Scenario Development of Industrial Production and Pollutant Loading

Prepared for:

Environment Canada

Final Report
March 31, 1995

Prepared by:

Apogee Research

Apogee Reference No. 393

APOGEE RESEARCH
International, Ltd.

April 13, 1995

Mr. Vic Shantora
Director General, Technology Development
Environmental Technology Office
Environment Canada, Ontario Region
867 Lakeshore Road
Burlington, Ontario
L7R-4A6

RE: SCENARIO DEVELOPMENT PROJECT

Dear Vic:

Enclosed is the final report of the Scenario Development of Industrial Production and Pollutant Loadings project. The final report consists of the historical information on production and pollutant loadings to air, water and land for four industry sectors in Ontario (pulp and paper, iron and steel, petroleum refining and electric power generation).

As per our agreement in the letter dated March 31, 1995, no further industry association meetings have taken place and the information that was learned at the Ontario Forest Industry Association (OFIA) meeting has been summarized in this letter.

This letter identifies the lessons that have been learned from undertaking the project. These lessons will facilitate future projects involving multi-media pollutant loadings and economic activity.

1.0 Purpose of the Project

The Scenario Development Project was commissioned to provide an answer to the question, " Is it possible to have declining pollutant loadings at the same time as enjoying increasing industrial production?". Over the last few years, pollutant loadings into the Great Lakes has declined significantly. There are two schools of thought as to the reason for this decline.

The recession has caused the overall economic activity in Ontario and the Great Lakes Basin to fall, thereby resulting in less production and a subsequent decline in pollutant loadings. As soon as the recession is over and pollutant loadings data become available, it will show that pollutant loadings have increased due to the increased economic activity.

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The second school of thought suggests that once economic activity rebounds, pollutant loadings will not increase. Instead, the movement towards sustainable development will result in the consistent decline in pollutant loadings, even when economic activity rebounds.

The Ontario Region of Environment Canada, through this project, sought to determine the appropriate economic indicators to track in order to determine which school of thought was correct. The three objectives of the project were to:

- illustrate the historical relationships between industrial financial performance indicators and multi-media pollutant loadings, focusing on four major industries in Ontario;

- project multi-media pollutant loadings based on forecasted output and growth and project multi-media pollutant loading reductions from planned investments; and

- determine the necessary conditions to bring about a simultaneous decline in pollutant loadings and increase in industrial production.

2.0 Summary of Conclusions

- The historical records in the pulp and paper, iron and steel and petroleum refining sectors in Ontario suggest that production is increasing at a slow and steady rate against a dramatic drop in conventional pollutant discharges to water. Therefore, for conventional pollutant discharges to water, the historical data support the contention that it is possible to have an increase in production occurring simultaneously with declining pollutant loadings. The OFIA at our meeting affirmed the accuracy of this interpretation for the pulp and paper sector in Ontario.

- The linkage of economic indicators to multi-media pollutant loadings is an extremely complex subject. The historical information that was obtained on general and industry specific economic indicators did not present any readily discernible linkages to multi-media pollutant loadings.

3.0 Lessons Learned

Not all of the research questions could be addressed due to the limitations in the pollutant loadings data. However, there were significant lessons learned from the scenario development project. We have identified the following lessons:

- the availability of multi-media pollutant loadings data;
- the interpretation of these data sets by industry;
- the knowledge that industry currently possesses on existing pollutant loadings data;

- the interest of industry to verify the pollutant loadings data that are attributed to them; and
- the willingness of industry to participate and work in conjunction with government to address the issues dealt with in this project.

3.1 Availability of Pollutant Loadings Data

The core historical information that is required to undertake a project linking the relationship of multi-media pollutant loadings to economic activity are the historical records on pollutant loadings.

The scenario development project has revealed that:

- accurate historical data does exist for conventional pollutant discharges to water in Ontario for certain sectors and that these data are available for an extensive period of time;
- historical data on air emissions are tied via an emission factor to industrial production. This approach hinders the linkage of air emission levels to economic indicators;
- historical data on hazardous waste generation is limited because no accurate reports exist for hazardous waste managed on-site. Recording only the generation of hazardous waste treated off-site does not present an accurate picture;
- there is very little information at all on discharges of the pollutants that have been identified by the International Joint Commission in their Binational Program to Restore and Protect the Lake Superior Basin or the pollutants identified in the Canada Ontario Agreement (COA); and
- the COA pollutants are attracting increasing attention and yet there is no historical information on their pollutant loadings.

Through these lessons, this project has identified:

- where future efforts should be concentrated to ensure that accurate and complete historical information will be available in the future. These efforts should be concentrated on:
    - developing accurate emission levels for air contaminants, which are not linked to an emission factor; and
    - the better recording of hazardous waste generation that covers both on and off-site waste management.
- the need for initiatives to be set up to ensure the tracking of pollutant loadings data for the COA pollutants.

3.2 Interpretation of Pollutant Loadings Data by Industry

The response of the OFIA to the hazardous waste data reported from the pulp and paper sector in Ontario is both interesting and similar to other industries' reactions to the governments' intention to publicize hazardous waste generation data. Industry is concerned over its public image if these hazardous waste figures would be released, without realizing that these data are publicly available. Industry realized that better reporting practices are needed from sectors and individual facilities on hazardous waste that is treated on-site. This will enable a more accurate reflection of the total production of hazardous waste at the individual facility and industry level.

3.3 The Linkage of Pollutant Loadings Data to Economic Indicators

The project allowed all parties concerned to realize that the linkage of pollutant loadings data to economic indicators is extremely complex. There are no simple relationships between pollutant loadings and industrial economic activity.

3.4 Current Industry Knowledge of Available Pollutant Loadings Data

There are three particular examples of the lack of industry knowledge on pollutant loadings data:

- the OFIA as well as representatives of some of its members were not cognizant of the existence of the Residual Discharge Information System (RDIS), maintained by Environment Canada. The RDIS reports emissions from many different SIC's, including the pulp and paper sector, as well as for individual firms within each SIC at the provincial and national level;

- industry stated that they do not review the Ontario Ministry of Environment and Energy's "green book" on pollutant discharges in Ontario to see if the pollutant loadings information contained is an accurate representation of the contribution from their respective sector and individual facilities; and

- industry was not aware that hazardous waste generation data are publicly available for Ontario through the Ontario Generator Registration Database (OGRD).

3.5 Industries' Interest in Verifying Pollutant Loadings Data

Both the OFIA and representatives of individual facilities expressed interest in taking part in discussions and activities to verify the pollutant loadings data. This would ensure that their sector and individual facilities within are represented accurately in such a project. OFIA representatives asked that in the future, pollutant loadings data be sent to the individual facilities first in order for them to verify the accuracy of the data.

3.6 Willingness of Industry to Participate in Conjunction with Government on Such Projects

This interest in verifying the pollutant loadings data at the industry and facility level indicates the willingness of industry to participate in future projects similar to the scenario development project. Both industry and government realize the importance that such a project could have to changing the negative perceptions about the results on production and profit of incorporating pollution prevention activities into the production process.

4.0 Applying Lessons Learned to Future Projects

The goals and objectives of the scenario development project were and will be important. The increasing importance of sustainable development makes it critical to develop relationships between pollutant loadings and industrial economic performance. An identification of declining pollutant loadings in conjunction with an increasing level of production would be an important step in obtaining further industry assistance to achieve environmental goals. This project has made a first step by identifying the declines in discharges of conventional pollutants to water from the iron and steel, pulp and paper and petroleum refining sectors at the same time that production in these sectors was increasing or remaining constant. Therefore, industry expansion and improved environmental performance can be achieved simultaneously. The two goals need not be incompatible.

We now provide three suggestions on how to apply the lessons learned to similar future projects:

- work from this inventory of available data;
- start to fill the significant data gaps; and
- get industry support early in the project.

4.1 Work From This Inventory of Data

The same information that was obtained for this project will have to be obtained in the future in the event that other similar projects are commissioned. The experience of this pilot project has led to an inventory of the information that is available in Ontario on multi-media pollutant loadings. Future work should build on this inventory.

4.2 Significant Data Gaps

The project has identified the following gaps in pollution loading data for the four industry sectors:

- no data on the pollutants identified by COA;
- no reliable information on common air contaminants; and
- no information on hazardous waste generated and treated on-site.

These gaps must be filled if future work is to be successful.

4.3 Gaining Industry Support Early in the Project

The meeting with the OFIA demonstrated that industry is interested and is willing to be an active partner in undertaking projects similar to this. It is therefore important to gain industries' support in the early stages of a project.

Industry representatives recognized the problem of data availability and realized that steps are required to address this problem. Individual facilities are interested in having their contribution to pollutant loadings reported accurately.

Both industry associations and individual facility representatives realize that they need to work with government to ensure that:

- pollutant loadings data are available;
- the information is accurate; and
- their pollutant loadings are represented accurately in reports similar to the scenario development project.

If there are any comments on the final report or this letter please call Mr. Patrick Moore of our office at (416) 971-7201.

Yours truly,

Pat Moore for

Eric Cowan

c.c. Mr. Tom Muir
Mr. Tom Tseng

Attachments

Table of Contents

Executive Summary

Background and Purpose

Environment Canada has initiated this pilot project in an effort to illustrate the relationships between industrial production, investment and multi-media pollutant loadings. The project will examine these relationships for four major Ontario industries.

The specific purposes of the project were to:

- illustrate the historical relationships between industrial financial performance and multi-media pollutant loadings, focusing on four major industries in Ontario;
- project multi-media pollutant loadings based on forecasted output and growth and project multi-media pollutant loading reductions from planned investments; and
- determine the necessary conditions to bring about a simultaneous decline in pollutant loadings and increase in industrial production.

Methodology

Illustration of the historical relationship between industrial production and multi-media pollutant loadings is conducted for four Ontario industry sectors:

- pulp and paper;
- petroleum refining;
- iron and steel; and
- electric power generation.

Measuring Trends in Production

Trends in industrial production are measured in physical terms, i.e. tonnes of output from a particular industry. Different measures of production are used for each sector.

Measuring Trends in Pollutant Loadings

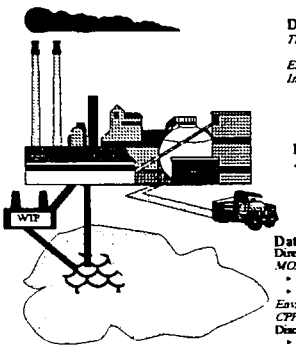
Trends in pollutant loadings are measured using a variety of data sources. Exhibit 1 lists, by environmental media, the various sources. Waste generation, for the purposes of this report, was defined as off-site shipments of hazardous and liquid industrial wastes.

There are limitations to using these data for measuring pollutant loadings. The limitations are detailed in this report.

Illustrating the Historical Relationships

The relationships between industrial production and pollutant loadings are presented graphically. For each industry and pollutant, graphs are presented which plot production trends against pollutant loading trends. No correlation statistics or regression analyses of the data are undertaken.

Exhibit 1
Pollutant Data Sources



Data Sources for Air Pollutants
The Ontario Ministry of Environment and Energy (MOEE)
- Air Emission Inventory (FRED)

Environment Canada
Industry Data
- CPPI Inventory

Data sources for Waste Generation
MOEE
- Ontario Generator Registration Database (OGRD)

Data Sources for Water Pollutants
Direct Discharges
MOEE
- Industrial Monitoring Information System (IMIS)
- MISA Sample Information System (SIS)

Environment Canada studies
CPPA Data
Discharges to WTP
- No single source

For each industry sector, the illustrations of the relationship between individual pollutants and production are followed by a brief analysis. A summary of production versus total loadings of all pollutants to each environmental medium is also presented for each industry.

The relationships between industrial production and pollutant loadings are presented at the sectoral level. No facility-specific information is provided in this report.

The report does not address the issue of why changes have occurred in production and pollutant loadings. It simply illustrates the historical relationships based on existing data.

Results

This final report presents the historical relationships for the selected industry sectors between industry production and multi-media pollutant loadings. Results vary across sector, pollutant and environmental media. Generally, however, the following results were found.

- Significant reductions have been achieved for pollutant loadings to water by three of the industry sectors (pulp and paper, petroleum refining and iron and steel) at the same time that production has either risen or remained relatively constant.

- Most of the air emissions are estimated using emission factors. The use of emission factors ties air emissions directly to industrial activity. This limits the ability to draw any conclusions on the relationship between production and pollutant loading.

- Difficulty with the data on hazardous waste generation preclude the determination of any relationship between hazardous waste generation and industrial production.

Conclusions

- The historical records in the pulp and paper, iron and steel and petroleum refining sectors in Ontario suggest that production has been rising or has remained relatively constant against a dramatic drop in conventional pollutant discharges to water.

- The historical data on conventional pollutant discharges to water support the contention that it is possible to have an increase in production occurring simultaneously with declining pollutant loadings.

- The historical data on air emissions and hazardous waste generation in Ontario were not suitable to establish a relationship with industrial production.

- The linkage of economic indicators to multi-media pollutant loadings is an extremely complex subject. The historical information that was obtained on general and industry specific economic indicators did not present any readily discernible linkage to multi-media pollutant loadings.

- There is little information at all on pollutant loadings that have been identified by the International Joint Commission in their Binational Program to Restore and Protect the Lake Superior Basin or the pollutants identified in the Canada Ontario Agreement (COA).

- The COA pollutant loadings are attracting increasing attention and yet there is no historical information on them.

1.0 Introduction

1.1 Background and Purpose

As demand for environmental protection grows and economic restructuring gains prominence on the public agenda, environment-economy linkages are becoming increasingly important. Policy makers need comprehensive answers to questions such as:

- how will industrial growth affect the total "stress" placed on the environment?
- will investments in new production technologies increase or decrease this "stress"?
- how much can investments in pollution prevention technologies reduce pollutant loadings to the environment? and
- what impact will these investments have on industrial performance?

There is no shortage of *possible* answers to these questions. The literature is filled with hypothesized relationships between the economy and pollutant loadings.

Unfortunately, *definitive* answers are rarely clear. Many empirical studies say more about methodological shortcomings than about the hypothesized relationships. Contradictory findings are frequently the rule rather than the exception.

Nonetheless, in Ontario, we have a growing body of data that could reveal significant insights into the relationships between the economy and multi-media pollutant loadings. Past trends in multi-media pollutant loadings are known for many major industries and pollutants. Reliable sources of economic data are very well developed.

In an effort to address questions like those noted above, Environment Canada (Ontario Region) has initiated this pilot project in an effort to illustrate the relationships between industrial production, investment and multi-media pollutant loadings in Ontario. The project examines these relationships for four major Ontario industries: petroleum refining, pulp and paper, iron and steel and electric power generation[1].

[1]. These sectors were selected based on their: contribution to the provincial economy; level of pollutant loadings; and data availability. For further detail on the selection process refer to an earlier project report "Scenario Development of Industrial Production and Pollutant Loading: Decision Paper, October 6, 1994.

The specific objectives of the project were to:

- illustrate the historical relationships between industrial financial performance indicators and multi-media pollutant loadings, focusing on four major industries in Ontario;
- project multi-media pollutant loadings based on forecasted output and growth and project multi-media pollutant loadings reductions from planned investments; and
- determine the necessary conditions to bring about a simultaneous decline in pollutant loadings and increase in industrial production.

1.2 Final Report Format

The remainder of this report is divided into 5 sections.

Section 2.0 outlines the methodology and sources of data used to illustrate the relationship between industrial production and pollutant loadings in Ontario.

Sections 3.0 through 6.0 present the results for each of the four sectors. For each sector the following are presented:

- an overview of the industry in Ontario;
- a description of the production processes and uses of the sector's products; and
- the relationship between the sectors' historical production and pollutant loading.

2.0 Methodology

As noted in the Introduction, the purpose of this report is to present the historical relationships between industrial production and pollutant loading. This section presents:

- the data sources used to measure trends in production;
- the data sources used to measure trends in pollutant loadings; and
- the methodology used to illustrate the relationship between industrial production and pollutant loadings.

2.1 Measuring Trends In Production

Production by each of the sectors examined in this project is measured in physical terms, e.g. tonnes of product from sector X. For each sector a different factor of production and different source of data are employed, as presented below.

Pulp and Paper

The pulp and paper industry's production is measured in tonnes per year.

The Canadian Pulp and Paper Association (CPPA) provided the consultant team with production data for the years 1968 to 1993.

Petroleum Refining

The production factor selected for the petroleum refining industry is crude charged per year in '000s of cubic metres. Crude charged represents the volume of crude oil converted by Ontario refineries into conventional petroleum products such as gasoline, aviation fuel, heating oils, and residual fuels oils, and crude converted to petrochemical feedstock.

Statistics Canada data for the years 1973 to 1993 are used for the petroleum refining sector.

Iron and Steel

The production factors used for iron and steel are: ingots and raw steel in '000s of net tonnes per year. The historical analysis of industrial production and pollutant loadings is conducted for three companies (four facilities) in Ontario[2]. Annual reports from the companies operating these four mills provided the production data for this sector.

Electric Power Generation

The production factor chosen for electric power generation is megawatt hours per year. In Ontario,

[2]. These facilities were selected as they were the only ones for which pollutant loading data were available across all environmental media.

