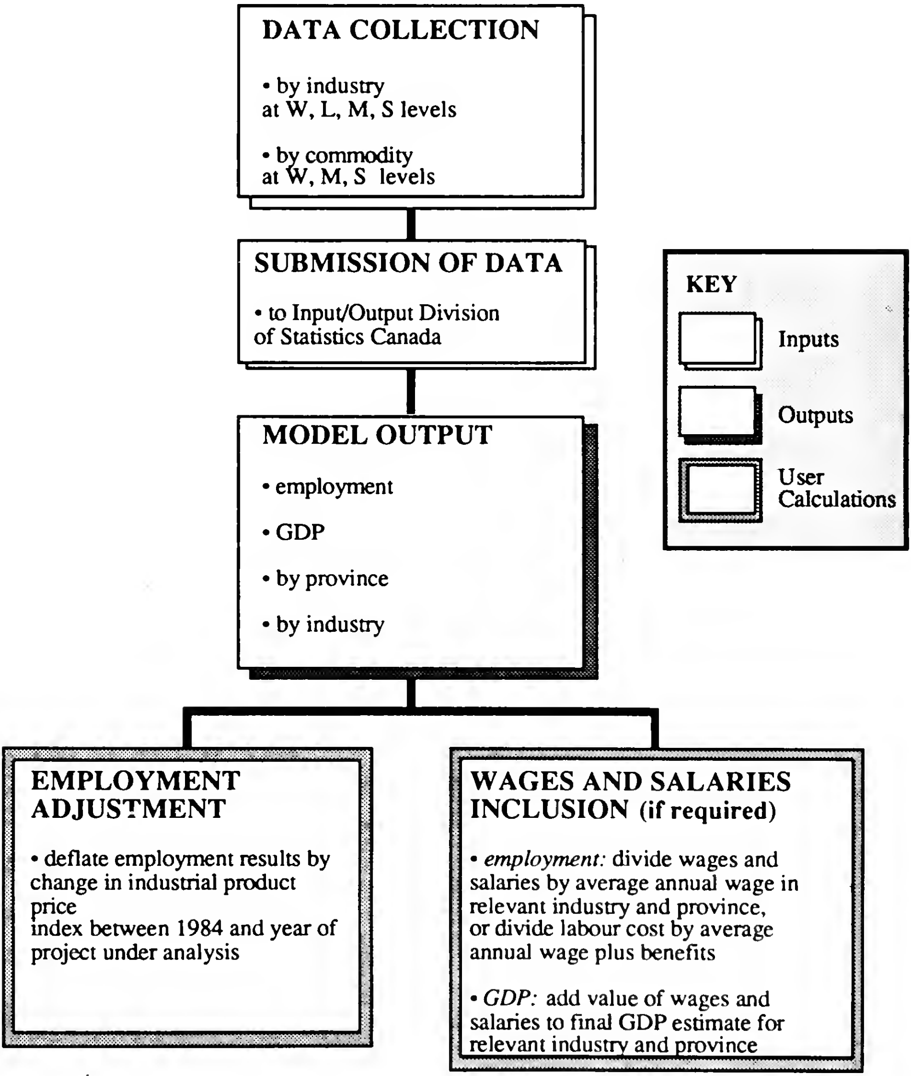
The I/O model can accept data on project spending in two fashions: by the **industries** that receive the spending, or by the **commodities** that are purchased for the project. When collecting data for entry into the model, there are several levels of aggregation (called W, M, and S, in increasing aggregation[65]) available for either the industries or commodities method. However, if data is collected using more aggregated industry or commodity classifications (such as M or S), Statistics Canada will allocate the spending among the various W categories included in each aggregated industry or commodity. Therefore, as often as possible, the Ministry should collect project spending data at the most disaggregated (W) level.[66]

---

65 An additional grouping "L" exists for industry classification, and falls between W and M in terms of aggregation.

66 Copies of the industry and commodity classfications are included at the end of this appendix. Source: Statistics Canada, *The input-output structure of the Canadian economy*, Catalogue 15-510, pgs. 104-106 and 110-114 for industries and pgs. 115-123 for commodities

EXHIBIT A7
USE OF STATISTICS CANADA INPUT/OUTPUT MODEL



Prior Judgement on Relevant Industry or Commodity Categories

The Ministry should review the industry or commodity groupings before developing a request for information on a project. There are 271 groupings of industries and 602 groupings of commodities, and clearly any firm or government agency would be hard pressed to go through all groupings to determine the amount of money directed to each one. Some judgement would be required to pare down the list of possible spending categories to make data collection tractable.

Submitting Data at Different Levels of Aggregation

It is possible to combine spending data at different levels of aggregation for submission to the I/O model. When the Ministry can identify some detailed spending information, but only has a general idea about the nature of other materials , it may be preferable to mix levels of aggregation, and allow Statistics Canada to allocate the general spending according to the parameters of the Input/Output model.

For example, say a particular project involves spending such as:

$250,000 spending on tanks (W level commodity classification 273),

$50,000 on plastic pipe (W level commodity – 135),

$100,000 on calcium chloride (W level commodity – 425), and,

$500,000 on iron & steel products (M level commodity – 45).

In this brief example, the Ministry was able to obtain detailed spending information on tanks, plastic pipe, and calcium chloride, but was only able to discern that the $500,000 amount would be spent on iron and steel products of some sort. Statistics Canada would allocate the $500,000 among the W level of all iron & steel products, according to their usage as embodied in the model parameters. While this mixing of level reduces the accuracy of the submission to the model compared with collecting all data at the W level, it is preferable to collecting all information at the more aggregated M level.

Wages, Salaries, and Other Labour Costs

Some labour cost information may be available on a given environmental protection project, perhaps from either the company installing the technology or from supplying firms. If wages and salaries or benefits data are available, they should be entered separately to increase the accuracy of the final estimate.[67] Otherwise, the I/O model will allocate spending to labour costs according to the parameters embodied within it, which are based on the average relationships in the industry and economy. However, users should be aware that entering labour cost data as a separate category will require some adjustments to be made by the user to the I/O model's results.[68]

A2.3 Input/Output Model Results

The model's results are provided at each level of aggregation (W, L, M, and S) on an industry and province basis.[69] The following economic variables are displayed:

• *final demand by province* – demand created in Canadian provinces by the project spending;

• *final demand by industry* – demand created in Canadian industries by the project spending;

• *direct GDP* – first round of GDP generated by the direct project spending itself;

• *direct employment* – person years of work created by the direct project spending itself;

• *gross production by province and industry (shipments)* – total sales by all businesses resulting from the project and its spin-offs;

---

67 Wages and salaries is represented by W level commodity classification 599, supplementary labour income (benefits) by W level commoodity 600.

68 These adjsustments are outlined in Section A2.4.

69 Statistics Canada can provide both a hard copy and floppy disk copy of the model's output. Users are advised to obtain both. The disk copy is obtainable in Lotus format which can permit manipulation of the data. In Ernst & Young's experience with I/O model analysis, we have frequently wanted to aggregate the results in a different fashion than the model provides. As well, a disk copy will make the adjustments to the output described in Section A2.4 much easier.

• *total endogenous employment* – person years of work created by project and spin-offs;

• *total endogenous GDP at factor cost* – total income/GDP generated by project and spin-offs;

• *summary of intermediate trade flows* – movement of goods and services between provinces and as imports as a result of project and spin-offs; and,

• *income and expenditure account summary* – breakdown of economic impact in the categories used in the National Income and Expenditure Accounts.

A2.4 Adjustments to the Model's Results

Employment

As noted in Section A2.2, in some instances, the Ministry may have information on certain amounts of direct spending on labour as a result of an environmental protection project. If the resulting person years of work are not available, then the Ministry must make its own calculation of the employment impact of the labour costs,[70] because the I/O model does not translate either wages and salaries or supplementary labour income into employment.[71]

If only wages and salaries spending was entered into the model, the user should divide the total amount paid in each industry and province by average annual earnings in the relevant industry and province.[72]

---

70 As also noted in Section A2.4, the accuracy of the model's output is enhanced if any known amounts of wages, salaries, and/or benefits are entered as such. If the Ministry knows the accompanying person years of employment generated, these figures can simply be added to the relevant industry and province. Therefore, the adjustment methods outlined in this section would not be necessary.

71 While this calculation may seem bothersome to the user, in fact it increases the accuracy of the final results. Since the data are entered as labour costs, the model is not able to tell in what industry the associated employees worked. However, the user would know, and can add the proper employment figure to the relevant industry and province results.

72 This information is obtainable by taking the annual average of the monthly data in Statistics Canada, *Employment, earnings and hours*, Catalogue 72-002, or from the Labour Division of Statistics Canada.

The resulting number of jobs should be added to the model's total in that industry and province (see Table A1 for an example involving a project in Ontario and Quebec).

Example Table A1

Calculating Employment Created by Wages and Salaries

	Ontario		Quebec	
	Industry A	Industry B	Industry A	Industry B
Total Wages and Salaries	$4,290,000	$1,700,000	$1,725,000	$2,365,000
Avg. Annual Earnings	$35,750	$42,500	$34,500	$43,000
Person Years Added to I/O Model Employment Results	120	40	50	55

When information on both wages/salaries and benefits (total "labour cost") is submitted to the I/O model, the employment adjustment should be modified. The annual average earnings for the relevant industry and province should still be obtained. In addition, the user will want to estimate an additional percentage for benefits in the relevant industry.[73] With the benefits estimate added, the user has calculated an annual average labour cost. This figure should be divided into the total labour cost by industry and province to yield the additional person years of employment to be added to the model's output (see Table A2 where the previous example is extended to deal with benefits).

73 One possible method of estimating benefits as a share of wages and salaries is to obtain supplementary labour income (SLI) and wages and salaries figures from Statistics Canada, Labour Division. The data is available at some disaggregation only on a nation-wide basis.

Example Table A2
Calculating Employment Created by Labour Costs

	Ontario		Quebec	
	Industry A	Industry B	Industry A	Industry B
Wages and Salaries	$4,290,000	$1,700,000	$1,725,000	$2,365,000
Benefits	$600,000	$145,000	$200,000	$160,000
Total "Labour Costs"	$4,890,000	$1,845,000	$1,925,000	$2,525,000
Avg. Annual Earnings	$35,750	$42,500	$34,500	$43,000
SLI / Wages and Salaries	12.8%	7.6%	12.8%	7.6%
Avg. Annual Labour Cost	$40,326	$45,730	$38,916	$46,268
Person Years Added to I/O Model Employment Results	121.3	40.3	49.5	54.6

GDP

Again, because the I/O model does not know to what industry to credit labour costs entered as wages and salaries or supplementary labour income, the user must adjust the model's total GDP output. The adjustment is simply to add the labour cost amount directly to the GDP result for the relevant industry and province. This approach can be understood by considering that GDP is equivalent to final income, and all wages, salaries, and benefits are final income.

SNA Industry Codes at the Worksheet Level (W) in Terms of 1980 SIC

Codes des industries du SCN au niveau de travail (W) selon la CTI de 1980

No.	INDUSTRY TITLE - W	L#	M#	S#	1980 SIC - CTI	NOM DES INDUSTRIES - W	No
	Business sector					**Secteur des entreprises**	
1	Agriculture, livestock	1	1	1	011 012 021	Agriculture, activite des animaux	1
2	Agriculture, fieldcrop	1	1	1	013-017 022 023	Agri., act. des grandes cultures	2
3	Fishing & trapping industries	2	2	2	031-033	Ind. de la pêche et du piegeage	3
4	Logging & forestry industries	3	3	3	0411 0412 0511	Exploitation forestiere	4
5	Gold mines	4	4	4	0611	Mines d'or	5
6	Other metal mines	5	4	4	0612-0616 0619	Autres mines de metaux	6
7	Iron mines	6	4	4	0617	Mines de fer	7
8	Asbestos mines	7	4	4	0621	Mines d amiante	8
9	Potash mines	8	4	4	0624	Mines de potasse	9
10	Salt mines	9	4	4	0625	Mines de sel	10
11	Misc non-metal mines exc coal	9	4	4	0622 0623 0629	Div mines non metal sauf charbon	11
12	Coal mines	10	4	4	063	Mines de charbon	12
13	Crude petroleum & natural gas	11	5	4	071	Petrole brut & gaz naturel	13
14	Quarry & sand pit industries	12	6	4	081 082	Carrieres & sablieres	14
15	Service related to mineral extract	13	7	4	091 092	Industries des services miniers	15
16	Meat & meat products (exc poultry)	14	8	5	1011	Viande sauf volaille	16
17	Poultry products industry	15	8	5	1012	Industrie de la volaille	17
18	Fish products industry	16	8	5	102	Transformation du poisson	18
19	Fruit and vegetable industries	17	8	5	103	Industries des fruits & legumes	19
20	Dairy products industries	18	8	5	104	Industries laitieres	20
21	Flour & cereal food industries	24	8	5	1051 1052	Ind de la farine et des cereales	21
22	Feed industry	19	8	5	1053	Industrie des aliments pour animaux	22
23	Vegetable oil mills (exc corn oil)	20	8	5	106	Huiles vegetales (sauf de mais)	23
24	Biscuit industry	21	8	5	1071	Industrie des biscuits	24
25	Bread & other bakery products ind	22	8	5	1072	Pain & autres prod de boulangerie	25
26	Cane & beet sugar industry	23	8	5	1081	Sucre de canne & de betterave	26
27	Sugar confectionery industries	24	8	5	1082 1083	Confiseries	27
28	Tea and coffee industry	24	8	5	1091	Industrie du the & du cafe	28
29	Misc food products industries nec	24	8	5	1092 1099	Divers produits alimentaires nca	29
30	Soft drink industry	25	9	5	111	Industrie des boissons gazeuses	30
31	Distillery products industry	26	9	5	112	Ind des produits de distillation	31
32	Brewery products industry	27	9	5	113	Industrie de la biere	32
33	Wine industry	28	9	5	114	Industrie du vin	33
34	Tobacco products industries	29	10	5	121 122	Industries du tabac	34
35	Rubber products industries	30	11	5	151-159	Ind des produits en caoutchouc	35
36	Foamed & expanded plastic products	31	12	5	161	Prod en plastique mousse & souffle	36
37	Plastic pipe & pipe fittings ind	31	12	5	162	Ind des tuyaux en plastique	37
38	Plastic film & sheeting industry	31	12	5	163	Pellicules & feuilles plastiques	38
39	Plastic bag industry	31	12	5	1691	Ind des sacs en matiere plastique	39
40	Other plastic products ind nec	31	12	5	1699	Autres prod matiere plastique nca	40
41	Leather tanneries	32	13	5	1711	Tanneries	41
42	Footwear industry	33	13	5	1712	Industrie de la chaussure	42
43	Misc. leather & allied prod ind	34	13	5	1713,1719	Ind des produits divers en cuir	43
44	Man-made fibre & filament yarn ind	35	14	5	181	Fibres chimiques files de filaments	44
45	Other spun yarn & woven cloth ind	35	14	5	1829	Autres files & tissus tisses	45
46	Wool yarn & woven cloth industry	36	14	5	1821	Filature & tissage de la laine	46
47	Broad knitted fabric industry	37	14	5	183	Ind des tissus larges a maille	47
48	Misc. textile products industries	38	14	5	191,193,1991 1993-1995,1999	Ind. des produits textiles divers	48
49	Contract textile dyeing & finishing	39	14	5	1992	Teinture & finissage prod textiles	49
50	Carpet, mat & rug industry	40	14	5	192	Tapis, carpettes & moquettes	50
51	Men's and boy's clothing industries	41	15	5	243	Vêtements pour hommes & garçonnets	51
52	Women's clothing industries	41	15	5	244	Industries des vêtements pour dames	52
53	Children's clothing industry	41	15	5	245	Ind. des vêtements pour enfants	53
54	Misc. clothing & apparel industries	41	15	5	2491-2493, 2495-2499	Div. industries de l'habillement	54
55	Hosiery industry	42	15	5	2494	Industrie des bas & chaussettes	55
56	Sawmills, planing & shingle mills	43	16	5	251	Scieries, rabotage & bardeaux	56
57	Veneer and plywood industries	44	16	5	252	Ind. des placages & contreplaques	57
58	Pre-fab. wooden bldg. & cabinet	45	16	5	2541,2542	Bâtiments préfab. & armoire en bois	58
59	Door, window & other millwork ind.	45	16	5	2543,2549	Portes, fenêtres & bois travaille	59
60	Wooden box & coffin industries	46	16	5	256,258	Ind. des boites & des cercueils	60
61	Particle & wafer board industries	47	16	5	2592,2593	Panneaux de particule et de copeaux	61
62	Misc. wood industries	47	16	5	2591,2599	Diverses industries du bois	62
63	Household furniture industries	48	17	5	261	Industrie des meubles de maison	63
64	Office furniture industries	49	17	5	264	Industrie des meubles de bureau	64
65	Other furniture & fixture ind.	50	17	5	269	Autres ind. de meubles et articles	65
66	Pulp industry	51	18	5	2711	Industrie des pates a papier	66
67	Newsprint industry	51	18	5	2712	Industrie du papier journal	67
68	Paperboard, bldg board & oth. paper	51	18	5	2713-2719	Carton, panneaux & aut ind papier	68
69	Asphalt roofing industry	52	18	5	272	Ind du papier toiture asphalte	69
70	Paper box & bag industries	53	18	5	273	Boites en carton et sacs en papier	70
71	Other converted paper products ind	54	18	5	279	Aut. produits en papier transforme	71
72	Commercial printing industries	55	19	5	281	Ind. de l'impression commerciale	72
73	Publishing industries	55	19	5	283	Industries de l'edition	73
74	Combined publishing & printing ind.	55	19	5	284	L'impression & l'edition combinees	74
75	Platemaking, typesetting & bindery	56	19	5	282	Clichage, composition & reliure	75
76	Ferro- alloy & steel foundries	57	20	5	2911-2912	Ferro-alliages & fonderies d'acier	76
77	Other primary steel industries	57	20	5	2919	Autres industries siderurgiques	77
78	Steel pipe & tube industry	58	20	5	292	Ind. des tubes & tuyaux d'acier	78
79	Iron foundries	59	20	5	294	Fonderies de fer	79
80	Non-ferrous smelting & refining ind.	60	20	5	295	Fonte & affinage metaux non ferreux	80
81	Aluminum rolling casting, extruding	61	20	5	296	Laminage & moulage de l'aluminium	81
82	Copper rolling, casting & extruding	62	20	5	297	Laminage, moulage, ext. du cuivre	82
83	Other metal rolling, casting etc.	63	20	5	299	Laminage & moulage d'autres metaux	83
84	Power boiler & heat exchanger ind	64	21	5	301	Chaudieres & echangeurs de chaleur	84
85	Pre-eng metal bldg (exc. portable)	64	21	5	3023	Bâtiments prefabriques en metal	85
86	Fabricated structural metal ind nec	64	21	5	3021 3022 3029	Fabrication charpentes en metal nca	86

No.	INDUSTRY TITLE – W	L#	M#	S#	1980 SIC – CTI	NOM DES INDUSTRIES – W	No
	Business sector – Continued					**Secteur des entreprises** – suite	
87	Ornamental & arch. metal prod. ind	65	21	5	303	Produits d'architecture en metal	87
88	Stamped, pressed & coated metals	66	21	5	304	Emboutissage & matricage des metaux	88
89	Wire and wire products industries	67	21	5	305	Fil metallique & ses produits	89
90	Hardware tool & cutlery industries	68	21	5	306	Articles de quincaillerie	90
91	Heating equipment industry	69	21	5	307	Industrie du materiel de chauffage	91
92	Machine shops industry	70	21	5	308	Ateliers d usinage	92
93	Other metal fabricating industries	71	21	5	309	Autres ind. de produits en metal	93
94	Agriculture implement industry	72	22	5	311	Industrie des instruments aratoires	94
95	Commercial refrigeration equipment	73	22	5	312	Equip. commercial de refrigeration	95
96	Compressor & turbine industries	74	22	5	3191 3194	Ind. des compresseurs et turbines	96
97	Construction & mining machinery	74	22	5	3192	Machinerie de construction & mines	97
98	Sawmill & other machinery inc. nec	74	22	5	3193 3199	Ind. de machines pour scierie & nca	98
99	Aircraft & aircraft parts industry	75	23	5	321	Ind. d aeronefs & pieces d aeronefs	99
100	Motor vehicle industry	76	23	5	323	Industrie des vehicules automobiles	100
101	Truck bus body & trailer industry	77	23	5	324	Carrosseries de camions & remorques	101
102	Motor vehicle engine & parts inc	78	23	5	3251	Moteurs & pieces de vehicules	102
103	Motor vehicle wiring assemblies	78	23	5	3252	Assemblages de cables pour vehicule	103
104	Motor vehicle stampings industry	78	23	5	3253	Pieces embouties pour vehicule	104
105	Motor vehicle steering & suspension	78	23	5	3254	Direction suspension pour vehicule	105
106	Motor vehicle wheel & brake inc	78	23	5	3255	Roues & freins pour vehicule	106
107	Motor vehicle plastic parts ind	78	23	5	3256	Pieces en plastique pour vehicule	107
108	Motor vehicle fabric accessories	78	23	5	3257	Accessoires textile pour vehicule	108
109	Other motor vehicle access & parts	78	23	5	3259	Autres pieces & acc. pour vehicule	109
110	Railroad rolling stock industry	79	23	5	326	Ind. du materiel ferroviaire roulant	110
111	Shipbuilding and repair industry	80	23	5	327	Construction reparation de navire	111
112	Misc transportation equipment ind	81	23	5	328 329	Ind. diverses du materiel transport	112
113	Small electrical appliance industry	82	24	5	331	Petits appareils electriques	113
114	Major appliances elec & non-elec	83	24	5	332	Gros appareils electriques ou non	114
115	Electric lighting industries	89	24	5	333	Ind. des appareils d eclairage	115
116	Record players radio & tv receiver	84	24	5	334	Phonographes recepteurs radio & tv	116
117	Telecommunication equipment ind	85	24	5	3351	Equipement de telecommunication	117
118	Electronic parts & components ind	85	24	5	3352	Pieces & composantes electroniques	118
119	Other electronic equipment inc	85	24	5	3359	Autre materiel electronique	119
120	Electronic computers & peripherals	86	24	5	3361	Ordinateurs & equip. peripherique	120
121	Misc office business machines	86	24	5	3362 3369	Diverses machines de bureaux	121
122	Electrical transformer industry	89	24	5	3371	Ind. des transformateurs electriques	122
123	Misc electrical industrial equip	89	24	5	3372 3379	Divers materiel elect. industriel	123
124	Communications energy wire & cable	87	24	5	338	Fils & cables elect. communication	124
125	Battery industry	88	24	5	3391	Industrie des accumulateurs	125
126	Misc electrical product industries	89	24	5	3392 3399	Divers produits electriques	126
127	Clay products industries	90	25	5	351	Industrie des produits en argile	127
128	Cement industry	91	25	5	352	Industrie du ciment	128
129	Concrete products industries	92	25	5	354	Industries des produits en beton	129
130	Ready-mix concrete industry	93	25	5	355	Industrie du beton prepare	130
131	Glass & glass products industries	94	25	5	356	Verre & articles en verre	131
132	Non-metal mineral insulation ind	95	25	5	3594	Isolant de min. non metalliques	132
133	Misc. non-metallic mineral products	95	25	5	357 358,3591-3593,3599	Divers prod. mineraux non metal	133
134	Refined petroleum & coal products	96	26	5	361 369	Prods raffines de petrole & charbon	134
135	Industrial inorganic chemicals nec	97	27	5	3711	Produits chimiques inorganiques nca	135
136	Industrial organic chemicals nec	97	27	5	3712	Produits chimiques organiques nca	136
137	Agricultural chemical industries	103	27	5	372	Produits chimiques d'usage agricole	137
138	Plastic & synthetic resin industry	98	27	5	373	Mat. plastique & resine synthetique	138
139	Pharmaceutical & medicine industry	99	27	5	374	Prod. pharmaceutiques & medicaments	139
140	Paint and varnish industry	100	27	5	375	Industrie des peintures & vernis	140
141	Soap & cleaning compounds industry	101	27	5	376	Savons & composes de nettoyage	141
142	Toilet preparations industry	102	27	5	377	Industrie des produits de toilette	142
143	Other chemical products industries	103	27	5	379	Autres ind. des produits chimiques	143
144	Indicating & recording instruments	108	28	5	3911	Instruments d'indication, etc.	144
145	Other scientific & prof. equipment	108	28	5	3912-3914	Autre equip. scientifique & prof.	145
146	Jewellery & precious metal ind	104	28	5	392	Bijouterie & orfevrerie	146
147	Sporting goods industry	105	28	5	3931	Industrie des articles de sport	147
148	Toys and games industry	105	28	5	3932	Industrie des jouets & jeux	148
149	Sign and display industry	106	28	5	397	Industrie des enseignes & etalages	149
150	Floor tile, linoleum, coated fabric	107	28	5	3993	Dalles, linoleum & tissus enduits	150
151	Musical instrument sound recording	108	28	5	3994	Enregistrement & instr. de musique	151
152	Misc. manufactured products nec	108	28	5	3991,3992,3999	Divers produits manufactures nca	152
153	Repair construction	109	29	6	401-449	Reparation (construction)	153
154	Residential construction	110	29	6	401-449	Construction domiciliaire	154
155	Non-residential bldg. construction	111	29	6	401-449	Batiments autres que domiciliaires	155
156	Road, highway & airstrip const.	112	29	6	401-449	Const. routes & pistes d'atter.	156
157	Gas & oil facility construction	113	29	6	401-449	Const. inst. gazif. & petrolif.	157
158	Dams & irrigation projects	114	29	6	401-449	Barrages & projets d'irrigation	158
159	Railway & telephone telegraph const.	115	29	6	401-449	Const. ch. de fer, teleg. telephone	159
160	Other engineering construction	116	29	6	401-449	Autres travaux de genie	160
161	Construction, other activities	117	29	8	401-449	Construction, autres activites	161
162	Air transport & services incidental	118	30	7	451,452	Transp. aerien & services relatifs	162
163	Railway transport & rel. services	119	30	7	453	Transp. ferroviaire & services rel.	163
164	Water transport & rel. services	120	30	7	454,455	Transp. par eau & services rel.	164
165	Truck transport industries	121	30	7	456	Industries du camionnage	165
166	Urban transit system industry	122	30	7	4571	Ind. du transport en commun urbain	166
167	Interurban & rural transit systems	123	30	7	4572	Transp. en commun interurbain/rural	167
168	Taxicab industry	124	30	7	4581	Industrie du taxi	168
169	Misc. transportation industries	125	30	7	4573-4575,4589	Diverses industries du transport	169
170	Other services incid. to transport	125	30	7	4592,4599,996,9991	Autres services relatifs au transp.	170
171	Highway & bridge maintenance ind	126	30	7	4591	Entretien des routes, rues & ponts	171

SNA Industry Codes at the Worksheet Level (W) in Terms of 1980 SIC – Concluded

Codes des industries du SCN au niveau de travail (W) selon la CTI de 1980 – fin

No.	INDUSTRY TITLE – W	L#	M#	S#	1980 SIC - CTI	NOM DES INDUSTRIES – W	No
	Business sector – Concluded					**Secteur des entreprises – fin**	
172	Natural gas pipeline transport ind	127	31	7	4611	Transp du gaz naturel par gazoduc	172
173	Crude oil & other pipeline transp	127	31	7	4612 4619	Transp par pipelines sauf gaz nat	173
174	Storage and warehousing industries	128	32	7	471 479	Ind d'entreposage & d'emmagasinage	174
175	Radio & television broadcasting ind	129	33	8	4811-4813	Ind de la radio & telediffusion	175
176	Cable television industry	129	33	8	4814	Industrie de la teledistribution	176
177	Telecommunication carriers & other	130	33	8	482 483	Telecommunications transmission/aut	177
178	Postal service industry	131	33	8	4841	Industrie des service postaux	178
179	Electric power systems industry	132	34	9	491	Industrie de l'energie electrique	179
180	Gas distribution systems industry	133	34	9	492	Industrie de la distribution de gaz	180
181	Other utility industries nec	134	34	9	499	Autres ind de services publics nca	181
182	Wholesale trade industries	135	35	10	501-599	Industries du commerce de gros	182
183	Retail trade industries	136	36	11	601-692	Industries du commerce de detail	183
184	Banks & oth. deposit accepting inst	137	37	12	701 702 709	Banques & aut intermediaires depot	184
185	Trust deposit accepting mortgage co	138	37	12	703 704	Soc de fiducie & de pret hypoth	185
186	Credit unions	137	37	12	705	Caisses d'epargne et de credit	186
187	Other finance & real estate ind	138	37	12	711-729 741-743 7499 7511 7512 759 761	Aut agents financiers immobiliers	187
188	Insurance industries	139	38	12	731 732 733	Industries des assurances	188
189	Govt royalties on nat resources	140	39	12	7495	Redevances gouv sur ressources nat	189
190	Owner occupied dwellings	141	40	12	7513	Immeubles occupes par proprietaire	190
191	Computer & related services	142	41	13	772	Services d'informatique & connexes	191
192	Professional business services	143	41	13	773 775 776	Serv professionnels aux entrepr	192
193	Advertising services	144	41	13	774	Services de publicite	193
194	Misc business services	145	41	13	771 777 779	Divers services aux entreprises	194
195	Educational service industries	145	42	13	851-859	Ind des services d'enseignement	195
196	Hospitals	146	43	13	861	Hopitaux	196
197	Homes for personal & nursing care	147	43	13	8621	Centres de soins infirmiers & person	197
198	Other health and social services	147	43	13	863 865 866 8671 8679 868 8691-8693 8699	Aut serv de soin de sante soc aux	198
199	Accommodation service industries	148	44	13	911-914	Industries de l'hebergement	199
200	Food & beverage service industries	148	44	13	921.922	Industries de la restauration	200
201	Motion picture & video prod dist	149	45	13	961	Proc & dist films & mat audiov	201
202	Motion picture exhibition	149	45	13	962	Projection de films cinema	202
203	Theatre sports & rec services	150	45	13	963 9641 9642 965 969	Theatres sports & serv loisirs	203
204	Race tracks and gambling operations	150	45	13	9643 9644 966	Hippodromes loteries & jeux hasard	204
205	Laundries & cleaners	151	46	13	972	Blanchissage et nettoyage a sec	205
206	Other personal services	152	46	13	971 973.979	Autres services personnels	206
207	Photographers	153	47	13	993	Photographes	207
208	Bus ass./mach. car leasing/oth serv	154	47	13	982.983.991. 992.9999.4842	Ass. com. loc. mach. auto./ aut serv	208
209	Other repair & maintenance services	154	47	13	994.995	Aut. serv. reparation/aux bâtiments	209
210	Operating supplies	155	48	14	Fictive	Fournitures d'exploitation	210
211	Office supplies	156	48	14	Fictive	Fournitures de bureau	211
212	Cafeteria supplies	157	48	14	Fictive	Fournitures de cafeteria	212
213	Laboratory supplies	158	48	14	Fictive	Fournitures de laboratoire	213
214	Travel & entertainment	159	49	15	Fictive	Deplacement & representation	214
215	Advertising & promotion	160	49	15	Fictive	Publicite & promotion	215
216	Transportation margins	161	50	16	Fictive	Marge de transports	216
	Non-business sector					**Secteur non commercial**	
251	Mining industries	162	51	17	061-092	Industries des mines	251
252	Manufacturing industries	163	52	18	101-399	Industries manufacturières	252
253	Forestry services industry	164	53	19	051	Industrie des services forestiers	253
254	Other transport industries	165	54	20	451-457	Autres industries du transport	254
255	Highway & bridge maintenance ind.	166	54	20	4591	Entretien des routes, rues & ponts	255
256	Radio & television broadcasting ind	167	55	21	4811-4813	Ind. de la radio & télédiffusion	256
257	Water systems industry	168	56	22	493	Industrie de la distribution d'eau	257
258	Insurance & other finance industry	169	57	23	711-743 7499.7512.759.761	Assurance & aut. agents financiers	258
259	Business service industries	170	58	25	771-773. 775-779	Services aux entreprises	259
260	Defence services	171	59	24	811	Services de defense	260
261	Other federal government services	172	59	24	812-817.841	Aut. services de l'admin. federale	261
262	Provincial government services	173	59	24	822 827	Services des admin. provinciales	262
263	Local government services	174	59	24	832-837	Services des admin. locales	263
264	Educational service industries	175	60	25	851-859	Ind. des services d'enseignement	264
265	Hospitals	176	61	25	861	Hopitaux	265
266	Institutional, social services	177	61	25	8622-8629.864. 8672.8694	Etabl. de soins & services sociaux	266
267	Other health & social services	178	61	25	8621.863.865. 866.8671.8679. 8691-8693.8699	Aut. services soin de santé/sociaux	267
268	Amusement & other service ind.	179	62	25	963.9641.9642. 911-922.971.973. 979.994.995	Divertissements & autres services	268
269	Private households	180	63	25	974	Ménages	269
270	Religious organizations	181	63	25	981	Organisations religieuses	270
271	Other non-profit organizations	182	63	25	984-986	Aut. organisations sans but lucratif	271