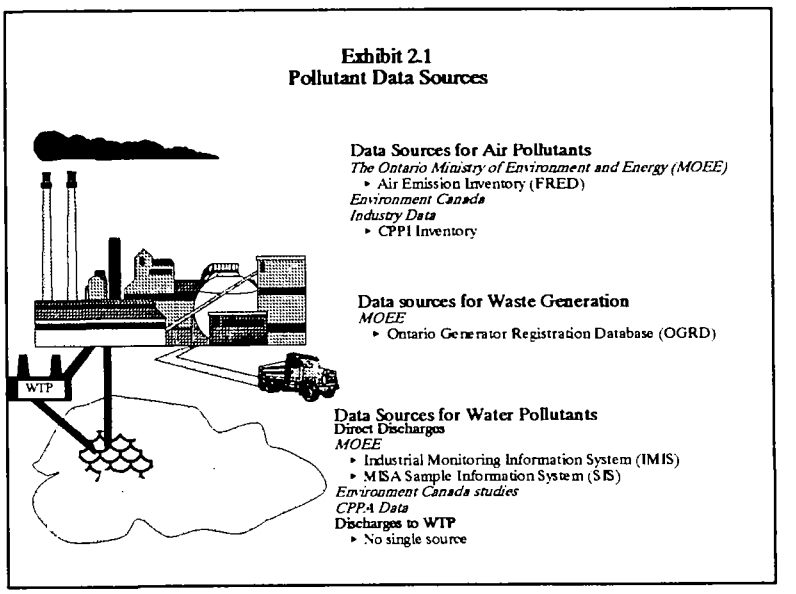
almost all electric power is generated by Ontario Hydro. Ontario Hydro data for selected facilities are used for this sector.

2.2 Measuring Trends in Pollutant Loading

This section describes each source of pollutant loading data, by environmental medium. The purpose of conducting this study on a multi-media basis is to potentially illustrate how reductions in loadings to one environmental medium can have an impact on loadings to other media.

Exhibit 2.1 identifies the various sources of data used to measure pollutant loading trends. The exhibit groups data sources by the three environmental media: water, air and land. Note that there are no data sources listed for discharges to municipal wastewater treatment plants (WTP). There are two reasons for this.

Exhibit 2.1
Pollutant Data Sources



- According to officials at the Ontario Ministry of Environment and Energy (MOEE), most of the industries being examined in this project primarily discharge directly to a waterbody. In most cases, the municipal WTPs are used for sanitary wastes only.

- Discharges to municipal WTPs are monitored by each individual municipality. No central source of data exist.

Before describing each of the sources there are some general constraints about the pollutant loading data that should be noted.

2.2.1 Constraints on the Data

The data sources were selected based on an assessment of all available data. The two most important criteria in the assessment were that:

- data be available on a historical basis, i.e. a time series; and

- data be available on an industry-specific basis.

In order to illustrate the historical relationship between industrial production and pollutant loadings, pollutant data are required on a time-series basis. This limits the number of pollutants which can be examined. Historical pollutant loading data are available for "conventional" pollutants only. It is not possible to illustrate the historical relationships for many of the toxic pollutants which have the been the focus of more recent regulations, such as the MOEE's Municipal/Industrial Strategy for Abatement (MISA).

This is unfortunate. At the outset of this project, Environment Canada provided a list of "pollutants of interest" to the consultant team that the Department hoped could be included in the study. Of particular interest to Environment Canada were the Tier I and II pollutants of the Canada-Ontario Agreement on the Environment (COA). Exhibit 2.2 on the following page provides a list of the Tier I and II pollutants. The Tier I pollutants are the same as those targeted by the International Joint Commission (IJC) for virtual elimination from the Great Lakes Basin.

While there are various studies on the loadings of some of these pollutants, historical data are not available in a time-series format.

Three important points should be made regarding the time-series of pollutant loading data presented later in this report.

- The number of years for which data exist vary by industry. Some industries have data on pollutant loadings as far back as 1968, whereas for others the data begin in 1977.

- The number of years for which data exist vary by environmental medium. Data on discharges to water are available for many more years than for loadings to air or land. This makes it difficult to assess multi-media relationships between production and pollutant loading.

- For the illustration of historical relationships, data were obtained for as many years as possible. In some cases this meant combining different sources of pollutant data. Combining different data sets introduces a potential problem in interpreting the results. For different data sets, pollutant loading data may have been collected and/or reported using different techniques. This may cause fluctuations in the data that are unrelated to changes in actual pollutant loadings. It was not possible to account for these differences.

The second criterion was that data had to be available on an industry-specific basis. Many of the studies which contain data on loadings of COA Tier I and II pollutants do not identify clearly the particular industries generating the pollutants. Data not available on an industry-specific basis could not be included in developing historical relationships.

EXHIBIT 2.2
CANADA-ONTARIO AGREEMENT (COA) ON THE ENVIRONMENT
HAZARDOUS CHEMICALS TARGETED FOR ELIMINATION OR REDUCTION IN THE GREAT LAKES

TIER 1 SUBSTANCES

Aldrin/dieldrin	Benzo(a)pyrene
Chlordane	DDT
Hexachlorobenzene	Alkyl-lead
Mercury	Mirex
Octachlorostyrene	PCBs
PCDD	PCDF
Toxaphene	

TIER 2 SUBSTANCES

Anthracene	Cadmium
1,4-diclorobenzene	3,3-dichlorobenzidine
Dinitropyrene	Hexachlorocyclohexane
4,4-methylenebis(2-chloraniline)	Pentachlorophenol
Tributyl tin	

Plus 17 polyaromatic hydrocarbons (PAH) as a group including but not limited to

Benz(a)anthracene	Benzo(b)fluoranthene
Benzo(g,h,i)perylne	Perylene
Phenanthrene	

Source: Environment Canada, 1994

2.2.2 Pollutant Loadings to Water

Pollutant loadings to water are drawn from four sources:

- the Industrial Monitoring Information System (IMIS) and the MISA Sample Information System (SIS), both maintained by the Ontario Ministry of Environment and Energy (MOEE);

- Environment Canada; and
- the Canadian Pulp and Paper Association (CPPA).

The IMIS and MISA Data

The IMIS is an annual update of all industrial direct dischargers in Ontario. The IMIS contains pollutant loading data for the years 1984 to 1990. The pollutants which are covered vary by sector.

In 1986, the Ontario Ministry of the Environment introduced the Municipal/Industrial Strategy for Abatement (MISA). The goal of the MISA program is the virtual elimination of toxic contaminants from industrial and municipal effluents. Extensive monitoring was conducted for a one-year period for nine Ontario industries (including the four of interest to this study). The period of monitoring varied by sector, but generally monitoring was conducted between 1988 and 1990.

In 1990, the MISA SIS database was established to house the MISA effluent monitoring data. The SIS contains the effluent monitoring data collected during the 12 month MISA monitoring periods. The SIS includes detailed data for these 12 month periods for all industries of interest to this study.

Following the 12 month MISA monitoring period, firms continued to report on the pollutants contained in the IMIS. The MISA SIS is used to house these data. The SIS contains data for the years 1990 through to 1992. It is expected that 1993 data will be available early in 1995.

Therefore, between the IMIS and the MISA SIS, data on industrial direct dischargers are available from 1984 to 1992 for those pollutant covered in each database.

It should be noted that the historical data on water pollutants for the electric power generation sector are limited to temperature rise and pH. As these offer little insight on pollutant loadings, the historical relationship between industrial production and pollutant loadings to water is not undertaken for this sector.

There are two caveats that should be noted about interpreting the results using these two datasets.

- Under IMIS, firms used different protocols and methodologies for effluent monitoring. This could cause discrepancies among firms in the same industry and in time series for the same firms. Under MISA effluent monitoring regulations, the protocols and methodologies for effluent monitoring were standardized. As a result, the loadings reported by a facility may change from IMIS to MISA simply due to different monitoring practices.
- Under IMIS, some firms reported on net loadings and others on gross loadings. The difference between the two reporting systems in terms of loadings can be significant. In some cases, reporting by the same firm changed from one year to another, i.e. from gross to net or vice versa. Under MISA, firms are regulated to report on gross loadings.

Environment Canada

Environment Canada has conducted a number of studies concerning pollutant loadings to water for two of the sectors of interest (pulp and paper and petroleum refining). Data from these studies are used primarily for years prior to those covered by IMIS and MISA. Further detail on these data sources is provided in later sections of this report.

The Canadian Pulp and Paper Association (CPPA)

Data on pollutant loadings to water were obtained from the CPPA for the years 1968 to 1993. The data cover two pollutants: total suspended solids and biological oxygen demand.

There are some cautions about the CPPA data which are explained in further detail in Section 3.0.

Exhibit 2.3 on the following page shows, by sector, the pollutants to water covered in this study.

EXHIBIT 2.3
POLLUTANTS TO WATER FOR WHICH HISTORICAL DATA ARE AVAILABLE

PULP AND PAPER	PETROLEUM REFINING	IRON AND STEEL	ELECTRIC GENERATION
total suspended solids (TSS) BOD (biological oxygen demand)	phenols TSS oil and grease sulphides ammonia nitrogen	phenols oil and grease ammonia TSS cyanide iron	No Data Available

2.2.3 Pollutant Loadings to Air

Two sources of data are employed for measuring emissions to air:

- the air emissions inventory maintained by the MOEE (referred to as the FRED (Fast Reference Emission Document) database); and
- air emission inventories conducted by the Canadian Petroleum Producers Institute (CPPI).

The FRED Database

The FRED database provides estimates of air emissions in Ontario for the years 1985 to 1990. The inventory covers the following pollutants: SO_2, NO_x, VOC, Particulates, and CO. The information is provided by facility, sector and by pollutant. The quality of data varies by pollutant and by industry. The electric power generation sector offers the best opportunity for illustrating the relationship between production and pollutant loadings to air. MOEE officials stated that the air emission data for the electric power industry are the most accurate of any Ontario sector.

The usefulness of FRED is limited by several factors.

- At best, on a sector basis, data are available for five years only. This limits the historical relationship to these five years.
- There is no documentation available on the method used to establish the MOEE air emission inventory. This makes it difficult to accurately determine the reliability of the data. MOEE staff stated that the accuracy and reliability of the data vary by sector and by pollutant.
- Most of the emissions are estimated using emission factors. This limits the ability to draw any conclusions on the relationship between production and pollutant loading. The use of emission factors ties air emissions directly to industrial activity. This makes it impossible to demonstrate a relationship between industrial production and air emissions beyond that assumed in developing the emission factors.

The FRED database is used for all sectors of interest except petroleum refining.

The CPPI Inventory

The CPPI has undertaken an air emissions inventory of its member companies every five years beginning in 1973 and up to 1988. The inventories are used for this sector. The inventory covers the following pollutants: SO_2, NO_x, VOC, Particulates, and CO. The CPPI inventories are described in more detail in Section 4.0.

2.2.4 Pollutant Loadings to Land

For the purposes of this project, pollutant loadings to land are considered to be waste generation and disposal. The data sources for waste generation are divided into two areas:

- solid waste; and
- hazardous and liquid industrial waste.

Solid Waste

No historical data on solid waste are available by industry or by type of waste. Therefore, it was not possible to include solid waste in this project.

Hazardous and Liquid Industrial Waste

One source of data is used for estimating hazardous waste generation: the Ontario Generator Registration Database (OGRD).

The Ontario Generator Registration Database (OGRD) contains data, by calendar year, on generators, carriers and receivers of hazardous, liquid industrial, and registerable solids wastes, as defined under

the Ontario Environmental Protection Act Regulation 347[3]. It is maintained by the Ontario Ministry of the Environment and Energy in support of Regulation 347.

For each facility generating waste, carrying waste, treating waste or importing waste into Ontario, the OGRD contains a detailed file. The file identifies the facility by company name, address, the SIC to which it belongs, and a contact name and telephone number. Each file also provides detailed information on the wastes generated by that facility. The information that is available includes the:

- type of waste, recorded by MOEE waste type;
- hazardous characteristic of the waste, e.g. toxic, corrosive; and
- volume of waste generated.

There are a number of significant limitations in using the OGRD data for measuring trends in waste generation.

The OGRD contains data on both wastes treated/disposed of on-site and those disposed of off-site. On-site waste data are not reliable and are not used in this project. Off-site waste estimates are more reliable[4]. The comparison of industrial production to hazardous waste generation is conducted for off-site wastes only. However, fluctuations in off-site waste can occur year to year which have little relationship to industrial production. For example, wastes are often stored on-site until sufficient quantities are attained to warrant sending them off-site for treatment and/or disposal. Additionally, waste management practices of a company may change from year to year, e.g. companies may decide to ship wastes off-site that had traditionally been managed on-site. Examples such as these can cause spikes in the quantity of waste recorded as being shipped off-site from year to year. These fluctuations may have absolutely no relation to the total quantity of hazardous waste generated in a given year.

In order to be able to establish a comprehensive and more accurate measurement of trends in hazardous waste generation better on-site data are required.

While off-site waste data are considered to be more reliable than on-site data, there are still problems with using the data. The OGRD was established in 1986. Many companies did not comply with the reporting requirements of the OGRD for the first several years. Wastes shipped off-site by these companies would not be captured by the OGRD for these years, but would show up in later years. This can artificially increase the rate of waste generation recorded for a particular industry.

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3. A waste is considered liquid industrial if it meets none of the criteria for hazardous and is liquid defined by the slump test described in Ontario Regulation 347. A waste is classified as registerable solid if it produces a leachate that contains any of the substances in Schedule 4 of Ontario Regulation 347 and at concentrations between 10 and 100 times the concentrations listed in Schedule 4.

4. Apogee Research, *The Canadian Hazardous Waste Inventory*, prepared for Environment Canada, October, 1994.

Wastes are identified using the MOEE waste classification system. Specific pollutants are not identified in this system. For example, MOEE waste code 121 is described as "Alkaline Solutions, Sludges, and Residues Containing Heavy Metals". The comparison of hazardous waste generation to industrial production is conducted using total waste generated per year, not individual wastes or pollutants.

2.2.5 Summary of Pollutant Loading Data Sources

Exhibit 2.4 on the next page summarizes the sources of pollutant data used in this project and the pollutants to be examined for each industry.

EXHIBIT 2.4
SUMMARY OF DATA SOURCES AND POLLUTANTS

ENVIRONMENTAL MEDIA	PULP AND PAPER	PETROLEUM REFINING	IRON AND STEEL	ELECTRIC GENERATION
WATER	Data Sources CPPA Pollutants total suspended solids (TSS) BOD (biological oxygen demand)	Data Sources Environment Canada, MISA and IMIS Pollutants phenols TSS oil and grease sulphides ammonia nitrogen	Data Sources MISA and IMIS Pollutants phenols oil and grease ammonia TSS cyanide iron	No Data Available
AIR	Data Source FRED Pollutants SO_2, NO_x, VOC, Particulates, CO	Data Source CPPI Inventories Pollutants SO_2, NO_x, VOC, Particulates, CO	Data Source FRED Pollutants SO_2, NO_x, VOC, Particulates, CO	Data Source FRED Pollutants SO_2, NO_x, VOC, Particulates, CO
LAND	Data Source OGRD Pollutants All Waste Types Grouped into Total Waste Generation	Data Source OGRD Pollutants All Waste Types Grouped into Total Waste Generation	Data Source OGRD Pollutants All Waste Types Grouped into Total Waste Generation	Data Source OGRD Pollutants All Waste Types Grouped into Total Waste Generation

2.3 Illustrating the Historical Relationships

There are a number of analytical methods available for illustrating the relationships between production and pollutant loadings. Three common examples are:

- graphics allowing readers to "eye-ball" relationships;
- correlation statistics; and
- regression analysis.[5]

Each technique has strengths and weaknesses.

Graphical techniques display all the fluctuations over the time period, but do not provide empirical estimates of the relationships.

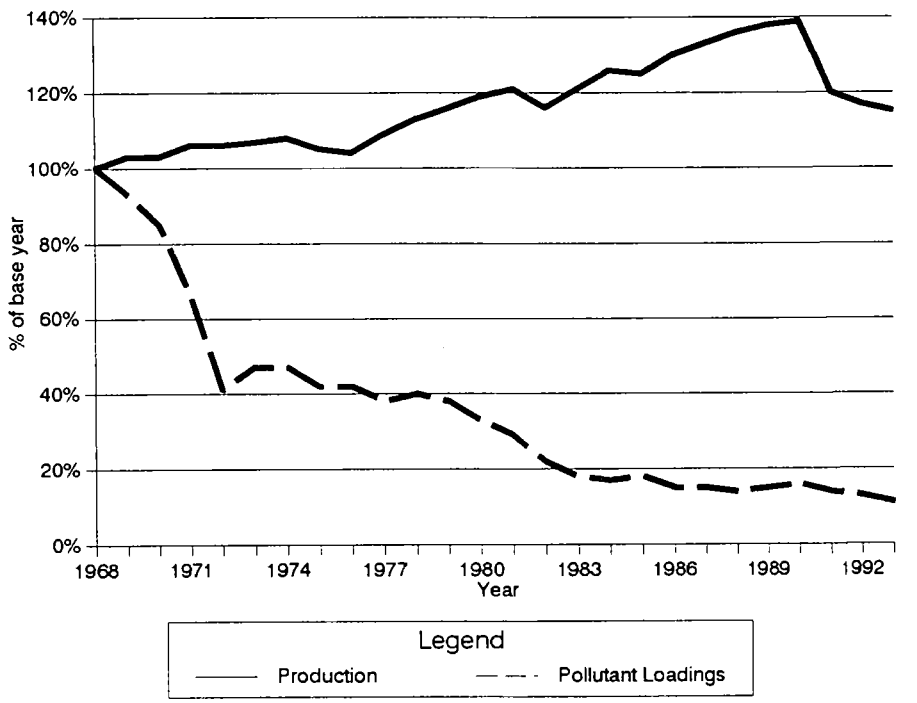
Correlation statistics provide empirical estimates of the relationships, but unfortunately conceal fluctuations in the data over the time period being examined. Regression analysis offers a more formal approach to empirically estimating the relationships.

There are also other approaches to assessing relationships between the economic variables and multi-media pollutant loadings, such as input-output models.

For the purposes of this pilot project, the relationships between industrial production and pollutant loadings are presented graphically. For each industry and each pollutant, graphs are presented which present production trends and pollutant loading trends. No correlation statistics or regression analyses of the data are undertaken. Exhibit 2.5 provides an example of the graphical presentation provided later in this report.

[5] Apogee Research (1993) *Environmental Measures, Competitiveness and Productivity* Toronto: Ontario Ministry of the Environment and Energy.

Exhibit 2.5
Illustrating Production vs Pollutant Loadings



Note that the exhibit presents percentage changes in production and pollutant loadings. All exhibits in later sections of this report are presented in this format. The format was selected in order to provide a common basis for the two different types of data.

For each industry sector, the illustrations of the relationship between individual pollutants and production are followed by a brief analysis. A summary of production versus total loadings of all pollutants to each environmental medium is also presented for each industry.

The relationships between industrial production and pollutant loadings are presented at the sectoral level. No facility-specific information is provided in this report.

This report does not address the issue of why changes have occurred in production and pollutant loadings. It simply illustrates the historical relationships based on existing data.

3.0 The Pulp and Paper Industry

3.1 Sector Overview

The pulp and paper industry plays an important role in both Canada's and Ontario's economies. As the exhibit below illustrates, total shipments of the industry in 1990 were close to $19.0 billion. Over 77,000 employees received wages and salaries of $3.5 billion.

In Ontario, pulp and paper is also an important industry. Ontario accounts for about 25 % of the Canadian pulp and paper industry. The industry accounted for approximately 2 % of all manufacturing activity in Ontario in 1990, and 2 % and 3 % respectively of total manufacturing employees and wages and salaries.

In 1990, there were 27 pulp and paper mills operating in Ontario. These mills are located throughout the province. The total output of these 27 mills in 1990 was 8.3 million tonnes[6]

Exhibit 3.1
The Pulp and Paper Industry in Canada and Ontario, 1990

Variable	Canada	Ontario	% Ontario/Canada	All Ontario Manufacturing	% Pulp & Paper/Ontario Manufacturing
Shipments	$18.7 Billion	$4.4 Billion	24	$195.0 Billion	2
Value Added	$8.0 Billion	$2.0 Billion	25	$68.5 Billion	3
Employees	77,768	18,592	24	945,930	2
Wages/ Salaries	$3.5 Billion	$0.8 Billion	23	$31.3 Billion	3

Source: Statistics Canada, 1993.

Note: Statistics are based on SIC 271 "Pulp and Paper Industries"

6. Redgrave & Associates, *The Pulp and Paper Industry in Ontario - Economic Issues Affecting Environmental Regulation*, Prepared for the Ontario Ministry of Environment and Energy, April 1993, p. 5.

3.2 The Pulp and Paper Industry: Environmental Impact of Production and Consumption of the Industry's Products

Presented in this section is a brief overview of the environmental impact associated with the production and consumption of the pulp and paper industry's products.

The purpose of presenting this information is to illustrate the total impact the industry may have on the environment. This information will be used in helping to establish the potential for future reductions in pollutant loadings to be carried out in later stages of this project.

The information presented is a preliminary assessment of the environmental impact associated with the industry. Further refinement and detail will be provided in future project reports.

3.2.1 The Production Processes[7]

In Ontario, there are a wide variety of processes used to produce pulp and paper which can be grouped into five general categories:

- chemical;
- semi-chemical;
- mechanical;
- chemi-mechanical; and
- defibrated/exploded.

Chemical

The most common forms of pulp production are chemical. In these mills, pulpwood is cooked in a chemical mixture to separate the lignin from the cellulose fibres. Chemical pulps are used in producing newsprint, paper bags, boards, and fabrics.

There are two kinds of chemical pulping: sulphite, which uses an acid mixture in the cooking process; and kraft, which employs an alkaline for the cooking process.

Semi-Chemical

Semi-chemical pulps require that the wood chips are first cooked in either an acid, neutral or alkaline mixture and treated mechanically to remove the fibres. The end fibre product is used to manufacture of heavy paper products.

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7. Information in this section is drawn from the following report:

Redgrave & Associates, *The Pulp and Paper Industry in Ontario - Economic Issues Affecting Environmental Regulation,* Prepared for the Ontario Ministry of Environment and Energy, April, 1993.

Mechanical

Mechanical production of pulp involves the grinding of the logs into separated fibres. The pulp is used in the production of newsprint and low-cost papers.

Chemi-Mechanical

Chemi-mechanical production of pulp utilizes a combination of both chemical and mechanical processes.

Defibrated/Exploded

Defibrated pulp utilizes wood chips which are processed with a combination of high temperature steam and mechanical treatment to separate the fibres.

The pollutants released to water from the pulp and paper industry vary by individual facility. The most common pollutants, however, include BOD, TSS, aluminum, cadmium, copper, lead, zinc, chloroform, and methyl chloride. Data on air pollutants from the industry are not well documented. The typical hazardous and liquid wastes generated by the industry include organic acids and sludges and alkaline solutions.

3.2.2 The Products

The pulp and paper industry produces a wide range of products that are used in almost every aspect of modern society. Exhibit 3.2 presents the various product categories and the total tonnage shipped in 1993.

Exhibit 3.2
Canadian Pulp and Paper Shipments by Product (1993)

Product	Shipments (000 Tonnes)	% of Total Shipments
Newsprint	9,341	35%
Printing and Writing Papers	3,937	15%
Kraft Papers	473	2%
Tissue and Special Papers	568	2%
Containerboard	2,241	8%
Boxboard	882	3%
Wood Pulp (exports only)	8,943	34%
Total	26,385	100%

Source: Canadian Pulp and Paper Association, 1993.

The exhibit reveals that newsprint and printing and writing papers accounted for 50 % of all shipments in 1993.

Exhibit 3.3 presents the shipments of the pulp and paper industry and its major products on a historical basis from 1980 to 1993.

Exhibit 3.3
Canadian Pulp and Paper Shipments By Product 1980-1993 (000 Tonnes)

Year	Paper	Paperboard	Pulp Exports	Total
1980	11,043	2,415	6,913	20,371
1981	11,218	2,328	6,352	19,898
1982	10,358	1,995	5,661	18,016
1983	11,014	2,273	6,730	20,017
1984	11,778	2,431	6,651	20,860
1985	12,047	2,398	6,975	21,420
1986	12,714	2,599	7,634	22,947
1987	13,443	2,721	8,021	24,185
1988	13,811	2,712	8,156	24,679
1989	13,867	2,698	8,099	24,664
1990	13,701	2,843	7,496	24,040
1991	13,257	3,003	8,408	24,668
1992	13,736	3,039	8.483	25,258
1993	14,338	3,157	8,719	26,214

Source: Reference Tables 1994 Canadian Pulp and Paper Association

The majority of these shipments are destined for export. Exhibit 3.4 presents the destination of Canadian pulp and paper shipments.

Exhibit 3.4
Canadian Pulp and Paper Shipments by Destination (000 tonnes)

Year	Can.	U.S.A	West. Eur.	Lat. Amer.	Jap.	Asia	Afr.	Oce.	Oth.	Total
1980	4,284	10,254	3,093	733	962	683	99	192	72	20,371
1981	4,352	9,964	2,922	795	747	739	139	161	77	19,898
1982	3,889	9,155	2,568	579	807	611	204	126	77	18.016
1983	4,165	10,288	2,710	573	908	884	263	135	91	20,017
1984	4,460	11,184	2,424	560	892	878	209	164	89	20,860
1985	4,525	11,409	2,277	515	973	1,219	184	192	124	21,420
1986	4,833	11,900	2,801	648	1,161	1,055	189	230	129	22,947
1987	5,012	12,610	2,886	663	1,277	1,278	129	221	110	24,185
1988	5,100	12,912	3,022	597	1,346	1,242	115	231	115	24,679
1989	4,914	12,927	3,249	518	1,458	1,033	160	257	148	24,664
1990	4,702	13,084	3,044	560	1,078	1,109	119	185	161	24,040
1991	4,396	12,688	3,570	685	1,163	1,697	158	122	188	24,668
1992	4,414	13,070	3,598	729	1,272	1,798	151	110	118	25,258
1993	4,623	13,684	3,340	903	1,481	1,893	145	121	25	26,214

Source: Reference Tables 1994 Canadian Pulp and Paper Association

Exhibit 3.4 reveals that a large proportion of pulp and paper manufacturing is destined for export.

The use of all these products also has an impact on the environment. One of the most significant impacts is the disposal of these products to landfill. The disposal of paper products to landfill places large demands on an increasingly scarce resource. However, the trends in disposal of paper products has changed significantly over the past five years.

From 1989 to 1993, the amount of paper recovered and reused in the production of further paper products has increased from 1,893 tonnes to 3,527 tonnes[8]. Upwards of two-thirds of the raw material for Canadian pulp and paper now comes from recovered paper and sawmill residue[9].

The data necessary for a complete analysis of the impact of the pulp and paper industry on the environment are not presently available. However, the CPPA is currently working the Canadian Standards Association (CSA) to develop a certification program for sustainable forestry practices. Part of this work involves preparing a life-cycle analysis of the pulp and paper industry. When the certification program is completed, this information may prove valuable for better understanding the total impact of the pulp and paper industry on the environment.

3.3 Relationships between Industrial Production and Pollutant Loadings

3.3.1 Pollutant Loadings to Water

CPPA data for Ontario mills for the years 1968 to 1993 were used to measure trends in pollutant loadings. Trends in loadings of total suspended solids (TSS) and biological oxygen demand (BOD) are presented.

As noted in Section 2.0 there are some cautions which should be made regarding the CPPA data.

For the years prior to 1985 there are no historical records which indicate whether the same facilities are included in both the production and pollutant loading data. It is also not possible to tell how many facilities were included in either set of data. It is assumed for these years that the data represent the same facilities.

For the years 1988 to 1993 there are some specific cautions:

- for one company only partial estimates of production and pollutant loading data are included in the data for the years 1988 through 1990. For 1991 to 1993 this company did not provide any data production or pollutant loading data to the CPPA;
- for another company no production or pollutant data are included for 1991 or 1992; and
- for two other companies, no production or pollutant data are included for 1992 and 1993.

To what degree this has an impact on the results is not possible to determine.

The exhibits on the following pages illustrate the relationship between industrial production and pollutant loadings to water. It is clear from these exhibits that pollutants loadings of TSS and BOD have fallen significantly over the past 25 years at the same time production has increased, reaching 140 % of base year levels by the year 1990.

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8. Canadian Pulp and Paper Association, *Paper: Positively Everywhere: Economic and Environmental Report*, 1993, p. 10.

9. ibid.

Exhibit 3.5
Pulp and Paper Industry
Production vs TSS

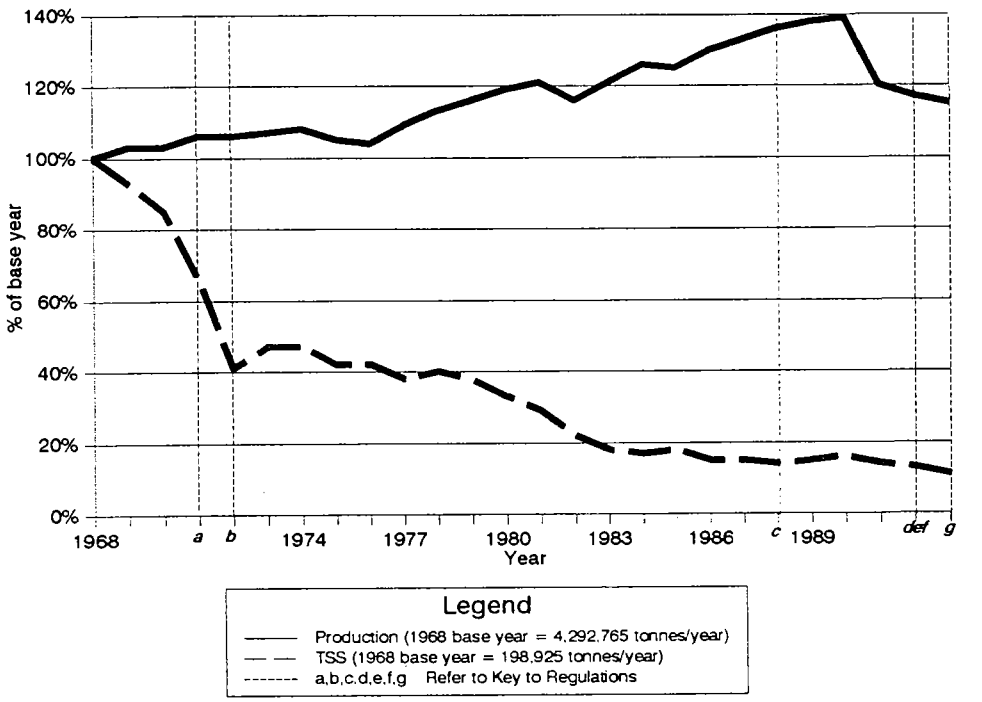


Exhibit 3.5 reveals that:

- production climbed steadily in Ontario from a base of 4.3 million tonnes in 1968 to a high of 6.0 million tonnes in 1990, an increase of approximately 40 %. Since 1990 production has fallen to 5.0 million tonnes. However, recall that for the years 1991 to 1993 several companies' data are not included in production totals; and
- at the same time that production was steadily increasing, TSS loadings fell significantly. A reduction of about 90 % was achieved between 1968 and 1993, from a total of 198,925 tonnes to just over 20,000 tonnes. The largest percentage decreases in loadings occurred from 1968 to 1972 and again from 1978 to 1984, where reductions of about 60 % and a further 25 % were achieved respectively, compared to the base year. At the same time production was increasing, up 25 % in 1984 over the base year.