SNA Industry Codes at the Aggregation Level (L) in Terms of Both 1980 SIC and Worksheet Level (W) and 1970 SIC and Worksheet Level (W)

Codes des industries du SCN au niveau d'agrégation (L) selon la CTI et les niveaux de travail (W) de 1980 et selon la CAÉ et les niveaux de travail (W) de 1970

No.	INDUSTRY TITLE - L	1980 W - #	1980 SIC - CTI	1970 W - #	1970 SIC - CAE	NOM DES INDUSTRIES - L	No
	Business sector					**Secteur des entreprises**	
1	Agricultural & related services ind	1 2	011-23	1	001-021	Ind. agricoles & de serv. connexes	1
2	Fishing & trapping industries	3	031-033	3	041-047	Ind. de la peche et du piegeage	2
3	Logging & forestry industries	4	0411,0412, 0511	2	031,039	Exploitation forestiere	3
4	Gold mines	5	0611	4	051-052	Mines d'or	4
5	Other metal mines	6	0612-0616, 0619	5,7	057,059	Autres mines de metaux	5
6	Iron mines	7	0617	6	058	Mines de fer	6
7	Asbestos mines	8	0621	10	071	Mines d'amiante	7
8	Non-metal mines ex coal & asbestos	9,11	0622-0624 0629	11,13	072 073 0791, 0792 0794-0799	Mines non metal. ex charbon amiante	8
9	Salt mines	10	0625	12	0793	Mines de sel	9
10	Coal mines	12	063	8	061	Mines de charbon	10
11	Crude petroleum & natural gas	13	071	9	064	Petrole brut & gaz naturel	11
12	Quarry & sand pit industries	14	081 082	14	083,084	Carrieres & sablieres	12
13	Service related to mineral extract	15	091 092	15	096 098 099	Industries des services miniers	13
14	Meat & meat prod (exc poultry)	16	1011	16	1011	Viande sauf volaille	14
15	Poultry products industry	17	1012	17	1012	Industrie de la volaille	15
16	Fish products industry	18	102	19	102	Transformation du poisson	16
17	Fruit and vegetable industries	19	103	20	103	Industries des fruits & legumes	17
18	Dairy products industries	20	104	18	104	Industries laitieres	18
19	Feed industry	22	1053	21	106	Industrie des aliments pour animaux	19
20	Vegetable oil mills (exc corn oil)	23	106	27	1083	Huiles vegetales (sauf de mais)	20
21	Biscuit industry	24	1071	23	1071	Industrie des biscuits	21
22	Bread & other bakery products ind	25	1072	24	10721	Pain & autres prod. de boulangerie	22
23	Cane & beet sugar industry	26	1081	25	1082	Sucre de canne & de betterave	23
24	Misc. food products industries	21, 27-29	109 1051 1052 1082 1083	22 25,29	105 1081 1089	Produits alimentaires divers	24
25	Soft drink industry	30	111	29	1091	Industrie des boissons gazeuses	25
26	Distillery products industry	31	112	30	1092	Ind. des produits de distillation	26
27	Brewery products industry	32	113	31	1093	Industrie de la biere	27
28	Wine industry	33	114	32	1094	Industrie du vin	28
29	Tobacco products industries	34	121 122	33 34	151 153	Industries du tabac	29
30	Rubber products industries	35	151-159	36 37	1623 1629	Ind. des produits en caoutchouc	30
31	Plastic products industries	36-40	161-169	38	1651,27332	Produits en matiere plastique	31
32	Leather tanneries	41	1711	39	172	Tanneries	32
33	Footwear industry	42	1712	35,40	1624,174	Industrie de la chaussure	33
34	Misc. leather & allied prod. ind	43	1713,1719	42	179	Ind. des produits divers en cuir	34
35	Man-made fibre yarn & woven cloth	44,45	181,1829	43,45	181,183	Fibres chimiques & tissus tissés	35
36	Wool yarn & woven cloth industry	46	1821	44	182	Filature & tissage de la laine	36
37	Broad knitted fabric industry	47	183	57	2391	Ind. des tissus larges a maille	37
38	Misc. textile products industries	48	191,193,1991 1993-1995, 1999	46-50 53-55	184,1651, 1852 1671, 1872,1691-1893,1899	Ind. des produits textiles divers	38
39	Contract textile dyeing & finishing	49	1992	52	1894	Teinture & finissage prod. textiles	39
40	Carpet, mat & rug industry	50	192	51	186	Tapis, carpettes & moquettes	40
41	Clothing industries exc. hosiery	51-54	243-245, 2491-2493, 2495-2499	41,58	175,2392, 243-249	Ind. de l'habillement sauf bas	41
42	Hosiery industry	55	2494	56	231	Industrie des bas & chaussettes	42
43	Sawmills, planing & shingle mills	56	251	59	251	Scieries, rabotage & bardeaux	43
44	Veneer and plywood industries	57	252	60	252	Ind. des placages & contreplaqués	44
45	Sash, door & other millwork ind.	58,59	254	61	254	Portes, châssis, autres bois ouvrés	45
46	Wooden box & coffin industries	60	256,258	62,63	256,258	Ind. des boites & des cercueils	46
47	Other wood industries	81,62	259	64	259	Autres industries du bois	47
48	Household furniture industries	63	261	65	2619	Industrie des meubles de maison	48
49	Office furniture industries	64	264	66	264	Industrie des meubles de bureau	49
50	Other furniture & fixture ind.	65	269	67	266	Autres ind. de meubles & articles	50
51	Pulp & paper industries	66-68	271	69	271	Industries des pâtes et papier	51
52	Asphalt roofing industry	69	272	70	272	Ind. du papier-toiture asphalte	52
53	Paper box & bag industries	70	273	71	2731,2732, 27331	Boites en carton et sacs en papier	53
54	Other converted paper products ind.	71	279	72	274	Aut. produits en papier transforme	54
55	Printing & publishing ind.	72-74	281,283 284	73	286 288,289	Imprimerie & edition	55
56	Platemaking, typesetting & bindery	75	282	74	287,8932	Clichage, composition & reliure	56
57	Primary steel industries	76,77	291	75	291	Industries siderurgiques	57
58	Steel pipe & tube industry	78	292	76	292	Ind. des tubes & tuyaux d'acier	58
59	Iron foundries	79	294	77	294	Fonderies de fer	59
60	Non-ferrous smelting & refining ind	80	295	78,79	295	Fonte & affinage metaux non ferreux	60
61	Aluminum rolling casting, extruding	81	296	80	296	Laminage & moulage de l'aluminium	61
62	Copper rolling casting & extruding	82	297	81	297	Laminage, moulage, ext. du cuivre	62
63	Other metal rolling, casting etc.	83	299	82	298	Laminage & moulage d'autres metaux	63
64	Power boiler & struct. metal ind.	84-86	301-302	83,84	301,302	Chaudières & éléments de charpente	64
65	Ornamental & arch. metal prod. ind.	87	303	85	303	Produits d'architecture en metal	65
66	Stamped, pressed & coated metals	88	304	86	304	Emboutissage & matriçage des metaux	66
67	Wire and wire products industries	89	305	87	305	Fil métallique & ses produits	67
68	Hardware, tool & cutlery industries	90	306	88	306	Articles de quincaillerie	68
69	Heating equipment industry	91	307	89	307	Industrie du matériel de chauffage	69
70	Machine shops industry	92	308	90	308	Ateliers d'usinage	70
71	Other metal fabricating industries	93	309	91	309	Autres ind. de produits en metal	71
72	Agriculture implement industry	94	311	92	311	Industrie des instruments aratoires	72
73	Commercial refrigeration equipment	95	312	94	316	Equip. commercial de refrigeration	73
74	Other machinery & equipment ind	96-98	319	93	315	Autre machinerie & equipement	74

SNA Industry Codes at the Aggregation Level (L) in Terms of Both 1980 SIC and Worksheet Level (W) and 1970 SIC and Worksheet Level (W) - Continued

Codes des industries du SCN au niveau d'agrégation (L) selon la CTI et les niveaux de travail (W) de 1980 et selon la CAÉ et les niveaux de travail (W) de 1970 - suite

No.	INDUSTRY TITLE - L	1980 W - #	1980 SIC - CTI	1970 W - #	1970 SIC - CAE	NOM DES INDUSTRIES - L	No
	Business sector - Continued					**Secteur des entreprises - suite**	
75	Aircraft & aircraft parts industry	99	321	96	321	Ind d'aeronefs & pieces d'aeronefs	75
76	Motor vehicle industry	100	323	97	323	Industrie des vehicules automobiles	76
77	Truck bus body & trailer industry	101	324	98	324	Carrosseries de camions & remorques	77
78	Motor vehicle parts & accessories	102-109	325	99	1652 188 325	Pieces & accessoires pour vehicules	78
79	Railroad rolling stock industry	110	326	100	326	Ind du materiel ferroviaire roulant	79
80	Shipbuilding and repair industry	111	327	101	327	Construction reparation de navire	80
81	Misc transportation equipment ind	112	328 329	102	328 329	Ind diverses du materiel transport	81
82	Small electrical appliance industry	113	331	103	331	Petits appareils electriques	82
83	Major appliances (elec & non-elec)	114	332	104	332	Gros appareils (electriques ou non)	83
84	Record players radio & tv receiver	116	334	105	334	Phonographes recepteurs radio & tv	84
85	Electronic equipment industries	117-119	335	106	335	Industrie du materiel electronique	85
86	Office store & business machines	120 121	336	95	318	Ordinateurs & autre mach de bureau	86
87	Communic energy wire & cable	124	338	109	338	Fils & cables, elect communication	87
88	Battery industry	125	3391	108	3391	Industrie des accumulateurs	88
89	Other elect & electronic products	115 122 123 126	333 337 3392-3399	58 107 110	268 333 336 3399	Autres prod elect & electroniques	89
90	Clay products industry	127	351	115	351	Industrie des produits en argile	90
91	Cement industry	128	352	111	352	Industrie du ciment	91
92	Concrete products industry	129	354	113	354	Industries des produits en beton	92
93	Ready-mix concrete industry	130	355	114	355	Industrie du beton prepare	93
94	Glass & glass products industries	131	356	119	356	Verre & articles en verre	94
95	Non-metallic mineral products nec	132 133	357 359	112 120 116-118	353 357-359	Produits mineraux non metal nca	95
96	Refined petroleum & coal products	134	361 369	121 122	365 369	Prods raffines de petrole & charbon	96
97	Industrial chemicals industries nec	135 136	371	129	378	Prods chimiques a usage indust nca	97
98	Plastic & synthetic resin industry	138	373	124	373	Mat plastique & resine synthetique	98
99	Pharmaceutical & medicine industry	139	374	125	374	Prod pharmaceutiques & medicaments	99
100	Paint and varnish industry	140	375	126	375	Industrie des peintures & vernis	100
101	Soap & cleaning compounds ind	141	376	127	376	Savons & composes de nettoyage	101
102	Toilet preparations industry	142	377	128	377	Industrie des produits de toilette	102
103	Chemical & chemical products nec	137 143	372 379	123,130	372 379	Industries chimiques nca	103
104	Jewellery & precious metal ind	146	392	132	392	Bijouterie & orfevrerie	104
105	Sporting goods & toy industries	147 148	393	134	393	Ind des articles de sport & jouets	105
106	Sign and display industry	149	397	136	397	Industrie des enseignes & etalages	106
107	Floor tile linoleum coated fabric	150	3993	135	3993	Dalles linoleum & tissus enduits	107
108	Other manufacturing ind nec	144 145 151 152	391 3991 3992 3994, 3999	131 133 137	391 3991 3992-3994 3999	Aut industries manufacturieres nca	108
109	Repair construction	153	401-449	138	404-421	Reparation (construction)	109
110	Residential construction	154	401-449	139	404-421	Construction domiciliaire	110
111	Non-residential bldg construction	155	401-449	140	404-421	Batiments autres que domiciliaires	111
112	Road, highway & airstrip const	156	401-449	141	404-421	Const routes & pistes d'atter	112
113	Gas & oil facility construction	157	401-449	142	404 421	Const inst gazif & petrolif	113
114	Dams & irrigation projects	158	401-449	143	404 421	Barrages & projets d'irrigation	114
115	Railway & telephone teleg const	159	401-449	144	404-421	Const ch de fer, teleg telephone	115
116	Other engineering construction	160	401-449	145	404-421	Autres travaux de genie	116
117	Construction, other activities	161	401-449	146	404-421	Construction, autres activites	117
118	Air transport & services incidental	162	451,452	147	501,502	Transp. aerien & services relatifs	118
119	Railway transport & rel. services	163	453	150	503	Transp. ferroviaire & services rel.	119
120	Water transport & rel. services	164	454,455	149	504-505	Transport par eau & services rel.	120
121	Truck transport industries	165	456	151	506,507	Industries du camionnage	121
122	Urban transit system industry	166	4571	153	509	Ind du transport en commun urbain	122
123	Interurban & rural transit systems	167	4572	152	508	Transp en commun interurbain/ rural	123
124	Taxicab industry	168	4581	154	512	Industrie du taxi	124
125	Other transport & serv. to transp.	169,170	4573-4575, 4589 4592, 4599,996 9991	148	517,519	Aut. ind. & serv. rel. aux transp.	125
126	Highway & bridge maint. ind	171	4591	156	518	Entretien des routes, rues & ponts	126
127	Pipeline transport industries	172,173	461	155	515	Ind du transport par pipelines	127
128	Storage and warehousing ind.	174	471,479	157	524 527	Ind d'entreposage & d'emmagasinage	128
129	Telecommun broadcasting ind	175 176	481	158	543	Ind de la diffusion des telecom	129
130	Telecommunication carriers & other	177	482 483	159	544 545	Telecommunications transmission aut	130
131	Postal service industry	178	4841	160	548	Industrie des service postaux	131
132	Electric power systems industry	179	491	161	572	Industrie de l'energie electrique	132
133	Gas distribution systems industry	180	492	162	574	Industrie de la distribution de gaz	133
134	Other utility industries nec	181	499	163	579	Autres ind de services publics nca	134
135	Wholesale trade industries	182	501-599	164	602-629	Industries du commerce de gros	135
136	retail trade industries	183	601-692	165	10722,2611, 631-699	Industries du commerce de detail	136
137	Banks, credit union & oth. dep. inst.	184,186	701,702,705 709	166	7011-7013, 7016, 7019	Banques, caisses d'epargne aut. inst.	137
138	Trust, other finance & real estate	185,187	703,704, 711-729 741-743, 7499, 7511, 7512,759 761	170	7014-7015, 7212 703- 715,735- 7371	Soc fiducie aut. agents fin immob	138
139	Insurance industries	188	731 733	169	7211	Industries des assurances	139
140	Govt royalties on nat. resources	189	7495	167	7372	Redevances gouv sur ressources nat.	140

SNA Industry Codes at the Aggregation Level (L) in Terms of Both 1980 SIC and Worksheet Level (W) and 1970 SIC and Worksheet Level (W) – Concluded

Codes des industries du SCN au niveau d'agrégation (L) selon la CTI et les niveaux de travail (W) de 1980 et selon la CAE et les niveaux de travail (W) de 1970 – fin

No.	INDUSTRY TITLE - L	1980 W - #	1980 SIC - CTI	1970 W - #	1970 SIC - CAÉ	NOM DES INDUSTRIES - L	N°
	Business sector – Concluded					**Secteur des entreprises – fin**	
141	Owner occupied dwellings	190	7513	166	7373	Immeubles occupes par proprietaire	141
142	Other business service industries	191 194	771 772, 777 779	183	851-855, 867 869	Aut. ind. des serv. aux entreprises	142
143	Professional business services	192	773 776.775	176	861.863, 864.866	Serv. professionnels aux entrepris	143
144	Advertising services	193	774	177	862	Services de publicite	144
145	Educational service industries	195	851-859	171	801-809	Ind. des services d'enseignement	145
146	Hospitals	196	861	172	821	Hôpitaux	146
147	Other health services	197 198	8621 863 865 866 8671.8679 868 8691-8693 8699	173	822-827	Aut ind. des serv de soins de sante	147
148	Accommodation & food serv. ind.	199 200	911-922	179	881-886	Hebergement & restauration	148
149	Motion picture & video industries	201.202	961 962	174	841.842	Ind. du cinema & de l'audiovisuel	149
150	Other amusement & recreational serv	203 204	963-969	175	843-845.849	Autre serv. de divert. & de loisir	150
151	Laundries & cleaners	205	972	178	874 876	Blanchissage et nettoyage a sec	151
152	Other personal services	206	971 973 979	180	871 872 877 879	Autres services personnels	152
153	Photographers	207	993	181	8931	Photographes	153
154	Misc. service industries	208 209	982 983 991 992 994 995 9999 4842	182	891 894-899	Industries des services divers	154
155	Operating supplies	210	Fictive	184	Fictive	Fournitures d'exploitation	155
156	Office supplies	211	Fictive	185	Fictive	Fournitures de bureau	156
157	Cafeteria supplies	212	Fictive	186	Fictive	Fournitures de cafeteria	157
158	Laboratory supplies	213	Fictive	188	Fictive	Fournitures de laboratoire	158
159	Travel & entertainment	214	Fictive	189	Fictive	Deplacement & representation	159
160	Advertising & promotion	215	Fictive	190	Fictive	Publicite & promotion	160
161	Transportation margins	216	Fictive	187	Fictive	Marge de transports	161
	Non-business sector					**Secteur non commercial**	
162	Mining industries	251	061-092	201	051-099	Industries des mines	162
163	Manufacturing industries	252	101-399	202	101-399	Industries manufacturieres	163
164	Forestry services industry	253	051	203	039	Industrie des services forestiers	164
165	Other transport industries	254	451-457	204	501 505	Autres industries du transpor	165
166	Highway & bridge maint. ind.	255	4591	205	516	Entretien des routes, rues & ponts	166
167	Radio & telev. broadcasting ind	256	4811-4813	206	543	Ind. de la radio & telediffusion	167
168	Water systems industry	257	493	207	576	Industrie de la distribution d'eau	168
169	Insurance & other finance ind.	258	711-743, 7499, 7512, 759,761	208	7014,7015, 721, 703-715, 735-737	Assurance & aut. agents financiers	169
170	Business service industries	259	771-773, 775-779	209	851-869	Services aux entreprises	170
171	Defence services	260	811	210	902	Services de défense	171
172	Federal government services	261	812-817,841	211	909,991	Services de l'admin. fédérale	172
173	Provincial government services	262	822-827	212	931	Services des admin. provinciales	173
174	Local government services	263	832-837	213	951	Services des admin. locales	174
175	Educational service industries	264	851-859	214	801-809	Ind. des services d'enseignement	175
176	Hospitals	265	861	215	821	Hôpitaux	176
177	Institutional, social services	266	8622-8629, 8694, 864 8672,	216	828	Établ. de soins & services sociaux	177
178	Other health & social services	267	8621,863,865 866, 8671, 8679, 8691 8693, 8699	217	822-827	Aut. services soin de santé/sociaux	178
179	Amusement & other service ind.	268	963,9641, 9642 911-, 922971,973 979,994,995	218	841-849, 881-886, 897.898	Divertissements & autres services	179
180	Private households	269	974	219	873	Menages	180
181	Religious organizations	270	981	220	831	Organisations religieuses	181
182	Other-non profit organizations	271	984-986	221	891.899	Aut. organisations sans but lucratif	182

SNA Industry Codes at the Aggregation Level (M) in Terms of 1980 and 1970 Worksheet Levels

Codes des industries du SCN au niveau d'agregation (M) selon les niveaux de travail (W) de 1980 et de 1970

No.	INDUSTRY TITLE - M	1980 W - #	1970 W - #	NOM DES INDUSTRIES - M	No
	Business sector			**Secteur des entreprises**	
1	Agricultural & related services ind	1 2	1	Ind agricoles & de serv connexes	1
2	Fishing & trapping industries	3	3	Ind de la peche et du piegeage	2
3	Logging & forestry industries	4	2	Exploitation forestiere	3
4	Mining industries	5 12	4-8 10-13	Industries des mines	4
5	Crude petroleum & natural gas	13	9	Petrole brut & gaz naturel	5
6	Quarry & sand pit industries	14	14	Carrieres & sablieres	6
7	Service related to mineral extract.	15	15	Industries des services miniers	7
8	Food industries	16-29	16-28	Industries des aliments	8
9	Beverage industries	30-33	29-32	Industries des boissons	9
10	Tobacco products industries	34	33 34	Industries du tabac	10
11	Rubber products industries	35	36-37	Ind des produits en caoutchouc	11
12	Plastic products industries	36-40	38	Produits en matiere plastique	12
13	Leather & allied products ind	41-43	35 39,40,42	Ind du cuir & produits connexes	13
14	Primary textile & textile prod ind	44-50	43 55,57	Ind textiles & produits textiles	14
15	Clothing industries	51-55	41 56 58	Industries de l'habillement	15
16	Wood industries	56-62	59-64	Industries du bois	16
17	Furniture & fixture industries	63-65	65 67	Meubles & articles d ameublement	17
18	Paper & allied products industries	66 71	69 72	Ind du papier & produits connexes	18
19	Printing publishing & allied ind	72-75	73 74	Imprimerie edition & ind connexes	19
20	Primary metal industries	76 83	75 82	Premiere transformation des metaux	20
21	Fabricated metal product industries	84-93	83-91	Fabrication des produits en metal	21
22	Machinery industries	94-98	92 94	Industries de la machinerie	22
23	Transportation equipment industries	99-112	96-102	Industries du materiel de transport	23
24	Electrical & electronic products	113 126	58 95 103 110	Prod electriques & electroniques	24
25	Non metallic mineral products ind	127 133	111 120	Produits mineraux non metalliques	25
26	Refined petroleum & coal products	134	121 122	Prod raffines de petrole & charbon	26
27	Chemical & chemical products ind	135-143	123 130	Industries chimiques	27
28	Other manufacturing industries	144 152	131-137	Autres industries manufacturieres	28
29	Construction industries	153 161	138-146	Industries de la construction	29
30	Transportation industries	162-171	147-154 156	Industries du transport	30
31	Pipeline transport industries	172-173	155	Ind du transport par pipelines	31
32	Storage & warehousing industries	174	157	Ind d entreposage & d'emmagasinage	32
33	Communication industries	175 178	158-160	Industries des communications	33
34	Other utility industries	179 181	161-163	Aut industries de services publics	34
35	Wholesale trade industries	182	164	Industries du commerce de gros	35
36	Retail trade industries	183	165	Industries du commerce de detail	36
37	Finance & real estate industries	184 187	168 170	Ind financieres et immobilieres	37
38	Insurance industries	188	169	Industries des assurances	38
39	Govt royalties on nat. resources	189	167	Redevances gouv sur ressources nat	39
40	Owner occupied dwellings	190	166	Immeubles occupes par proprietaire	40
41	Business service industries	191-194	176,177 183	Ind des services aux entreprises	41
42	Educational service industries	195	171	Ind des services d'enseignement	42
43	Health services industry	196-198	172,173	Ind des services de soins de sante	43
44	Accommodation & food service ind	199-200	179	Hebergement & restauration	44
45	Amusement & recreational services	201-204	174 175	Serv de divertissements et loisirs	45
46	Personal & household service ind	205-206	178,180	Ind des serv personnels & domest.	46
47	Other service industries	207-209	181,182	Autres industries des services	47
48	Operating, off., cafet. & lab. sup.	210-213	184-186,188	Fourn explo., bur., lab et caf.	48
49	Travel, advertising & promotion	214,215	189,190	Tourisme, promotion et publicite	49
50	Transportation margins	218	187	Marge de transports	50
	Non-business sector			**Secteur non commercial**	
51	Mining industries	251	201	Industries des mines	51
52	Manufacturing industries	252	202	Industries manufacturieres	52
53	Forestry services industry	253	202	Industrie des services forestiers	53
54	Transportation industries	254,255	204,205	Industries du transport	54
55	Radio & television broadcasting ind.	256	206	Ind de la radio et telediffusion	55
56	Water systems industry	257	207	Industrie de la distribution d'eau	56
57	Insurance & other finance industry	258	208	Assurance & aut. agents financiers	57
58	Business service industries	259	209	Services aux entreprises	58
59	Government service industries	260-263	210-213	Ind des services gouvernementaux	59
60	Educational service industries	264	214	Ind des services d'enseignement	60
61	Health & social service industries	265-267	215-217	Serv de soins de sante & sociaux	61
62	Amusement & other service ind	268	218	Divertissements & autres services	62
63	Personal, household & other serv	269-271	219-221	Serv person., domestiques & autres	63

SNA Industry Codes at the Aggregation Level (S) in Terms of 1980 and 1970 Worksheet Levels

Codes des Industries du SCN au niveau d'agrégation (S) selon les niveaux de travail (W) de 1980 et de 1970

No.	INDUSTRY TITLE - S	1980 W - #	1970 W - #	NOM DES INDUSTRIES - S	Nº
	Business sector			**Secteur des entreprises**	
1	Agricultural & related services ind.	1,2	1	Ind. agricoles & de serv. connexes	1
2	Fishing & trapping industries	3	3	Ind. de la peche et du piegeage	2
3	Logging & forestry industries	4	2	Exploitation forestiere	3
4	Mining, quarrying & oil well ind.	5-15	4-15	Mines, carrieres & puits de petrole	4
5	Manufacturing industries	16-152	16-137	Industries manufacturieres	5
6	Construction industries	153-161	138-146	Industries de la construction	6
7	Transportation & storage industries	162-174	147-157	Ind. du transport et entreposage	7
8	Communication industries	175-178	158-160	Industries des communications	8
9	Other utility industries	179-181	161-163	Aut. industries de services publics	9
10	Wholesale trade industries	182	164	Industries du commerce de gros	10
11	Retail trade industries	183	165	Industries du commerce de detail	11
12	Finance, insurance & real est. ind.	184-190	166-170	Finances, ass. & aff. immobilieres	12
13	Community, business, person. serv.	191-209	171-183	Serv. socio-cult. commer. & pers.	13
14	Operating, off., cafet. & lab. sup.	210-213	184.186.188	Fourn. exploi. bur. lab. & caf.	14
15	Travel, advertising & promotion	214.215	189.190	Tourisme, promotion & publicite	15
16	Transportation margins	216	137	Marge de transports	16
	Non-business sector			**Secteur non commercial**	
17	Mining industries	251	201	Industries des mines	17
18	Manufacturing industries	252	202	Industries manufacturieres	18
19	Forestry services industry	253	203	Industrie des services forestiers	19
20	Transportation industries	254.255	204.205	Industries du transport	20
21	Communication industries	256	206	Industries des communications	21
22	Water systems industry	257	207	Industrie de la distribution d'eau	22
23	Insurance & other finance industry	258	208	Assurance & aut. agents financiers	23
24	Government service industries	260-263	210-213	Ind. des services gouvernementaux	24
25	Community & personal services	259.264-271	209.214-221	Serv. socio-culturels & personnels	25
	Special aggregations - G			**Agregations speciales - G**	
26	Total economy	1-209.251-271	1-183.201-221	Ensemble	26
27	Business sector industries	1-209	1-183	Secteur des entreprises	27
28	Business sector - goods	1-161.179-181	1-146.161-163	Secteur des entreprises - biens	28
29	Business sector - services	162-178.182-209	147-160.164-183	Secteur des entreprises - services	29
30	Non-business sector industries	251-271	201-221	Secteur non commercial	30
31	Non-business sector - goods	251-252.257	201.202.207	Secteur non commercial - biens	31
32	Non-business sector - services	253-256.258-271	203-206.208-221	Secteur non commercial - services	32
33	Goods producing industries	1-161,179-181, 251-252,257	1-146,161-163, 201,202,207	Industries productrices de biens	33
34	Services producing industries	162-178,182-209, 253-256,258-271	147-160,164-183, 203-206, 208-221	Industries productrices de services	34
35	Industrial production	5-152,179-181, 251,252,257	4-137,161-163, 201,202,207	Production industrielle	35
36	Non-durable manufacturing ind.	16-55,66-75, 134-143	16-58,69-74, 121-130	Manufacturiers - biens non durables	36
37	Durable manufacturing industries	56-65,76-133, 144-152	59-68,75-120, 131-137	Manufacturiers - biens durables	37

AGGREGATION PARAMETERS (COMMODITIES)

PARAMÈTRES D'AGRÉGATION (BIENS & SERVICES)