Exhibit 3.6
Pulp and Paper Industry
Production vs BOD

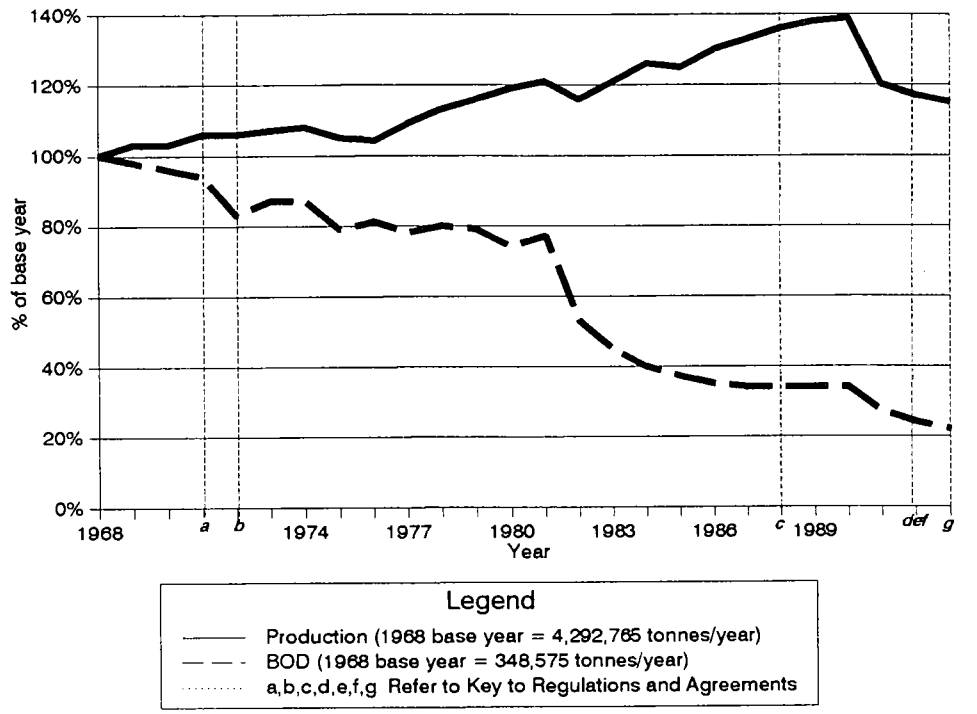


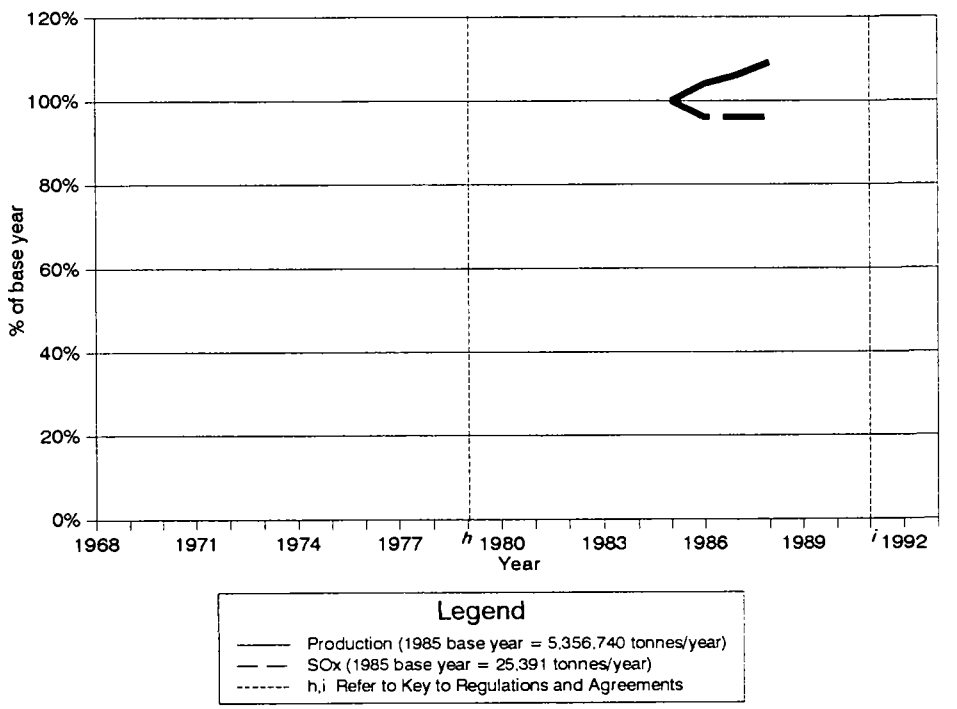
Exhibit 3.6 illustrates the results for BOD loadings versus production. Similar to TSS, significant reductions have occurred over the past 25 years in BOD loadings. Reductions of approximately 80 % have been achieved over the base year total of 348,575 tonnes. By 1983 total loadings of BOD were 78,000 tonnes. The bulk of these reductions occurred during the 1980's, when production was increasing most rapidly. By 1990, production was up 40 % over base year levels.

3.3.2 Pollutant Loadings to Air

The FRED database is used to illustrate trends in air emissions from the pulp and paper sector. Several notes should be made about the data. Data are available for the years 1985 through 1989. For the years 1986 to 1989 the MOEE updated the 1985 figures based on very little new information[10]. The MOEE notes that these data are not considered to be very reliable.

The use of emission factors ties industrial production directly to emission levels as shown in exhibits 3.7 through 3.11. Only SO_x and particulates have shown any deviation from production trends. The differences, however, are small. These results illustrate the difficulty in relying upon emission data derived using emission factors.

Exhibit 3.7
Pulp and Paper Industry
Production vs SOx



[10]. As per a cover letter from Mr. Simon Wong, Emission Inventory Engineer, MOEE, November 8, 1994.

Exhibit 3.8
Pulp and Paper Industry
Production vs NOx

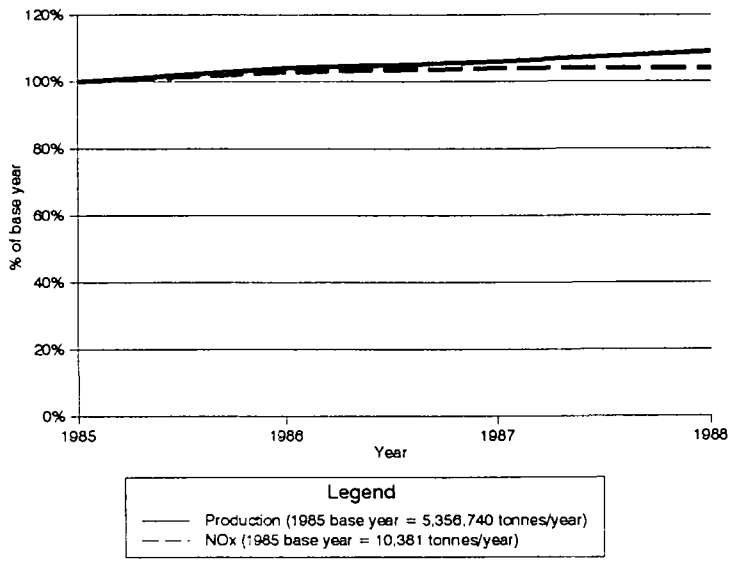


Exhibit 3.9
Pulp and Paper Industry
Production vs Particulates

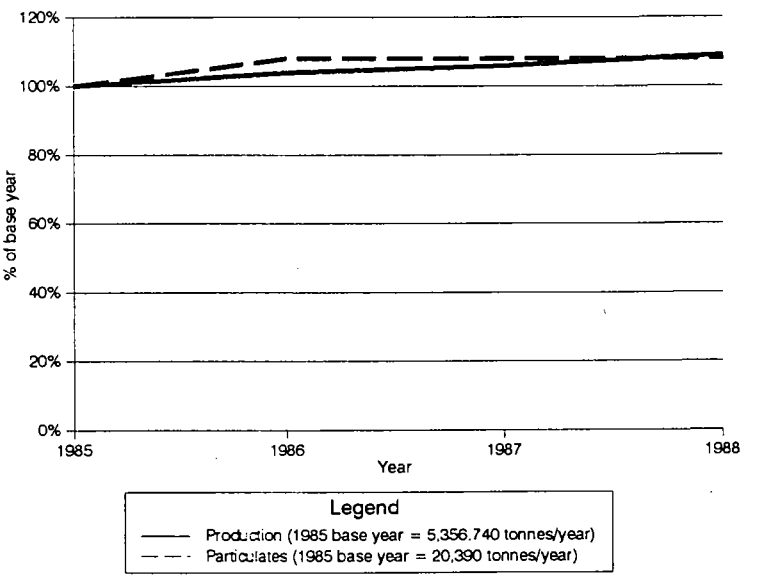


Exhibit 3.10
Pulp and Paper Industry
Production vs Carbon Monoxide

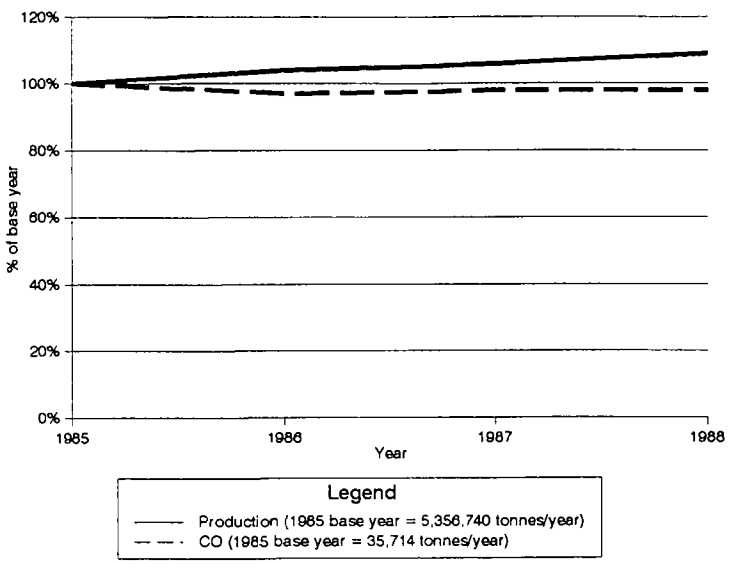
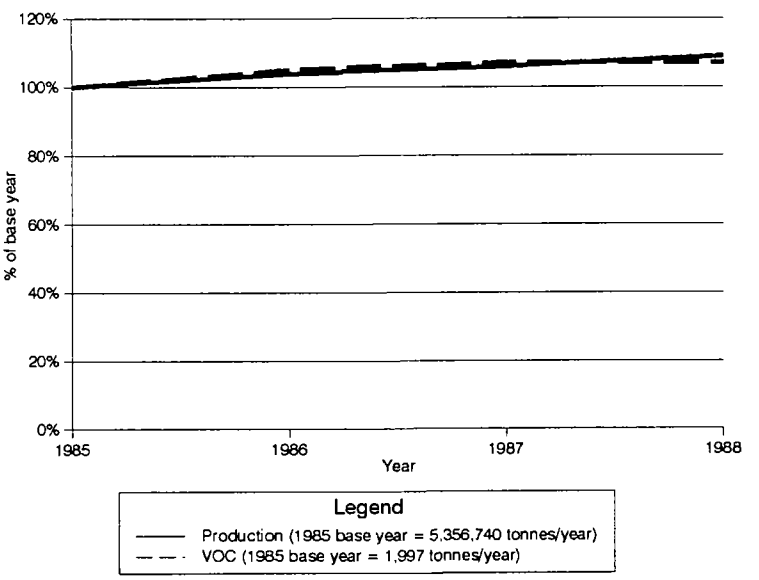


Exhibit 3.11
Pulp and Paper Industry
Production vs VOC



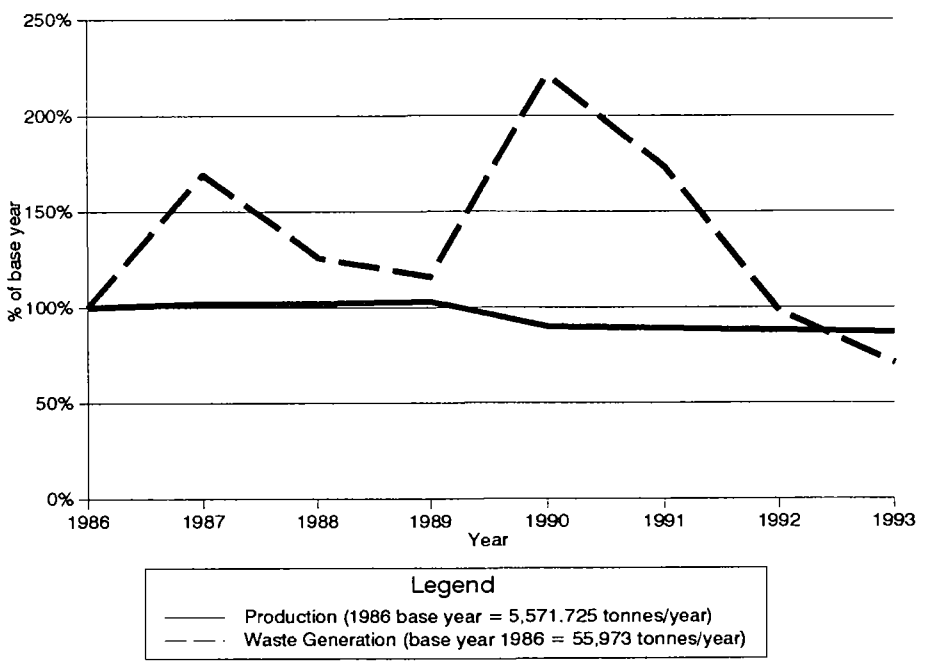
3.3.3 Hazardous and Liquid Industrial Waste Generation

The Ontario Generator Registration Database (OGRD) is used to illustrate trends in hazardous and liquid industrial wastes treated off-site for the years 1986 to 1993. Total waste generation is plotted against industrial production. Recall the caveats noted in Section 2.0 regarding the use of OGRD data for illustrating historical trends in waste generation.

In order to track the off-site waste generation by the pulp and paper industry a detailed examination of the OGRD was undertaken to identify all 27 mills operating in Ontario during 1986 to 1993. The examination, however, located only 26 mills.

The pollutant data in exhibit 3.12 are therefore based on a slightly different sample than the production data. It is possible that the exclusion of this one mill could have an impact on the results. As is discussed below, two of the mills account for the large majority of the waste attributed to this sector. If the mill not found is also a major generator, or had significant reductions in waste shipped off-site, this would have an impact on the results.

Exhibit 3.12
Pulp and Paper Industry
Production vs Waste Generation



Note: Waste Generation refers to hazardous and liquid industrial wastes treated off-site.

Exhibit 3.12 reveals that there appears to be little relationship between industrial production and off-site waste generation. Waste generation fluctuated widely between 1986 and 1993. In 1986, 56,000 tonnes of waste were shipped off-site for treatment and disposal. This total increased by more than 50

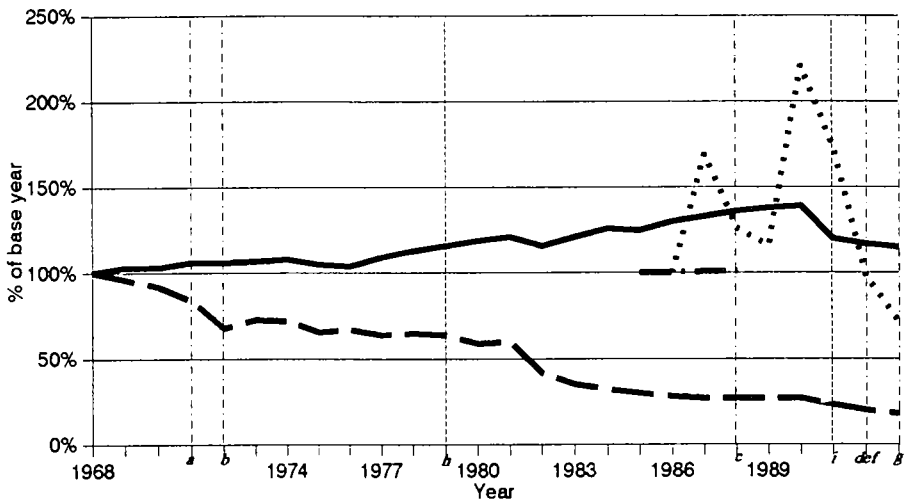
% by 1987, fell back close to base year levels and then more than doubled by 1990. Since 1990, waste generation fell to below base year levels.

A review of the OGRD revealed that two facilities account for the large majority of the waste in each of the years. Fluctuations in the total waste each year are almost entirely a result of changes in wastes shipped off-site by these two facilities. The Ontario Forest Industry Association (OFIA) has reported that a significant waste stream from one of the companies has been exempted from reporting under the OGRD as of the fall of 1994. The material is not actually a waste as it is used as a road binding product[11].

3.3.4 Summary of Findings

In this section trends in total loadings to each environmental media are plotted against production data. Exhibit 3.13 illustrates these relationships.

Exhibit 3.13
Pulp and Paper Industry
Production vs Total Loadings



[11]. Conversation with Catherine Cobden, OFIA, November 9, 1994.

Exhibit 3.13 reveals that:

- total pollutant loadings to water fell significantly over the past 25 years, while production increased. Total loadings of TSS and BOD fell 82 %, while production increased steadily, falling off only in the early 1990's;
- it is not possible to draw any conclusions regarding air emissions due to the use of emission factors which tie emissions to industrial activity; and
- difficulty with the data on hazardous waste generation preclude the determination of any relationship between hazardous waste generation and industrial production.

3.4 Ontario Forest Industry Association (OFIA) Meeting

On March 6, 1995 a meeting was held between the Ontario Forest Industry Association, some of its members, representatives from Environment Canada and Apogee Research.

3.4.1 Purpose

The purpose of the meeting was to:

- identify differing goals between the pulp and paper industry in Ontario and the various provincial, federal and international environmental objectives;
- discuss the possible approaches to resolving these different goals;
- obtain the OFIA's comments on the pulp and paper chapter of the interim report;
- discuss the accuracy and relevance of the historical pollutant loadings data for the pulp and paper industry in Ontario;
- identify the economic indicators that the OFIA believe are the most appropriate to track; and
- identify the expected future environmental performance of the pulp and paper industry in Ontario.

3.4.2 Agenda of the OFIA Meeting

Exhibit 3.14 on the following page displays the agenda that was sent to the OFIA prior to the March 6th meeting.

3.4.3 Exhibits Sent to the OFIA

Exhibits 3.15 - 3.20 are the various displays that were sent to the OFIA.

Exhibit 3.15 presents an example of the differing goals that the pulp and paper industry is faced with. It displays the present MISA limits and Accelerated Reduction/Elimination of Toxics (ARET) goals for chloroform discharges from an average pulp and paper mill in Ontario, along with a projected steady increase in future production. Exhibit 3.15 was used to facilitate discussions on the dual objectives (environmental and economic) that industry is presently faced with.

Exhibit 3.16 and 3.17 are full page blow-ups of Exhibits 3.5 and 3.7 displayed earlier in this chapter. They are to be used in conjunction with Exhibits 3.19 and 3.20.

Exhibit 3.14
Proposed Agenda for the Meeting

1. **Introduction** — 5 minutes

2. **Overview of project** — 5 minutes

3. **Phase I review** — 5 minutes

4. **Purpose of phase II** — 5 minutes

5. **Information needed from the Ontario Forest Industry Association as follows:** — 60 minutes

(i) appropriate economic indicators to use on overlay are:
- those that are most closely correlated to pollutant loadings; and
- those that will be available in future forecasts

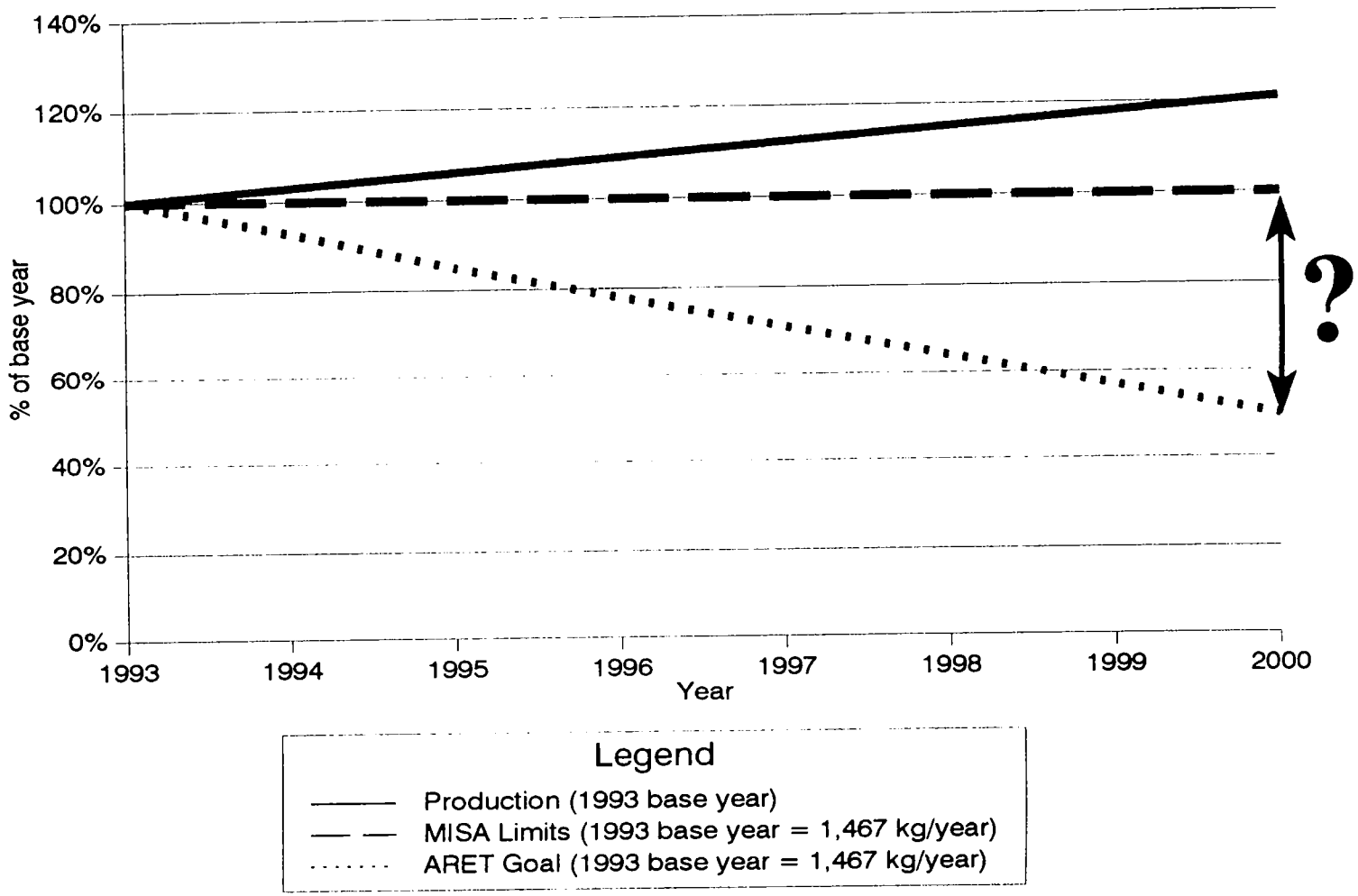
(ii) the outlook for the pulp and paper industry in Ontario on such issues as:
- capacity expansion or contraction;
- production;
- sales; and
- investments in pollution abatement and control.

(iii) planned reductions in pollutant loadings, such as:
- is the pulp and paper industry achieving goals specified in pollution prevention initiatives within Ontario?
- are there any industry specific objectives?
- how would you characterize the penetration and development of control technologies in your industry? and
- will there be future changes in production technologies or pollution control measures in your industry?

(iv) impact of environmental regulations such as the:
- historical impact of the institution of environmental regulations on pollutant loadings; and
- possibility of future regulations and their impact on pollutant loadings.

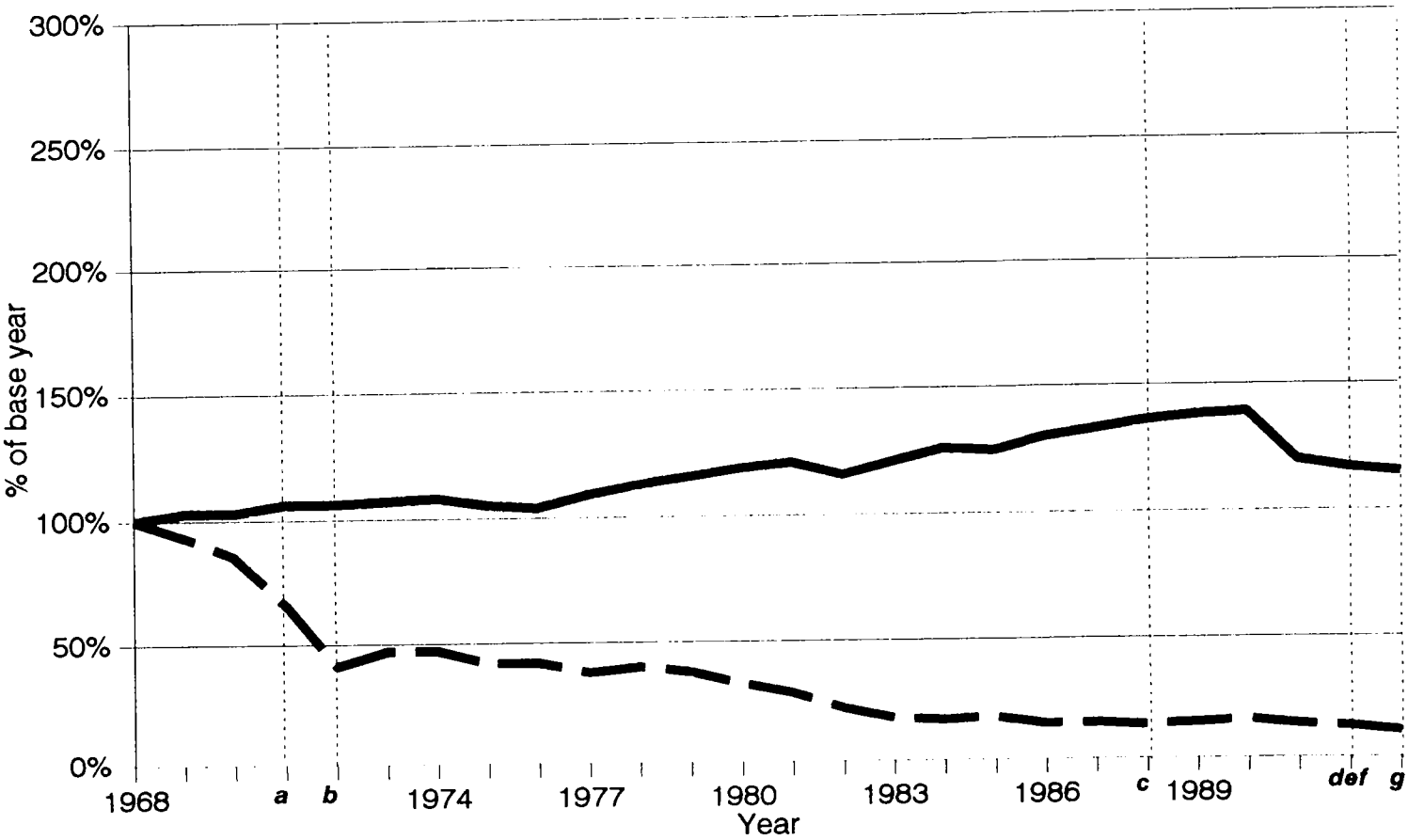
6. **Conclusions and the Next Steps** — 5 min

Exhibit 3.15
MISA Limits and ARET Goals for Chloroform Reduction in an Average Pulp and Paper Mill in Ontario



MISA limits for an average mill were calculated by identifying the two mills with the highest monthly limits. These limits were then converted into total loadings and averaged. This resulted in the figure of 1,467 kg/year.

Exhibit 3.16
Pulp and Paper Industry
Production vs TSS



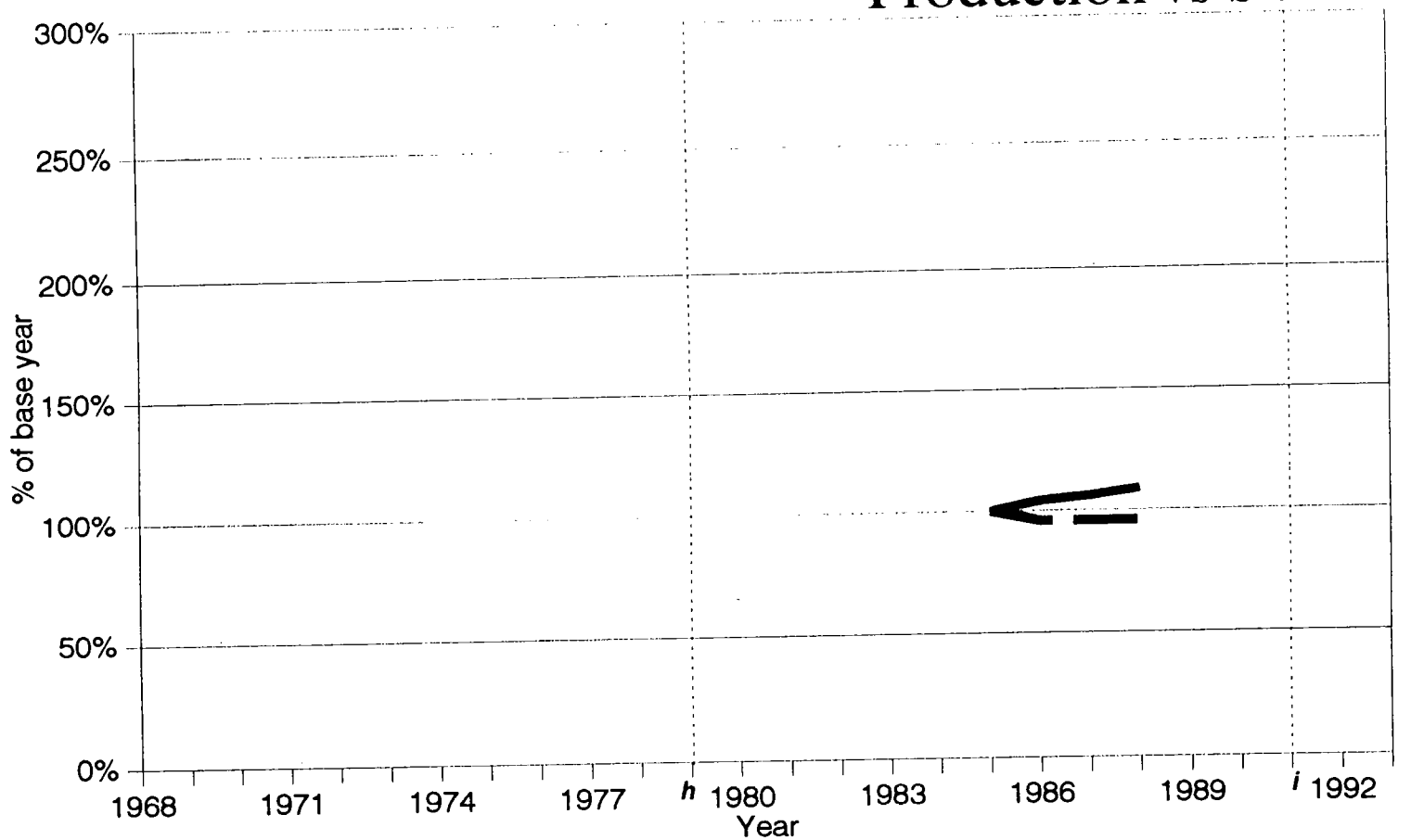
Legend

——— Production (1968 base year = 4,292,765 tonnes/year)

— — TSS (1968 base year = 198,925 tonnes/year)

------- a,b,c,d,e,f,g Refer to Key to Regulations

Exhibit 3.17
Pulp and Paper Industry
Production vs SOx



Legend

——— Production (1985 base year = 5,356,740 tonnes/year)

— — SOx (1985 base year = 25,391 tonnes/year)

------- h,i Refer to Key to Regulations and Agreements

Exhibit 3.18
Key to Regulations and Agreements

Pulp and Paper Regulations

To Water

a Pulp and Paper Effluent Regulations (1971) (Federal)
b Guidelines for Pulp and Paper Effluent Regulations (1972) under the Canadian Fisheries Act (Federal)
c Objectives for the Control of Industrial Waste Discharges in Ontario (1988) under the Ontario Water Resources Act (Provincial)
d Pulp and Paper Mill Defoamer and Wood Chip Regulations (1992) under the Canadian Environmental Protection Act (Federal)
e Pulp and Paper Mill Effluent Chlorinated Dioxins and Furans Regulations (1992) under the Canadian Environmental Protection Act (Federal)
f Pulp and Paper Effluent Regulations (1992) under the Fisheries Act (Federal)
g Effluent Monitoring and Effluent Limits - Pulp and Paper Sector Regulation (1993) under the Environmental Protection Act (Provincial)

To Air

h Wood Pulping Industry National Emission Guidelines for New Stationary Sources (1979) under the Clean Air Act (Federal)

i Canada-US Air Quality Agreement (1991) (International Agreement)

Iron and Steel

To Water

j Objectives for the Control of Industrial Waste Discharges in Ontario (1988) under the Ontario Water Resources Act (Provincial)

To Air

k Air Contaminants from Ferrous Foundries Regulation (1980) under the Environmental Protection Act (Provincial)
l Algoma Sinter Operation (1986) under the Environmental Protection Act (Provincial)
m Canada-US Air Quality Agreement (1991) (International Agreement)