#	COMMODITY TITLE - W	M	S	TITRE BIENS & SERVICES - W	#
1	CATTLE AND CALVES	2	2	BETAIL & VEAUX	1
2	SHEEP AND LAMBS	2	2	MOUTONS & AGNEAUX	2
3	HOGS	2	2	PORCS	3
4	POULTRY	2	2	VOLAILLE	4
5	OTHER LIVE ANIMALS	2	2	AUTRES ANIMAUX VIVANTS	5
6		0	0		6
7	WHEAT,UNMILLED	1	1	BLE NON MOULU	7
8	BARLEY,OATS,RYE,CORN,GRAIN,NES	1	1	ORGE,AVOI.,FAR.,MAIS.,GRAIN NCA	8
9	MILK,WHOLE,FLUID,UNPROCESSED	3	2	LAIT - ENTIER,FLUIDE,NON TRAITE	9
10	EGGS IN THE SHELL	3	2	OEUFS AVEC COQUILLE	10
11	HONEY AND BEESWAX	3	2	MIEL & CIRE D ABEILLE	11
12	NUTS EDIBLE,NOT SHELLED	3	2	NOIX COMESTIBLES SANS COQUILLE	12
13	FRUITS FRESH EX TROPICAL	3	2	FRUITS FRAIS (SAUF TROPICAUX)	13
14	VEGETABLES FRESH	3	2	LEGUMES FRAIS	14
15	HAY FORAGE AND STRAW	3	2	FOIN FOURRAGE & PAILLE	15
16	SEEDS EX OIL AND SEED GRADES	3	2	SEMENCES (SAUF HUILE & GRAINES)	16
17	NURSERY STOCK & RELATED MAT	3	2	MATERIEL DE PEPIN & CONNEXE	17
18	OIL SEEDS,NUTS AND KERNELS	3	2	GRAINES OLEAGIN.,NOIX & AMADES	18
19	HOPS INC LUPULIN	3	2	HOUBLON (Y COMPRIS LUPULIN)	19
20	TOBACCO,RAW	3	2	TABAC BRUT	20
21	MINK SKINS RANCH UNDRESSED	3	2	PEAUX VISON RANCH,INAPRETE	21
22	WOOL IN GREASE	3	2	LAINE EN SUINT	22
23	SERV INCIDENTAL TO AGR &FORESTRY	3	2	AUTRES AUXIL AGRIC & FOREST	23
24	LOGS AND BOLTS	4	3	BILLOTS & BOULONS	24
25	POLES,PIT PROPS FENCE-POSTS ETC	4	3	POTEAUX (FOSS.,CLOT.),ETAIS ETC	25
26	PULPWOOD	4	3	BOIS A PATE	26
27	OTHER CRUDE WOOD MATERIALS	4	3	AUTRES DERIVES BRUTS DU BOIS	27
28	CUSTOM FORESTRY	4	3	FORESTAGE COMMANDE	28
29	FISH LANDINGS	5	4	SORTIE DE L EAU (POISSONS)	29
30	HUNTING & TRAPPING PRODUCTS	6	4	PROD DE LA CHASSE & DU PIEGEAGE	30
31		0	0		31
32	GOLD & ALLOYS IN PRIMARY FORM	8	5	OR & ALLIAGES FORME PRIMAIRE	32
33	RADIO-ACTIVE ORES&CONCENTRATES	8	5	MINERAI & CONCENT RADIOACTIFS	33
34	IRON ORES & CONCENTRATES	[illegible]	5	MINERAI & CONCENT DE FER	34
35	BAUXITE + ALUMINA	8	5	BAUXITE & ALUMINE	35
36	METAL ORES + CONCENTRATES N E S	8	5	MINERAI & CONCEN DE METAL NCA	36
37	COAL	9	6	CHARBON	37
38	CRUDE MINERAL OILS	10	6	HUILES MINERALES BRUTES	38
39	NATURAL GAS	11	6	GAZ NATUREL	39
40		0	0		40
41	SULPHUR,CRUDE & REFINED	12	7	SOUFRE BRUT & RAFFINE	41
42	ASBESTOS,UNMFG.,CRUDE& FIBROUS	12	[illegible]	AMIANTE BRUTE & FIBREUSE	42
43	GYPSUM	12	7	GYPSE	43
44	SALT	12	7	SEL	44
45	PEATMOSS	12	7	TOURBE	45
46	CLAY&OTHER CRUDE REFRACTORY MAT	12	7	ARGILE & AUT MAT BRUTES REFR	46
47	NATURAL ABRASIVES&INDUST DIAMOND	12	7	ABRASIFS NAT DIAMANT INDUSTRIEL	47
48	CRUDE MINERAL NES	12	7	MINERAUX BRUTS NCA	48
49	SAND AND GRAVEL	12	7	SABLE & GRAVIER	49
50	STONE,CRUDE	12	7	PIERRE NON TAILLEE	50
51	SERVICES INCIDENTAL TO MINING	13	8	SERVICES AUXILIAIRES AUX MINES	51
52	BEEF,VEAL,MUTT&PORK,FRESH&FROZEN	14	9	BO.,VEAU,MOUT.,PORC FRAIS & CON	52
53	HORSE MEAT FRESH,CHILLED,FROZEN	14	9	VIANDE DE CHEV FR REFR CONG	53
54	MEAT,CURED	14	9	VIANDE SALEE	54
55	MEAT PREP COOKED NOT CANNED	14	9	VIANDE PREP CUITE NON EN CONS	55
56	MEAT PREP CANNED	14	9	VIANDE PREPAREE EN CONSERVE	56
57	ANIMAL OILS & FATS & LARD	14	9	HUILES,GRAISSES & LARD ANIMAUX	57
58	MARGERINE,SHORTENING&LIKE PROD	14	9	MARGARINE,GRAISSE & PROD. CONN.	58
59	SAUSAGE CASINGS,NATURAL&SYNTH.	14	9	EMBALL. DES SAUC. NAT. & SYNTH	59
60	PRIMARY TANKAGE	14	9	RESIDUS DE GRAISSE PRIMAIRES	60
61	FEEDS OF ANIMAL ORIGIN NES	14	9	ALIM POUR ANIM -ORIG. ANIM. NCA	61
62	HIDES AND SKINS,RAW,NES	14	9	CUIRS & PEAUX BRUTES NCA	62
63	ANIMAL MAT FOR DRUGS & PERFUME	14	9	MAT ANIM. POUR PHARM. PARF.	63
64	CUSTOM WORK MEAT & FOOD	14	9	TRAV VIANDE & ALIM. SUR COMM	64
65	POULTRY,FRESH,CHILLED,FROZEN	14	9	VOLAILLE FRAICHE,REFR.,CONGELEE	65
66	POULTRY,CANNED	14	9	VOLAILLE EN CONSERVE	66
67	MILK,WHOLE,FLUID,PROCESSED	15	9	LAIT ENTIER,FLUIDE,TRAITE	67
68	CREAM,FRESH	15	9	CREME FRAICHE	68
69	BUTTER	15	9	BEURRE	69
70	CHEESE,CHEDDAR & PROCESSED	15	9	FROMAGE,CHEDDAR & LAIT	70
71	MILK EVAPORATED	15	9	LAIT EVAPORE	71
72	ICE CREAM	15	9	CREME GLACEE	72
73	OTHER DAIRY PRODUCTS	15	9	AUTRES PRODUITS LAITIERS	73
74	MUSTARD MAYONNAISE	15	9	MOUTARDE MAYONNAISE	74
75	FISH PRODUCTS	16	9	PRODUITS DU POISSON	75
76	FRUIT,BERRIES,DRIED,CRYSTALIZED	17	10	FRUITS,BAIES SECH.,DESHYDRATEES	76
77	FRUITS & PREPARATIONS CANNED	17	10	FRUITS & PREP EN CONSERVE	77
78	VEGET FROZEN,DRIED & PRESERVED	17	10	LEG CONG.,SECHES & PRESERVES	78
79	VEGETABLES&PREPARATIONS CANNED	17	10	LEGUMES & PREPAR EN CONSERVE	79
80	SOUPS CANNED	17	10	SOUPES EN CONSERVE	80
81	INFANT&JUNIOR FOODS,CANNED	17	10	ALIM EN CONS BEBES & ENFANTS	81
82	PICKLES,RELISHES,OTHER SAUCES	17	10	CORNICH.,ASSAIS. & AUTR. SAUCES	82
83	VINEGAR	17	10	VINAIGRE	83
84	OTHER FOOD PREPARATIONS	17	10	AUTRES PREPARATIONS ALIMENTAIRES	84
85	PRIMARY OR CONCENTRATED FEEDS	18	10	ALIM PRIM OU CONC. POUR ANIM.	85
86	FEED FOR COMMERCIAL LIVESTOCK	18	10	ALIM POUR BETAIL DE COMMERCE	86
87	FEEDS, GRAIN ORIGIN, N.E.S.	18	10	ALIM. ANIM OR. GRAINES NCA	87
88	FEEDS OF VEGETABLE ORIGIN NES	18	10	ALIM POUR ANIM -ORIG. LEG.	88
89	PET FEEDS	18	10	ALIM POUR ANIMAUX D'AGREMENT	89
90	WHEAT FLOUR	19	10	FARINE DE BLE	90
91	MEAL&FLOUR OF OTHER CEREALS&VEG	19	10	FARINE D'AUTRES CER. & LEG.	91
92	BREAKFAST CEREAL PRODUCTS	20	10	CEREALES POUR LE DEJEUNER	92
93	BISCUITS	20	10	BISC.,COR. DE CREME GLAC. ETC.	93
94	BREAD & ROLLS	20	10	PAIN & PETITS PAINS	94
95	OTHER BAKERY PRODUCTS	20	10	AUTRES PRODUITS DE BOULANGERIE	95
96	COCOA & CHOCOLATE	22	10	CACAO & CHOCOLAT	96
97	NUTS,KERNELS & SEEDS PREPARED	22	10	NOIX,AMANDES & GRAIN PREPAREES	97
98	CHOCOLATE CONFECTIONERY	22	10	CONFISERIE EN CHOCOLAT	98
99	OTHER CONFECTIONERY	22	10	AUTRE CONFISERIE	99
100	BEET PULP	18	10	PULPE DE BETTERAVE	100

#	COMMODITY TITLE - W	M	S	TITRE BIENS & SERVICES - W	#
101	SUGAR	21	10	SUCRE	101
102	MOLASSES,SUGAR REFINERY PROD	22	10	MELASSES,PROD RAFF DE SUCRE	102
103	OILSEED,MEAL & CAKE	18	10	GRAINES OLEAGI ,FARINE & GATEAUX	103
104	VEG OILS & FATS, CRUDE	22	10	HUILES & GRAISSES VEG BRUTES	104
105	NITROGEN FUNCTION COMPOUNDS NES	67	27	COMPOSES FONCTIO DE L'AZOTE NCA	105
106	MALT,MALT FLOUR&WHEAT STARCH	22	10	MALT,FARINE DE MALT,FECULE BLE	106
107	MAPLE SUGAR&SYRUP	22	10	SUCRE & SIROP D'ERABLE	107
108	PREPARED CAKE & SIMILAR MIXES	22	10	MELANGES A GATEAU & AUTRES	108
109	SOUPS,DRIED&SOUP MIXES&BASES	22	10	SOUPES (DESHYD ,MELANGE BASES)	109
110	COFFEE,ROASTED,GROUND,PREPARED	22	10	CAFE TORREFIE,MOULU,INSTANTANE	110
111	TEA	22	10	THE	111
112	POTATO CHIPS&SIMILAR PRODUCTS	22	10	CROUSTILLEES & PROD SIMIL	112
113	MISC FOOD NES	22	10	ALIMENTS DIVERS NCA	113
114	SOFTDRINK CONCENTRATES&SYRUPS	23	11	CONCEN & SIROPS DE BOISS GAZ	114
115	CARBONATED BEV ,SOFT DRINKS	23	11	BOISSONS GAZEUSES	115
116	ALCOHOLIC BEVERAGES DISTILLED	24	11	BOISSONS ALCOOLISEES DISTILLEES	116
117	ALCOHOL, NATURAL, ETHYL	64	27	ALCOOL ETHYLIQUE NATUREL	117
118	BREWERS'&DISTILLERS'GRAINS	18	10	GRAINS (BRASSEURS & DISTILLER)	118
119	ALE BEER,STOUT & PORTER	24	11	ALE,BIERE,PORTER,STOUT	119
120	WINES	24	11	VINS DE RAISIN	120
121	TOBACCO PROCESSED UNMANUFACT	25	12	TABAC TRAITE NON MANUF	121
122	CIGARETTES	26	12	CIGARETTES	122
123	TOBACCO MFG EX CIGARETTES	26	12	FABR DE TABAC SAUF CIGARETTES	123
124	FOOTWEAR RUBBER AND PLASTIC	28	13	CHAUSSURES CAOUTC & PLASTIQUE	124
125	TIRES & TUBES PASSENGER CARS	27	13	PNEUS & CH A AIR AUTOS	125
126	TIRES & TUBES,TRUCKS & BUSES	27	13	PNEUS CH A AIR CAMIONS AUTOBUS	126
127	TIRES & TUBES N E S	27	13	PNEUS & CH A AIR NCA	127
128	TIRES RETREADING	27	13	PNEUS RECHAPES	128
129	RECLAIMED RUBBER	28	13	COMPOSES DU CAOUTCHOUC	129
130	RUBBER BELTS & COATED FABRICS	28	13	CEINT DE CAOUT & TISSUS END	130
131	RUBBER SHEETING SHOE STOCK ETC	28	13	STOCK CHAUSS TOILES CAOUT ETC	131
132	HOSE & TUBING MAINLY RUBBER	28	13	BOYAU D ARR TUBES SURT CAOUT	132
133	RUBBER WASTE & SCRAP	28	13	REBUTS DE CAOUTCHOUC	133
134	RUBBER END PRODUCTS NES	28	13	PRODUITS FINIS DE CAOUTCHOUC NCA	134
135	PLASTIC PIPE FITTINGS & SHEET	29	13	FEUILLES TUYAUX & RACCORDS DE PL	135
136	PLASTIC CONTAINERS&BOTTLE CAPS	29	13	CONT PLAST COUVERC BOUTEILLE	136
137	PREFAB BLDGS&STRUCTURES NES	29	13	PLAST PREFAB ,CONST STRUCT	137
138	PLASTIC HOSE,PAILS&END PROD NES	29	13	BOYAU ARR ,SEAUX,PROD FIN NCA	138
139	LEATHER	30	13	CUIR	139
140	FOOTWEAR EX RUBBER & PLASTIC	30	13	CHAUSSURES (CAOUTC ,PLAST ,ETC)	140
141	LEATHER GLOVES&MITTENS EX SPORT	30	13	GANTS MITAINES CUIR SAUF SPORT	141
142	LEATHER BELTING,SHOE STOCK	30	13	STOCK CHAUSS & CEINT DE CUIR	142
143	LUGGAGE	30	13	VALISES	143
144	LEATHER HANDBAGS,WALLETS ETC	30	13	SACOCHES PORTEF ,ETC EN CUIR	144
145	YARN, COTTON	31	14	FILES DE COTON	145
146	YARNS MIX&BLENDED&COTTON WASTE	31	14	FILES SIMP OU MIXTES,REB COT	146
147	FABRICS, BROAD WOVEN OF COTTON	32	14	TISSUS LARGES DE COTON TISSES	147
148	TIRE CORD & TIRE FABRICS	32	14	FABR PNEUS & CORD DE PNEUS	148
149	NETS & NETTING	33	14	FILETS	149
150	BLANKETS,BEDSHEETS,TOWELS&CLOTHS	33	14	DRAPS,COUV ,SERVIET & CHIFFONS	150
151	YARN OF WOOL AND HAIR	31	14	FILATURE DE LAINE & DU POIL	151
152	FABRICS,BROADWOVEN,WOOL,HAIR&MIX	32	14	TISS LARG ,LAINE,POIL,MEL	152
153	PAPERMAKERS' FELTS	33	14	FEUTRES DE PAPETERIE	153
154	MAN MADE FIBRES	31	14	FIBRES SYNTHETIQUES	154
155	POLYAMIDE RESINS (NYLON)	31	14	RESINES DE POLYAMIDE (NYLON)	155
156	YARNS, SILK, FIBREGLASS	31	14	FIL.,SOIE,FIB. VERRE	156
157	TIRE YARNS	31	14	FILATURE DE PNEUS	157
158	FABRIC, WOVEN, TEXTILE FIBRES	32	14	TISS. FIBRES TEXTILES	158
159	FABRICS,BROAD WOVEN,MIX&BLENDS	32	14	TISS. LARGES,MIXTES	159
160	RAGS&WASTE,COTTON&TEXTILE MAT.	33	14	CHIFF.,REB ,COTON & MAT. TEXT	160
161	WOOL&FINE ANIMAL HAIR,SPINNING	31	14	LAINE & POIL FIN,FILATURE	161
162	THREAD,OF COTTON FIBRES	33	14	FIL,FIBRES DE COTON	162
163	THREAD, OF MAN-MADE FIBRES	33	14	FIL,FIBRES SYNTHETIQUES	163
164	YARN&THREAD,OTHER VEG. FIBRES	31	14	FILES & FIL, AUTRES FIB. VEGET	164
165	BALER AND BINDER TWINE	33	14	FICELLE A EMPAQUETER & A LIER	165
166	OTHER CORDAGE, TWINE & ROPE	33	14	AUTRES CORDES,FICELLES & CABLES	166
167	NARROW FABRICS	32	14	TISSUS ETROITS	167
168	LACE FABRICS,BOBBINET & NET	32	14	TISS. DENTELLES & FIL.	168
169	FELT, CARPET CUSHION	33	14	FEUTRE COUSSIN A TAPIS	169
170	CARPETING&FABRIC RUGS,MATS,ETC.	33	14	TAPIS DE TISSU & DE CAOUTCHOUC	170
171	TEXTILE DYEING & FINISHING SER.	33	14	SERV TEINT & APPRET DES TEXT	171
172	AWNINGS, OF CLOTH & PLASTIC	33	14	AUVENTS DE TISSUS & DE PLASTIQUE	172
173	TENTS,HAMMOCKS,SLEEP BAGS&SAILS	33	14	TENTES,HAM ,S DE COU & VOIL	173
174	TARPAULINS & OTHER COVERS	33	14	BACHES & AUTRES REVETEMENTS	174
175	TEXTILE CONTAINERS	33	14	CONTENANTS EN MAT TEXTILE	175
176	VEGETABLE TEXTILE FIBRES NES	33	14	FIBRES TEXTILES VEGETALES NCA	176
177	MISC TEXTILE FAB MAT INC RAGS	33	14	DIV TISS TEXT Y COMPRIS CHIFF	177
178	HOUSEHOLD TEXTILES, NES	33	14	TEXTILES MENAGERS NCA	178
179	LACES AND TEXTILE PROD N E S	33	14	AUTRES PROD FINIS TEXT ,LACETS	179
180	HOSIERY	34	15	BAS & CHAUSSETTES	180
181	FABRICS,KNITTED&NETTED,ELASTIC	32	14	TISS TRICOT & EN FILET,ELAST	181
182	FABRICS, KNITTED, NES	32	14	TISSUS EN TRICOT,NCA	182
183	KNITTED WEAR	34	15	VETEMENTS EN TRICOT	183
184	CLOTHING	35	15	VETEMENTS	184
185	APPAREL ACCESSORIES&OTHER MISC.	35	15	VETEMENTS,ACCESSOIRES & DIVERS	185
186	FURS, DRESSED	35	15	FOURRURES APPRETEES	186
187	FUR PLATES, MATS AND LININGS	35	15	REVET.,TAPIS & DOUBL. DE FOUR.	187
188	FUR APPAREL	35	15	ART ,VET FOURR ,FOURR SYNTH	188
189	CUSTOM TAILORING	35	15	VETEMENTS SUR MESURE	189
190	PULPWOOD CHIPS	38	16	COPEAUX DE BOIS A PATE	190
191	LUMBER & TIMBER	36	16	SCIAGE & BOIS D'OEUVRE	191
192	RAILWAY TIES	38	16	TRAVERSES DE CHEMIN DE FER	192
193	WOOD WASTE	38	16	REBUTS DE BOIS	193
194	CUSTOM WOOD WORKING & MILLWORK	38	16	TRAV BOIS FORF.,BOIS D'O. BRUT	194
195	VENEER AND PLYWOOD	37	16	PLACAGES & CONTRE-PLAQUES	195
196	MILLWORK (WOODWORK)	38	16	BOIS D'OEUVRE BRUT	196
197	WOOD FABRICATED MAT.FOR STRUCT.	38	16	MAT FAB EN BOIS POUR STRUCT.	197
198	PREFAB BLDGS,WOOD	38	16	IMM & STRUC BOIS PREFABRIQUES	198
199	CONTAINERS,CLOSURES&WOOD PALLETS	38	16	CONT ,FERMETURES & PAL DE BOIS	199
200	CASKETS,COFFINS&OTHER MORT GOODS	38	16	CERCUEILS & AUTRES ART FUN	200

AGGREGATION PARAMETERS (COMMODITIES) - Continued
PARAMÈTRES D'AGRÉGATION (BIENS & SERVICES) - suite

#	COMMODITY TITLE - W	M	S	TITRE BIENS & SERVICES - W	#
201	MISC WOOD	38	16	DIVERS PRODUITS DE BOIS	201
202	BARRELS & KEGS OF WOOD	38	16	BARILS & TONNEAUX DE BOIS	202
203	WOOD END PRODUCTS,NES	38	16	PRODUITS FINIS DE BOIS,NCA	203
204	HOUSEHOLD FURN INCL CAMP&LAWN	39	17	MEUB MAISON,CAMPING & PELOUSE	204
205	OFFICE FURN&VISIBLE RECORD EQUIP	39	17	MEUB BUR & MAT CLASS VISIB	205
206	SPECIAL PURPOSE FURNITURE	39	17	MEUBLES SPECIAUX	206
207	MISC FURNITURE AND FIXTURES	39	17	MEUBLES & ART D'AMEUB DIVERS	207
208	PORTABLE LAMPS RESIDENTIAL TYPE	39	17	LAMPES PORT TYPE RESIDENTIEL	208
209	PULP	40	18	PATE DE BOIS	209
210	NEWSPRINT PAPER	41	18	PAPIER JOURNAL	210
211	OTHER PAPER FOR PRINTING	41	18	AUTRE PAPIER D'IMPRIMERIE	211
212	FINE PAPER	41	18	PAPIER FIN	212
213	TISSUE & SANITARY PAPER	41	18	TISSU & PAPIER HYGIENIQUES	213
214	WRAPPING PAPER	41	18	PAPIER D'EMBALLAGE	214
215	PAPER BOARD	41	18	CARTON	215
216	BLDG PAPER	41	18	PAPIER CONSTRUCTION	216
217	TOWELS, NAPKINS & TOILET PAPER	42	18	LINGES,SERV TABLE & PAP HYG	217
218	VANILLIN	42	18	VANILLINE	218
219	MISC IND PAPER MAT,BY PROD&WASTE	42	18	DIV MAT PA IND ,SOU-PR ,REB	219
220	TILES VINYL-ASBESTOS	42	18	TUILES,DALLES - VINYLE,AMIANTE	220
221	PAPER CARTONS BAGS CANS&BOTTLES	42	18	CART ,SACS PAP BOIT CON ,BOU	221
222	CONVERTED PAPER,GUM WAX OR PRINT	42	18	PAP TRANSF ,GOM CIRE OU D IM	222
223	CONVERTED ALUMINUM FOIL	42	18	PAPIER D ALUMINIUM TRANSFORME	223
224	FACIAL TISSUES &SANITARY NAPKINS	42	18	TISSU FACIAL & SERV SANIT	224
225	PAPER CONTAINERS,NES	42	18	CONTENANTS DE PAPIER NCA	225
226	OFFICE AND STATIONERY SUPPLIES	42	18	PAPET & PAPIER FOURN BUREAU	226
227	PAPER END PRODUCTS	42	18	PRODUITS FINIS DE PAPIER	227
228	NEWSPAPERS MAGAZINES&PERIODICALS	43	19	JOURNAUX REVUES & PERIODIQUES	228
229	BOOKS PAMPHLETS MAPS&PICTURES	43	19	LIVRES,DEPL CARTES & ILLUST	229
230	BANKNOTES BONDS DRAFTS ETC	43	19	BIL DE BAN ,BONS TRAITES ETC	230
231	OTHER PRINTED MATTER	43	19	AUTRE PAPIER IMPRIME	231
232	ADVERTISING PRINT MEDIA	43	19	PUBLICITE JOURNAUX	232
233	SPECIALIZED PUBLISHING SERVICE	43	19	SERV DE PUBLICATION SPECIALISES	233
234	PRINTING PLATES SET TYPE ETC	43	19	PLAQUES D IMPRESSION COMPOSITION	234
235	FERRO-ALLOYS	45	20	FERRO-ALLIAGES	235
236	IRON STEEL INGOTS	45	20	LINGOTS DE FER & D'ACIER	236
237	STEEL BLOOMS,BILLETS & SLABS	45	20	MASSES,BILLETTES,PLAQUES D ACIER	237
238	STEEL CASTINGS	45	20	MOULAGES D'ACIER	238
239	STEEL BARS AND RODS	45	20	BARRES & TIGES D ACIER	239
240	STEEL PLATES, NOT FABRICATED	45	20	PLAQUES D'ACIER NON FABRIQUEES	240
241	CARBON STEEL SHEETS NOT COATED	45	20	FEUI D ACIER CARB NON REVETUES	241
242	TINPLATE	45	20	FEUILLES D'ETAIN	242
243	GALVANIZED STEEL SHEET & STRIP	45	20	FEUILLES & BARR D ACIER GALV	243
244	RAILS&RLY TRACK MATERIALS,STEEL	45	20	MAT D ACIER RAILS CHEMIN DE FER	244
245	COAL TAR	63	26	GOUDRON	245
246	NAT &SYN GRAPHITE&CARBON PROD	49	20	PROD NAT ,SYNTH GRAPH CARBONE	246
247	MECHANICAL STEEL TUBING	45	20	TUYAUX D ACIER MECANIQUE	247
248	OIL COUNTRY GOODS	45	20	PRODUITS DOMESTIQUES DU PETROLE	248
249	LINE PIPE,TRANS NAT GAS & OIL	45	20	PIPEL ACIER,TRANS GAZ & PETR	249
250	STEEL PIPES & TUBES NES	45	20	TUBES & TUYAUX D'ACIER, NCA	250
251	GRINDING BALLS,INGOT MOULDS ETC	45	20	BOULES BROY ,MOULES LINGOTS ETC.	251
252	CAST&WROUGHT IRON PIPE &FITTINGS	45	20	TUYAUX & MONT ,FER MOULE TORDU	252
253	NICKEL IN PRIMARY FORMS	48	20	NICKEL PROFILES PRIMAIRES	253
254	COPPER&COPPER ALLOYS,PRIME FORMS	47	20	CUIVRE & ALL CUIV ,PROF PRIM	254
255	LEAD,PRIMARY FORMS	49	20	PLOMB & ALL PLOMB, PROF PRIM	255
256	ZINC&ZINC ALLOYS PRIMARY FORMS	49	20	ZINC & ALL. ZINC PROF PRIM	256
257	ALUMINUM&ALUMINUM ALLOYS PRIME.	46	20	ALUM ALL ALUM.,PROF PRIM	257
258	TIN&TIN ALLOYS PRIMARY FORMS	49	20	ETAIN & ALL ETAIN,PROF. PRIM	258
259	PRECIOUS METAL&ALLOYS PRIME FORM	49	20	METAUX PREC ALLIAG. PROF. PRIM.	259
260	OTH NON-FERROUS BASE METALS	49	20	AUTRES METAUX BASE NON FERREUX	260
261	ALUMINUM FLUORIDES&SODIUM ALUM.	49	20	FLUORU. ALUM.,ALUMINATE SODIUM	261
262	INORGANIC BASES&MET OXIDES,NES	49	20	OXYDES INORG. BASE & MET., NCA	262
263	SCRAP&WASTE MATERIALS NES	49	20	FERRAILLE & REBUTS NCA	263
264	ALUMINUM&ALUMINUM ALLOYS, CAST	46	20	ALUMINIUM ALL ALUMINIUM,MOULES	264
265	COPPER PROD CAST,ROLLED&EXTRUDED	47	20	PROD CUIV. MOUL.,LAM.,REFOULES	265
266	COPPER ALLOY PROD CAST,ROLL,EXTR	47	20	PROD ALL CUIV. MOUL.,LAM ,RE	266
267	LEAD&LEAD ALLOY PROD.CAST,R&E	49	20	PROD. PLOMB ALLIAGES M L.R.	267
268	NICKEL&NICKEL ALLOY FAB MATERIAL	48	20	MAT. FAB NICKEL & ALLIAGES	268
269	TIN&TIN ALLOY FAB MATERIALS	49	20	MAT FAB ETAIN & ALLIAGES	269
270	ZINC DIE CASTING&OTH ZINC MAT	49	20	MOUL.PRES ZINC,AUT MAT ZINC	270
271	SOLDERS INC BLOCK,RODS,WIRE,ETC.	49	20	SOUD ,Y COM BLOCS,TIG ,FILS,ETC	271
272	PLATES, STEEL, FABRICATED	50	21	PLAQUES ACIER FABRIQUEES	272
273	TANKS	50	21	RESERVOIRS	273
274	POWER BOILERS	50	21	CHAUDIERES ENERGETIQUES	274
275	BOILERS, MARINE TYPE	50	21	CHAUDIERES,TYPES MARIN	275
276	BEAMS AND OTHER STRUCT STEEL	51	21	POUT AUT STRUCT ACIER	276
277	SCAFFOLDING EQUIP., DEMOUNTABLE	51	21	MAT ECHAFAUDAGE DEMONTABLE	277
278	PREFAB BLDGS&STRUCT ,MAINLY MET	51	21	MAT PREF CONS STR SURT MET	278
279	METAL PRODUCTS NES	51	21	PRODUITS METALLIQUES NCA	279
280	STEEL SHEET&STRIP COATED OR FAB	52	21	FEUILL ,BARR ACIER REV OU FAB	280
281	CULVERT PIPE, CORRUGATED METAL	52	21	TUYAU D'EGOUT,METAL ONDULE	281
282	METAL BASIC PROD &RANGE BOILERS	52	21	PRO MET BASE,CHAUD A FOURNEAU	282
283	METAL PIPES,FITTINGS & SIDINGS	52	21	TUYAUX,RACCORDS & PAREMENTS EN M	283
284	METAL AWNINGS,ASH CANS,PAILS ETC	52	21	AUVENTS MET ,CENDRIERS,SEAUX,ETC	284
285	KITCHEN UTENSILS	52	21	USTENSILES DE CUISINE	285
286	CONTAINERS&BOTTLE CAPS OF METAL	52	21	CONTEN.,COUVERCLES METALL	286
287	WIRE & WIRE ROPE, OF STEEL	52	21	FILS & CABLES D'ACIER	287
288	WIRE FENCING,SCREENING&NETTING	52	21	CLOTURES,GRILLAGES,FILETS MET	288
289	CHAIN,EX AUTO TIRE&POWER TRANS	52	21	CHAINES SAUF PN.,AUTOS,AUT VEH.	289
290	RODS,WIRE&ELECTRODES,WELDING	52	21	TIGES,FILS,ELECTRODES,SOUDURE	290
291	SPRINGS FOR UPHOLSTERY&MISC VEH	52	21	RESSORTS REMB.,DIVERS VEHICULES	291
292	BOLTS,NUTS,SCREWS,WASHERS ETC	52	21	BOULONS,ECROUS,VIS,RONDEL ETC	292
293	BUILDERS' HARDWARE	52	21	QUINCAILLERIE DE BATIMENT	293
294	FITTINGS,FURN.CABINETS&CASKETS	52	21	GARN.,MEUBLES,ARMOIRES & CERC.	294
295	BASIC HARDWARE,NES	52	21	QUINC DE BASE, NCA	295
296	CUTTING&FORMING TOOLS	52	21	OUTILS A COUPER & A MODELER,ETC	296
297	MEASURING,EDGING,MECHANIC'S TOOL	52	21	OUTILS MECAN MESURE TAILLE	297
298	SCISSORS,RAZOR BLADES,IND CUTLER	52	21	CISEAUX,LAMES RAS ,COUT IND	298
299	DOMESTIC EQUIPMENT, NES	58	24	MATERIEL DOMESTIQUE NCA	299
300	HEATING EQ.HOT WATER&STEAM ETC	50	21	APP CHAUFF EAU CH ,VAP ,ETC	300