Exhibit 3.19
Economic Indicators

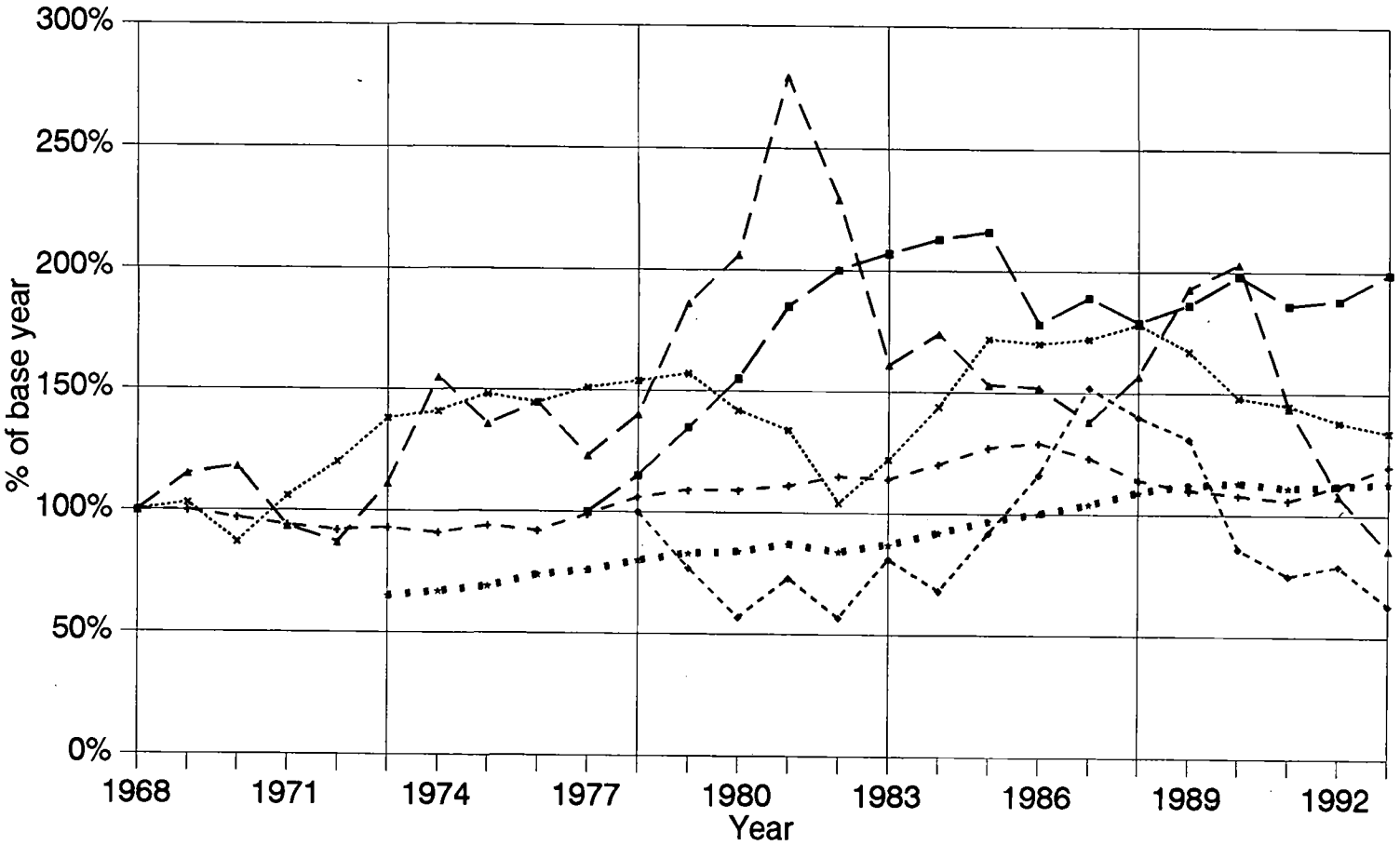
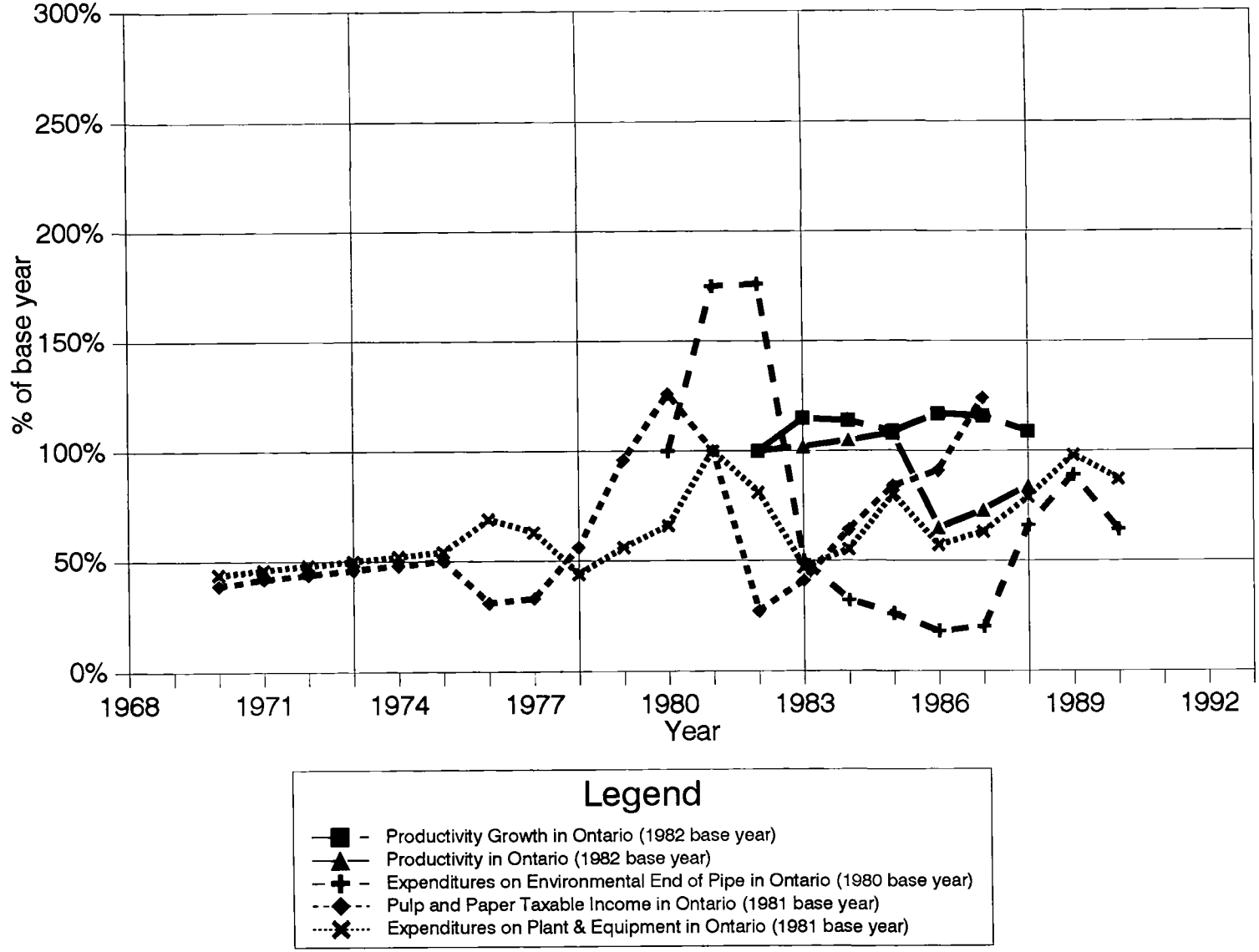


Exhibit 3.20
Economic Indicators
For the Pulp and Paper Industry



Key to Regulations - Continued

Electropower Generation

To Air

n Ontario Hydro Regulation (1987) under the Environmental Protection Act (Provincial)
o Thermal Power Generation Emissions National Guidelines for New Stationary Sources (1990) under the Environmental Protection Act (Federal)
p Canada-US Air Quality Agreement (1991) (International Agreement)

Petroleum Refining

To Water

q Existing Petroleum Refinery Liquid Effluent Guidelines (1974) under the Canadian Fisheries Act (Federal)
r Petroleum Refinery Liquid Effluent Guidelines (1974) under the Canadian Fisheries Act (Federal)
s Petroleum Refinery Liquid Effluent Regulations (1978) under the Canadian Fisheries Act (Federal)
t Objectives for the Control of Industrial Waste Discharges in Ontario under the Ontario Water Resource Act (1988) (Provincial)
u Effluent Monitoring and Effluent Limits - Petroleum Sector Regulations (1993) under the Environmental Protection Act (Provincial)

To Air

v Fuels Information Regulations, No.1 (1978) under the Canadian Environmental Protection Act (Federal)
w Gasoline Regulations (1990) under the Canadian Environmental Protection Act (Federal)
x Canada-US Air Quality Agreement (1991) (International Agreement)

Exhibit 3.18 is a key to the relevant regulations in the four sectors that affect the release of multi-media pollutants.

Exhibit 3.19 and 3.20 are hardcopies of transparencies attached to the final report. These transparencies contain historical information on a series of economic variables which are to be overlaid on Exhibits 3.16 and 3.17.

Exhibit 3.19 is a time series of the following general economic indicators:

- raw material price index;
- prime rate;
- U.S. exchange rate;
- housing starts; and
- new motor vehicle sales.

Exhibit 3.20 is a time series of the following sector specific economic indicators for the pulp and paper industry:

- pulp and paper productivity growth in Ontario;
- pulp and paper productivity in Ontario;
- pulp and paper expenditures on environmental end of pipe in Ontario;
- pulp and paper taxable income in Ontario; and
- pulp and paper expenditures on plant and equipment in Ontario.

The purpose of Exhibits 3.16 - 3.20 was to display the relationship between economic performance indicators and multi-media pollutant loadings.

3.4.4 Results of the OFIA Meeting

The OFIA meeting provided an avenue from which comments by the pulp and paper industry in Ontario could be incorporated into the scenario development report. The discussions at the meeting were concentrated on:

- the availability of pollutant loadings data in Ontario;
- the interpretation of pollutant loadings data by industry;
- the current industry knowledge of available pollutant loadings data;
- the industries' interest in verifying pollutant loadings data; and
- the willingness of industry to participate in conjunction with government on future projects similar to the scenario development project.

3.4.4.1 Availability of Pollutant Loadings Data in Ontario

Discussions focused on the relevance of the historical data presented on air emissions and hazardous waste generation.

The historical data on air emissions are tied via an emission factor to industrial production. This approach hinders the linkage of air emission levels to economic indicators.

The historical data on hazardous waste generation is limited because no accurate reports exist for hazardous waste treated on-site. Using only the generation of hazardous waste treated off-site does not present an accurate picture.

3.4.4.2 Interpretation of Pollutant Loadings Data By Industry

The response of the OFIA to the hazardous waste data reported was both interesting and similar to other industries' reactions to the government's intention to publicize hazardous waste generation data. The OFIA was concerned about potential misunderstanding if these hazardous waste figures were make public. The OFIA realized that better reporting practices are needed from its members on hazardous waste generated that is treated on-site.

The relevance of the air emission totals emitted from the pulp and paper industry in Ontario was dismissed by the OFIA. The connection of air emissions to production makes these data questionable and dismisses the possibility of using these data to make any interpretations on linkages between economic activity and pollutant loadings.

3.4.4.3 Current Industry Knowledge of Available Pollutant Loadings Data

The meeting with the OFIA produced three interesting results as to the knowledge that industry currently possesses on the availability of pollutant loadings data:

- the OFIA as well as representatives of some of its members were not cognizant of the existence of the Residual Discharge Information System (RDIS), maintained by Environment Canada. The RDIS reports emissions from many different SIC's, including the pulp and paper sector, as well as for individual firms within each SIC at the provincial and national level;

- the OFIA and its members stated that they do not review the Ontario Ministry of Environment and Energy's "green book" on pollutant discharges in Ontario to see if the pollutant loadings information contained are an accurate representation of the contribution from their respective sector and individual facilities; and

- the OFIA and its members were not aware that hazardous waste generation data are publicly available for Ontario through the Ontario Generator Registration Database (OGRD).

3.4.4.4 Industries' Interest in Verifying Pollutant Loadings Data

Both the OFIA and representatives of individual facilities expressed interest in taking part in discussions and activities to verify the pollutant loadings data. OFIA representatives asked that in the future, pollutant loadings data be sent to the individual facilities first in order for them to verify the accuracy of the data.

3.4.4.5 Willingness of Industry to Participate in Conjunction with Government on Such Projects

The interest in verifying the pollutant loadings data at the industry and facility level indicates the willingness of industry to participate in future projects similar to the scenario development project.

The OFIA realizes the importance that such a project could have to changing the negative perceptions about the results on production and profit of incorporating pollution prevention activities into the production process.

3.4.5 Impact of the OFIA Meeting on the Direction of the Project

Prior to the OFIA meeting, it was planned that meetings would take place with the respective industry associations of the four industries under study in the scenario development project. However, after the results of the OFIA meeting, representatives of Environment Canada and Apogee Research decided that the remaining industry association meetings would not be necessary.

The OFIA's comments on the accuracy and reliability of the historical data on air emissions and hazardous wast generation in the pulp and paper sector would apply to the remaining three sectors as well. The usefulness of the data on pollutant discharges to water and the unreliability of the air and hazardous waste data are not unique to the pulp and paper sector. These characteristics are present as well in the remaining three sectors. Environment Canada and Apogee Research concluded that the same comments that the OFIA voiced would also be raised from the other industry associations.

The lack of reliable historical data on hazardous waste generation and air emissions did not allow all research questions to be addressed in the project. It was therefore decided that the results and lessons learned to date would be summarized in the final report.

4.0 The Petroleum Refining Industry

4.1 Sector Overview

Petroleum refining is a major Canadian industry. In 1990, the industry had total shipments of approximately $19 billion, employed close to 15,000 people and had value-added of $2.6 billion (See exhibit 4.1 on the following page).

In 1992, there were 28 refineries operating in Canada with a total crude throughput of approximately 239,000 cubic metres.

Petroleum refining in Ontario accounts for approximately 40 % of the Canadian industry. Ontario shipments in 1990 were approximately $7.2 billion. Approximately 6,200 persons are employed at the 7 refineries.

Seven refineries, owned by five companies, presently operate in Ontario. Four of the refineries are located around Sarnia in southwest Ontario, 2 in Oakville, west of Toronto, and one in the town of Nanticoke, on the shore of Lake Erie.

Six of the refineries are conventional petroleum product refineries, producing gasoline, aviation fuel, heating oils, and residual fuels oils. One of the refineries is a petroleum based producer of petrochemical feedstocks.

Exhibit 4.1
The Petroleum Refining Industry in Canada and Ontario, 1990

Variable	Canada	Ontario	% Ontario/Canada	All Ontario Manufacturing	% Petroleum Refining /Ontario Manufacturing
Shipments	$19.0 Billion	$7.2 Billion	38	$195.0 Billion	4
Value Added	$2.6 Billion	$1.1 Billion	42	$68.5 Billion	2
Employees	14,868	6,237	42	945,930	1
Wages/ Salaries	$0.8 Billion	$0.3 Billion	38	$31.3 Billion	1

Source: Statistics Canada, 1993.
Note: Statistics are based on SIC 361 "Refined Petroleum Products Industry"

4.2 The Petroleum Refining Industry: Environmental Impact of Production and Consumption of the Industry's Products

Presented in this section is a brief overview of the pollutants associated with the production and consumption of the petroleum industry's products.

The purpose of presenting this information is to illustrate the impact the industry may have on the environment.

The information presented is a preliminary assessment of the pollutants associated with the industry.

4.2.1 The Production Processes[12]

The petroleum refining industry converts crude oil into a variety of different products. There are four major steps necessary for this conversion to take place:

- separation;
- conversion;
- treating; and
- blending.

The first step in refining crude oil is to separate it into selected fractions, mainly by distillation and, to a lesser extent, by solvent extraction and crystallization.

Conversion of the separated fractions is used to change the size and shape of the hydrocarbon molecules. Conversion is conducted using catalytic cracking (where molecules in the crude are broken down into smaller units), catalytic reforming and isomerization (where molecules are rearranged) and alkylation/polyermization (where molecules are joined together).

Treatment of the converted crude is undertaken to remove impurities such as sulfur, nitrogen and oxygen compounds. A number of methods are used to treat the converted crude, including desulfurization, chemical treatment, and denitrification.

The final step in the production process is the blending of different refined oils into the various products of the industry.

Figure 4.1 presents a simplified schematic of the petroleum refining process.

Pollutants are created at various stages in the production process. Contaminants in wastewaters

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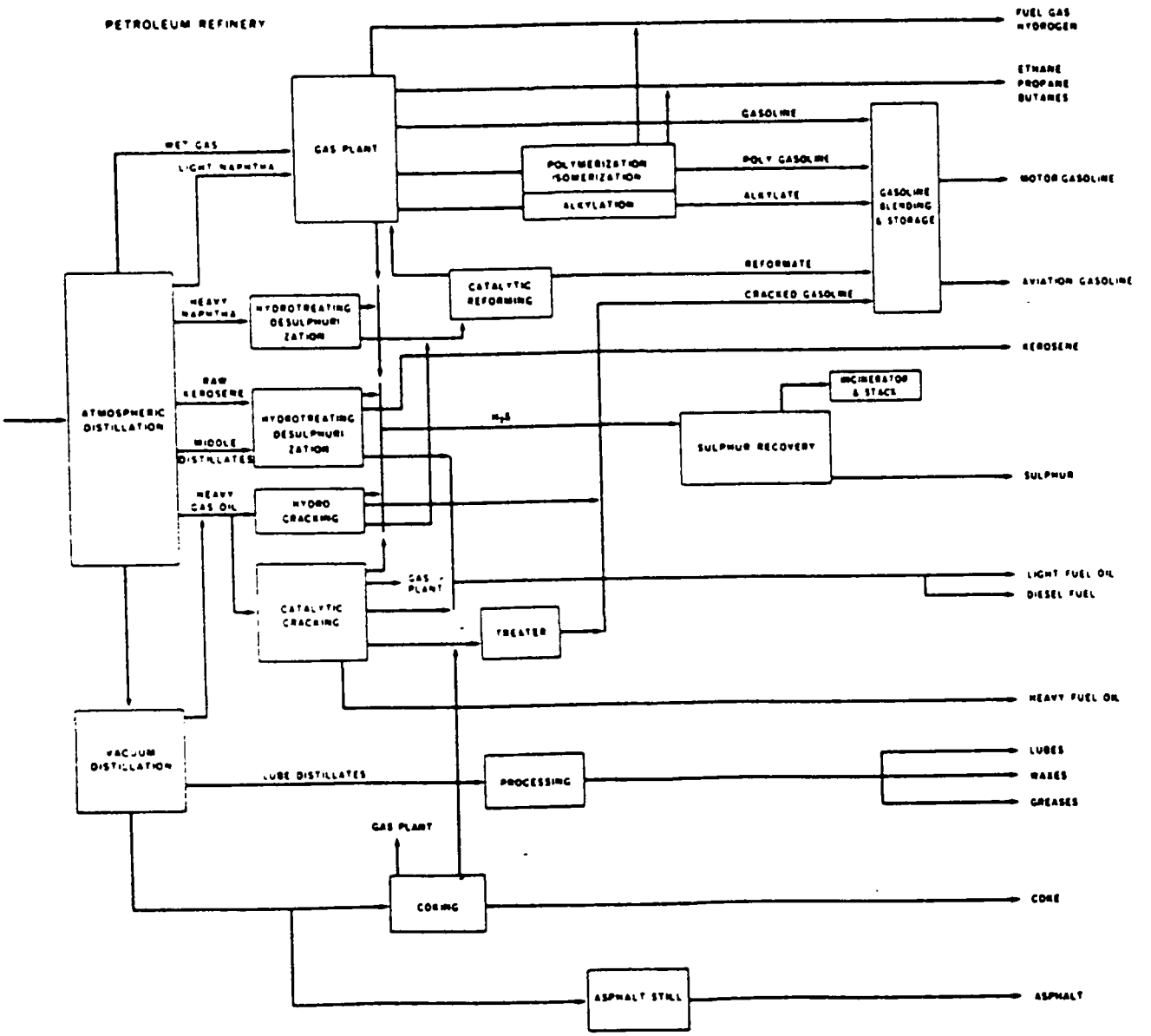
[12]. The material on the petroleum refining production processes is drawn primarily from the following report:

Environment Canada, *Environmental Status Report for the Canadian Petroleum Refining Industry, 1983-1984*, Environment Canada, 1987.