AGGREGATION PARAMETERS (COMMODITIES) - Continued
PARAMÈTRES D'AGRÉGATION (BIENS & SERVICES) - suite

#	COMMODITY TITLE - W	M	S	TITRE BIENS & SERVICES - W	#
301	HEATING EQ.WARM AIR EX PIPES&ETC	52	21	APP CH AIR CHAUD.SAUF TUYAUX	301
302	UNIT&WATER TANK HEATERS NON-ELEC	52	21	ELEM & RESERV EAU NON EL	302
303	FUEL BURNING EQUIPMENT	52	21	MATERIEL A COMBUSTIBLE	303
304	COM APPLIANCES.COOK&WARMING FOOD	52	21	APP COMM CUISS RECH NOUR	304
305	CUSTOM METAL WORKING	52	21	TRAVAUX DE METAL SUR COMMANDE	305
306	FORGINGS OF CARBON&ALLOY STEEL	52	21	FORGE ACIER CARB & ALL	306
307	VALVES	52	21	SOUPAPES	307
308	PIPE FITTINGS.NOT IRON & STEEL	52	21	ACC TUY .AUT QUE FER & ACIER	308
309	GAS METERS AND WATER METERS	52	21	COMPTEURS A GAZ & A EAU	309
310	FIRE FIGHT&TRAFFIC CONTROL EQUIP	52	21	MAT CONTRE INCEND & CONT CIRC	310
311	TAXI&PARK METERS.BLOCKS&LADDERS	52	21	TAXIME .PARCOM .POULIES.ECHELLES	311
312	FIREARMS & MILITARY HARDWARE	52	21	ARMES A FEU & INST MILITAIRES	312
313	COLLAPSIBLE TUBES.METAL	52	21	TUBES TELESCOPIQUES.METAL	313
314	TRACTORS, FARM & GARDEN TYPE	53	22	TRACTEURS TYPE FERME & JARDIN	314
315	OTHER AGRICULTURAL MACHINERY	53	22	AUTRES MACHINES AGRICOLES	315
316	MECHANICAL POWER TRANS EQUIP	54	22	MAT MECANIQUE DE TRANSMISSION	316
317	PUMPS.COMPRESSORS&BLOWERS ETC	54	22	POMPES.COMPRESSEURS VENTIL ETC	317
318	CONVEYORS.ESCAL.ELEV&HOIST MACH	54	22	MACH CONV .ASCENS .APP LEV	318
319	IND TRUCKS.TRACTORS.TRAILERS ETC	54	22	CAMIONS.TRACTEURS REMO IND ETC	319
320	FANS AIR CIRCULATORS&AIR UNITS	54	22	VENT .APP CIRC. D'AIR & AERAT	320
321	PKG MACH.,LUB EQ&OTH MISC MACH	54	22	MACH EMBALL .GRAIS .AUT DIV	321
322	INDUSTRIAL FURNACES KILNS&OVENS	54	22	FOURNAISES.FOURNEAUX FOURS IND	322
323	MACH IND SPECIFIED&SPECIAL PURP	54	22	MACH INDUSTRIELLES SPECIALISEES	323
324	POWER DRIVEN HAND TOOLS	54	22	OUTILS A MAIN MUNIS D'UN MOTEUR	324
325	METAL END PRODUCTS. NES	54	22	PRODUITS FINIS METALLIQUES NCA	325
326	REFRIG&AIR CON EQ.EX HOUSEHOLD	54	22	MAT REFR CLIMAT , SAUF MAISON	326
327	SCALES & BALANCES	54	22	BALANCES	327
328	VENDING MACHINES	54	22	DISTRIBUTEURS AUTOMATIQUES	328
329	OFFICE MACHINES AND EQUIPMENT	54	22	MACHINES & MATERIEL DE BUREAU	329
330	AIRCRAFT ALL TYPES	57	23	AERONEFS TOUS GENRES	330
331	AIRCRAFT ENGINES	57	23	MOTEURS D AERONEFS	331
332	SPECIALIZED AIRCRAFT EQUIPMENT	57	23	MATERIEL AER EN SPECIALISE	332
333	MODIFICATIONS.CONVERSIONS SERV	57	23	SERV MODIFICATION & CONVERSION	333
334	PASSENGER AUTOMOBILES & CHASSIS	55	23	VOITURES PART CUL & CHASSIS	334
335	TRUCKS, CHASSIS, TRACTORS, COM	55	23	CAMIONS.CHASSIS.TRACTEURS COMM	335
336	BUSES AND CHASSIS	55	23	AUTOBUS & CHASSIS	336
337	MILITARY MOTOR VEH, MOTORCYCLES	55	23	VEHICULES MILIT .MOTOCYCLETTES	337
338	MOBILE HOMES	55	23	REMORQUE CABINE OU MAISON	338
339	OTH TRAILERS&SEMI-TRAILERS.COM	55	23	AUTRES REM & SEMI-REM COMM	339
340	BODIES AND CABS FOR TRUCKS	56	23	CARROSSER & CABINES DE CAMIONS	340
341	MOTOR VEHICLE ENGINES AND PARTS	56	23	VEHICULES-MOTEURS & MORCEAUX	341
342	AUXILIARY ELECTRIC EQUIPMENT	56	23	MATERIEL ELECTRIQUE AUXILIAIRE	342
343	MOTOR VEH ACCESS, PARTS&ASSEMB	56	23	ACC .MORC .ASSEMB VEHIC MOT	343
344	AUTOMOTIVE HARDWARE, EX SPRINGS	56	23	QUINC VEH MOT SAUF RESSORTS	344
345	LOCOMOTIVES.CARS&TENDERS.RLY SER	57	23	LOC .WAGONS.TENDERS.SERV RAIL	345
346	SELF-PROPEL CARS	57	23	WAGONS AUTOMOTEURS	346
347	PARTS&ACCESS FOR RLY ROLL STOCK	57	23	MORC.ACC MAT ROUL CHEMIN FER	347
348	SHIPS&BOATS.MILITARY&COMMERCIAL	57	23	NAVIRES.EMBARC MILIT COMM	348
349	SUB-ASSEMBLIES.PARTS.ETC SHIPS	57	23	MONTAGES AUXIL MORC .ETC -NAV	349
350	SHIP REPAIRS	57	23	REPARATION DE NAVIRES	350
351	SNOWMOBILES&MISC NON-MOTOR VEH	57	23	MOTON. & DIV VEHIC NON MOTOR	351
352	PLEASURE & SPORTING CRAFT	57	23	EMBARCATION PLAISANCE & SPORT	352
353	SMALL ELEC APPLIANCES.DOMESTIC	58	24	PETITS APP ELECTR DOMESTIQUES	353
354	SPACE HEATER.HEATING STOVES ETC	58	24	APP CHAUFF .POELES.ETC	354
355	REFRIG.FREEZERS&COMB DOMESTIC	58	24	REFR.CONG .APP COMBINES-DOMES	355
356	GAS RANGES&ELEC STOVES.DOMESTIC	58	24	FOURS A GAZ.POELES ELECT -DOMES	356
357	T.V.,RADIO.RECORD PLAYERS	58	24	TELEV .RADIOS .TOURN -DISQUES	357
358	TEL&TELEG.LINE APPARATUS&EQUIP.	59	24	TELEP. & TELEG.,CABLES & MAT.	358
359	RADIO&TV BROADCASTING&TRANS EQ.	59	24	RADIO.TELEV .MAT. EMIS. TRANSP.	359
360	RADAR EQUIP. & RELATED DEVICES	59	24	MAT RADAR & APP. CONNEXES	360
361	ELEC.TUBES&SEMI-CONDUCTORS ETC.	59	24	TUBES ELECTRON.,SEMI-COND.,ETC.	361
362	ELECTRONIC EQUIPMENT COMPONENTS	59	24	MATERIEL ELECTRONIQUE - MORCEAUX	362
363	INTERIOR SIGNAL,ALARM&CLOCK SYST	59	24	SYST. INT. SIGN.,ALARM.,HORLOG.	363
364	POLE LINE HARDWARE	59	24	QUINCAILL. DE LIGNES SUR POTEAUX	364
365	WELDING MACHINERY & EQUIPMENT	59	24	APPAREILS & MATERIEL DE SOUDURE	365
366	ENGINES.MARINE.ELECTRIC TURBINES	59	24	MOT. MARIN.,TURB ELECT.	366
367	TRANSFORMERS&CONVERTERS EX.T&T	59	24	TRANSF. & CONVERT. SAUF TELC.	367
368	ELEC. EQUIP. INDUSTRIAL, NES	59	24	MATERIEL ELECT. INDUSTRIEL NCA	368
369	BATTERIES	59	24	PILES & BATTERIES	369
370	WIRE AND CABLE, INSULATED	59	24	FILS & CABLES ISOLES	370
371	ALUM. WIRE&CABLE.NOT INSULATED	59	24	FILS & CAB. ALUM NON ISOLES	371
372	ENCLOSED SAFETY SWITCHES ETC.	59	24	INTERR. SECURITE INCORPORES	372
373	ELEC.LIGHT BULBS&TUBES, ETC	59	24	AMPOULES & LAMPES ELECT ETC.	373
374	ELECTRIC LIGHTING FIXTURES ETC	59	24	ACC. ELECT ECLAIRAGE ETC	374
375	CEMENT	60	25	CIMENT	375
376	LIME	61	25	CHAUX	376
377	CONCRETE BASIC PRODUCTS	60	25	PROD BASE BETON	377
378	SAND LIME BRICKS AND BLOCKS	60	25	BRIQUES.BLOCS SILICO-CALCAIRES	378
379	READY-MIX CONCRETE	60	25	BETON PREPARE	379
380	BRICKS AND TILES, CLAY	61	25	BRIQUES & TUILES D'ARGILE	380
381	INSULATORS&ELEC FITTINGS.PORCELN	61	25	ISOLANTS.ACC ELECT PORCELAINE	381
382	PLUMB EQ. VITREOUS CHINA.& ETC.	61	25	MAT PLOMB .PORC VITR ETC	382
383	REFRACTORIES	61	25	PRODUITS REFRACTAIRES	383
384	NATURAL STONE BASIC PROD.STRUCT.	61	25	PROD BASE PIERRE NATUR STRUCT	384
385	STONE.CLAY&CONCRETE END PROD NES	61	25	PROD FIN PIER ARG BETON NCA	385
386	PLASTERS&OTH GYPSUM BASIC PROD.	61	25	PLATRE & AUT. PROD GYPSE	386
387	MIN.WOOL&THERMAL INSUL.MAT.NES	61	25	MAT LAINE MIN ISOL. THERM. NCA	387
388	ASBESTOS PRODUCTS	61	25	PRODUITS BASE AMIANTE	388
389	NON-METALLIC MIN.BASIC PROD.NES	61	25	AUT. PRO. BASE MIN. NON MET. NCA	389
390	GLASS, PLATE, SHEET, WOOL	61	25	VERRE-PLAQ.,FEUIL.,STRUCT.,ORN.	390
391	GLASS CONTAINERS	61	25	CONTENANTS DE VERRE	391
392	GLASS TABLEWRE&HOUSEWRE,END&NES	61	25	ART. VERRE TABLE MAIS FIN NCA	392
393	ABRASIVE BASIC PRODUCTS	61	25	PRODUITS BASE ABRASIFS	393
394	AVIATION GASOLINE	62	26	ESSENCE A AVIATION	394
395	MOTOR GASOLINE	62	26	ESSENCE A MOTEUR	395
396	FUEL OIL	62	26	MAZOUT	396
397	LUBRICATING OILS AND GREASES	63	26	HUILES & GRAISSES LUBRIFIANTES	397
398	BENZENE, TOLUENE AND XYLENE	63	26	BENZENE.TOLUENE & XYLENE	398
399	BUTANE,PROPANE&OTH LIQ PET GAS	63	26	BUT .PROP .AUT LIQ PET ESS	399
400	NAPHTHA	63	26	HUILE DE NAPHTE	400

AGGREGATION PARAMETERS (COMMODITIES) - Continued
PARAMÈTRES D'AGRÉGATION (BIENS & SERVICES) - suite

#	COMMODITY TITLE - W	M	S	TITRE BIENS & SERVICES - W	#
401	ASPHALT AND COAL OILS, N E S	63	26	ASPHALTE,HUILES CHARB NCA	401
402	PETROCHEMICAL FEED STOCK	63	26	ALIMENTATION IND PETROCHIMIQUE	402
403	FERTILIZERS	65	27	ENGRAIS	403
404	PLASTIC RESINS&MAT ,NOT SHAPED	64	27	RESINES,MAT PLAST BRUTES	404
405	FILM&SHEET, CELLULOSIC PLASTIC	64	27	PELLICULES,FEUILLES CELLULOSE	405
406	ETHANOLAMINES	64	27	ETHANOCAMINES	406
407	ETHYLENE GLYCOL, MONO	64	27	ETHYLENE GLYCOL,MONO	407
408	PHARMACEUTICALS	66	27	PRODUITS PHARMACEUTIQUES	408
409	PAINTS & RELATED PRODUCTS	67	27	PEINTURE & PRODUITS CONNEXES	409
410	VEG OILS,OTH THAN CORN OIL,REF	67	27	HUILES VEG AUTRES QUE MAIS,RAF	410
411	GLYCERIN, REFINED	64	27	GLYCERINE,RAFFINEE	411
412	DENTIFRICES, ALL KINDS	67	27	DENTIFRICES TOUS GENRES	412
413	SOAPS DETERGENTS,CLEANING PRODUC	67	27	SAVONS,DETERGENTS,PROD NETT	413
414	INDUSTRIAL CHEMICAL PREP N E S	67	27	PREP CHIM IND NCA	414
415	TOILET PREPARATIONS & COSMETICS	67	27	PRODUITS TOILETTE COSMETIQUES	415
416	CHLORINE	64	27	CHLORE	416
417	OXYGEN	64	27	OXIGENE	417
418	PHOSPHORUS	64	27	PHOSPORE	418
419	CHEMICAL ELEMENTS, NES	64	27	ELEMENTS CHIMIQUES NCA	419
420	SULPHURIC ACID	64	27	ACIDE SULPHURIQUE	420
421	CARBON DIOXIDE (GAS AND DRY ICE)	64	27	BIOXIDE CARB (GAZ GLACE SECHE)	421
422	INORGANIC ACIDS&OXYGEN	64	27	ACIDES INORG COMP OXYG ETC	422
423	AMMONIA ANHYDROUS AND AQUA	64	27	AMMONIAQUE ANHYDRIQUE & AQU	423
424	CAUSTIC SODA (SOD HYDROXIDE)DRY	64	27	SOUDE CAUST (HYDR SOD) SECHE	424
425	CALCIUM CHLORIDE	64	27	CHLORURE DE CALCIUM	425
426	SODIUM CHLORATE	64	27	CHLORATE DE SODIUM	426
427	ALUMINUM SULPHATE	64	27	SULPHATE D ALUMINIUM	427
428	SODIUM PHOSPHATES	64	27	PHOSPHATES DE SODIUM	428
429	SODIUM CARBONATE (SODA ASH)	64	27	CARBONATE SODIUM (CENDRE SOUDE)	429
430	SODIUM CYANIDE	64	27	CYANURE DE SODIUM	430
431	SODIUM SILICATE	64	27	SILICATE DE SODIUM	431
432	METALLIC SALTS&PEROXYSALTS NES	64	27	SELS METAL & DE PEROX NCA	432
433	PHOTOGRAPHICS,INORGANIC CHEM N E	64	27	PRODUITS CHIM INORG NCA	433
434	ETHYLENE	64	27	ETHYLENE	434
435	BUTYLENES	64	27	BUTYLENES	435
436	BUTADIENE	64	27	BUTADIENE	436
437	ACETYLENE	64	27	ACETYLENE	437
438	STYRENE MONOMER	64	27	STYRENE MONOMERE	438
439	CARBON TETRACHLORIDE	64	27	TETRACHLORURE DE CARBONE	439
440	VINYLCHLORIDE MONOMER	64	27	VINYLCHLORURE MONOMETRE	440
441	TRICHLOROETHYLENE	64	27	TRICHLOROETHYLENE	441
442	PERCHLOROETHYLENE	64	27	PERCHLOROETHYLENE	442
443	FLUORINATED HALOGEN HYDROCARBONS	64	27	CHLOROFLUOROHYDROCARBONES NCA	443
444	HYDROCARBONS&THEIR DERIVATIVES	64	27	HYDROCARBONES & DERIVES	444
445	METHYL ALCOHOL	64	27	ALCOOL METHYLIQUES	445
446	PROPYL AND ISOPROPYL ALCOHOLS	64	27	ALCOOLS PROPY & ISOPROPYLIQUES	446
447	BUTYL AND ISOBUTYL ALCOHOLS	64	27	ALCOOLS BUTYL & ISOBUTYLIQUES	447
448	PENTAERYTHRITOL	64	27	PENTAERYTHRITOL	448
449	ALCOHOLS AND THEIR DERIVATIVES	64	27	ALCOOLS & LEURS DERIVES	449
450	PHENOL	64	27	PHENOL	450
451	PHENOLS,PHEN ALCOHOLS&DERIVATVES	64	27	PHENOLS,ALCOOLS PHEN & DERIVES	451
452	ETHERS,ALCOHOL PEROXIDES,ETC	64	27	ETHERS,PEROXYDES D'ALCOOL,ETC.	452
453	METYL-ETHYL,ALDEHYDE-FUNCTIONS,N	64	27	FONCT METHYL-ETHYL,ADEH. NCA	453
454	ACETONE	64	27	ACETONE	454
455	ACETIC ACID	64	27	ACIDE ACETIQUE	455
456	ACETIC ANHYDRIDE	64	27	ANHYDRIDE ACETIQUE	456
457	ADIPIC ACID	64	27	ACIDE ADIPIQUE	457
458	CITRIC ACIDS	64	27	ACIDES CITRIQUES	458
459	STEARIC AND ORGANIC ACIDS	64	27	ACIDES STEAR & ORGANIQUES	459
460	HEXAMETHYLENEDIAMINE	64	27	HEXAMETHYLENEDIAME	460
461	SODIUM GLUTAMATE, MONO	64	27	GLUTAMATE DE SODIUM,MONO	461
462	DICYANDIAMIDE	64	27	GUANIDINES	462
463	ORGANO-INORGANIC COMPOUNDS ETC	64	27	COMP ORGANO-INORGANIQUES,ETC.	463
464	ORGANIC CHEMICALS, NES	64	27	PRODUITS CHIMIQUES ORGANIQUES	464
465	TITANIUM DIOXIDE	64	27	DIOXIDE DE TITANIUM	465
466	BLACK, ACETYLENE AND CARBON	64	27	CHARBON,ACETHYLENE,CARBONE	466
467	PIGMENTS, LAKES & TONERS,PROPER	64	27	COLORANTS,LAQUES,TONS,PROPRES	467
468	IRON OXIDES	64	27	COLORANTS,LAQUES,TONS,NCA	468
469	FERTILIZER CHEMICALS	64	27	ENGRAIS,CHIMIQUES	469
470	SYNTHETIC RUBBER	64	27	CAOUTCHOUC SYNTHETIQUE	470
471	ANTIFREEZE COMPOUNDS	67	27	COMPOSES ANTIGEL	471
472	ADDITIVES FOR MINERAL OILS,NES	67	27	ADDITIFS HUILES MINERALES NCA	472
473	GLYCERINE, CRUDE	64	27	GLYCERINE BRUTE	473
474	RUBBER&PLASTICS COMPOUNDING AGTS	64	27	AGENTS COMP CAOUT PLASTIQUES	474
475	EXPLOSIVES, FUSES AND CAPS	67	27	EXPLOSIFS,FUSEES,DETONATEURS	475
476	AMMUNITION, NON-MILITARY	67	27	MUNITIONS NON MILITAIRES	476
477	AMMUNITION & ORDNANCE, MILITARY	67	27	MUNITIONS & ARTILLERIE MILIT	477
478	PYROTECHNIC ARTICLES & FIREWORKS	67	27	ARTICLES & PIECES PYROTECHNIQUES	478
479	CRUDE VEG MATERIALS & EXTRACTS	64	27	MAT ,EXTRAITS VEGETAUX BRUTS	479
480	PHTHALIC ANHYDRIDE	64	27	ANHYDRIDE PHTALIQUE	480
481	AGRICULTURAL CHEMICALS	67	27	PRODUITS CHIMIQUES AGRICOLES	481
482	ADHESIVES	67	27	ADHESIFS	482
483	AUTOMOTIVE CHEM EX. ANTIFREEZE	67	27	PROD CHIM VEHIC SAUF ANTIGEL	483
484	CONCRETE ADDITIVES	67	27	ADDITIFS ANTI-ACIDES AU CIMENT	484
485	BOILER CHEMICALS	67	27	PRODUITS CHIMIQUES A CHAUDIERE	485
486	COMPOUND CATALYSTS	67	27	COMPOSE CATALYSEUR	486
487	METAL WORKING COMPOUNDS	67	27	COMPOSES POUR TRAVAILLER METAL	487
488	PRINTING AND OTHER INKS	67	27	ENCRE D'IMPRIMERIE	488
489	TEXTILE SPECIALTY CHEMICALS	67	27	PROD CHIM SPECIALISES TEXTILE	489
490	POLISHES,WAXES,COMPOUNDS & ETC	67	27	POLIS,CIRES,COMPOSES,ETC.	490
491	WAXES,ANIMAL & VEGETABLE, OTHER	67	27	CIRES,ANIM VEGET AUTRE	491
492	ESSENTIAL OILS, NATURAL OR SYN.	67	27	HUILES ESSENT ,NAT OU SYNTH	492
493	TANNING MATERIALS AND DYESTUFFS	67	27	MAT TANNAGE & TEINTURES	493
494	FATS AND CHEMICAL MIXTURES	67	27	GRAS,MELANGES CHIMIQUES	494
495	EMBALMING CHEM & PREPARATIONS	67	27	PROD CHIM PREP EMBAUMEMENT	495
496	MATCHES	67	27	ALLUMETTES	496
497	AIRCRAFT&NAUTICAL INSTRUMENTS	68	28	INSTRUMENTS AER NAUT.	497
498	LAB&SCIENTIFIC APPARATUS ETC	68	28	APPAREILLAGE LAB SCIENT ETC.	498
499	MISC MEASURE&CONTROL INSTRUMENTS	68	28	DIV INST MESURE & CONTROLE	499
500	MEDICAL&RELATED INSTRUMENTS ETC	68	28	INSTR MEDICAUX & CONNEXES ETC	500

AGGREGATION PARAMETERS (COMMODITIES) - Concluded
PARAMÈTRES D'AGRÉGATION (BIENS & SERVICES) - fin

#	COMMODITY TITLE - W	M	S	TITRE BIENS & SERVICES - W	#
501	IND MILITARY&CIVIL DEF SAFETY EQ	68	28	MAT IND SECUR MIL DEF CIV	501
502	WATCHES,CLOCKS,CHRONOMETERS ETC	68	28	MONTRES,HORLOGES,CHRONOMET.,ETC	502
503	PHOTOGRAPHIC EQ&SUPPL INCL FILM	68	28	MAT FOURN PHOT. Y COMP FILM	503
504	JEWELRY,FINDINGS,MET &GEM STONES	69	28	BIJOUX,DEC.,MET & PIER PREC	504
505	PLATED&SILVERWARE,CUTLERY, ETC	69	28	COUTEL RECOUV ARGENTERIE,ETC	505
506	BROOMS,BRUSHES,MOPS&OTH CLEAN EQ	69	28	BAL.,BROSS.,VADR. AUT MAT NET	506
507	BICYCLES,CHILDREN'S VEH &PARTS	69	28	BICYCL POUR ENFANTS,MORCEAUX	507
508	SPORTING,FISHING&HUNTING EQUIP	69	28	MAT SPORT,PECHE,CHASSE	508
509	TOYS AND GAME SETS	69	28	JOUETS & JEUX	509
510	FABRICS,IMPREG EX RUBBER-COATED	69	28	TISSUS ENDUITS SAUF CAOUTCHOUTES	510
511	TILING RUBBER, PLASTIC	69	28	TUILES,CAOUTCHOUC,PLASTIQUE	511
512	ADVERTISING GOODS	69	28	MARCH PUBLICITE	512
513	SHADES&BLINDS	69	28	STORES & TOILES	513
514	FUR DRESSING & DYEING SERVICES	69	28	SERV APPRET TEINTURE FOURRURE	514
515	CUSTOM WORK, MISCELLANEOUS	69	28	TRAVAUX SUR COMMANDE, DIVERS	515
516	ICE	69	28	GLACE	516
517	ANIMAL HAIR,FEATHERS,QUILLS ETC	69	28	POILS PLUMES,PIQUANTS ANIM, ETC	517
518	MISC FAB MAT INCL BRISTLES ETC	69	28	DIV MAT FAB (SOIES, ETC)	518
519	BUTTONS,NEEDLES,PINS&MISC NOTION	69	28	BOUTONS,AIGUIL.,EPIN.,DIV ART	519
520	PHONO RECORDS AND ARTIST MATERIA	69	28	MAT AUDIT ENR ART	520
521	HOUSEHOLD ORNAMENTAL OBJECTS&ART	69	28	DECORATIONS & OBJ ART MAISON	521
522	REPAIR CONSTRUCTION	72	31	CONSTRUCTION DE REPARATION	522
523	RESIDENTIAL CONSTRUCTION	70	29	CONSTRUCTION DE RESIDENCES	523
524	NON-RESIDENTIAL CONSTRUCTION	71	30	CONSTR AUT QUE RESIDENCE	524
525	ROAD HIGHWAY AIRSTRIP CONST	71	30	CONST ROUTES,AUTOR.,PIST ATT	525
526	GAS AND OIL FACILITY CONST	71	30	CONSTR INST GAZ HUILE	526
527	DAMS AND IRRIGATION PROJECTS	71	30	BARRAGES,PROJETS D'IRRIGATION	527
528	RAILWAY TELEPHONE TELEGRAPH CON	71	30	CONST CH FER TEL TELEG	528
529	OTHER ENGINEERING CONSTRUCTION	71	30	AUTRES CONSTRUCTIONS INGENIERIE	529
530	AIR TRANSPORTATION	74	32	TRANSPORT AERIEN	530
531	OTHER TRANSPORTATION	74	32	AUTRE TRANSPORT	531
532	SERV INCIDENTAL TO TRANSPORT NES	74	32	SERV AUXIL AIR DES TRANSP NCA	532
533	WATER TRANSPORTATION	74	32	TRANSPORTS PAR EAU	533
534	SERV INCIDENTAL TO WATER TRANS	74	32	SERV AUX . DES TRANSP PAR EAU	534
535	RAILWAY TRANSPORTATION	74	32	TRANSPORTS FERROVIAIRES	535
536	TRUCK TRANSPORTATION	74	32	TRANSPORTS PAR CAMIONS	536
537	BUS TRANSPORT,INTERURBAN& RURAL	74	32	TRANSP INTER RUR PAR AUTOBUS	537
538	URBAN TRANSIT	74	32	TRANSPORTS URBAINS	538
539	TAXICAB TRANSPORTATION	74	32	TRANSPORTS PAR TAXIS	539
540	PIPELINE TRANSPORTATION	73	32	TRANSPORTS PAR PIPE-LINE	540
541	HIGHWAY AND BRIDGE MAINTENANCE	74	32	ENTRETIEN ROUTES PONTS	541
542	STORAGE	74	32	ENTREPOSAGE	542
543	RADIO & TELEVISION BROADCASTING	75	33	RADIODIFFUSION & TELEVISION	543
544	TELEPHONE & TELEGRAPH	76	33	TELEPHONE & TELEGRAPHE	544
545	POSTAL SERVICES	77	33	SERVICES POSTAUX	545
546	ELECTRIC POWER	78	34	ELECTRICITE	546
547	GAS DISTRIBUTION	79	34	DISTRIBUTION DU GAZ	547
548	COKE	63	26	COKE	548
549	WATER AND OTHER UTILITIES	79	34	EAU & AUTRES SERVICES	549
550	WHOLESALING MARGINS	80	35	MARGE,COMMERCE DE GROS	550
551	REPAIR SERVICE	89	40	SERVICES DE REPARATION	551
552	RENTAL OF OFFICE EQUIPMENT	89	40	LOCATION DE MATERIEL DE BUREAU	552
553	RETAILING MARGINS	81	36	MARGE,COMMERCE DE DETAIL	553
554	IMPUTED SERVICE, BANKS	83	38	SERVICE IMPUTE,BANQUES	554
555	OTH REAL EST (NON-RENT)&FIN SERV	83	38	AUT SER IMMOB (NON LOC) FIN	555
556	INSURANCE & W C B	83	38	ASSURANCE,IDEM ACC TRAVAIL	556
557	IMPUTED RENT OWNER OCPD DWEL	82	37	LOYER IMPUT LOG OCC. PROPR.	557
558	CASH RESIDENTIAL RENT	83	38	LOYER RESIDENTIEL COMPTANT	558
559	OTHER RENT	83	38	AUTRES LOYERS	559
560	GOVT.ROYALTIES ON NAT. RESOURCES	83	38	REDEV GOUV. RESS. NAT	560
561	EDUCATION SERVICES	85	40	ENSEIGNEMENT	561
562	HOSPITAL SERVICES	86	40	SERVICES HOSPITALIERS	562
563	HEALTH SERVICES	86	40	SERVICES SANITAIRES	563
564	MOTION PICTURE ENTERTAINMENT	87	40	CINEMAS	564
565	OTHER RECREATIONAL SERVICES	87	40	AUTRES SERVICES DE LOISIRS	565
566	SERVICES TO BUSINESS MANAGEMENT	84	39	SERVICES EXT. DES ENTREPRISES	566
567	ADVERTISING SERVICES	84	39	PUBLICITE	567
568	LAUNDRY,CLEANING&PRESSING SERV.	89	40	SERV BLANC.,NETT.,PRESS	568
569	ACCOMMODATION SERVICES	88	40	SERVICES DE LOGEMENT	569
570	MEALS	88	40	REPAS	570
571	SERV.MARG.ON ALCOHOLIC BEVERAGES	88	40	SERV LIM BOISS. ALCOOL	571
572	PERSONAL SERVICES	89	40	SERVICES PERSONNELS	572
573	PHOTOGRAPHIC SERVICES	89	40	PHOTOGRAPHIE	573
574	SERVICES TO BLDGS & DWELLINGS	89	40	DIV. SERV REP. SAUF IMM LOG	574
575	RENTAL DATA PROCESSING EQUIP	84	39	MATERIEL INFORMATIQUE LOCATION	575
576	OTHER SERV TO BUSINESSES&PERSONS	84	39	AUT SERV AUX ENTR. & PERS	576
577	RENTAL OF AUTOMOBILES & TRUCKS	89	40	LOCATION AUTOMOBILES CAMIONS	577
578	TRADE ASSOCIATION DUES	89	40	COTISATIONS ASS. COMM	578
579	RENTAL AO MACH&EQ INCL CONST MAC	89	40	LOC AUT MACH MAT ,CONS COMP	579
580	SPARE PARTS&MAINT SUPPL MACH&EQ	91	42	FOURN P DET. & ENT MAC. MAT	580
581	OFFICE SUPPLIES	91	42	FOURNITURES DE BUREAU	581
582	CAFETERIA SUPPLIES	91	42	FOURNITURES DE CAFETERIA	582
583	TRANSPORTATION MARGINS	90	41	MARGES DE TRANSPORTS	583
584	LABORATORY EQUIP AND SUPPLIES	91	42	MATERIEL FOURN. LABORATOIRE	584
585	TRAVELLING AND ENTERTAINMENT	92	43	DEPLACEMENTS & LOISIRS	585
586	ADVERTISING & PROMOTION	92	43	PUBLICITE & PROMOTION	586
587		0	0		587
588	COTTON RAW & SEMI-PROCESSED	93	44	COTON BRUT, SEMI-TRAITE	588
589	NATURAL RUBBER & ALLIED GUMS	93	44	CAOUTC. NAT & GOMMES CONNEXES	589
590	SUGAR, RAW	93	44	SUCRE DE CANNE BRUT	590
591	COCOA BEANS,UNROASTED	93	44	FEVES DE CACAO,NON ROTIES	591
592	GREEN COFFEE	93	44	CAFE VERT	592
593	TROPICAL FRUIT	93	44	FRUITS TROPICAUX	593
594	UNALLOCATED IMPORTS & EXPORTS	94	45	IMPORT & EXPORT NON REPARTIES	594
595	GOVERNMENT GOODS & SERVICES	89	40	BIENS & SERVICES DU GOUVERNEMENT	595
596	COMMODITY INDIRECT TAXES	95	46	IMPOTS INDIRECTS BIENS & SERV.	596
597	SUBSIDIES	96	46	SUBVENTIONS	597
598	OTHER INDIRECT TAXES	95	46	AUTRES IMPOTS INDIRECTS	598
599	WAGES AND SALARIES	97	47	SALAIRES & TRAITEMENTS	599
600	SUPPLEMENTARY LABOUR INCOME	98	47	REVENU SUPP DU TRAVAIL	600
601	NET INCOME UNINCORP BUSINESS	99	48	REV NET ENTREPR INDIV	601
602	OTHER OPERATING SURPLUS	100	49	AUTRE EXCEDENT D'EXPLOITATION	602

DEFINITION OF COMMODITY AGGREGATION - M IN TERMS OF W NUMBERS
DÉFINITION DE L'AGRÉGATION DES BIENS & SERVICES - M EN TERMES DES NUMÉROS W

#	COMMODITY TITLE - M	# - W	TITRE BIENS & SERVICES - M	#
1	GRAINS	7-8	CEREALES	1
2	LIVE ANIMALS	1-5	ANIMAUX VIVANTS	2
3	OTHER AGRICULTURAL PRODUCTS	9-23	AUTRES PRODUITS AGRICOLES	3
4	FORESTRY PRODUCTS	24-28	PRODUITS FORESTIERS	4
5	FISH LANDINGS	29	SORTIE DE L'EAU (POISSONS)	5
6	HUNTING & TRAPPING PRODUCTS	30	PROD DE LA CHASSE & DU PIEGEAGE	6
7	IRON ORES & CONCENTRATES	34	MINERAIS & CONCENTRES DE FER	7
8	OTHER METAL ORES & CONCENTRATES	32-33,35-36	AUTRES MINER METALL & CONCENTR	8
9	COAL	37	CHARBON	9
10	CRUDE MINERAL OILS	38	HUILES MINERALES BRUTES	10
11	NATURAL GAS	39	GAZ NATUREL	11
12	NON-METALLIC MINERALS	41-50	MINERAUX NON METALLIQUES	12
13	SERVICES INCIDENTAL TO MINING	51	SERVICES AUXILIAIRES AUX MINES	13
14	MEAT PRODUCTS	52-66	PRODUITS DE LA VIANDE	14
15	DAIRY PRODUCTS	67-74	PRODUITS LAITIERS	15
16	FISH PRODUCTS	75	PRODUITS DU POISSON	16
17	FRUITS & VEGETABLES PREPARATIONS	76-84	PREP A BASE DE FRUITS & DE LEG	17
18	FEEDS	85-89 100,103,118	ALIMENTS POUR ANIMAUX	18
19	FLOUR,WHEAT MEAL & OTHER CEREALS	90-91	FAR BLE,SEMOULE & AUTRES CEREAL	19
20	BREAKFAST CEREAL & BAKERY PROD	92-95	CEREAL DE TABLE & PROD DE BOUL	20
21	SUGAR	101	SUCRE	21
22	MISC FOOD PRODUCTS	96-99 102 104 106-113	PRODUITS ALIMENTAIRES DIVERS	22
23	SOFT DRINKS	114-115	BOISSONS GAZEUSES	23
24	ALCOHOLIC BEVERAGES	116,119-120	BOISSONS ALCOOLIQUES	24
25	TOBACCO PROCESSED UNMANUFACTURED	121	TABAC TRAITE NON MANUFACTURE	25
26	CIGARETTES & TOBACCO MFG	122-123	CIGARETTES & TABAC MANUFACTURES	26
27	TIRES & TUBES	125-128	PNEUS & CHAMBRES A AIR	27
28	OTHER RUBBER PRODUCTS	124 129-134	AUTRES PRODUITS DU CAOUTCHOUC	28
29	PLASTIC FABRICATED PRODUCTS	135-138	PRODUITS PLASTIQUES MANUFACTURES	29
30	LEATHER & LEATHER PRODUCTS	139-144	CUIR & PRODUITS DU CUIR	30
31	YARNS & MAN MADE FIBRES	145-146 151 154-157 161 164	FILS & FIBRES CHIMIQUES	31
32	FABRICS	147-148 152 158-159 167-168 181-182	TISSUS	32
33	OTHER TEXTILE PRODUCTS	149-150 153 160 162 163 165-166 169-179	AUTRES PRODUITS TEXTILES	33
34	HOSIERY & KNITTED WEAR	180,183	BAS & VETEMENTS EN TRICOT	34
35	CLOTHING & ACCESSORIES	184-189	VETEMENTS & ACCESSOIRES	35
36	LUMBER & TIMBER	191	SCIAGES ET BOIS D'OEUVRE	36
37	VENEER & PLYWOOD	195	PLACAGES & CONTRE-PLAQUES	37
38	OTHER WOOD FABRICATED MATERIALS	190 192-194 196-203	AUTRES MATER EN BOIS TRAVAILLES	38
39	FURNITURE & FIXTURES	204-208	MEUBLES & ART D AMEUBLEMENT	39
40	PULP	209	PATES DE BOIS	40
41	NEWSPRINT & OTHER PAPER STOCK	210-216	PAPIER JOURN & AUTR PATES TRAV	41
42	PAPER PRODUCTS	217-227	PRODUITS DU PAPIER	42
43	PRINTING & PUBLISHING	228-231 233-234	IMPRESSION & EDITION	43
44	ADVERTISING,PRINT MEDIA	232	PUBLICITE, JOURNAUX	44
45	IRON & STEEL PRODUCTS	235-244,247-252	PRODUITS DU FER & DE L'ACIER	45
46	ALUMINUM PRODUCTS	257,264	PRODUITS DE L'ALUMINIUM	46
47	COPPER & COPPER ALLOY PRODUCTS	254,265-266	PROD CUIV & ALLIAGE DE CUIVRE	47
48	NICKEL PRODUCTS	253,268	PRODUITS DU NICKEL	48
49	OTHER NON FERROUS METAL PRODUCTS	246,255-256,258-263, 267,269-271	AUTRES PROD DE MET NON FERREUX	49
50	BOILERS, TANKS & PLATES	272-275,300	CHAUDIERES, RESERVOIRS & PLAQUES	50
51	FABRICATED STRUCTURAL METAL PROD	276-279	PRODUITS METALLIQUES	51
52	OTHER METAL FABRICATED PRODUCTS	280-298,301-313	AUTRES SEMI-PROD METALLIQUES	52
53	AGRICULTURAL MACHINERY	314-315	MACHINES AGRICOLES	53
54	OTHER INDUSTRIAL MACHINERY	316-329	AUTRES MACHINES INDUSTRIELLES	54
55	MOTOR VEHICLES	334-339	VEHICULES AUTOMOBILES	55
56	MOTOR VEHICLE PARTS	340-344	PIECES, VEHICULES AUTOMOBILES	56
57	OTHER TRANSPORT EQUIPMENT	330-333,345-352	AUTRE MATERIEL DE TRANSPORT	57
58	APPLIANCES & RECEIVERS,HOUSEHOLD	299,353-357	APPAREILS & RECEPTEURS MENAGERS	58
59	OTHER ELECTRICAL PRODUCTS	358-374	AUTRES PRODUITS ELECTRIQUES	59
60	CEMENT & CONCRETE PRODUCTS	375,377-379	PRODUITS DU CIMENT ET DU BETON	60
61	OTHER NON-METALLIC MINERAL PROD	376,380-393	AUTRES PROD. MINER. NON METALL.	61
62	GASOLINE & FUEL OIL	394-396	ESSENCE ET MAZOUT	62
63	OTHER PETROLEUM & COAL PROD	245,397-402,548	AUTRES PROD. PETROLE & CHARBON	63
64	INDUSTRIAL CHEMICALS	117,404-407,411,416-470,473-474,479-480	PRODUITS CHIMIQUES INDUSTRIELS	64
65	FERTILIZERS	403	ENGRAIS	65
66	PHARMACEUTICALS	408	PRODUITS PHARMACEUTIQUES	66
67	OTHER CHEMICAL PRODUCTS	105,409-410,412-415, 471-472,475-478,481-496	AUTRES PRODUITS CHIMIQUES	67
68	SCIENTIFIC EQUIPMENT	497-503	MATERIEL SCIENTIFIQUE	68
69	OTHER MANUFACTURED PRODUCTS	504-521	AUTRES PRODUITS MANUFACTURES	69
70	RESIDENTIAL CONSTRUCTION	523	CONSTRUCTION DE RESIDENCES	70
71	NON-RESIDENTIAL CONSTRUCTION	524-529	CONSTRUCTION NON-RESIDENTIELLE	71
72	REPAIR CONSTRUCTION	522	CONSTRUCTION DE REPARATION	72
73	PIPELINE TRANSPORTATION	540	TRANSPORTS PAR PIPE-LINE	73
74	TRANSPORTATION & STORAGE	530-539,541-542	TRANSPORT & ENTREPOSAGE	74
75	RADIO & TELEVISION BROADCASTING	543	RADIODIFFUSION ET TELEVISION	75
76	TELEPHONE & TELEGRAPH	544	TELEPHONE & TELEGRAPHE	76
77	POSTAL SERVICES	545	SERVICES POSTAUX	77
78	ELECTRIC POWER	546	ELECTRICITE	78
79	OTHER UTILITIES	547,549	AUTRES SERVICES PUBLIQUES	79
80	WHOLESALE MARGINS	550	MARGE, COMMERCE DE GROS	80
81	RETAIL MARGINS	553	MARGE, COMMERCE DE DETAIL	81
82	IMPUTED RENT OWNER OCPD DWEL	557	LOYER IMPUTE, LOGEM OCC PROP	82
83	OTHER FINANCE,INS.,REAL ESTATE	554-556,558-560	AUTRES FIN.,ASS.,AFFAIR. IMMOBI.	83
84	BUSINESS SERVICES	566-567,575-576	SERVICES COMMERCIAUX	84
85	EDUCATION SERVICES	561	ENSEIGNEMENT	85
86	HEALTH SERVICES	562-563	SERVICES MEDICAUX	86
87	AMUSEMENT & RECREATION SERVICES	564-565	SERVICES DE DIVERT & DE LOISIRS	87
88	ACCOMMODATION & FOOD SERVICES	569-571	HEBERGEMENT & RESTAURATION	88
89	OTHER PERSONAL & MISC. SERVICES	551-552,568,572-574, 577-579,595	AUTRES SERV. PERSONN. & DIVERS	89
90	TRANSPORTATION MARGINS	583	MARGE, TRANSPORTS	90
91	SUPPLIES FOR OFFICE, LAB & CAFETERIA	580-582,584	FOURNITURES DE BUREAU,LAB & CAFE.	91
92	TRAVEL, ADVERTISING & PROMOTION	585-586	TOURISME,PROMOTION & PUBLICITE	92
93	NON-COMPETING IMPORTS	588-593	IMPORTATIONS NON CONCURENTIELLES	93
94	UNALLOCATED IMPORTS & EXPORTS	594	IMPORT & EXPORT NON REPARTIES	94

DEFINITION OF COMMODITY AGGREGATION - M IN TERMS OF W NUMBERS - Concluded
DÉFINITION DE L'AGRÉGATION DES BIENS & SERVICES - M EN TERMES DES NUMÉROS W - fin

#	COMMODITY TITLE - M	# - W	TITRE BIENS & SERVICES - M	#
95	INDIRECT TAXES	596 598	IMPOTS INDIRECTS	95
96	SUBSIDIES	597	SUBVENTIONS	96
97	WAGES & SALARIES	599	SALAIRES & TRAITEMENTS	97
98	SUPPLMENTARY LABOUR INCOME	600	REVENU SUPP. DU TRAVAIL	98
99	NET INCOME,UNINC. BUSINESS	601	REVENU NET, ENTRE. INDIV	99
100	OTHER OPERATING SURPLUS	602	AUTRE EXCEDENT D'EXPLOITATION	100

DEFINITION OF COMMODITY AGGREGATION – S IN TERMS OF W NUMBERS
DÉFINITION DE L'AGRÉGATION DES BIENS & SERVICES – S EN TERMES DES NUMÉROS W

#	COMMODITY TITLE - S	# - W	TITRE BIENS & SERVICES - S	#
1	GRAINS	7-8	CEREALES	1
2	OTHER AGRICULTURAL PRODUCTS	1-5,9-23	AUTRES PRODUITS AGRICOLES	2
3	FORESTRY PRODUCTS	24-28	PRODUITS DE LA FORET	3
4	FISHING & TRAPPING PRODUCTS	29-30	PROD DE LA PECHE & DU PIEGEAGE	4
5	METALLIC ORES & CONCENTRATES	32-36	MINERAIS METALLIQUES & CONCENTRE	5
6	MINERALS FUELS	37-39	COMBUSTIBLES MINERAUX	6
7	NON-METALLIC MINERALS	41-50	MINERAUX NON METALLIQUES	7
8	SERVICES INCIDENTAL TO MINING	51	SERVICES AUXILIAIRES AUX MINES	8
9	MEAT,FISH & DAIRY PRODUCTS	52-75	VIANDE,POISSON & PROD LAITIERS	9
10	FRUIT,VEG ,FEED MISC FOOD PROD	76-104 106-113,118	FRUITS LEG ,ALIM ANIM & DIVERS	10
11	BEVERAGES	114-116,119-120	BOISSONS	11
12	TOBACCO & TOBACCO PRODUCTS	121-123	TABAC & PRODUITS DU TABAC	12
13	RUBBER,LEATHER PLASTIC FAB PRO	124-144	PROD EN CAOUT ,EN CUIR,MAT PLA	13
14	TEXTILE PRODUCTS	145-179 181-182	PRODUITS TEXTILES	14
15	KNITTED PRODUCTS & CLOTHING	180,183-189	PRODUITS EN TRICOT & VETEMENTS	15
16	LUMBER,SAWMILL OTHER WOOD PROD	190-203	SCIAGES PROD DE SCIERIE & DIVER	16
17	FURNITURE & FIXTURES	204-208	MEUBLES & ARTICLES D'AMEUBLEMENT	17
18	PAPER & PAPER PRODUCTS	209-227	PAPIER & PRODUITS CONNEXES	18
19	PRINTING & PUBLISHING	228-234	IMPRESSION & EDITION	19
20	PRIMARY METAL PRODUCTS	235-244 246-271	PRODUITS METALLIQUES PRIMAIRES	20
21	METAL FABRICATED PRODUCTS	272-298 300-313	SEMI-PRODUITS METALLIQUES	21
22	MACHINERY & EQUIPMENT	314-329	MACHINES & MATERIEL	22
23	AUTOS TRUCKS OTHER TRANSP EQP	330-352	VOITURES,CAMIONS & AUTRES	23
24	ELEC & COMMUNICATIONS PROD	299 353-374	APPAREILS ELECT & DE TELECOMM	24
25	NON-METALLIC MINERAL PRODUCTS	375-393	PRODUITS MINERAUX NON METALLIQUE	25
26	PETROLEUM & COAL PRODUCTS	245 394-402,548	PRODUITS DU PETROLE & DU CHARBON	26
27	CHEMICALS CHEMICAL PROD	105 117 403-496	PRODUITS CHIMIQUES	27
28	MISC MANUFACTURED PRODUCTS	497-521	PRODUITS MANUFACTURIERS DIVERS	28
29	RESIDENTIAL CONSTRUCTION	523	CONSTRUCTION DE RESIDENCES	29
30	NON-RESIDENTIAL CONSTRUCTION	524-529	CONSTRUCTION NON RESIDENTIELLE	30
31	REPAIR CONSTRUCTION	522	CONSTRUCTION DE REPARATION	31
32	TRANSPORTATION & STORAGE	530-542	TRANSPORTS & ENTREPOSAGE	32
33	COMMUNICATION SERVICES	543-545	SERVICES DE COMMUNICATIONS	33
34	OTHER UTILITIES	546-547 549	AUTRES SERV D'UTILITE PUBLIQUES	34
35	WHOLESALE MARGINS	550	MARGE,COMMERCE DE GROS	35
36	RETAIL MARGINS	553	MARGE,COMMERCE DE DETAIL	36
37	IMPUTED RENT OWNER OCPD DWEL	557	LOYER IMPUTE LOGEM OCC PROP	37
38	OTHER FINANCE INS REAL ESTATE	554-556 558-560	AUTRES FIN ASS AFFAIR IMMOBI	38
39	BUSINESS SERVICES	566-567 575-576	SERVICES COMMERCIAUX	39
40	PERSONAL & OTHER MISC SERVICE	551-552 561-565,568-574 577-579 595	SERV PERSONNELS & AUTRES SERV	40
41	TRANSPORTATION MARGINS	583	MARGE TRANSPORTS	41
42	OPERATING OFFICE,LAB & FOOD	580-582,584	FOURNI EXPLOI ,BUR ,LAB & CAF	42
43	TRAVEL, ADVERTISING, PROMOTION	585-586	TOURISME,LOISIRS,PROM & PUBLICI	43
44	NON-COMPETING IMPORTS	588-593	IMPORTATIONS NON CONCURENTIELLES	44
45	UNALLOCATED IMPORTS & EXPORTS	594	IMPOR & EXPORT NON REPARTIES	45
46	NET INDIRECT TAXES	596-598	IMPOTS INDIRECTS NET	46
47	LABOUR INCOME	599-600	REVENU DU TRAVAIL	47
48	NET INCOME UNINC BUSINESS	601	REVENU NET,ENTRE INDIV	48
49	OTHER OPERATING SURPLUS	602	AUTRE EXCEDENT D'EXPLOITATION	49

APPENDIX 3

REPORT BY M.M. DILLON LIMITED

Our File: J3639-01

12 March 1992

Ernst & Young
Management Consultants
Royal Trust Tower
Toronto Dominion Centre
P. O. Box 251
TORONTO, Ontario
M5K 1J7

Attention: Dr. Steve Tanny

Ontario Environmental Protection Industry
Final Report

Dear Sirs:

Enclosed are four (4) copies of our Final Report for the above project. The Report describes the treatment technology and presents the Cost Estimate and Ontario Content for each process. An example is included to demonstrate the use of the scale-up coefficient for a treatment train consisting of two treatment technologies. An additional section was added to the Report (Appendix "B") showing the Ontario Content, based on the probability that equipment sold in Ontario is manufactured in the Province.

Yours truly,

M. M. DILLON LIMITED

Louis Tasfi

Louis Tasfi, Ph.D., P.Eng.
for Steve McMinn, P.Eng.
Project Manager

LT:mts

CONTENTS

1. INTRODUCTION

The objective of this project was to provide basic information for Ernst and Young Management Consultants to develop a model predicting the effect of environmental regulations on the Environmental Protection Industry in Ontario. The model would estimate the Ontario Content of Direct and Indirect Capital Costs and Operating Cost for abatement technologies. These costs could be used to estimate future revenues for the Environmental Protection Industry in Ontario. M. M. Dillon Limited (Dillon) was retained to estimate the Direct and Indirect Capital and Operating Costs and the Ontario Content of these costs for typical treatment technologies used for wastewater, air and solid waste treatment.

For this application, the Direct Capital Cost is broken down into the following items:

- Equipment
- Construction
- Piping
- Electrical and Instrumentation.

The total cost is presented as material and labour costs and the Ontario Content is estimated for each item. This estimate is based on information obtained from equipment and material suppliers. The Ontario Content is presented in two forms. One shows the Ontario Content based on dollar value (Appendix "A"), the other presents this value based on the probability that equipment purchased in Ontario is manufactured or assembled in the Province (Appendix "B").

Average Ontario Content is calculated for Material and Labour Costs and for each abatement technology.

Indirect Capital Cost is estimated as a percentage of the Direct Capital Cost.

Operating Cost includes: labour, maintenance, power and chemical costs.

The Direct Capital Cost is calculated for three flow rates for each abatement technology. Detailed calculations are presented in Appendix "A". Cost Estimates for three different flow rates were used to calculate a scale-up coefficient for Direct Capital, Equipment, Construction, Piping and Electrical, and Labour Costs.

The scale-up coefficient and the cost of a treatment technology at a selected flow rate can be used to estimate the Direct and Operating Costs for an abatement technology at a specific flow rate. An example of the cost calculation is presented in Section 3. The scale-up calculation is as follows:

$$C_Q = C_q \times \left(\frac{Q}{q}\right)^e \qquad \text{Equation (1)}$$

Where:
- C_Q - Treatment technology cost for a plant-specific flow rate of Q
- C_q - Treatment technology cost for base flow q
- Q - Plant specific flow rate
- q - Treatment technology base flow
- e - Scale-up coefficient

At the time of this report, no specific environmental regulations have been introduced for the Industrial and Municipal Sectors. Consequently, costs were calculated for treatment technologies considered as Best Available Technology (BAT) for the removal of typical contaminants. A process train, specific to an application or to a sector, can be assembled from individual treatment technologies. Treatment technologies for the process train could be selected to meet different levels of environmental regulations.

Cost can be calculated based on the cost of individual treatment technologies used in the process train and scaled-up to the plant-specific flow rate. The value of merchandise and services purchased in Ontario is calculated based on the Ontario Content of each treatment technology.

2. TREATMENT TECHNOLOGIES

2.1 Wastewater Treatment

2.1.1 Primary Clarifier

The main function of the Primary Clarifier is to remove settleable solids by gravity from the wastewater. The organic content of the wastewater can also be reduced if it is associated with settleable solids. The clarifier can be constructed as a circular or rectangular tank.

For a rectangular clarifier, wastewater is introduced at one end through several flow distribution ports. At the opposite end of the tank, effluent flows over a weir to the effluent collector trough. Solids are collected at the bottom of the tank as sludge. The sludge is moved by a sludge collector mechanism to a sump. This sump is used to temporarily store sludge, which is pumped out for final disposal.

The Primary Clarifier used for cost estimating was designed with a two-hour hydraulic retention time (HRT). This time is sufficient for most applications to remove 70 to 80% of the settleable suspended solids. It is assumed that the Primary Clarifier is followed by the Activated Sludge treatment step.

Design parameters for Primary Clarifier:

- Base Design Flow Rate: 250 m^3/hour
- Hydraulic Retention Time (HRT): 2 hours
- Surface Hydraulic Load: 4 m/hour
- Minimum Water Depth: 3.5m

Cost Estimates, Scale-up Factors and the Ontario Content are presented in Table 1, for a Primary Clarifier designed to treat 250 m^3/hour flow. Cost estimates for three different flow rates are presented in Table A.1, Appendix "A". These cost estimates are used to calculate the scale-up coefficient as shown in Figure A.1, Appendix "A".

TABLE 1. COST ESTIMATE FOR PRIMARY CLARIFIER

DIRECT CAPITAL COST						
FLOW (M3/HR)	ITEM	MATERIAL		LABOUR / INSTALLATION		SUBTOTAL
		ONT. CON. (%)	COST ($)	ONT. CON. (%)	COST ($)	($)
250	EQUIPMENT	93	$66,700	100	$5,100	$71,800
	CONSTRUCTION	100	$45,100	100	$61,400	$106,500
	PIPING	100	$1,800	100	$2,600	$4,400
	ELECT./AUTO.	100	$7,500	100	$7,500	$15,000
	SUBTOTAL	96	$121,100	100	$76,600	**$197,700**

COMMENTS: OVERALL SCALE-UP COEFFICIENT = 0.52; PIPING/ELECT./AUTO. SCALE-UP COEFF. = 0.75
EQUIPMENT SCALE-UP COEFFICIENT = 0.29; LABOUR SCALE-UP COEFFICIENT = 0.64
CONSTRUCTION SCALE-UP COEFF. = 0.60

INDIRECT CAPITAL COST	
ENGINEERING DESIGN AND SITE SUPERVISION (15% OF DIRECT COST)	$29,700
ONTARIO CONTENT	100%
TOTAL CAPITAL COST	**$227,400**

OPERATING COST	
LABOUR ($/YEAR)	$18,000
MAINTENANCE ($/YEAR)	$10,000
POWER ($/YEAR)	$2,000
TOTAL ANNUAL OPERATING COST ($/YEAR)	**$30,000**
ONTARIO CONTENT	**100%**
SCALE-UP COEFFICIENT	**0.6**

2.1.2 Activated Sludge Treatment

Activated sludge treatment is used to remove soluble and suspended organic matter from the wastewater. The system consists of two reactors; aeration tank and final/secondary clarifier.

A biomass (mixed liquid suspended solids, or MLSS) consisting of a large variety of bacteria and other micro-organisms is retained in the aeration tank. The biomass adsorbs and absorbs organic matter from the wastewater. The biomass utilizes a portion of the organic matter removed for biomass synthesis. Air required for the biological process is supplied by mechanical aeration equipment.

The biomass is separated from the treated wastewater in the final/secondary clarifier. Treated effluent overflows from the clarifier and the biomass is collected in the tank as underflow sludge.

Sludge collected at the bottom of the final clarifier is returned to the aeration tank. This ensures that the necessary biomass concentration is maintained in the aeration tank.

A portion of the sludge, representing excess biomass growth, is wasted to maintain a constant biomass inventory in the treatment system. Excess biomass left in the system would result in loss of solids to the treated effluent and poor effluent quality.

The biological system was sized based on the daily organic load expressed as BOD_5. This design basis was chosen so that the activated sludge system specified here could be used for municipal and industrial wastewater treatment. The system was designed to remove 85 to 95% of the BOD_5 from the wastewater.

Design parameters for the Activated Sludge System:

- Design Base BOD Load Rate: 1,200 kg/d
- HRT Aeration Tank: 6 hours

- MLSS: 2,000 to 3,500 mg/l
- Food to Microorganism Ratio: 0.3
- HRT Final Clarifier: 4 hours
- Surface Hydraulic Load: 1 m/hour
- Surface Solids Load: < 5 kg/m^2 x hour
- Water Depth: 4m

A summary of the Cost Estimate for an activated sludge system treating 1,200 kg/d BOD is presented in Table 2. Cost estimates for these different flow rates are presented in Table A.2, Appendix "A". These cost estimates are used to calculate the scale-up coefficient for the Activated Sludge System as shown in Figure A.2, Appendix "A".

2.1.3 Anaerobic Sludge Digestion

Primary and waste activated sludge produced during biological wastewater treatment have to be treated before final disposal. This is essential to stabilize sludge and to reduce the amount of sludge to be disposed of. The most frequently used waste sludge stabilization technology is the Anaerobic Digestion Process. During this process, about 50% of the organic content of the waste sludge is transferred to biogas. The biogas contains about 70% methane and 30% carbon dioxide and it can be used as an energy source.

Primary and waste activated sludges are mixed and thickened in a Gravity Sludge Thickener before treatment in the Anaerobic Digester. This step increases the solids concentration of sludge from 1% to 3% and reduces the volume of sludge to be treated.

The total solids content of waste sludge is reduced during anaerobic digestion as a result of transferring organic matter to biogas. The process also stabilizes the sludge and minimizes odour problems during disposal. The digested sludge settles better than the raw sludge. This further reduces the volume of sludge to be disposed of. The Anaerobic Digester used for cost estimating is designed as a two-stage system with a 20-day combined hydraulic retention time. The first stage is mixed, while the second stage is

TABLE 2 COST ESTIMATE SUMMARY FOR AERATION BASIN + FINAL CLARIFICATION

DIRECT CAPITAL COST						
BOD LOAD (kg/d)	ITEM	MATERIAL		LABOUR		TOTAL COST ($)
		ONT CON. (%)	COST ($)	ONT CON. (%)	COST ($)	
1200	**EQUIPMENT**	55	$246,700	100	$28,800	$275,500
	CONSTRUCTION	100	$185,000	100	$278,000	$463,000
	PIPING	100	$14,600	100	$14,600	$29,200
	ELECT./AUTO.	100	$76,800	100	$76,800	$153,600
	TOTAL	100	$523,100	100	$398,200	**$921,300**

COMMENTS: OVERALL SCALE-UP COEFFICIENT= **0.57** PIPING/EQUIP./AUTO. SCALE-UP COEFF.= **0.67**
EQUIPMENT SCALE-UP COEFFICIENT= **0.37** LABOUR SCALE-UP COEFFICIENT= **0.57**
CONSTRUCTION SCALE-UP COEFF.= **0.54**

INDIRECT CAPITAL COST	
ENGINEERING DESIGN AND SITE SUPERVISION (15% OF DIRECT COST)	$138,200
ONTARIO CONTENT	100%
TOTAL CAPITAL COST	**$1,059,500**

OPERATING COST	
LABOUR ($/YEAR)	$80,000
MAINTENANCE ($/YEAR)	$40,000
POWER ($/YEAR)	$125,000
TOTAL ANNUAL OPERATING COST ($/YEAR)	**$245,000**
ONTARIO CONTENT	**100%**
SCALE-UP COEFFICIENT	**0.6**

used for gas extraction, settling and sludge storage. A portion of the settled sludge is pumped back to seed the first stage.

The operating temperature is 35°C in the digester. Raw sludge is normally heated in a heat exchanger before entering the digester. Heat is provided by boilers utilizing biogas generated during the digestion process, augmented as necessary by natural gas or oil. Mixing of the digester content is provided to enhance even distribution of sludge in the reactors and to improve the digestion process.

The following design parameters were used for the Anaerobic Digester:

• Basis of Design:	Wastewater flow to treatment plant, 250 m^3/hour
• HRT:	20 days
• Number of Stages:	2
• Volatile Solids Load:	1.6 kg/m^3/d
• Operating Temperature:	35°C
• Raw Sludge Solids Content:	3%
• Digested Sludge Solids Content:	4%
• First Stage Mixing System:	Gas Mixers

A summary of the Cost Estimate for the base sized Anaerobic Digester for a treatment plant treating 250 m^3/hour of wastewater is presented in Table 3. Cost estimates for three different load rates are presented in Table A.3, Appendix "A". These cost estimates are used to calculate the scale-up coefficient for the Anaerobic Digester as shown in Figure A.3, Appendix "A".

2.1.4 Sludge Dewatering

Waste biological and primary sludge are dewatered after digestion and before final disposal. This step is essential to reduce the volume of sludge. High solids content is also the prerequisite for landfill disposal, incineration and composting. Mechanical

TABLE 3 COST ESTIMATE FOR ANAEROBIC SLUDGE DIGESTION

DIRECT CAPITAL COST						
RAW WW FLOW (m3/hr)	ITEM	MATERIAL		LABOUR		TOTAL COST ($)
		ONT CON. (%)	COST ($)	ONT CON. (%)	COST ($)	
250	**EQUIPMENT**	70	$579,000	100	$76,000	$655,000
	CONSTRUCTION	100	$81,600	100	$97,200	$178,800
	PIPING	100	$82,000	100	$82,000	$164,000
	ELECT./AUTO.	50	$61,500	100	$61,500	$123,000
	TOTAL	75	$804,100	100	$316,700	**$1,120,800**

COMMENTS: OVERALL SCALE-UP COEFFICIENT= **0.50** CONSTRUCTION SCALE-UP COEFFICIENT= **0.81**
EQUIPMENT SCALE-UP COEFFICIENT= **0.45** PIPING/ELECT./AUTO. SCALE-UP COEFF.= **0.35**
LABOUR SCALE-UP COEFFICIENT= **0.56**

INDIRECT CAPITAL COST	
ENGINEERING DESIGN AND SITE SUPERVISION (15% OF DIRECT COST)	$168,100
ONTARIO CONTENT	100%
TOTAL CAPITAL COST	**$1,288,900**

OPERATING COST	
LABOUR ($/YEAR)	$62,400.00
MAINTENANCE ($/YEAR)	$40,800.00
POWER ($/YEAR)	$37,400.00
TOTAL ANNUAL OPERATING COST ($/YEAR)	**$140,600.00**
ONTARIO CONTENT	**100%**
SCALE -UP COEFFICIENT	**0.6**

equipment, such as belt filter presses, recessed filter presses and centrifuges, are frequently used for sludge dewatering.

Belt and recessed filter presses use mechanical and hydraulic pressure to squeeze the water out of the sludge and press it through a filter media. The remaining sludge cake has a solids content of 20 to 25% and 40 to 50% for belt and recessed filter presses, respectively.

A centrifuge increases the settling force on the solids particles by exposing the sludge to a centripetal force 3,000 to 5,000 times greater than the gravity force. Solids particles settle out in the centrifuge and are removed as a sludge cake with a mechanical scraper. The sludge cake has a minimum 18 to 25% solids content.

A belt filter press was selected for cost estimating, since this device is used frequently in municipal and industrial applications. The capital cost of this equipment lies between the cost for a recessed filter press or centrifuge.

The sludge dewatering device was sized based on wastewater flow to the treatment plant. The design basis is also shown in solids load to the dewatering equipment. This information could be used for an industrial application, where wastewater flow is not always related to the amount of waste sludge produced.

The Cost Estimate also includes sludge pumping and conveying and polymer dosage systems.

Design basis for the sludge dewatering system:

• Dewatering Equipment:	Belt filter press
• Basis of Design:	1. Wastewater flow to treatment plant at 250 m^3/hour 2. Waste sludge load to dewatering equipment at 2,250 kg/d

- Load Rate: $14\ m^3$ sludge/m belt x h
- Solids Concentration of Feed: 4%
- Solids Concentration of Cake: 25%

A summary of the Cost Estimate for the base sized sludge dewatering device at a plant wastewater flow of 250 m^3/hour and/or a 2,250 kg/d sludge load to the dewatering device is shown in Table 4. Calculations used to determine the scale-up coefficient for Sludge Dewatering are presented in Table A.4 and Figure A.4, Appendix "A".

2.1.5 Oil/Water Separator

An Oil/Water Separator is used to remove oil and grease droplets by gravity. Oil and grease droplets are allowed to rise to the water surface in a tank, while water free of oil is discharged from the bottom section of the tank. This system can reduce the free oil content of the wastewater to 15 mg/L. However, this process cannot be used to remove emulsified oil, because the oil droplets in this mixture are too small to be separated by gravity.

The Oil/Water Separator used for cost estimating is an underground cylindrical steel tank equipped with baffles and piping, and is installed into the sewer system. This unit could be used for effluent polishing before final discharge to the sewer system. The Separator is equipped with an oil/water interface sensor which automatically activates the oil pump. Oil is pumped out from the Separator when the volume of oil in the tank exceeds the set point.

Design parameters for Oil/Water Separator:

- Design Basis: Wastewater flow rate at 5L/sec
- Maximum Oil Concentration in Flow: 150 mg/l
- Oil Removal Efficiency: 90%
- Oil in Effluent: <15 mg/L

TABLE 4 COST ESTIMATE SUMMARY FOR SLUDGE DEWATERING

DIRECT CAPITAL COST						
RAW WW FLOW (m3/hr)	ITEM	MATERIAL		LABOUR		TOTAL COST ($)
		ONT CON. (%)	COST ($)	ONT CON. (%)	COST ($)	
250	**EQUIPMENT**	20	$414,000	100	$17,700	$431,700
	CONSTRUCTION	100	$90,000	100	$95,000	$185,000
	PIPING	100	$27,000	100	$27,000	$54,000
	ELECT./AUTO.	60	$31,000	100	$31,000	$62,000
	TOTAL	31	$562,000	100	$170,700	**$732,700**

COMMENTS: OVERALL SCALE-UP COEFFICIENT= **0.45** CONSTRUCTION SCALE-UP COEFFICIENT= **0.44**
EQUIPMENT SCALE-UP COEFFICIENT= **0.45** PIPING/ELECT./AUTO. SCALE-UP COEFF.= **0.38**
LABOUR SCALE-UP COEFFICIENT= **0.45**

INDIRECT CAPITAL COST	
ENGINEERING DESIGN AND SITE SUPERVISION (15% OF DIRECT COST)	$109,900
ONTARIO CONTENT	100%
TOTAL CAPITAL COST	**$842,600**

OPERATING COST	
LABOUR ($/YEAR)	$62,400
CHEMICAL/POLYMER COST ($/YEAR)	$15,000
MAINTENANCE ($/YEAR)	$40,800
POWER ($/YEAR)	$37,400
TOTAL ANNUAL OPERATING COST ($/YEAR)	**$155,600**
ONTARIO CONTENT	**100%**
SCALE -UP COEFFICIENT	**0.6**

A summary of the Cost Estimate for the base sized Oil/Water Separator at a 5 L/sec flow rate is presented in Table 5. Calculations used to determine the scale-up coefficient for oil removal are presented in Table A.5 and Figure A.5, Appendix "A".

2.1.6 Chemical Oxidation/Reduction and Final Clarifier

This process may be used to oxidize cyanide and other metal chelators such as citric acid, and to remove heavy metals from industrial effluents.

In the first step, the pH is adjusted to an optimum for the oxidation process and the oxidizing reagent is added to the wastewater. The oxidizing compound considered for this application is hydrogen peroxide or sodium sulfite. Alkaline chlorination may also be used to oxidize cyanide in wastewater.