Figure 4.1
Simplified Petroleum Refinery Process Flow Diagram



Source: Environmental Status Report for the Canadian Petroleum Refining Industry 1983-1984, Environment Canada, 1987

originate from crude oil, refinery intake water, process chemicals and catalysts, refinery stormwater, and reaction products from conversion units and chemical additives. The contaminants include ammonia, hydrogen sulfide, organic acids, benzene, toluene, cyanides and sulfates.[13]

Air emissions originate from four major sources:

- process emissions: which include discharges from continuous vents, stacks, flares and combustion sources;
- primary fugitive emissions: defined as leakage from pump seals, compressor seals, valves, flanges, pressure relief devices, sampling connections and open-ended lines;
- secondary fugitive emissions: originating from waste water treatment, cooling towers and landfarming; and
- transfer emissions: a result of loading tank trucks, railcars and ships.[14]

During the refining of crude oil, a number of hazardous and liquid wastes are generated. The most predominant types of waste are: waste oils, organic sludges and alkaline solutions.

4.2.2 The Products

The refinement of crude oil results in a wide variety of products. Figure 4.2 on the following page provides an illustration of the path oil takes from its crude form into the many uses to which it is put. The figure shows two major categories of uses: fuels and greases and petrochemicals.

No comprehensive analysis of the impact the use of these products has on the environment has been conducted. However, some individual impacts are noted below.

- The impact of the consumption of fuels on the environment is substantial. The burning of fuel accounts for the large majority of emissions of pollutants to air each year[15]. The combustion of petroleum products leads to the occurrence of ground level ozone and greenhouse gases. However, the emissions of certain substances, such as lead, have been reduced due to increasingly stringent fuel and emission standards.

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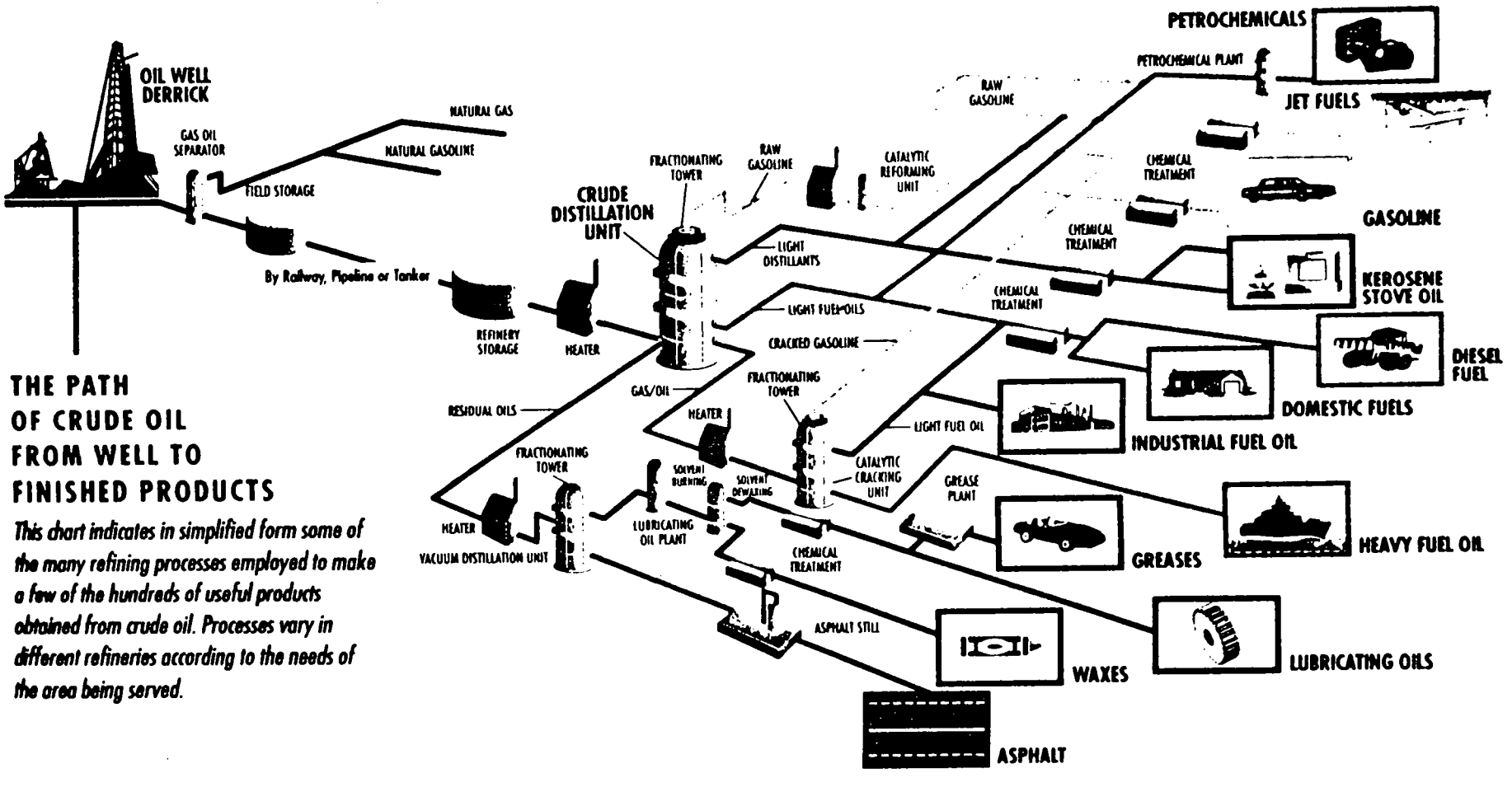
[13]. Environment Canada, *Environmental Status Report for the Canadian Petroleum Refining Industry 1983-1984*, Report EPS 1/PN/1, December 1987, p. 28.

[14]. Canadian Petroleum Products Institute (CPPI), *Atmospheric Emissions from Canada Petroleum Refineries and the Associated Gasoline Distribution Systems*, CPPI Report No. 91-7, February, 1991, p. ii.

[15]. Environment Canada, *Environmental Protection Series: Canadian Emissions Inventory of Common Air Contaminants (1985)*, March 1990, p. 5.

Figure 4.2 Refined Petroleum Products



Source: Petroleum Communication Foundation, *Our Petroleum Challenge: Into the 21 st Century*, 1993, p.57.

- The Canadian Petroleum Products Institute (CPPI) estimates that 250 million litres of used motor oil are disposed every year using environmentally inappropriate methods, such as into landfills, sewers, laneways and yards[16].

Figure 4.3 illustrates the large number of uses to which petrochemicals are put and the major consuming industries. The potential impact on the environment of the use of these products may be substantial. However, no comprehensive analysis of these impacts could be found.

4.3 Relationships between Industrial Production and Pollutant Loadings

4.3.1 Pollutant Loadings to Water

In developing as extensive a time-series as possible for pollutant loading to water, a variety of data sources are used. A time-series from 1973 to 1993 is possible for the following pollutants:

- phenols;
- total suspended solids (TSS);
- oil and grease; and
- ammonia nitrogen.

Environment Canada data are used for the years 1973, 1977, 1992 and 1993. Data for the years 1978 to 1988 inclusive are from the MOEE. It was not possible to assess differences in monitoring and/or reporting of pollutant loadings between the two data sources. Accordingly, caution should be exercised in interpreting the data. Environment Canada officials have verified, however, that despite some possible differences in monitoring and/or reporting, these are the best pollutant loadings data to water for the petroleum refining industry[17].

Each source of data reports on kilograms per day of loadings. For the purposes of this report kilogram per day were converted to tonnes per year in order to be consistent with the production data. A factor of 365 (based on the assumption that petroleum refineries operate all days of the year[18]) was multiplied by all kilogram per day loadings and divided by 1000 to arrive at tonnes per year.

The exhibits on the following pages illustrate the relationship between industrial production and pollutant loadings to water.

It is clear from the exhibits that loadings of all pollutants have fallen significantly while production has never fallen below the base year total of 23.5 million cubic metres. More detail on each exhibit is presented below.

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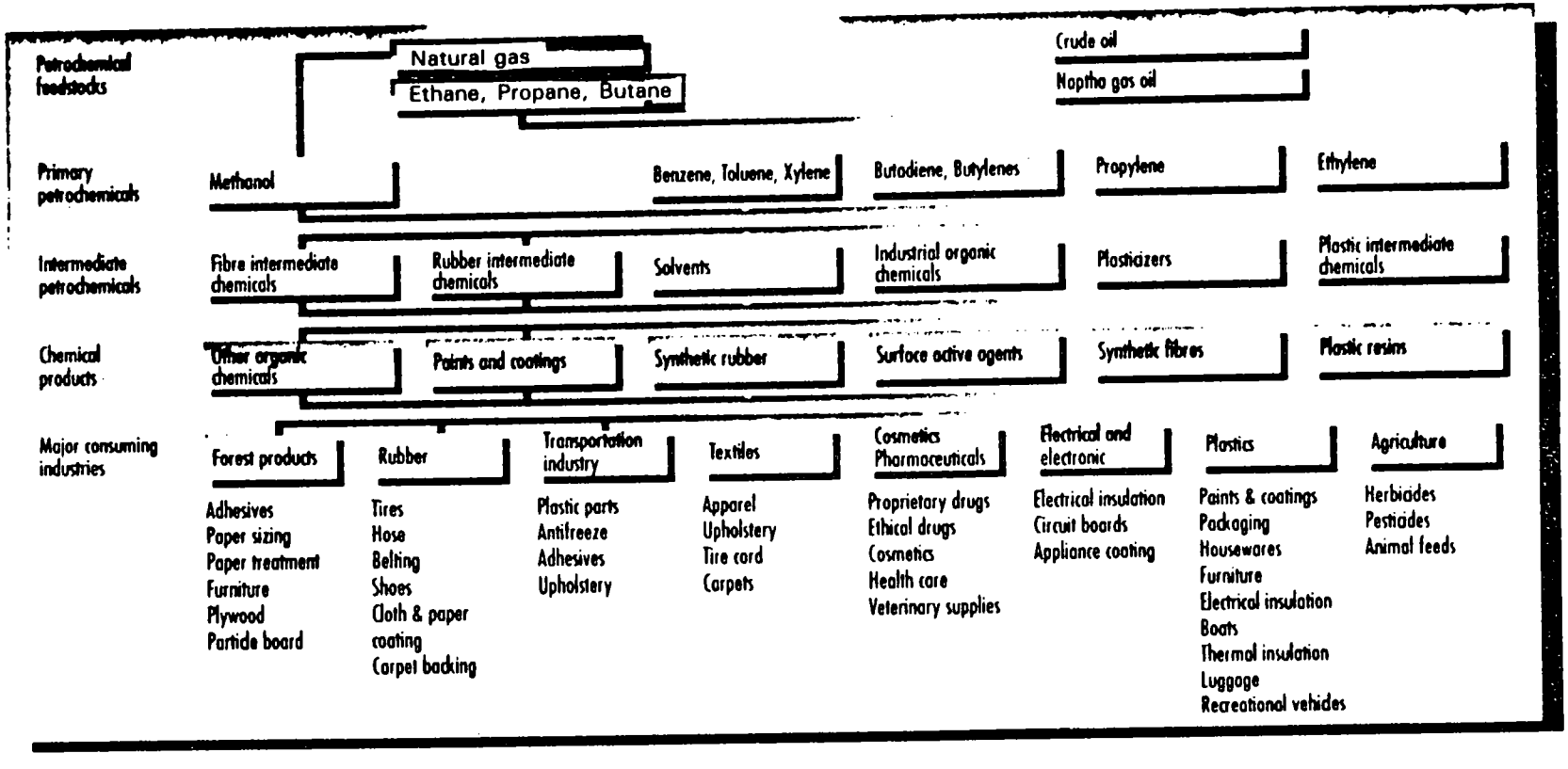
16. Petroleum Communication Foundation, *Our Petroleum Challenge: Into the 21st Century*, 1993, p. 60.

17. Conversation with Mr. Tom Tseng, Environment Canada Ontario Region, October 25, 1994.

18. Factor arrived at following discussions with CPPI, MOEE and Environment Canada officials.

Figure 4.3 Petrochemical Products



Source: Petroleum Communication Foundation, *Our Petroleum Challenge: Into the 21st Century*, 1993, p.58.

Exhibit 4.2
Petroleum Refining Industry
Production vs Phenols

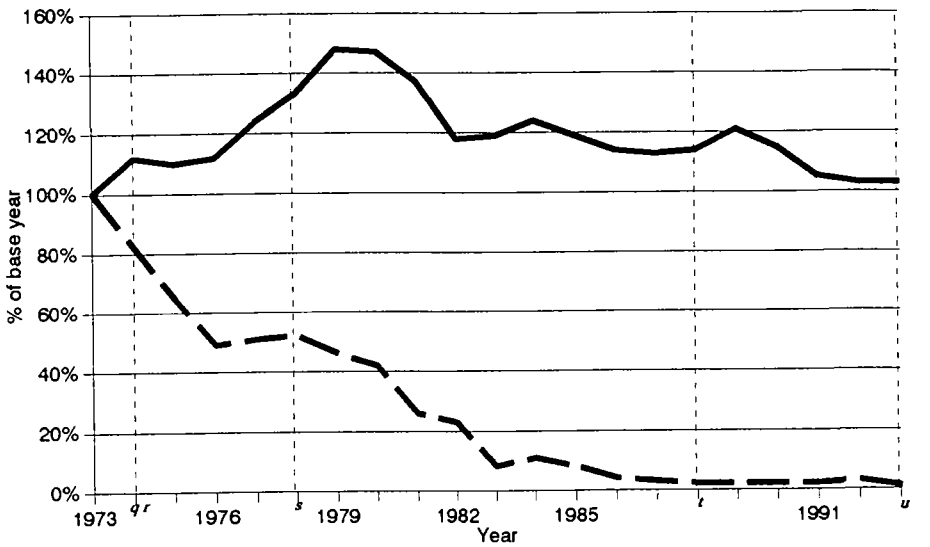


Exhibit 4.2 illustrates that loadings of phenol fell approximately 99 % from 1973 to 1993, from a total of 13,870 kilograms in 1973 to under 200 kilograms in 1993. Production over this period fluctuated but never fell below 1973 levels. The largest decrease occurred between 1973 and 1983 when total loadings fell by approximately 90 %. Production peaked in 1979, up 50 % over the base year of 23.5 million cubic metres, and by 1981 was still up 20 % over the base year.

Exhibit 4.3
Petroleum Refining Industry
Production vs Oil and Grease and TSS

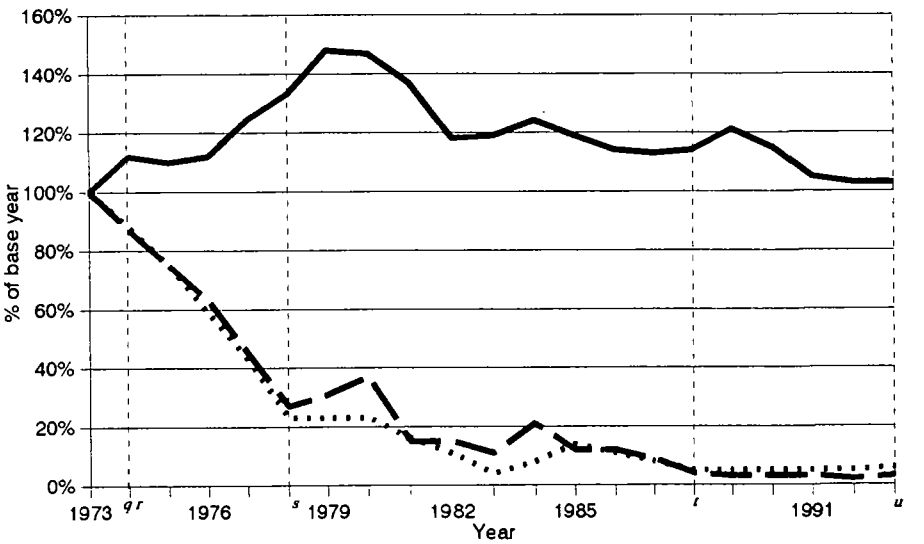


Exhibit 4.3 demonstrates that loadings of oil and grease and total suspended solids underwent similar reductions as phenols. Oil and grease loadings fell by over 95 % from 1973 to 1993. Again, production never fell below base year levels during this period. From 1973 to 1981 loadings fell by 85 %. It was during this same time that production was at its highest levels. Total suspended solids follow almost the exact same trend as oil and grease: a total decrease of about 95 %, and the largest percent decrease occurring between 1973 and 1981.