In the second step of the treatment process, the pH is readjusted to the optimum for metal precipitation. The precipitated metal hydroxide flocs are separated in a Lamella Clarifier and the metal hydroxide sludge pumped to a sludge storage tank. Sludge is dewatered in a filter press. Polymer is added to the Lamella Clarifier's inflow and to the sludge fed to the filter press. This improves metal hydroxide floc removal in the clarifier and sludge dewatering in the filter press.

Design Parameters for Chemical Treatment:

- Design Basis: wastewater flow rate at 5 m^3/h
- HRT pH Adjustment: 1 hour
- HRT Oxidation Tank: 2 hours
- Lamella Clarifier: 120 $ft^2/55°$

The Cost Estimate for the above system is shown in Table 6. Calculations used to determine the scale-up coefficient for chemical oxidation/reduction are presented in Table A.6 and Figure A.6, Appendix "A".

TABLE 5 COST ESTIMATE SUMMARY FOR OIL/WATER SEPERATORS

DIRECT CAPITAL COST

FLOW (L/s)	ITEM	MATERIAL ONT. CON. (%)	MATERIAL COST ($)	LABOUR ONT. CON. (%)	LABOUR COST ($)	TOTAL COST ($)
5	EQUIPMENT	99	$15,500	100	$7,000	$22,500
	CONSTRUCTION	100	$1,500	100	$3,500	$5,000
	PIPING	100	$5,800	100	$6,500	$12,300
	ELECT./AUTO.	100	$2,500	100	$2,500	$5,000
	TOTAL	99	$25,300	100	$19,500	$44,800

COMMENTS: OVERALL SCALE-UP COEFFICIENT = 0.41
EQUIPMENT SCALE-UP COEFFICIENT = 0.53
LABOUR SCALE-UP COEFFICIENT = 0.37
CONSTRUCTION SCALE-UP COEFFICIENT = 0.43
PIPING/ELECT./AUTO. SCALE-UP COEFF. = 0.20

INDIRECT CAPITAL COST

ENGINEERING DESIGN AND SITE SUPERVISION (20% OF DIRECT COST)	$8,900
ONTARIO CONTENT	100%
TOTAL CAPITAL COST	$53,700

OPERATING COST

LABOUR ($/YEAR)	$7,800
MAINTENANCE ($/YEAR)	$5,000
POWER ($/YEAR)	$1,000
TOTAL ANNUAL OPERATING COST ($/YEAR)	$13,800
ONTARIO CONTENT	100%
SCALE-UP COEFFICIENT	0.6

TABLE 6 COST ESTIMATE SUMMARY FOR CHEMICAL OXIDATION REDUCTION & FINAL CLARIFIER

DIRECT CAPITAL COST

FLOW (m3/hr)	ITEM	MATERIAL ONT CON (%)	MATERIAL COST ($)	LABOUR ONT CON (%)	LABOUR COST ($)	TOTAL COST ($)
5	**EQUIPMENT**	36	$100,500	100	$24,400	$124,900
	CONSTRUCTION	100	$10,700	100	$14,700	$25,400
	PIPING	100	$15,000	100	$15,000	$30,000
	ELECT./AUTO.	100	$15,000	100	$7,500	$22,500
	TOTAL	55	$141,200	100	$61,600	**$202,800**

COMMENTS:
OVERALL SCALE-UP COEFFICIENT = **0.56**
PIPING/EQUIP./AUTO. SCALE-UP COEFF. = **0.48**
EQUIPMENT SCALE-UP COEFFICIENT = **0.60**
LABOUR SCALE-UP COEFFICIENT = **0.53**
CONSTRUCTION SCALE-UP COEFF. = **0.48**

INDIRECT CAPITAL COST

ENGINEERING DESIGN AND SITE SUPERVISION (15% OF DIRECT COST)	$30,500
ONTARIO CONTENT	100%
TOTAL CAPITAL COST	**$233,300**

OPERATING COST

LABOUR ($/YEAR)	$35,100
CHEMICAL/POLYMER COST ($/YEAR)	$25,000
MAINTENANCE ($/YEAR)	$5,000
POWER ($/YEAR)	$16,400
TOTAL ANNUAL OPERATING COST ($/YEAR)	**$81,500**
ONTARIO CONTENT	**100%**
SCALE-UP COEFFICIENT	**0.6**

2.1.7 pH Control System

Wastewater pH may have to be adjusted to the optimum specific to the chemical and biological treatment processes or before final discharge to the receiving water or sewer. The pH control system consists of a tank with a minimum of 0.5 hours hydraulic retention time. The tank contents are thoroughly mixed with a mechanical mixer. Acid or base addition is controlled by a pH meter. This sensor measures the pH in the mixed reactor.

The pH Control System was sized for a 10 m^3/hour wastewater flow. The summary of the Cost Estimate for this system is presented in Table 7. Calculations used to determine the scale-up coefficient for the pH control system are presented in Table A.7 and Figure A.7, Appendix "A".

2.1.8 Sand Filtration

Sand filtration is often used to improve the quality of biological or chemical treatment process effluents. The objective of this treatment process is to remove the suspended solids from the effluent. This would also reduce BOD, phosphorus, and heavy metal concentrations. It is expected that sand filtration will have to be used for many municipal and industrial wastewater treatment plants to meet future effluent quality regulations for these contaminants.

Solids are captured as water flows through the sand filter media. The flow rate through the filter gradually decreases and the headloss increases as more and more solids are accumulated in the filter media. At a preset maximum headloss, the filter is backwashed with treated effluent to remove the accumulated solids from the media. The filter backwash, loaded with solids, is returned to the treatment system.

Design parameters for sand filtration:

- Design Basis: Wastewater flow rate at 250 m^3/hour
- Surface Hydraulic Load: 12 m/hour
- Filter: Dual media sand filter

TABLE 7 COST ESTIMATE SUMMARY FOR PH CONTROL

DIRECT CAPITAL COST						
FLOW (m3/hr)	ITEM	MATERIAL ONT CON. (%)	MATERIAL COST ($)	LABOUR ONT CON. (%)	LABOUR COST ($)	TOTAL COST ($)
10	EQUIPMENT	74	$12,500	100	$2,500	$15,000
	CONSTRUCTION	100	$3,600	100	$7,100	$10,700
	PIPING	100	$2,500	100	$2,500	$5,000
	ELECT./AUTO.	100	$3,500	100	$2,000	$5,500
	TOTAL	85	$22,100	100	$14,100	$36,200

COMMENTS: OVERALL SCALE-UP COEFFICIENT= 0.44
EQUIPMENT SCALE-UP COEFFICIENT= 0.55
CONSTRUCTION SCALE-UP COEFF.= 0.31
PIPING/EQUIP./AUTO. SCALE-UP COEFF.= 0.46
LABOUR SCALE-UP COEFFICIENT= 0.38

INDIRECT CAPITAL COST	
ENGINEERING DESIGN AND SITE SUPERVISION (20% OF DIRECT COST)	$7,200
ONTARIO CONTENT	100%
TOTAL CAPITAL COST	$43,400

OPERATING COST	
LABOUR ($/YEAR)	$11,700
CHEMICAL COST ($/YEAR)	$15,000
MAINTENANCE ($/YEAR)	$2,000
POWER ($/YEAR)	$4,100
TOTAL ANNUAL OPERATING COST ($/YEAR)	$32,800
ONTARIO CONTENT	100%
SCALE-UP COEFFICIENT	0.6

The filtration system was sized to treat 250 m^3/hour wastewater flow. The summary of the Cost Estimate for this system is presented in Table 8. Calculations used to determine the scale-up coefficient for the sand filtration are shown in Table A.8 and Figure A.8, Appendix "A".

2.2 Air Emission Control

2.2.1 Dry Collectors

Baghouses were selected as typical dry collector systems. These systems use fabric or paper cartridge filters and remove 99 to 99.9% of particles greater than 0.5 microns. Air is introduced to the dry collector with fans. Dust particles collected on the filter media are automatically removed by applying compressed air reversed pulses. Dust particles are collected in a bin underneath the dust collector.

Dust collector design was based on air flow rate. The Cost Estimate shown in Table 9 was prepared for a system treating 280 m^3/hour air flow. Calculations used to determine the scale-up coefficient for dry collectors are shown in Table A.9 and Figure A.9, Appendix "A".

2.2.2 Wet Collectors

Wet scrubbers or collectors are typically used to remove larger particles and absorb gaseous contaminants from the air . The representative system used for Cost Estimating has a 90% removal efficiency for particles above 5 microns and absorbs 90% of gaseous contaminants. This system may be used as the first treatment step, removing larger particles and most of the gaseous contaminants. Air from wet collectors may be further treated in dry collectors to improve particulate matter removal.

The summary of a Cost Estimate for a Wet Collector System treating 280 m^3/hour air flow, is shown in Table 10. Calculations to determine the scale-up coefficient for Wet Collectors are presented in Table A.10 and Figure A.10, Appendix "A".

TABLE 8 COST ESTIMATE SUMMARY FOR SAND FILTRATION

DIRECT CAPITAL COST						
FLOW	ITEM	MATERIAL		LABOUR		TOTAL
(m3/hr)		ONT. CON. (%)	COST ($)	ONT. CON. (%)	COST ($)	COST ($)
250	**EQUIPMENT**	51	$198,500	100	$20,900	$219,400
	CONSTRUCTION	100	$20,700	100	$23,500	$44,200
	PIPING	100	$10,000	100	$10,000	$20,000
	ELECT./AUTO.	100	$15,000	100	$7,500	$22,500
	TOTAL	58	$244,200	100	$61,900	**$306,100**

COMMENTS: OVERALL SCALE-UP COEFFICIENT= **0.81** CONSTRUCTION SCALE-UP COEFFICIENT= **0.60**
EQUIPMENT SCALE-UP COEFFICIENT= **0.90** PIPING/ELECT./AUTO. SCALE-UP COEFF.= **0.34**
LABOUR SCALE-UP COEFFICIENT= **0.48**

INDIRECT CAPITAL COST	
ENGINEERING DESIGN AND SITE SUPERVISION (15% OF DIRECT COST)	$44,400
ONTARIO CONTENT	100%
TOTAL CAPITAL COST	**$350,500**

OPERATING COST	
LABOUR ($/YEAR)	$12,000
MAINTENANCE ($/YEAR)	$10,000
POWER ($/YEAR)	$1,000
TOTAL ANNUAL OPERATING COST ($/YEAR)	**$23,000**
ONTARIO CONTENT	**100%**
SCALE-UP COEFFICIENT	**0.6**

TABLE 9 COST ESTIMATE SUMMARY FOR DRY COLLECTORS (BAG HOUSE)

DIRECT CAPITAL COST						
FLOW (m3/hr)	ITEM	MATERIAL ONT CON. (%)	MATERIAL COST ($)	LABOUR ONT CON. (%)	LABOUR COST ($)	TOTAL COST ($)
280	**EQUIPMENT**	25	$24,900	100	$6,000	$30,900
	CONSTRUCTION	100	$3,000	100	$6,000	$9,000
	PIPING	100	$1,500	100	$1,500	$3,000
	ELECT./AUTO.	100	$1,500	100	$1,500	$3,000
	TOTAL	91	$30,900	100	$15,000	**$45,900**

COMMENTS: OVERALL SCALE-UP COEFFICIENT = **0.67** PIPING/EQUIP./AUTO. SCALE-UP COEFF. = **0.44**
EQUIPMENT SCALE-UP COEFFICIENT = **0.82** LABOUR SCALE-UP COEFFICIENT = **0.48**
CONSTRUCTION SCALE-UP COEFF. = **0.44**

INDIRECT CAPITAL COST	
ENGINEERING DESIGN AND SITE SUPERVISION (20% OF DIRECT COST)	$9,200
ONTARIO CONTENT	100%
TOTAL CAPITAL COST	**$55,100**

OPERATING COST	
LABOUR ($/YEAR)	$3,000
MAINTENANCE ($/YEAR)	$2,000
POWER ($/YEAR)	$15,000
TOTAL ANNUAL OPERATING COST ($/YEAR)	**$20,000**
ONTARIO CONTENT	**100%**
SCALE-UP COEFFICIENT	**0.6**

TABLE 10 COST ESTIMATE SUMMARY FOR WET COLLECTORS

DIRECT CAPITAL COST						
FLOW (m3/hr)	ITEM	MATERIAL ONT CON. (%)	MATERIAL COST ($)	LABOUR ONT CON. (%)	LABOUR COST ($)	TOTAL COST ($)
280	**EQUIPMENT**	84	$15,900	100	$3,500	$19,400
	CONSTRUCTION	100	$3,000	100	$6,000	$9,000
	PIPING	100	$1,500	100	$1,500	$3,000
	ELECT./AUTO.	100	$1,500	100	$1,500	$3,000
	TOTAL	89	$21,900	100	$12,500	**$34,400**

COMMENTS: OVERALL SCALE-UP COEFFICIENT = **0.58**; PIPING/EQUIP./AUTO. SCALE-UP COEFF. = **0.44**; EQUIPMENT SCALE-UP COEFFICIENT = **0.82**; LABOUR SCALE-UP COEFFICIENT = **0.55**; CONSTRUCTION SCALE-UP COEFF. = **0.44**

INDIRECT CAPITAL COST	
ENGINEERING DESIGN AND SITE SUPERVISION (20% OF DIRECT COST)	$6,900
ONTARIO CONTENT	100%
TOTAL CAPITAL COST	**$41,300**

OPERATING COST	
LABOUR ($/YEAR)	$3,500
MAINTENANCE ($/YEAR)	$3,000
POWER ($/YEAR)	$15,000
TOTAL ANNUAL OPERATING COST ($/YEAR)	**$21,500**
ONTARIO CONTENT	**100%**
SCALE-UP COEFFICIENT	**0.6**

2.3 Solid Waste Treatment

2.3.1 Composting

Composting may be used to convert solid waste and waste biological sludge to a valuable product. During composting, organic matter is oxidized by aerobic bacteria in the presence of air. The end product of this process is a soil-like material (humus) which can be used for gardening and soil conditioning.

The solid waste received by the composting facility is first screened to remove metal and glass particles. After this step, waste materials from different sources are blended to obtain an uniform raw material.

If necessary, water is added to this mixture to establish the optimum moisture content. This mixture is introduced into one of a row of parallel composting channels. Mixing and loading of solid waste are usually performed with a front end loader.

In the channel, which is about 6m wide, 4m deep and 60m long, the raw material is mixed and moved toward the end of the channel with a mechanical mixer. This equipment travels on top of the channel walls and is moved from one channel to the next as required. Air is introduced to the bottom of the channel with blowers. Air supplies the oxygen required for the biological oxidation of organic matter.

After 10 to 15 days, the composted material reaches the channel end. Here, compost is collected and removed to a storage area where it is cured for several more days.

A Cost Estimate for the basic sized composting unit, treating 75 tonnes/day of solid waste, is presented in Table 11. Calculations to determine the scale-up coefficient for composting are presented in Table A.11 and Figure A.11, Appendix "A".

TABLE 11 COST ESTIMATE SUMMARY FOR SOLID WASTE COMPOSTING

DIRECT CAPITAL COST						
FLOW	ITEM	MATERIAL		LABOUR		TOTAL
		ONT. CON. (%)	COST ($)	ONT. CON. (%)	COST ($)	COST ($)
(t/d)						
75	**EQUIPMENT**	46	$725,000	100	$65,000	$790,000
	CONSTRUCTION	100	$296,100	100	$468,900	$765,000
	PIPING	100	$3,000	100	$3,000	$6,000
	ELECT./AUTO.	100	$5,000	100	$5,000	$10,000
	TOTAL	62	$1,029,100	100	$541,900	**$1,571,000**

COMMENTS: OVERALL SCALE-UP COEFFICIENT= **0.88** CONSTRUCTION SCALE-UP COEFFICIENT= **0.83**
EQUIPMENT SCALE-UP COEFFICIENT= **0.93** PIPING/ELECT./AUTO. SCALE-UP COEFF.= **0.43**
LABOUR SCALE-UP COEFFICIENT= **0.76**

INDIRECT CAPITAL COST	
ENGINEERING DESIGN AND SITE SUPERVISION (10% OF DIRECT COST)	$157,100
ONTARIO CONTENT	100%
TOTAL CAPITAL COST	**$1,728,100**

OPERATING COST	
LABOUR ($/YEAR)	$75,000
MAINTENANCE ($/YEAR)	$50,000
POWER ($/YEAR)	$15,000
TOTAL ANNUAL OPERATING COST ($/YEAR)	**$140,000**
ONTARIO CONTENT	**100%**
SCALE-UP COEFFICIENT	**0.6**

3. EXAMPLE OF TREATMENT COST CALCULATIONS

The treatment system used for this example is a primary and secondary treatment process, consisting of a Primary Clarifier and an Activated Sludge Process. The treatment plant is designed for 500 m^3/hour flow rate. The scale-up factors for individual treatment technologies are used to calculate the Capital and Operating Costs.

Using Equation 1 in Section 1, the cost of the treatment system treating 500 m^3/hour can be calculated as follows:

$$C_{500\ m3/h} = C_{250\ m3/h}\ x \left(\frac{500}{250}\right)^{e}$$

or

$$C_{500} = C_{250}\ x\ (2)^{e}$$

Costs, scale-up coefficients and Ontario Content for these treatment technologies are presented in Tables 1 and 2.

Tables 12 and 13 show the scale-up calculations for the Primary Clarifier and Activated Sludge System. The combined cost of these two treatment technologies, at 500 m^3/hour flow rate, is presented in Table 14.

TABLE 12

PRIMARY CLARIFIER

Item	Cost ($) at 250 m^3/hour	Scale-up Coefficient	Cost ($) at 500 m^3/hour	Ontario Content ($)
Material Cost				
Equipment	66,700	0.29	81,500	75,800
Construction	45,100	0.60	68,400	68,400
Piping and Electrical/ Automation	9,300	0.75	15,600	15,600
Subtotal Material Cost	121,100	-	165,500	159,800
Labour Cost	76,600	0.64	119,400	119,400
Direct Capital Cost (Material and Labour Costs)	-	-	284,900	279,200
Indirect Capital Cost (15% of Direct Capital Cost)	28,800	-	42,700	42,700
Operating Cost ($/year)	30,000	0.6	45,500	45,500

TABLE 13

ACTIVATED SLUDGE

Item	Cost ($) at 250 m^3/hour	Scale-up Coefficient	Cost ($) at 500 m^3/hour	Ontario Content ($)
Material Cost				
Equipment	246,700	0.37	318,800	173,400
Construction	185,000	0.54	269,000	269,000
Piping and Electrical	112,100	0.67	178,400	178,400
Subtotal - Material Cost	543,800	-	766,200	620,800
Labour Cost	398,200	0.57	591,100	591,100
Direct Capital Cost (Material and Labour Costs)	-	-	1,357,300	1,211,900
Indirect Capital Cost (15% of Direct Capital Cost)			203,600	203,600
Operating Cost ($/year)	245,000	0.6	371,400	371,400

TABLE 14

PRIMARY CLARIFIER WITH ACTIVATED

SLUDGE TREATMENT AT 500 M^3/HR FLOW

Item	Cost ($)	Ontario Content ($)
Material Cost		
Equipment	400,300	249,200
Construction	337,400	337,400
Piping and Electrical	194,000	194,000
Subtotal - Material	931,700	780,600
Labour Cost	710,500	710,500
Direct Capital Cost (Material and Labour Costs)	1,642,200	1,491,100
Indirect Capital Cost	246,300	246,300
Operating Cost ($/year)	416,900	416,900

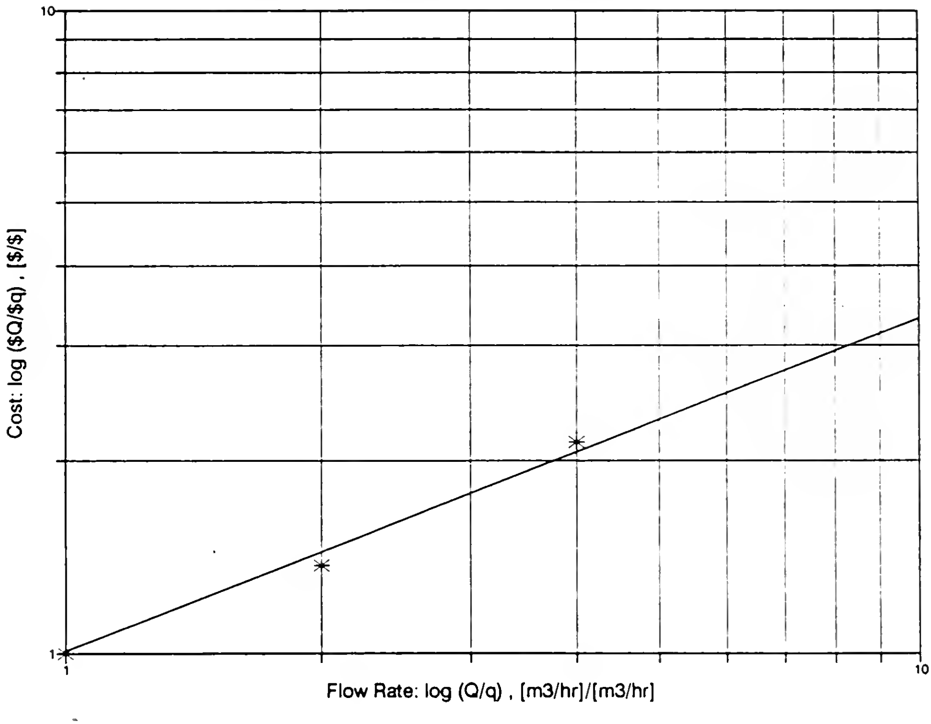
APPENDIX "A"

DETAILED CALCULATIONS

TABLE A 1 COST ESTIMATE FOR PRIMARY CLARIFIERS

TANK FLOW (m3/hr)	ITEM	MATERIAL ONT. CON. (%)	MATERIAL COST ($)	LABOUR ONT. CON. (%)	LABOUR COST ($)	TOTAL COST ($)
250	**EQUIPMENT**					
	-SLUDGE COLLECTOR	75	$63,800	100	$4,500	$68,300
	-PUMP	60	$2,900	100	$600	$3,500
	CONSTRUCTION					
	-CONCRETE	100	$45,100	100	$45,200	$90,300
	-EXCAVATION			100	$5,400	$5,400
	-BACKFILL			100	$10,800	$10,800
	PIPING	100	$1,800	100	$2,600	$4,400
	ELECT./AUTO.	100	$7,500	100	$7,500	$15,000
	TOTAL	86	$121,100	100	$76,600	$197,700
500	**EQUIPMENT**					
	-SLUDGE COLLECTOR	75	$73,900	100	$6,000	$79,900
	-PUMP	60	$2,900	100	$600	$3,500
	CONSTRUCTION					
	-CONCRETE	100	$64,800	100	$64,700	$129,500
	-EXCAVATION			100	$9,100	$9,100
	-BACKFILL			100	$18,000	$18,000
	PIPING	100	$3,100	100	$4,600	$7,700
	ELECT./AUTO.	100	$12,200	100	$12,200	$24,400
	TOTAL	87	$156,900	100	$115,200	$272,100
1000	**EQUIPMENT**					
	-SLUDGE COLLECTOR	75	$94,300	100	$9,000	$103,300
	-PUMP	60	$2,900	100	$600	$3,500
	CONSTRUCTION					
	-CONCRETE	100	$105,800	100	$105,700	$211,500
	-EXCAVATION			100	$16,100	$16,100
	-BACKFILL			100	$32,200	$32,200
	PIPING	100	$5,600	100	$8,200	$13,800
	ELECT./AUTO.	100	$21,300	100	$21,300	$42,600
	TOTAL	89	$229,900	100	$193,100	$423,000

Figure A.1 PRIMARY CLARIFIER



ABLE A.2.A COST ESTIMATE FOR AERATION BASIN

BOD LOAD (kg/d)	ITEM	MATERIAL		LABOUR		TOTAL COST ($)
		ONT. CON. (%)	COST ($)	ONT. CON. (%)	COST ($)	
1200	**EQUIPMENT**					
	–AIR DIFFUSER EQUIP.	20	$38,500	100	$8,000	$46,500
	–BLOWER	10	$75,000	100	$7,500	$82,500
	CONSTRUCTION					
	–CONCRETE	100	$111,000	100	$111,000	$222,000
	–EXCAVATION			100	$20,000	$20,000
	–BACKFILL			100	$40,000	$40,000
	PIPING	100	$8,900	100	$8,900	$17,800
	ELECT./AUTO.	100	$42,900	100	$42,900	$85,800
	TOTAL	64	$276,300	100	$238,300	**$514,600**
3000	**EQUIPMENT**					
	–AIR DIFFUSER EQUIP.	20	$75,500	100	$15,100	$90,600
	–BLOWER	10	$100,000	100	$10,000	$110,000
	CONSTRUCTION					
	–CONCRETE	100	$180,000	100	$180,000	$360,000
	–EXCAVATION			100	$40,000	$40,000
	–BACKFILL			100	$80,000	$80,000
	PIPING	100	$10,500	100	$10,500	$21,000
	ELECT./AUTO.	100	$63,200	100	$63,200	$126,400
	TOTAL	65	$429,200	100	$398,800	**$828,000**
6000	**EQUIPMENT**					
	–AIR DIFFUSER EQUIP.	20	$110,900	100	$22,200	$133,100
	–BLOWER	10	$125,000	100	$12,500	$137,500
	CONSTRUCTION					
	–CONCRETE	100	$225,000	100	$225,000	$450,000
	–EXCAVATION			100	$60,000	$60,000
	–BACKFILL			100	$120,000	$120,000
	PIPING	100	$11,900	100	$12,000	$23,900
	ELECT./AUTO.	100	$69,400	100	$69,400	$138,800
	TOTAL	63	$542,200	100	$521,100	**$1,063,300**

TABLE A.2 B COST ESTIMATE FOR FINAL CLARIFIERS

BOD LOAD (kg/d)	ITEM	MATERIAL		LABOUR		TOTAL COST ($)
		ONT. CON. (%)	COST ($)	ONT CON. (%)	COST ($)	
1200	**EQUIPMENT**					
	-SLUDGE COLLECTOR	75	$120,000	100	$12,000	$132,000
	-PUMP	65	$13,200	100	$1,300	$14,500
	CONSTRUCTION					
	-CONCRETE	100	$74,000	100	$74,000	$148,000
	-EXCAVATION			100	$11,000	$11,000
	-BACKFILL			100	$22,000	$22,000
	PIPING	100	$5,700	100	$5,700	$11,400
	ELECT./AUTO.	100	$33,900	100	$33,900	$67,800
	TOTAL	86	$246,800	100	$159,900	$406,700
3000	**EQUIPMENT**					
	-SLUDGE COLLECTOR	75	$156,500	100	$21,600	$178,100
	-PUMP	65	$17,200	100	$2,400	$19,600
	CONSTRUCTION					
	-CONCRETE	100	$128,200	100	$133,000	$261,200
	-EXCAVATION			100	$19,800	$19,800
	-BACKFILL			100	$39,600	$39,600
	PIPING	100	$11,300	100	$10,300	$21,600
	ELECT./AUTO.	100	$67,400	100	$61,000	$128,400
		86	$380,600	100	$287,700	$668,300
6000	**EQUIPMENT**					
	-SLUDGE COLLECTOR	75	$192,000	100	$33,600	$225,600
	-PUMP	65	$21,000	100	$3,700	$24,700
	CONSTRUCTION					
	-CONCRETE	100	$195,000	100	$207,300	$402,300
	-EXCAVATION			100	$30,800	$30,800
	-BACKPILL			100	$61,600	$61,600
	PIPINO	100	$19,600	100	$16,000	$35,600
	ELECT./AUTO.	100	$114,000	100	$95,000	$209,000
	TOTAL	86	$541,600	100	$448,000	$989,600

Figure A.2 AERATION BASIN AND SECONDARY CLARIFIER

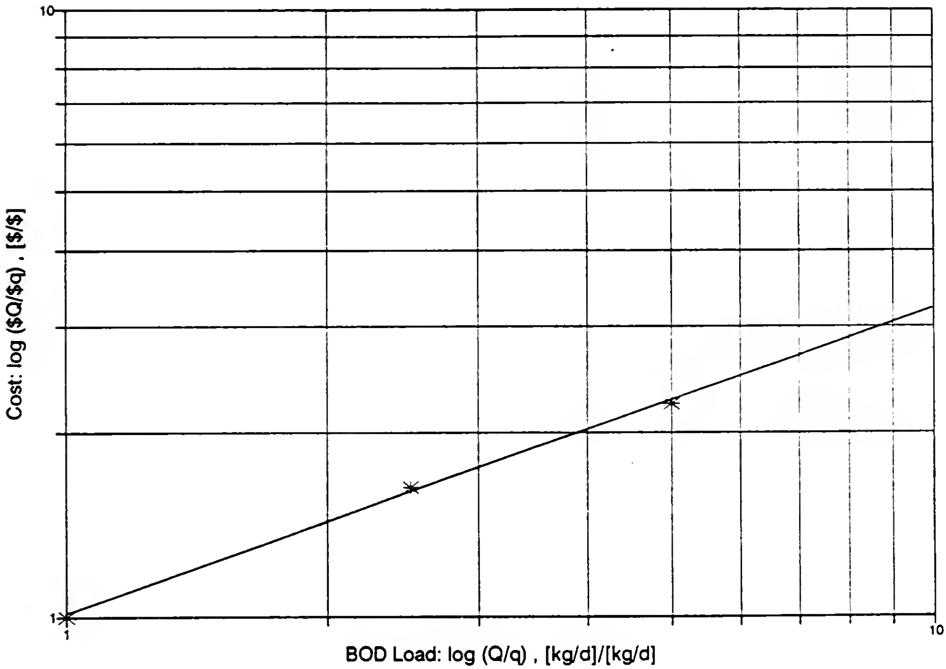


TABLE A.3 COST ESTIMATE FOR ANAEROBIC SLUDGE DIGESTION

RAW WW FLOW (m3/hr)	ITEM	MATERIAL ONT CON. (%)	MATERIAL COST ($)	LABOUR ONT CON. (%)	LABOUR COST ($)	TOTAL COST ($)
250						
	EQUIPMENT					
	- HEAT EXCHANGER	5	$50,000	100	$3,000	$53,000
	- FLOATING COVER	100	$280,000	100	$45,000	$325,000
	- MIXING SYSTEM	40	$189,000	100	$20,000	$209,000
	- GAS SYSTEM	100	$40,000	100	$4,000	$44,000
	- SLUDGE WASTE PUMP	50	$20,000	100	$4,000	$24,000
	CONSTRUCTION					
	- CONCRETE	100	$81,600	100	$81,600	$163,200
	- EXCAVATION			100	$5,400	$5,400
	- BACKFILL			100	$10,200	$10,200
	PIPING	100	$82,000	100	$82,000	$164,000
	ELECT./AUTO.	50	$61,500	100	$61,500	$123,000
	TOTAL	75	$804,100	100	$316,700	**$1,120,800**
500	**EQUIPMENT**					
	- HEAT EXCHANGER	5	$75,000	100	$6,000	$81,000
	- FIXED COVER	100	$300,000	100	$40,000	$340,000
	- FLOATING COVER	100	$155,000	100	$25,000	$180,000
	- MIXING SYSTEM	40	$189,000	100	$20,000	$209,000
	- GAS SYSTEM	100	$40,000	100	$4,000	$44,000
	- SLUDGE WASTE PUMP	50	$30,000	100	$6,000	$36,000
	CONSTRUCTION					
	- CONCRETE	100	$147,000	100	$147,000	$294,000
	- EXCAVATION			100	$13,200	$13,200
	- BACKFILL			100	$25,300	$25,300
	PIPING	100	$103,900	100	$104,000	$207,900
	ELECT./AUTO.	50	$77,900	100	$78,000	$155,900
	TOTAL	79	$1,117,800	100	$468,500	**$1,586,300**
1000	**EQUIPMENT**					
	- HEAT EXCHANGER	5	$75,000	100	$6,000	$81,000
	- FIXED COVER	100	$360,000	100	$50,000	$410,000
	- FLOATING COVER	100	$180,000	100	$27,000	$207,000
	- MIXING SYSTEM	40	$378,000	100	$40,000	$418,000
	- GAS SYSTEM	100	$40,000	100	$4,000	$44,000
	- SLUDGE WASTE PUMP	50	$30,000	100	$6,000	$36,000
	CONSTRUCTION					
	- CONCRETE	100	$236,500	100	$236,500	$473,000
	- EXCAVATION			100	$25,300	$25,300
	- BACKFILL			100	$47,300	$47,300
	PIPING	100	$132,800	100	$132,900	$265,700
	ELECT./AUTO.	50	$99,600	100	$99,700	$199,300
	TOTAL	76	$1,531,900	100	$674,700	**$2,206,600**

Figure A.3 ANAEROBIC SLUDGE DIGESTION

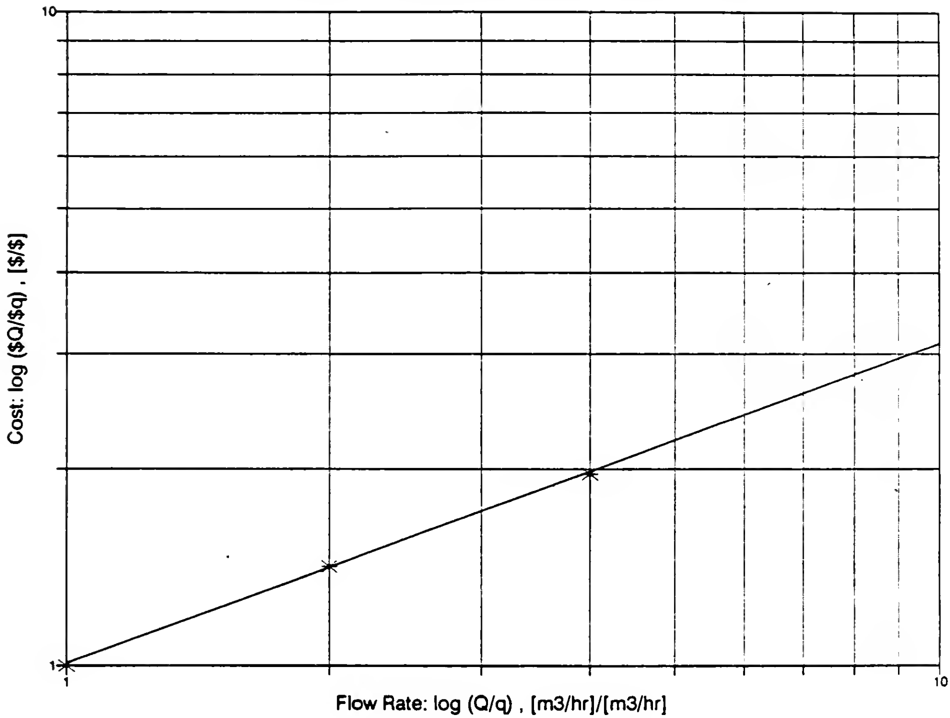


TABLE A.4 COST ESTIMATE FOR SLUDGE DEWATERING

RAW WW FLOW (m3/hr)	ITEM	MATERIAL ONT CON. (%)	MATERIAL COST ($)	LABOUR ONT CON. (%)	LABOUR COST ($)	TOTAL COST ($)
250	**EQUIPMENT**					
	-1 m3 TANKS	100	$4,000	100	$500	$4,500
	-DOSAGE PUMPS	40	$5,000	100	$1,000	$6,000
	-MIXERS	40	$12,000	100	$3,000	$15,000
	-TRANSFER PUMPS	50	$2,000	100	$1,000	$3,000
	-BELT FILTER PRESS	5	$378,000	100	$10,000	$388,000
	-SLUDGE PUMPS	60	$6,000	100	$1,200	$7,200
	-STORAGE TANKS	100	$7,000	100	$1,000	$8,000
	CONSTRUCTION					
	-BUILDING	100	$45,000	100	$45,000	$90,000
	-CONCRETE	100	$45,000	100	$45,000	$90,000
	-EXCAVATION			100	$4,500	$4,500
	-BACKFILL			100	$500	$500
	PIPING	100	$27,000	100	$27,000	$54,000
	ELECT./AUTO.	60	$31,000	100	$31,000	$62,000
	TOTAL	31	$562,000	100	$170,700	**$732,700**
500	**EQUIPMENT**					
	-1 m3 TANKS	100	$4,000	100	$1,000	$5,000
	-DOSAGE PUMPS	40	$5,000	100	$1,000	$6,000
	-MIXERS	40	$12,000	100	$3,000	$15,000
	-TRANSFER PUMPS	50	$2,000	100	$500	$2,500
	-BELT FILTER PRESS	5	$535,000	100	$20,000	$555,000
	-SLUDGE PUMPS	60	$6,000	100	$1,200	$7,200
	-STORAGE TANKS	100	$7,000	100	$700	$7,700
	CONSTRUCTION					
	-BUILDING	100	$65,000	100	$65,000	$130,000
	-CONCRETE	100	$55,000	100	$55,000	$110,000
	-EXCAVATION			100	$5,500	$5,500
	-BACKFILL			100	$500	$500
	PIPING	100	$40,000	100	$40,000	$80,000
	ELECT./AUTO.	60	$35,000	100	$35,000	$70,000
	TOTAL	30	$766,000	100	$228,400	**$994,400**

ABLE A.4 COST ESTIMATE FOR SLUDGE DEWATERING (CONT'D)

RAW WW FLOW (m3/hr)	ITEM	MATERIAL		LABOUR		TOTAL COST ($)
		ONT. CON. (%)	COST ($)	ONT. CON. (%)	COST ($)	
1000	**EQUIPMENT**					
	-1 m3 TANKS	100	$4,000	100	$1,000	$5,000
	-DOSAGE PUMPS	40	$5,000	100	$1,000	$6,000
	-MIXERS	40	$12,000	100	$3,000	$15,000
	-TRANSFER PUMPS	50	$2,000	100	$500	$2,500
	-BELT FILTER PRESS	5	$756,000	100	$40,000	$796,000
	-SLUDGE PUMPS	60	$6,000	100	$1,200	$7,200
	-STORAGE TANKS	100	$7,000	100	$700	$7,700
	CONSTRUCTION					
	-BUILDING	100	$90,000	100	$90,000	$180,000
	-CONCRETE	100	$80,000	100	$80,000	$160,000
	-EXCAVATION			100	$8,000	$8,000
	-BACKFILL			100	$500	$500
	PIPING	100	$60,000	100	$60,000	$120,000
	ELECT./AUTO.	60	$40,000	100	$40,000	$80,000
	TOTAL	30	$1,062,000	100	$325,900	$1,387,900

Figure A.4 SLUDGE DEWATERING

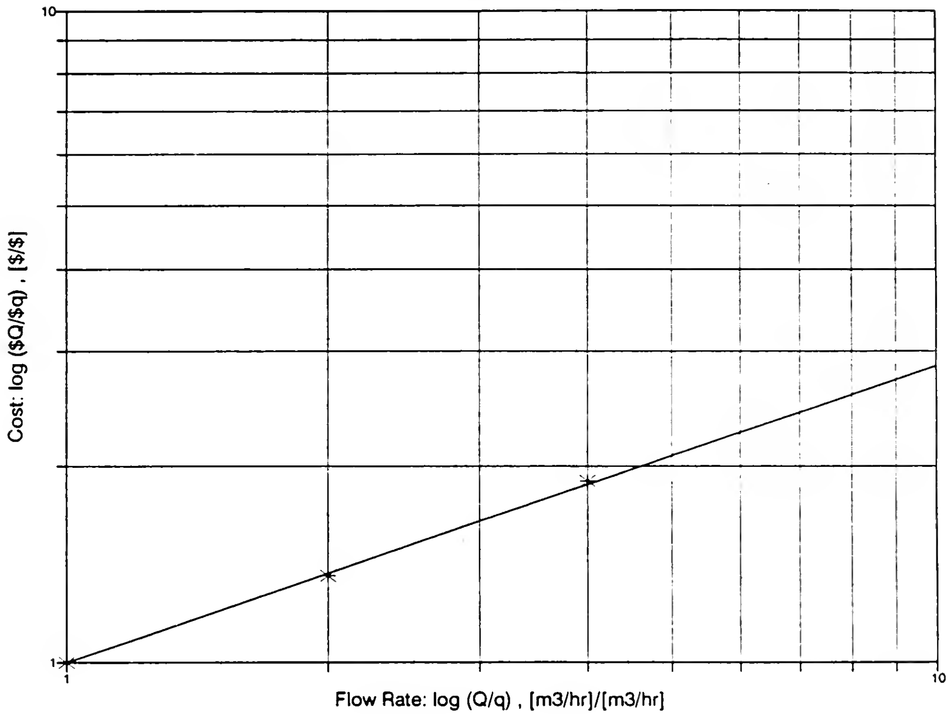


TABLE A 5 COST ESTIMATE FOR OIL WATER SEPERATORS

FLOW (L/s)	ITEM	MATERIAL ONT. CON. (%)	MATERIAL COST ($)	LABOUR ONT. CON. (%)	LABOUR COST ($)	TOTAL COST ($)
5	**EQUIPMENT**					
	-SEPERATORS	100	$12,000	100	$6,000	$18,000
	-SENSOR/ALARM	100	$2,500	100	$500	$3,000
	-OIL PUMP	80	$1,000	100	$500	$1,500
	CONSTRUCTION					
	-CONCRETE	100	$1,400	100	$1,400	$2,800
	-EXCAVATION			100	$1,000	$1,000
	-BACKFILL	100	$100	100	$1,100	$1,200
	PIPING	100	$5,800	100	$6,500	$12,300
	ELECT./AUTO.	100	$2,500	100	$2,500	$5,000
	TOTAL	99	$25,300	100	$19,500	**$44,800**
10	**EQUIPMENT**					
	-SEPERATORS	100	$22,000	100	$9,900	$31,900
	-SENSOR/ALARM	100	$2,500	100	$500	$3,000
	-OIL PUMP	80	$1,000	100	$500	$1,500
	CONSTRUCTION					
	-CONCRETE	100	$1,500	100	$1,500	$3,000
	-EXCAVATION			100	$1,000	$1,000
	-BACKFILL	100	$200	100	$2,100	$2,300
	PIPING	100	$6,300	100	$7,000	$13,300
	ELECT./AUTO.	100	$3,000	100	$3,000	$6,000
	TOTAL	99	$36,500	100	$25,500	**$62,000**
50	**EQUIPMENT**					
	-SEPERATORS	100	$40,000	100	$16,000	$56,000
	-SENSOR/ALARM	100	$2,500	100	$500	$3,000
	-OIL PUMP	80	$1,000	100	$500	$1,500
	CONSTRUCTION					
	-CONCRETE	100	$3,900	100	$3,900	$7,800
	-EXCAVATION			100	$1,200	$1,200
	-BACKFILL		$400	100	$5,800	$6,200
	PIPING	100	$7,300	100	$8,000	$15,300
	ELECT./AUTO.	100	$3,500	100	$3,500	$7,000
	TOTAL	99	$58,600	100	$39,400	**$98,000**

TABLE A 5 COST ESTIMATE FOR OIL/WATER SEPERATORS (CONT'D)

FLOW (L/s)	ITEM	MATERIAL ONT. CON. (%)	MATERIAL COST ($)	LABOUR ONT CON (%)	LABOUR COST ($)	TOTAL COST ($)
110	**EQUIPMENT**					
	-SEPERATORS	100	$65,000	100	$22,700	$87,700
	-SENSOR/ALARM	100	$2,500	100	$500	$3,000
	-OIL PUMP	80	$1,000	100	$500	$1,500
	CONSTRUCTION					
	-CONCRETE	100	$5,200	100	$5,200	$10,400
	-EXCAVATION			100	$1,800	$1,800
	-BACKFILL	100	$1,000	100	$8,000	$9,000
	PIPING	100	$10,400	100	$11,000	$21,400
	ELECT./AUTO.	100	$4,000	100	$4,000	$8,000
	TOTAL	100	$89,100	100	$53,700	**$142,800**

Figure A.5 OIL/WATER SEPARATOR

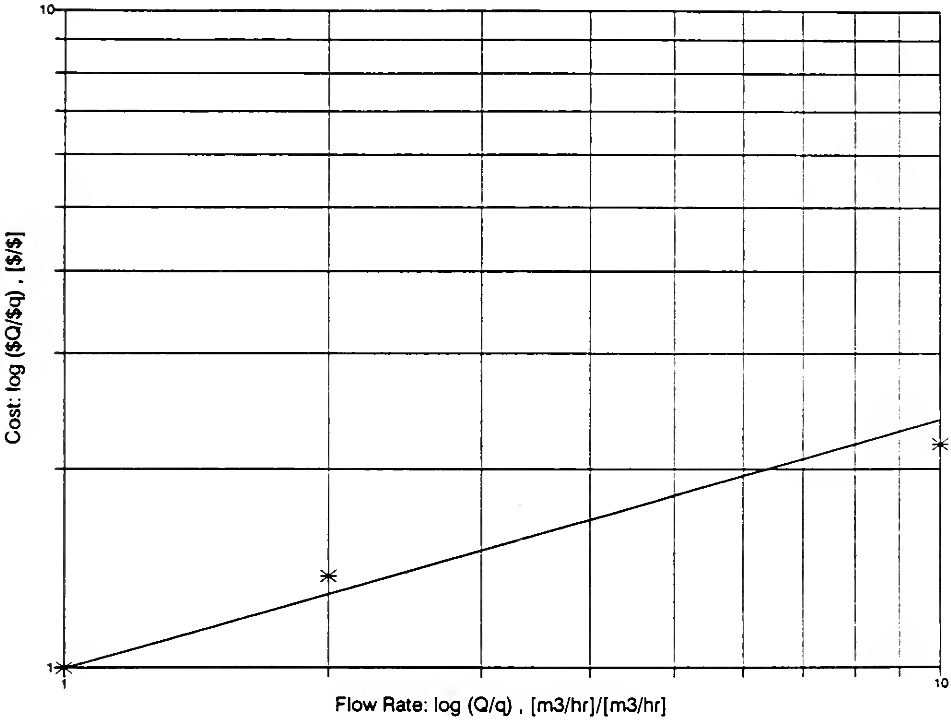


TABLE A 6 COST ESTIMATE FOR CHEMICAL OXIDATION/REDUCTION & FINAL CLARIFIER

FLOW (m3/hr)	ITEM	MATERIAL ONT CON. (%)	MATERIAL COST ($)	LABOUR ONT CON (%)	LABOUR COST ($)	TOTAL COST ($)
5						
	EQUIPMENT					
	- LAMELLA CLARIFIER	0	$22,500	100	$4,500	$27,000
	- METERING PUMPS	65	$12,000	100	$1,200	$13,200
	- MIXING SYSTEM	60	$26,000	100	$5,200	$31,200
	- SLUDGE TH. TANK	100	$5,000	100	$10,000	$15,000
	- SLUDGE WASTE PUMP	80	$10,000	100	$1,000	$11,000
	- FILTER PRESS	0	$25,000	100	$2,500	$27,500
	CONSTRUCTION					
	- CONCRETE	100	$10,700	100	$12,700	$23,400
	- EXCAVATION			100	$1,000	$1,000
	- BACKFILL			100	$1,000	$1,000
	PIPING	100	$15,000	100	$15,000	$30,000
	ELECT./AUTO.	100	$15,000	100	$7,500	$22,500
	TOTAL	55	$141,200	100	$61,600	$202,800
10	EQUIPMENT					
	- LAMELLA CLARIFIER	0	$34,200	100	$6,900	$41,100
	- METERING PUMPS	65	$12,000	100	$1,200	$13,200
	- MIXING SYSTEM	60	$50,000	100	$10,000	$60,000
	- SLUDGE TH. TANK	100	$7,600	100	$15,200	$22,800
	- SLUDGE WASTE PUMP	80	$10,000	100	$1,000	$11,000
	- FILTER PRESS	0	$37,900	100	$3,800	$41,700
	CONSTRUCTION					
	- CONCRETE	100	$15,500	100	$17,600	$33,100
	- EXCAVATION			100	$1,000	$1,000
	- BACKFILL			100	$1,000	$1,000
	PIPING	100	$22,500	100	$22,500	$45,000
	ELECT./AUTO.	100	$17,500	100	$8,800	$26,300
	TOTAL	53	$207,200	100	$89,000	$296,200
25	EQUIPMENT					
	- LAMELLA CLARIFIER	0	$45,300	100	$9,100	$54,400
	- METERING PUMPS	65	$12,000	100	$1,200	$13,200
	- MIXING SYSTEM	60	$119,000	100	$23,800	$142,800
	- SLUDGE TH. TANK	100	$13,200	100	$26,400	$39,600
	- SLUDGE WASTE PUMP	80	$10,000	100	$1,000	$11,000
	- FILTER PRESS	0	$65,600	100	$6,600	$72,200
	CONSTRUCTION					
	- CONCRETE	100	$26,100	100	$28,100	$54,200
	- EXCAVATION			100	$1,000	$1,000
	- BACKFILL			100	$1,200	$1,200
	PIPING	100	$39,000	100	$39,000	$78,000
	ELECT./AUTO.	100	$20,000	100	$10,000	$30,000
	TOTAL	53	$350,200	100	$147,400	$497,600

Figure A.6 CHEMICAL OXIDATION/REDUCTION
AND FINAL CLARIFIER

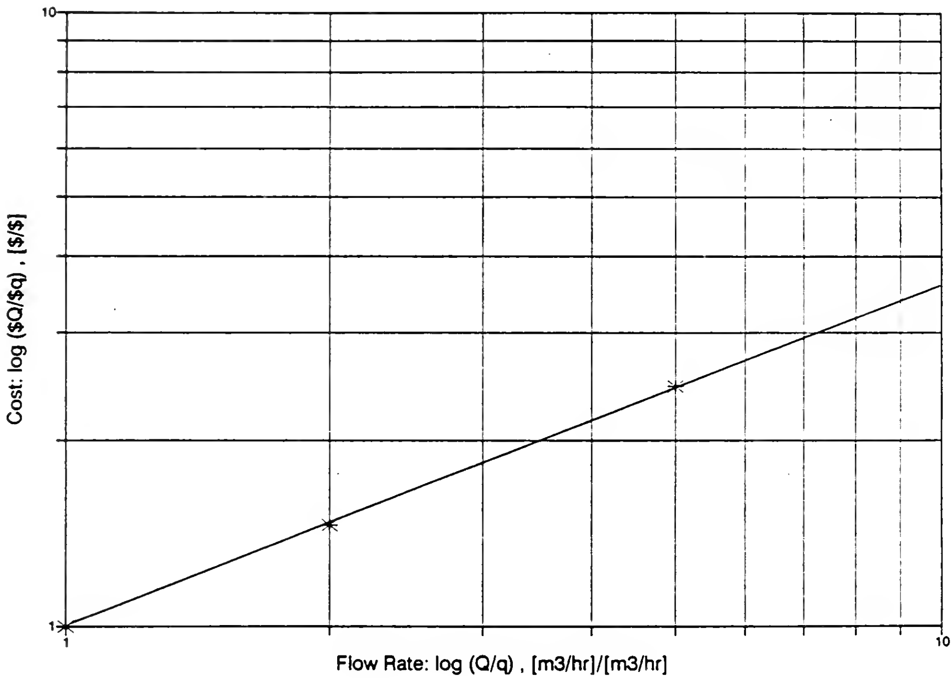


TABLE A.7 COST ESTIMATE FOR PH CONTROL

FLOW (m3/hr)	ITEM	MATERIAL ONT CON. (%)	MATERIAL COST ($)	LABOUR ONT CON. (%)	LABOUR COST ($)	TOTAL COST ($)
10						
	EQUIPMENT					
	- MIXING SYSTEM	80	$8,000	100	$1,600	$9,600
	- METERING PUMPS	65	$3,000	100	$600	$3,600
	- PROBE/ANALYZERS	60	$1,500	100	$300	$1,800
	CONSTRUCTION					
	- CONCRETE	100	$3,600	100	$5,100	$8,700
	- EXCAVATION			100	$1,000	
	- BACKFILL			100	$1,000	$1,000
	PIPINO	100	$2,500	100	$2,500	$5,000
	ELECT./AUTO.	100	$3,500	100	$2,000	$5,500
	TOTAL	85	$22,100	100	$14,100	**$36,200**
50	**EQUIPMENT**					
	- MIXING SYSTEM	80	$26,000	100	$5,200	$31,200
	- METERING PUMPS	65	$3,000	100	$600	$3,600
	- PROBE/ANALYZERS	60	$1,500	100	$300	$1,800
	CONSTRUCTION					
	- CONCRETE	100	$5,900	100	$7,900	$13,800
	- EXCAVATION			100	$1,000	
	- BACKFILL			100	$1,000	$1,000
	PIPING	100	$5,200	100	$5,200	$10,400
	ELECT./AUTO.	100	$6,000	100	$4,000	$10,000
	TOTAL	86	$47,600	100	$25,200	**$72,800**
100	**EQUIPMENT**					
	- MIXING SYSTEM	80	$40,200	100	$8,100	$48,300
	- METERING PUMPS	65	$3,000	100	$600	$3,600
	- PROBE/ANALYZERS	60	$1,500	100	$300	$1,800
	CONSTRUCTION					
	- CONCRETE	100	$10,000	100	$12,000	$22,000
	- EXCAVATION				$1,000	
	- BACKFILL			100	$1,000	$1,000
	PIPINO	100	$7,700	100	$7,700	$15,400
	ELECT./AUTO.	100	$8,500	100	$6,000	$14,500
	TOTAL	86	$70,900	97	$36,700	**$107,600**

Figure A.7 pH CONTROL

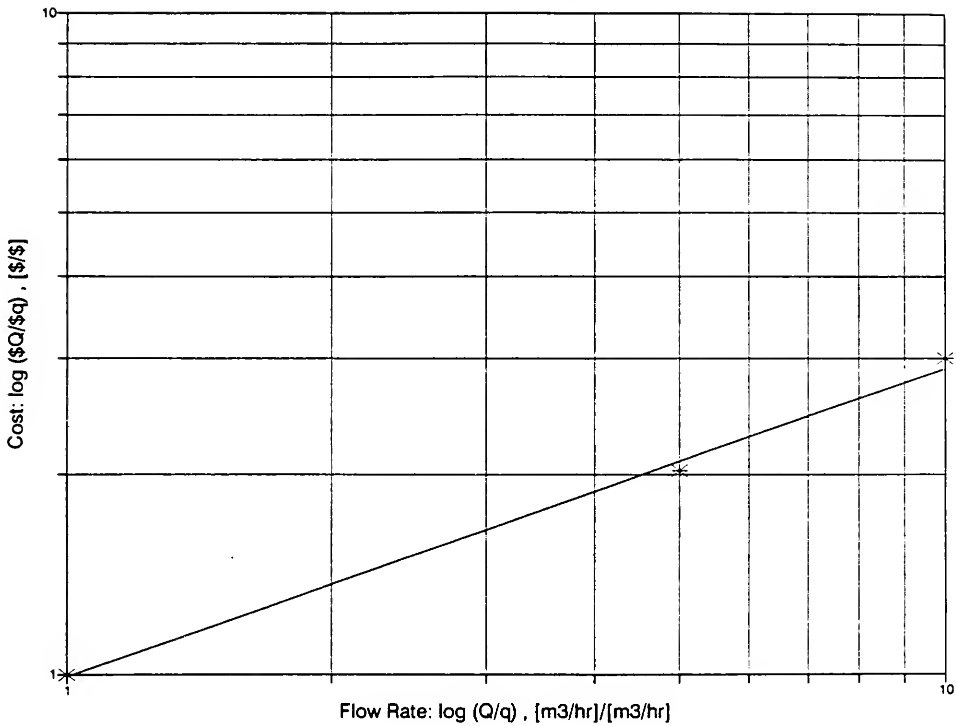


TABLE A 8 COST ESTIMATE FOR SAND FILTRATION

FLOW (m3/hr)	ITEM	MATERIAL		LABOUR		TOTAL COST ($)
		ONT. CON. (%)	COST ($)	ONT. CON. (%)	COST ($)	
250	**EQUIPMENT**					
	-FILTER MODULES	50	$194,000	100	$19,400	$213,400
	-BACKWASH PUMPS	80	$2,500	100	$500	$3,000
	-SPLITTER BOX MISC.	100	$2,000	100	$1,000	$3,000
	CONSTRUCTION					
	-CONCRETE	100	$20,700	100	$20,700	$41,400
	-EXCAVATION			100	$1,000	$1,000
	-BACKFILL			100	$1,800	$1,800
	PIPING	100	$10,000	100	$10,000	$20,000
	ELECT./AUTO.	100	$15,000	100	$7,500	$22,500
	TOTAL	60	$244,200	100	$61,900	**$306,100**
500	**EQUIPMENT**					
	-FILTER MODULES	50	$372,000	100	$27,900	$399,900
	-BACKWASH PUMPS	80	$5,000	100	$1,000	$6,000
	-SPLITTER BOX MISC.	100	$2,500	100	$1,000	$3,500
	CONSTRUCTION					
	-CONCRETE	100	$31,200	100	$31,200	$62,400
	-EXCAVATION			100	$1,200	$1,200
	-BACKFILL			100	$2,400	$2,400
	PIPING	100	$12,500	100	$12,500	$25,000
	ELECT./AUTO.	100	$17,500	100	$10,000	$27,500
	TOTAL	58	$440,700	100	$87,200	**$527,900**
1000	**EQUIPMENT**					
	-FILTER MODULES	50	$714,000	100	$35,700	$749,700
	-BACKWASH PUMPS	80	$7,500	100	$1,000	$8,500
	-SPLITTER BOX MISC.	100	$3,000	100	$1,000	$4,000
	CONSTRUCTION					
	-CONCRETE	100	$43,800	100	$43,900	$87,700
	-EXCAVATION			100	$1,900	$1,900
	-BACKFILL			100	$3,700	$3,700
	PIPING	100	$15,000	100	$15,000	$30,000
	ELECT./AUTO.	100	$20,000	100	$12,500	$32,500
	TOTAL	55	$803,300	100	$114,700	**$918,000**

Figure A.8 SAND FILTRATION

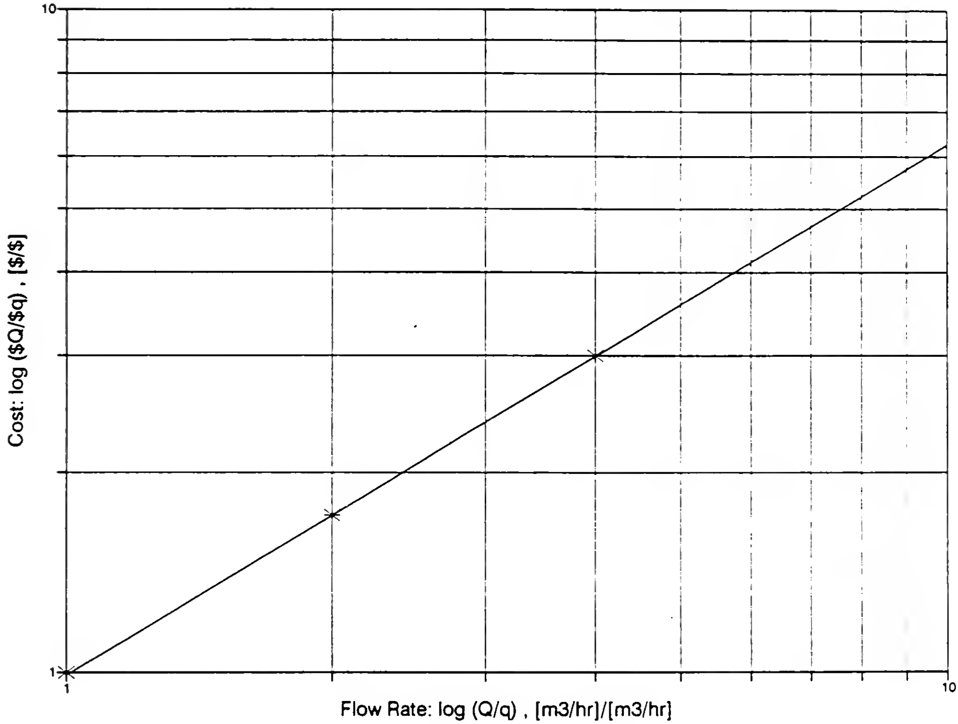


TABLE A 9 COST ESTIMATE FOR DRY COLLECTORS (BAG HOUSE)

FLOW (m3/hr)	ITEM	MATERIAL ONT CON (%)	MATERIAL COST ($)	LABOUR ONT CON (%)	LABOUR COST ($)	TOTAL COST ($)
280						
	EQUIPMENT					
	-TUBEJET	20	$20,400	100	$5,000	$25,400
	-AUXILLARY EQUIP.	50	$4,500	100	$1,000	$5,500
	CONSTRUCTION					
	-STRUCTURAL	100	$3,000	100	$6,000	$9,000
	PIPING	100	$1,500	100	$1,500	$3,000
	ELECT./AUTO.	100	$1,500	100	$1,500	$3,000
	TOTAL	82	$30,900	100	$15,000	$45,900
560	**EQUIPMENT**					
	-TUBEJET	20	$38,700	100	$6,500	$45,200
	-AUXILLARY EQUIP.	50	$7,800	100	$2,500	$10,300
	CONSTRUCTION					
	-STRUCTURAL	100	$4,500	100	$7,500	$12,000
	PIPING	100	$2,000	100	$2,000	$4,000
	ELECT./AUTO.	100	$2,000	100	$2,000	$4,000
	TOTAL	37	$55,000	100	$20,500	$75,500
840	**EQUIPMENT**					
	-TUBEJET	20	$53,100	100	$8,000	$61,100
	-AUXILLARY EQUIP.	50	$9,600	100	$4,000	$13,600
	CONSTRUCTION					
	-STRUCTURAL	100	$6,000	100	$9,000	$15,000
	PIPING	100	$2,500	100	$2,500	$5,000
	ELECT./AUTO.	100	$2,500	100	$2,500	$5,000
	TOTAL	36	$73,700	100	$26,000	$99,700

Figure A.9 DRY COLLECTOR (BAG HOUSE)

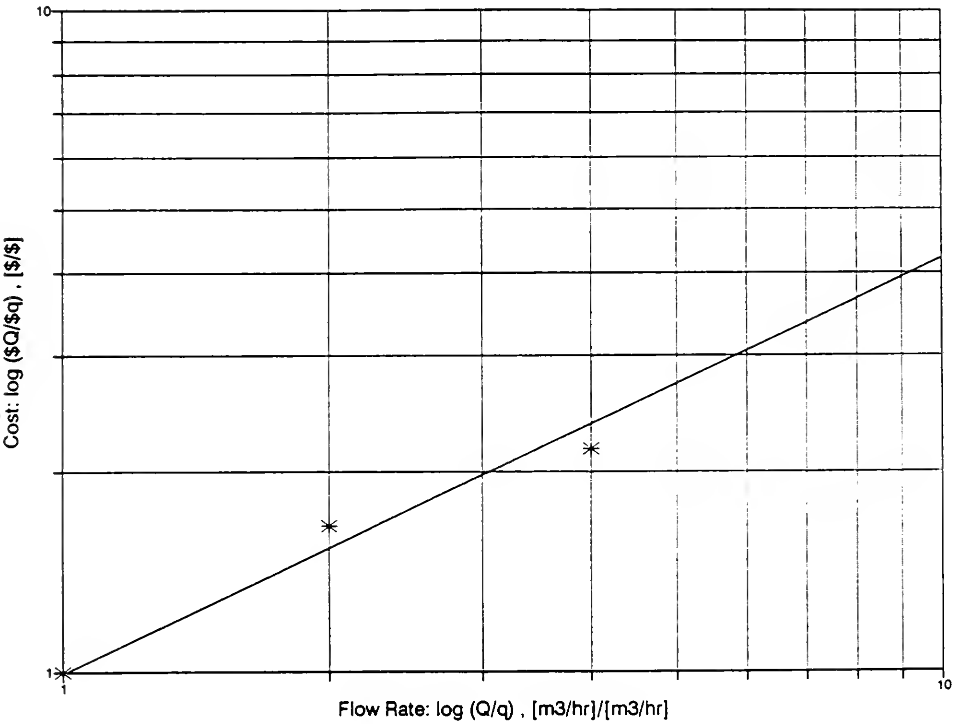


TABLE A.10 COST ESTIMATE FOR WET COLLECTORS

FLOW (m3/hr)	ITEM	MATERIAL ONT CON. (%)	MATERIAL COST ($)	LABOUR ONT CON. (%)	LABOUR COST ($)	TOTAL COST ($)
280						
	EQUIPMENT					
	-INPINJET	95	$12,000	100	$2,500	$14,500
	-AUXILLARY EQUIP.	50	$3,900	100	$1,000	$4,900
	CONSTRUCTION					
	-STRUCTURAL	100	$3,000	100	$6,000	$9,000
	PIPING	100	$1,500	100	$1,500	$3,000
	ELECT./AUTO.	100	$1,500	100	$1,500	$3,000
	TOTAL	89	$21,900	100	$12,500	**$34,400**
560	**EQUIPMENT**					
	-INPINJET	95	$21,800	100	$4,000	$25,800
	-AUXILLARY EQUIP.	50	$6,600	100	$2,500	$9,100
	CONSTRUCTION					
	-STRUCTURAL	100	$4,500	100	$7,500	$12,000
	PIPING	100	$2,000	100	$2,000	$4,000
	ELECT./AUTO.	100	$2,000	100	$2,000	$4,000
	TOTAL	89	$36,900	100	$18,000	**$54,900**
840	**EQUIPMENT**					
	-INPINJET	95	$29,200	100	$5,500	$34,700
	-AUXILLARY EQUIP.	50	$8,200	100	$4,000	$12,200
	CONSTRUCTION					
	-STRUCTURAL	100	$6,000	100	$9,000	$15,000
	PIPING	100	$2,500	100	$2,500	$5,000
	ELECT./AUTO.	100	$2,500	100	$2,500	$5,000
	TOTAL	89	$48,400	100	$23,500	**$71,900**

Figure A.10 WET COLLECTOR

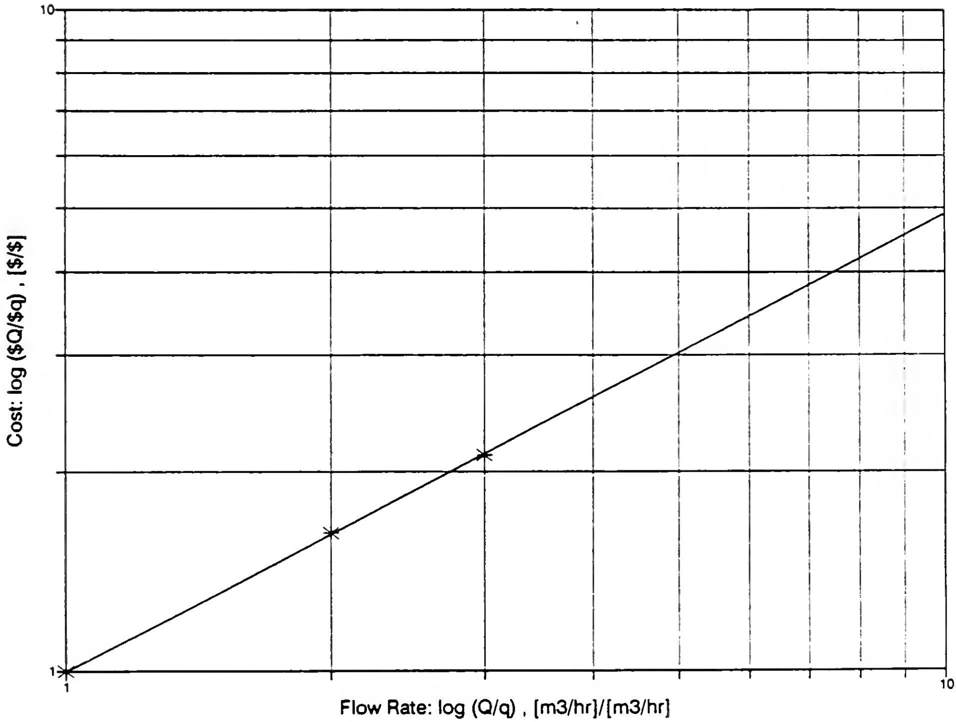
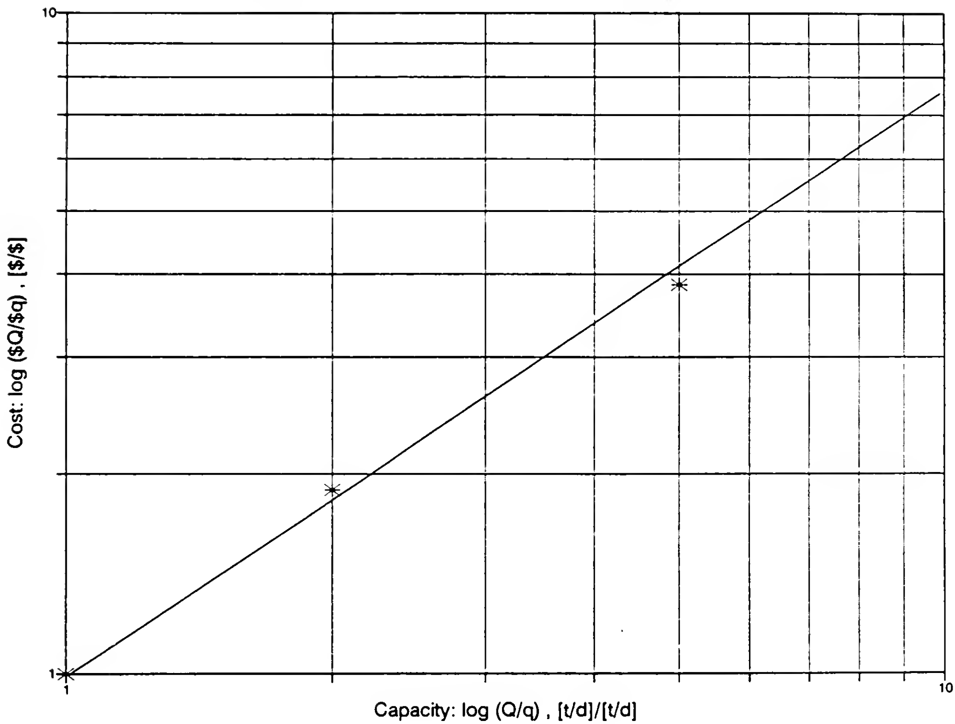


TABLE A 11 COST ESTIMATE FOR SOLID WASTE COMPOSTING

CAPACITY (Tonnes/d)	ITEM	MATERIAL ONT CON. (%)	MATERIAL COST ($)	LABOUR ONT CON. (%)	LABOUR COST ($)	TOTAL COST ($)
75	**EQUIPMENT**					
	-COMPOSTER	50	$650,000	100	$65,000	$715,000
	-FRONT END LOADER	10	$75,000		$0	$75,000
	CONSTRUCTION					
	-BUILDING	100	$141,000	100	$300,000	$441,000
	-CONCRETE	100	$153,100	100	$153,100	$306,200
	-EXCAVATION			100	$2,700	$2,700
	-BACKFILL	100	$2,000	100	$13,100	$15,100
	PIPING	100	$3,000	100	$3,000	$6,000
	ELECT./AUTO.	100	$5,000	100	$5,000	$10,000
	TOTAL	62	$1,029,100	100	$541,900	**$1,571,000**
150	**EQUIPMENT**					
	-COMPOSTER	50	$1,300,000		$85,000	$1,385,000
	-FRONT END LOADER	10	$200,000		$0	$200,000
	CONSTRUCTION					
	-BUILDING	100	$250,000		$460,000	$710,000
	-CONCRETE	100	$304,200		$304,200	$608,400
	-EXCAVATION				$18,500	$18,500
	-BACKFILL	100	$3,500		$25,700	$29,200
	PIPING	100	$4,500		$4,500	$9,000
	ELECT./AUTO.	100	$6,500		$6,500	$13,000
	TOTAL	60	$2,068,700	0	$904,400	**$2,973,100**
375	**EQUIPMENT**					
	-COMPOSTER	50	$2,800,000	100	$105,000	$2,905,000
	-FRONT END LOADER	10	$250,000	100	$0	$250,000
	CONSTRUCTION					
	-BUILDING	100	$310,000	100	$1,000,000	$1,310,000
	-CONCRETE	100	$733,200	100	$733,300	$1,466,500
	-EXCAVATION			100	$38,500	$38,500
	-BACKFILL	100	$5,000	100	$49,000	$54,000
	PIPING	100	$6,000	100	$6,000	$12,000
	ELECT./AUTO.	100	$8,000	100	$8,000	$16,000
	TOTAL	60	$4,112,200	100	$1,939,800	**$6,052,000**

Figure A.11 SOLID WASTE COMPOSTING



APPENDIX "B"

ONTARIO CONTENT BASED ON THE PROBABILITY THAT EQUIPMENT SOLD IN ONTARIO IS MANUFACTURED IN THE PROVINCE

TABLE B 1 PRIMARY CLARIFIERS. ONTARIO MANUFACTURE SHARE (OMS)*

ITEM	MATERIAL OMS* (%)
EQUIPMENT	
- SLUDGE COLLECTOR	100
- PUMP	100
CONSTRUCTION	
- CONCRETE	100
- EXCAVATION	
- BACKFILL	
PIPING	100
ELECT./AUTO.	100

* OMS REFERS TO ONTARIO MANUFACTURE SHARE, AS DEFINED IN THE ADDENDUM NO.1 DESCRIPTION

TABLE B 2 AERATION BASIN ONTARIO MANUFACTURE SHARE (OMS)*

ITEM	MATERIAL OMS* (%)
EQUIPMENT	
-AIR DIFFUSER EQUIP	100
-BLOWER	100
CONSTRUCTION	
-CONCRETE	100
-EXCAVATION	
-BACKFILL	
PIPING	100
ELECT./AUTO.	100

* OMS REFERS TO ONTARIO MANUFACTURE SHARE, AS DEFINED IN THE ADDENDUM NO 1 DESCRIPTION

TABLE B 3 ANAEROBIC SLUDGE DIGESTION ONTARIO MANUFACTURE SHARE (OMS)*

ITEM	MATERIAL OMS* (%)
EQUIPMENT	
- HEAT EXCHANGER	100
- FIXED COVER	100
- MIXING SYSTEM	100
- GAS SYSTEM	100
- SLUDGE WASTE PUMP	100
CONSTRUCTION	
- CONCRETE	100
- EXCAVATION	
- BACKFILL	
PIPING	100
ELECT./AUTO.	80

* OMS REFERS TO ONTARIO MANUFACTURE SHARE, AS DEFINED IN THE ADDENDUM NO.1 DESCRIPTION.

TABLE B 4 SLUDGE DEWATERING ONTARIO MANUFACTURE SHARE (OMS)*

ITEM	MATERIAL OMS* (%)
EQUIPMENT	
- 1 m3 TANKS	100
- DOSAGE PUMPS	100
- MIXERS	100
- TRANSFER PUMPS	100
- BELT FILTER PRESS	0
- SLUDGE PUMPS	100
- STORAGE TANKS	100
CONSTRUCTION	
- BUILDING	100
- CONCRETE	
- EXCAVATION	
- BACKFILL	
PIPING	100
ELECT./AUTO.	80

* OMS REFERS TO ONTARIO MANUFACTURE SHARE, AS DEFINED IN THE ADDENDUM NO 1 DESCRIPTION

TABLE B.5 OIL WATER SEPERATORS ONTARIO MANUFACTURE SHARE (OMS)*

ITEM	MATERIAL OMS* (%)
EQUIPMENT	
-SEPERATORS	100
-SENSOR/ALARM	0
-OIL PUMP	100
CONSTRUCTION	
-CONCRETE	100
-EXCAVATION	
-BACKFILL	100
PIPING	100
ELECT./AUTO.	100

* OMS REFERS TO ONTARIO MANUFACTURE SHARE, AS DEFINED IN THE ADDENDUM NO.1 DESCRIPTION.

TABLE B 6 CHEMICAL OXIDATION/REDUCTION & FINAL CLARIFIER ONTARIO MANUFACTURE SHARE (OMS)*

ITEM	MATERIAL OMS* (%)
EQUIPMENT	
- LAMELLA CLARIFIER	0
- METERING PUMPS	70
- MIXING SYSTEM	100
- SLUDGE TH. TANK	100
- SLUDGE WASTE PUMP	100
- FILTER PRESS	0
CONSTRUCTION	
- CONCRETE	100
- EXCAVATION	
- BACKFILL	
PIPING	100
ELECT./AUTO.	70

* OMS REFERS TO ONTARIO MANUFACTURE SHARE, AS DEFINED IN THE ADDENDUM NO 1 DESCRIPTION

TABLE B - pH CONTROL ONTARIO MANUFACTURE SHARE (OMS)*

ITEM	MATERIAL OMS* (%)
EQUIPMENT	
- MIXING SYSTEM	100
- METERING PUMPS	70
- PROBE/ANALYZERS	25
CONSTRUCTION	
- CONCRETE	100
- EXCAVATION	
- BACKFILL	
PIPING	100
ELECT./AUTO.	100

* OMS REFERS TO ONTARIO MANUFACTURE SHARE, AS DEFINED IN THE ADDENDUM NO.1 DESCRIPTION.

TABLE B 8 SAND FILTRATION ONTARIO MANUFACTURE SHARE (OMS)*

ITEM	MATERIAL OMS* (%)
EQUIPMENT	
-FILTER MODULES	100
-BACKWASH PUMPS	100
-SPLITTER BOX MISC.	100
CONSTRUCTION	
-CONCRETE	100
-EXCAVATION	
-BACKFILL	
PIPING	100
ELECT./AUTO.	60

* OMS REFERS TO ONTARIO MANUFACTURE SHARE, AS DEFINED IN THE ADDENDUM NO 1 DESCRIPTION

TABLE B 9 DRY COLLECTORS (BAG HOUSE) ONTARIO MANUFACTURE SHARE (OMS)*

ITEM	MATERIAL OMS* (%)
EQUIPMENT	
-TUBEJET	0
-AUXILLARY EQUIP.	100
CONSTRUCTION	
-STRUCTURAL	100
PIPING	100
ELECT./AUTO.	90

* OMS REFERS TO ONTARIO MANUFACTURE SHARE, AS DEFINED IN THE ADDENDUM NO.1 DESCRIPTION

TABLE B.10 WET COLLECTORS ONTARIO MANUFACTURE SHARE (OMS)*

ITEM	MATERIAL OMS* (%)
EQUIPMENT	
-INPINJET	100
-AUXILLARY EQUIP.	100
CONSTRUCTION	
-STRUCTURAL	100
PIPING	100
ELECT./AUTO.	90

* OMS REFERS TO ONTARIO MANUFACTURE SHARE, AS DEFINED IN THE ADDENDUM NO.1 DESCRIPTION

TABLE B.11 SOLID WASTE COMPOSTING ONTARIO MANUFACTURE SHARE (OMS)*

ITEM	MATERIAL OMS* (%)
EQUIPMENT	
- COMPOSTER	100
- FRONT END LOADER	0
CONSTRUCTION	
- BUILDING	100
- CONCRETE	100
- EXCAVATION	
- BACKFILL	100
PIPING	100
ELECT./AUTO.	100

* OMS REFERS TO ONTARIO MANUFACTURE SHARE, AS DEFINED IN THE ADDENDUM DESCRIPTION.

PART A: FOR THE DIRECTORY

Products and/or Services Offered (Check all applicable items)

1. What do you consider to be your principal line business, e.g., production of environmental products, smelting metal ores, turning wood pulp into paper, etc. ?

   ____

Do you consider environmental products/services to be a significant line of business?	Yes ☐	No ☐
If your answer is "no", do you produce any environmental products/services at all?	Yes ☐	No ☐
If your answer is "no", do you plan to commence the production of environmental products/services within the next 12 months?	Yes ☐	No ☐

If you answered "no" to all three questions above, please **RETURN THE WHOLE QUESTIONNAIRE BLANK in the large, postage-paid envelope, so that we will not follow up with you. If <u>some</u> of your products/services are "environmental" as defined above, please continue with the rest of the survey, answering questions as appropriate to you.**

2. **Please identify the specific environmental products and/or services which you currently have available for sale, by checking the appropriate items in the list enclosed. (Please check all items relevant to you.)**

3. Principal Markets for Ontario-Produced Environmental Products/Services in which you **are** now active:

Ontario ☐	Quebec ☐	Atlantic Canada ☐	Western Canada ☐
U.S.: Northeast ☐	U.S.: Midwest ☐	U.S.: West ☐	U.S.: South ☐
Caribbean ☐	Latin America ☐	Western Europe ☐	Eastern Europe ☐
Middle East ☐	Africa ☐	Japan ☐	Other Asia ☐
Other Pacific Rim ☐			

4. Principal Purchaser(s) of Your Ontario-Produced Environmental Products/Services

Municipalities ☐	Manufacturing industries:
Resource-based industries:	Petroleum refining ☐
Mining ☐	Iron and steel ☐
Oil and gas ☐	Pulp and paper ☐
Agriculture ☐	Chemicals ☐
Other (Please specify)	Other (Please specify):
____________________	____________________

Utilities ☐ ☐	Commercial/industrial building owners/managers ☐
Residential building owners/managers ☐	Provincial governments ☐
Federal government ☐	Hospitals ☐ Schools, universities ☐

   Other (Please specify) ______________________________

5. Please describe briefly the technology which your major product/service uses or is based upon, e.g., "separation using reverse osmosis":

   ____

   ____

   ____

ENVIRONMENTAL CLASSIFICATION

GOODS

Natural Resource Conservation
___agriculture
___fisheries
___forestry
___water/coastal areas
___parks/wildlife
___oceaography/hydrology
___meteorology/climatology
___mapping/geog. info systems
___other

Air Pollution Control
___absorption/adsorption
___air handling
___catalytic converters
___chemical recovery
___dust collectors
___electrostatic precipitators
___fabric filters/media
___filter accessories
___incinerators
___scrubbers - dry
___scrubbers - wet
___air pollution control systems

Water Pollution Control
___aeration systems
___biological treatment
___centrifuges
___chemical feeding/mixing
___chemical recovery
___filters
___gravity sedimentation systems
___ion exchange
___oil/water separation
___potable water treatment
___screens/strainers
___sewage treatment
___water handling
___water purification
___water pollution control systems

Waste Management
___incineration
___recycling
___waste collection - liquid
___waste collection - solid
___waste disposal
___waste handling
___waste separation
___waste pollution control systems

Chemicals for Pollution Control
___absorbents/adsorbents
___agglomeration/pelletizing
___bacteria/enzymes
___cleaning
___corrosion/scale control
___dust control
___water treatment

Measuring, Monitoring, Instrumentation and Controls
___measuring and monitoring instruments
___sampling equipment
___control equipment
___data acquisition equipment
___electrical drive and control equipment

Scientific, Research and Laboratory
___analytical instruments
___bacteriological supplies
___calibration equipment
___laboratory chemicals
___laboratory data acquisition systems
___laboratory equipment - other

SERVICES

Natural Resource, Conservation and Protection
___agriculture/soil/water
___fisheries
___forestry
___water/coastal areas
___parks/wildlife
___meteorology/climatology
___oceanography/hydrology
___mapping/geog. info systems
___other

Consulting Engineering Services
___process evaluation
___project management
___site reclamation/remediation
___environmental standards
___computer systems
___financial/market analyses
___socio-economic studies
___training

Environmental consulting services
___environmental audits
___environmental monitoring
___environmental permitting
___impact assessments
___risk management
___spills clean-up
___other

Waste Management Consulting Services
___municipal solid waste
___sewage
___hazardous/toxic waste
___radioactive waste
___energy from waste
___recycling
___other

Pollution Assessment and Control
___atmospheric modelling
___air quality assessment
___water quality assessment
___waste surveys/characterization
___air pollution control
___water pollution control
___waste management pollution control

Construction
___pollution control facilities

Waste Handling Operation
___waste collection
___waste handling/sorting/transport
___composting
___waste treatment plants
___landfills
___incinerators
___sewage treatment plants
___septic tank services
___potable water
___recycling

Laboratory/Field Services
___analytical services
___sampling, monitoring/measurement
___environmental research

PART B: STRICTLY CONFIDENTIAL WHEN COMPLETED

Note: This portion of the survey is to be completed only if you **produce** environmental products and services **in Ontario**. If your operation is engaged only in wholesale and retail sales of products produced elsewhere, please return the questionnaire blank **along with your response to Part A**.

1. How long has your firm been in the business of producing environmental products/services in Ontario?

   We have been in the business for _____ years, since 19___.

2. Who are the principal purchaser(s) of your Ontario-produced environmental products/services, and who would you plan to approach as markets in the future?

	Now Active:	Interested in Developing:
Municipalities	☐	☐
Resource-based industries	☐	☐
Manufacturing industries	☐	☐
Utilities	☐	☐
Residential/commercial property owners/managers	☐	☐
Provincial/Federal governments	☐	☐
Institutions (e.g., hospitals)	☐	☐
Other (Please specify)		

____

3. In which geographic markets are you currently active or interested in developing for your Ontario-produced environmental products/services?

	Now Active:	Interested in Developing:		Now Active:	Interested in Developing:
Ontario	☐	☐	Quebec	☐	☐
Atlantic Canada	☐	☐	Western Canada	☐	☐
U.S.: Northeast	☐	☐	U.S.: Midwest	☐	☐
U.S.: West	☐	☐	U.S.: South	☐	☐
Caribbean	☐	☐	Latin America	☐	☐
Western Europe	☐	☐	Eastern Europe	☐	☐
Middle East	☐	☐	Africa	☐	☐
Japan	☐	☐	Other Asia	☐	☐
Other Pacific Rim	☐				

4. In 1990, what approximate proportion of your firm's Ontario-produced products/services was sold in each of the following geographic locations?:

Ontario	_____ %
Rest of Canada	_____ %
Outside of Canada	_____ %

5. Which of the following types of technologies is/are used in your Ontario-produced products/services? (Please check all those which are relevant to you.)

- o **"Standard"** technologies or equipment in widespread use in **both** environmental and non-environmental sectors, e.g., pipes and valves, commodity chemicals ☐
- o **Advanced technologies** geared specifically to environmental prevention and treatment/clean-up/remediation (e.g., biosensors, metal chelation, multi-media treatment) ☐
- o Technologies focused on the **prevention** of pollution ☐
- o Technologies focused on the **treatment/clean-up/remediation** of pollution ☐
- o Other (Please specify)

____

6. Approximately what proportion of your environmental products/services is actually **produced in Ontario**, taking into account imported materials, components, etc.?

0% ☐
1% - 24% ☐
25% - 50% ☐
51% - 74% ☐
75% - 100% ☐

Of the Ontario-based portion, approximately what proportion is **labour**, and what **materials**?

Labour _____ % Materials _____ %

Of the Ontario-based portion, please estimate the dollar value for labour and materials involved in **sales within Ontario**.

Labour: $ ____________ in 1990 Materials: $ ____________ in 1990

7. At what average annual rate have the input costs (materials, components, labour) of your Ontario-produced environmental products/services been growing or decreasing within the past five years, or less, as applicable?

Input costs have been growing at _____ % on average, each year over the last 5 years (1986-1990), or if, less than 5 years in business, then, on average _____ % over the last _____ years, or

Input costs have been decreasing at ____ %, on average, over the last _____ years

Has the gap between input costs and final sales prices been widening or narrowing over the time period noted?

Widening ☐ Narrowing ☐ About same ☐

8. Does your firm sell/lease used machinery and equipment for environmental protection purposes? Yes ☐ No ☐

If "yes", what is the approximate proportion of your total Ontario-based environmental sales involved?

Under 1% ☐ 1%-24% ☐ 25%-50% ☐ 51%-74% ☐ 75%-100% ☐

Where do most of these sales take place?:

Ontario _____ % Rest of Canada _____ % Outside of Canada _____ %

9. Please indicate below your total and Ontario-produced environmental sales revenues in thousands of dollars, according to the primary problem area to which the products/services are addressed. (Please indicate zero where appropriate.)

	Total Sales ($ Thousands)	Ontario-produced Sales ($ Thousands)	
		Products	Services
Air Pollution Prevention/ Control/Monitoring	________	________	________
Water Pollution Prevention/ Control/Monitoring	________	________	________
Solid Waste Reduction/ Disposal/Treatment/ Site Remediation	________	________	________
Other Environmental Problems	________	________	________
TOTAL	________	________	________

10. Could you please indicate the amounts of total and of Ontario-produced sales revenues in the year 1986, or in your first full year of operations, if after 1986.

For 1986 ☐ or for first year: 19__	Total Sales ($ Thousands)	Ontario-produced Sales ($ Thousands)	
		Products	Services
Air Pollution Prevention/ Control/Monitoring	________	________	________
Water Pollution Prevention/ Control/Monitoring	________	________	________
Solid Waste Reduction/ Disposal/Treatment/ Site Remediation	________	________	________
Other Environmental Problems	________	________	________
TOTAL	________	________	________

11. Do you plan to remain in the business of producing environmental products/services in Ontario?
Yes ☐ No ☐

Any comments as to reasons for leaving the business, if this is your intention:

____

____

12. If you plan to remain in the Ontario environmental products and services business, please indicate your projected annual growth rate for Ontario-produced environmental products/services for the next five years:

We project _____ % each year for the next five years, 1991-1995

13. Approximately what proportion of your total sales revenues went into Research and Development activities in 1990? _____ %

What was the proportion over the last five years, 1986-1990, or since you began in business? ______%

14. For 1990, please give the estimated number of employees engaged in Ontario-produced environmental products and/or services. Number ____________

15. For 1986, or your first year of operations, if since 1986, please give the estimated number of employees engaged in Ontario-produced environmental products and/or services. Number ____________

16. (Optional) We invite you to provide any comments which you may wish on barriers and opportunities you face in expanding your business or on other topics in relation to your environmental products and services, including the role of government in promoting your business.

____

____

____

____

____

____

Thank you very much for your assistance with this survey. Please return it in the postage-paid envelope provided by October 11, 1991.

References

Apogee Research International Ltd., Peat Marwick S&K, James Hickling Management Consultants Ltd. (1990) *Overview Economic Assessment of Remedial Action Plans for the Great Lakes' Areas of Concern.* (Report prepared for the Ontario Ministry of the Environment: Queen's Printer for Ontario)

Burnham, C.D. (1989) "Ontario Hydro's Acid Gas Program" *1989 Ontario Waste Management Conference.* (Ontario Ministry of the Environment: Toronto)

Business International (1990) *Information Kit for Ontario Firms Considering Doing Business in Eastern Europe.* (Prepared for the Ontario Ministry of Industry, Trade and Technology)

Canadian Council of Ministers of the Environment (1990). *Management Plan for Nitrogen Oxides (NOx) and Volatile Organic Compounds (VOCs): Phase I.* (CCME: Winnipeg)

CH2M Hill (1991) *The Physical and Economic Dimensions of Municipal Solid Waste Management in Ontario.* (Ontario Ministry of the Environment: Toronto)

Ciulini, Adam (1990) "Waste Reduction Initiatives" *1990 Ontario Waste Management Conference* (Ministry of the Environment: Toronto)

Collins, Susan and Harry Dahme (1989). "The Muck Stops Here: What will Ontario's new and tougher sewer use by-law mean to industry?" *Process Industries Canada.* May.

Dalcor Innoventures Ltd. (1990) *Engineering the Future.* Prepared for the Canadian Engineering Manpower Board and the Employment and Immigration Commission. (Edmonton)

Darcey, Sue (1990) "MRFs Ride High on Recycling's Coattails" *The Management of World Wastes.* October.

Dun & Bradstreet Canada (1991). *Market Survey of Environmental Expenditures by Canadian Business.* (prepared for Environment Canada)

The Economist (1991) "California cashes in on cleaning up" November 16.

Environment Caanda (1990) *The Green Plan.* (Ottawa)

Environmental Business Journal (1991) "The Industry Takes Shape" Vol 4, no 4 (April)

Ember, Lois (1991) "Strategies for Reducing Pollution at the Source are Gaining Ground" *Chemical and Engineering News* July 8.

Ernst & Young [Woods Gordon] (1989) *Study of the Ontario Environmental Protection Industry.* (prepared for the Ontario Ministry of the Environment)

Ernst & Young (1990a) *Europe 1992 and the Ontario Environmental Protection Industry.* (prepared for the Ontario Ministry of Industry, Trade and Technology: Toronto)

Ernst & Young (1990b) *The Canadian Market for Environmental Products and Services.* (prepared for Industry, Science and Technology Canada: Ottawa).

Ernst & Young (1991) *Germany Reunified: New Opportunities for Ontario Firms.* (prepared for the Ontario Ministry of Industry, Trade and Technology)

Ernst & Young (1992a) *The Eastern U.S. Market for Canadian Environmental Engineers.* (prepared for the Department of External Affairs and International Trade Canada)

Ernst & Young (1992b) *Fifth Action Program on the Environment.* (E&Y European Business Advisory Centre: Brussels)

Flemington, Robert A. (1990) "OMMRI: Corporations in Support of Recycling" *1990 Waste Management Conference* (Ministry of the Environment: Toronto)

Fouhy, Ken (1990) "Europe Clamps Down on Eutrophication" *Chemical Engineering.* October.

Gigles, Kent (1991) "Days of Reckoning" *Chemical Engineering.* February

Glenn, William M. (1989) "The environmental protection industry" *Water and Pollution Control.* October.

_______________ (1991) "So, what do you think of the NDP?"*Water and Pollution Control.* April

Grier, Ruth (1991) "A Statement to the Legislature on the MISA Issues Resolution Process – Final Report." (Ontario Ministry of the Environment: mimeo) Dated September 26.

Gross, Neil (1992) "The Green Giant? It May be Japan" *Business Week.* February 24.

Hains, Richard. (1990) "Forecasting the Environmental Market". *Process Engineering.*

Journal of the Air & Waste Management Association. (1990) "Hazardous Waste Services Market Seen Tripling in Four Years" Vol 40 no 3.

The Lawyers Weekly (1991) "A sampler of environmental laws (federal and provincial)" November 29.

Lee, Bryan (1991) "Highlights of the Clean Air Act Amendments of 1991" *Journal of the Air & Waste Management Association.* Vol 41, no 1.

Levy, Patricia (1990) "Czechs need help to clean up environment" *The Financial Post.* January 18.

McIlvaine, Robert W. (1990) "Air and Waste Management Markets in New Decade" *Journal of the Air & Waste Management Association.* Vol 40, no 3.

_________________(1991) "The 1991 Global Air Pollution Control Industry" *Journal of the Air & Waste Management Association.* Vol 41, no 3.

McInnes, Robert and Ross Van Royen (1990). "Desulfurizing Fluegases"*Chemical Engineering.* September

_______________, Kevin Jameson and Dorothy Austin (1990). "Scrubbing Toxic Inorganics"*Chemical Engineering.* September

_______________, Steven Jelinek and Victoria Putsche (1990). "Cutting Toxic Organics" *Chemical Engineering*. September

NETAC (1992) *U.S. Environmental Industry Overview.* (Presentation materials for a semanar held in Toronto, March 9, 1992)

Nichols, Alan B. (1989) "Crisis in Eastern Europe: opportunity for U.S. business"*Journal of the Water Pollution Control Federation.* Vol. 61, no. 7.

Onyshko, Tom (1991) "Environmental liability creates uncertainty for creditors" *The Lawyers Weekly.* November 29.

O'Riordan, Timothy (1989) "Air Pollution Legislation and Regulation in the European Community: A Review Essay" *Atmospheric Environment.* Vol. 23, No 2.

Offen, George and Ralph F. Altman (1991) "Issues and Trends in Electrostatic Precipitation Technology for U.S. Utilities" *Journal of the Air & Waste Management Association.* Vol 41.

Ontario Ministry of the Environment (1990). *Clean Air Program Draft Regulation Overview.* (Toronto)

Orchard, Deborah (1991) "The Green Plan: A National Challenge for Canada" *Journal of the Air & Waste Management Association.* Vol 41, no 3.

Porter, J. Winston. (1989) "Waste Management: A Look to the Future" *Journal of the Water Pollution Control Federation.* Vol. 61, no. 5.

Process Engineering (1989) "Environment Spending Set for Strong Growth" November.

Process Industries Canada (1990a) "Environmental Spending" March.

_______________________(1990b) "Plastic Opportunity" May.

Redma Consultants Ltd. (1990) *The U.S. Opportu8nities for Ontario Environmental Protection Products and Services.* (Prepared for the Ontario Ministry of Industry, Trade and Technology)

Ross, Nicola (1991) "Pulp & Paper: New Federal Regulations" *Enviroline*. Vol. 3 No.4.

Ross, Nicola (1992) "Oldman Decision: Narrows and Widens" *Enviroline*. February.

Rubin, D.K. (1991a) "Market finally comes into its own" *ENR* August 30.

__________ (1991b) "Clean Water Act debate swirls on" *ENR*. October 7.

Statistics Canada (1992) *Analysis of the 1989 Pollution Abatement and Control Survey*. (Investment and Capital Stock Division: Ottawa)

Surprenant, Norman (1990). "Shutting Off Fugitive Emissions" *Chemical Engineering*. September

Verut, Caroline (1990) Review of Mexican environmental protection markets for Canadian firms prepared for the Candian Embassy, Mexico City.

VHB Research and Consulting Inc. and CH2M Hill Engineering Ltd (1991) *Water Pollution Abatement Technology and Cost Study*. Prepared for the Ontario Ministry of the Environment. (Queen's Printer for Ontario: Toronto)

Water and Pollution Control (1991) "Environmental business blooming despite recession" April

Water and Pollution Control. (1990) "New treatment technology for pulp and paper industry" April.

White, Douglas (1990) "PCB Destruction Technology". *1990 Waste Management Conference* (Ministry of the Environment: Toronto)