Exhibit 4.4
Petroleum Refining Industry
Production vs Ammonia Nitrogen

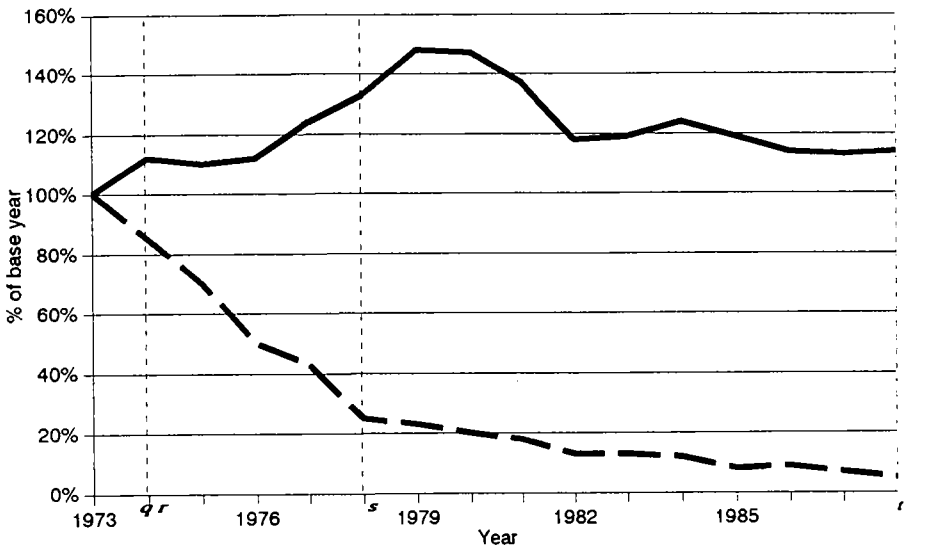


Exhibit 4.4 reveals, again, almost the exact same trend for loadings of ammonia nitrogen as for the other pollutants. Note that data are presented only to 1988. Total loadings were decreased by over 95 % during the fifteen year span between 1973 and 1988, and the largest decrease occurred during 1973 to 1978, when a reduction of about 80 % was achieved.

4.3.2 Pollutant Loadings to Air

The CPPI's air emissions inventories are used for illustrating trends in pollutant loadings to air. The CPPI data are available for the years 1973, 1978, 1983, and 1988. The following pollutants are covered:

- SO_x;
- NO_x;
- particulates;
- CO; and
- VOCs.

The exhibits on the following pages show the relationship between industrial production and pollutant loadings to air for the petroleum refining industry.

Exhibit 4.5
Petroleum Refining Industry
Production vs SO_x

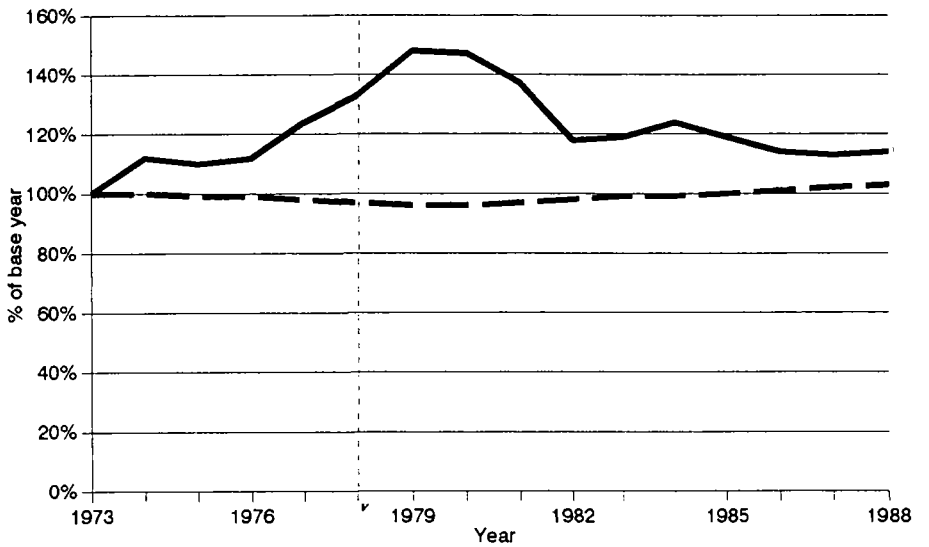


Exhibit 4.5 illustrates little relationship between production and emissions of SO_x. Emissions dropped slightly in 1978, at the same time production was at its highest point. Interestingly, by 1988 production fell again, almost to base year levels, while SO_x emissions rose to just above base year levels.

Exhibit 4.6
Petroleum Refining Industry
Production vs NO_x

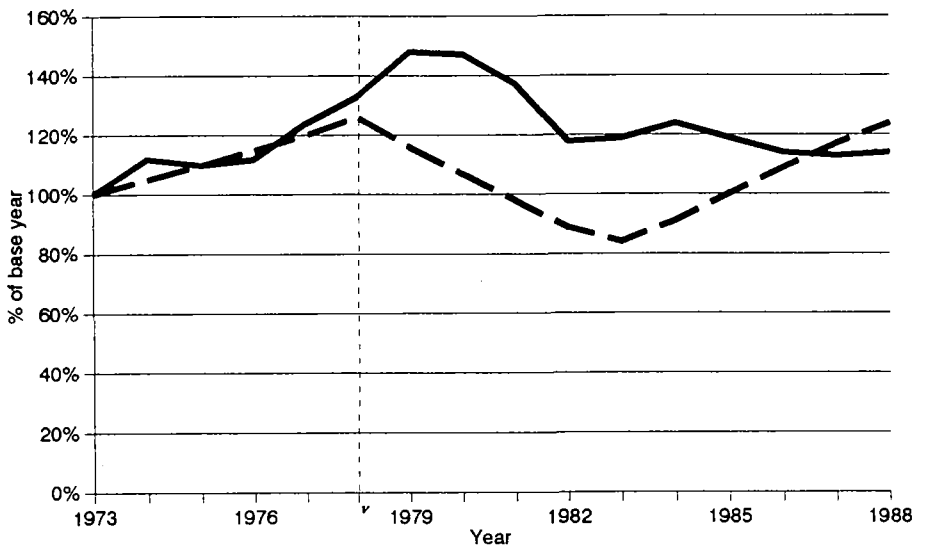
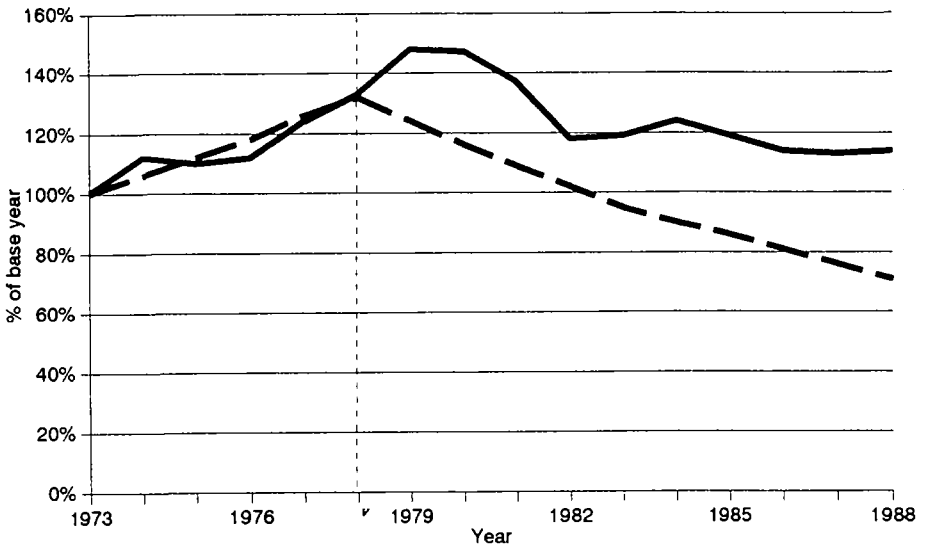


Exhibit 4.6 reveals that NO_x emissions for the years 1973 to 1978 follow levels of production very closely. From 1978 to 1983 NO_x emissions fell 20 % over base year levels, while production ranged from 50 % to 20 % over base year levels. From 1983 levels of production and pollutant loadings, an interesting result occurred. By 1988 production had fallen relative to 1983 levels. At the same time, however, NO_x emissions have risen significantly over 1983 levels.

The 1988 CPPI inventory report notes that the NO_x data should be used with caution.

Exhibit 4.7
Petroleum Refining Industry
Production vs Particulates



Over the 15 year period presented in exhibit 4.7, it is shown that emissions of particulates are related to production levels. Emissions of particulates are shown to have followed production closely from 1973 to 1978. Beginning in 1978 both production and emissions declined, although the percentage decline in emissions was greater than for production.

It should be noted that the 1988 CPPI inventory states that the bulk of the particulate emission reduction between 1983 and 1988 was due to reduced particulate estimates from fuel - an area the report notes as uncertain due to lack of definitive tests and the resulting need for the use of standard emission factors[19]

[19]. Canadian Petroleum Products Institute (CPPI), *Atmospheric Emissions from Canada Petroleum Refineries and the Associated Gasoline Distribution Systems*, CPPI Report No. 91-7, February, 1991, p. 84.

Exhibit 4.8
Petroleum Refining Industry
Production vs Carbon Monoxide

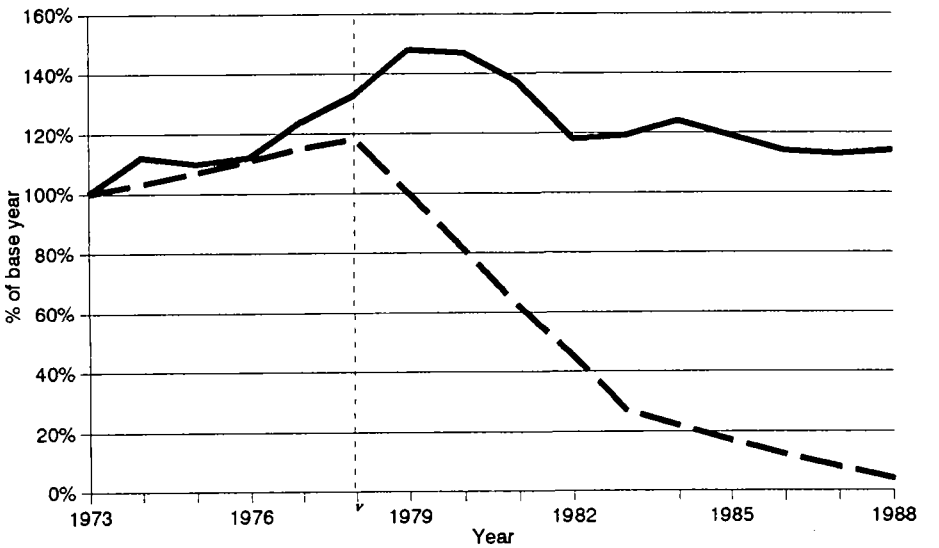


Exhibit 4.8 demonstrates a significant reduction in CO emissions at the same time production was increasing. From 1978 to 1983 CO emissions fell by about 80 % over base year levels of 117,035 tonnes per year. During the same period production rose approximately 45 % over base year levels. CO emissions continued to fall from 1983 to 1988. The bulk of the reductions are due to increased efforts to convert CO to CO_2.

Exhibit 4.9
Petroleum Refining Industry
Production vs VOCs

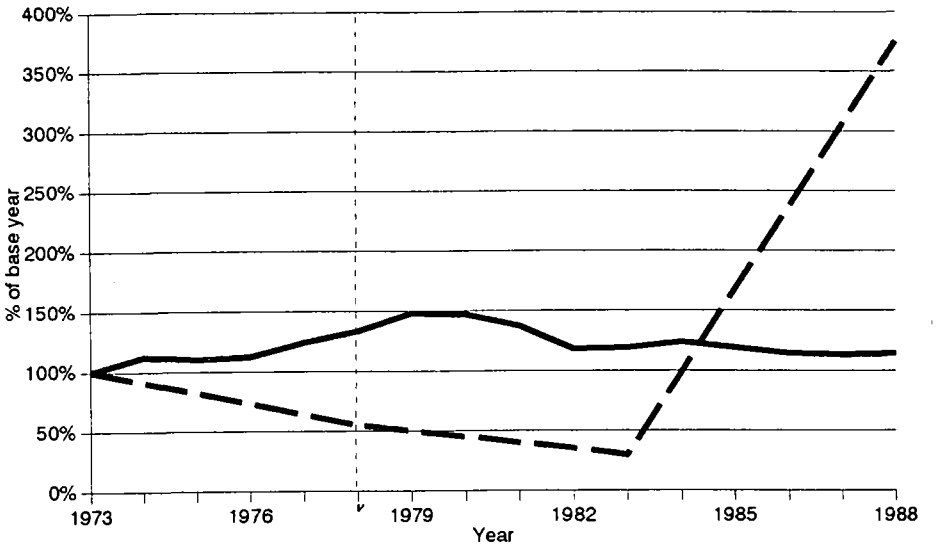


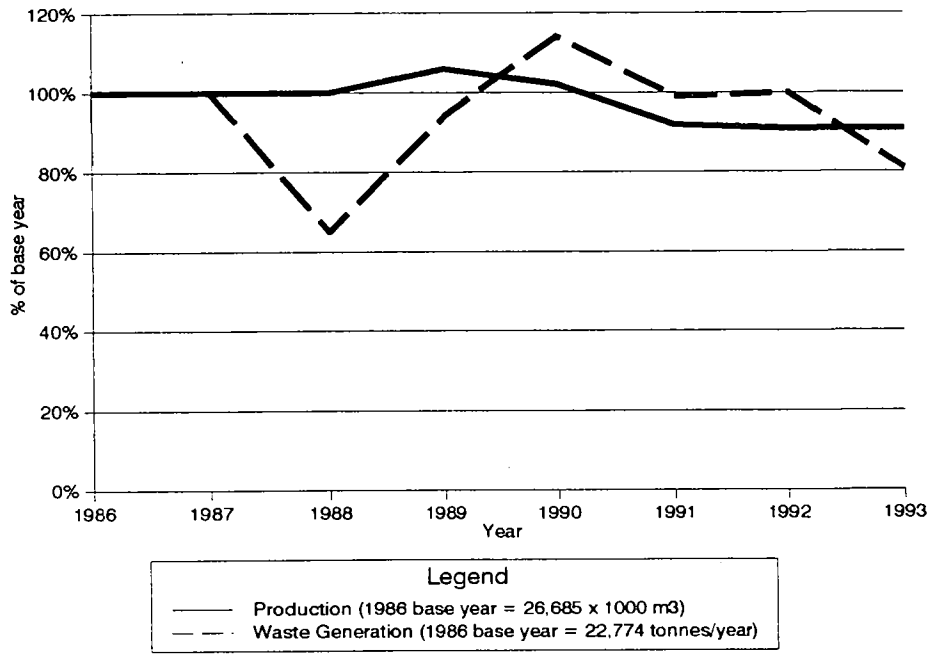
Exhibit 4.9 reveals quite a different picture than for other emissions by the petroleum refining industry. From 1973 to 1983, steady declines occurred in VOC emissions. By 1983 emissions were at about 35 % of base year levels. However, from 1983 to 1988, VOC emissions rose significantly, approaching 400 % of base year levels. The 1988 data include emissions not included in previous years and represent a much broader coverage than in previous years. The CPPI reports that these changes are believed to account for all of the increases in VOC emissions.

4.3.3 Hazardous and Liquid Industrial Waste Generation

The Ontario Generator Registration Database (OGRD) is used to illustrate trends in waste generation for the years 1986 to 1993. Data on waste generation are based on the seven refineries operating in Ontario during this time period. Total waste generation is plotted against industrial production.

Exhibit 4.10 on the following page illustrates the historical relationship between hazardous and liquid industrial waste generation and production.

Exhibit 4.10
Petroleum Refining Industry
Production vs Waste Generation



Note: Waste Generation refers to hazardous and liquid industrial wastes treated off-site.

The exhibit reveals that for the years 1986 to 1989 there was little relationship between production and waste generation. During the period 1986 to 1988 when production was constant, waste generation was falling. Waste generation fell by approximately 35 % during a period of slight growth in production. Following 1990, however, waste generation began to follow the same trends as production. In 1993, declines in waste generation were achieved while production remained relatively constant.

There are several possible explanations for the fluctuations in waste generation by the petroleum refining industry. Wastes may have been stored on-site during the late 1980's and not shipped until several years later, management practices may have changed from on-site to off-site, there may have been once-off wastes (e.g. contaminated site), etc.

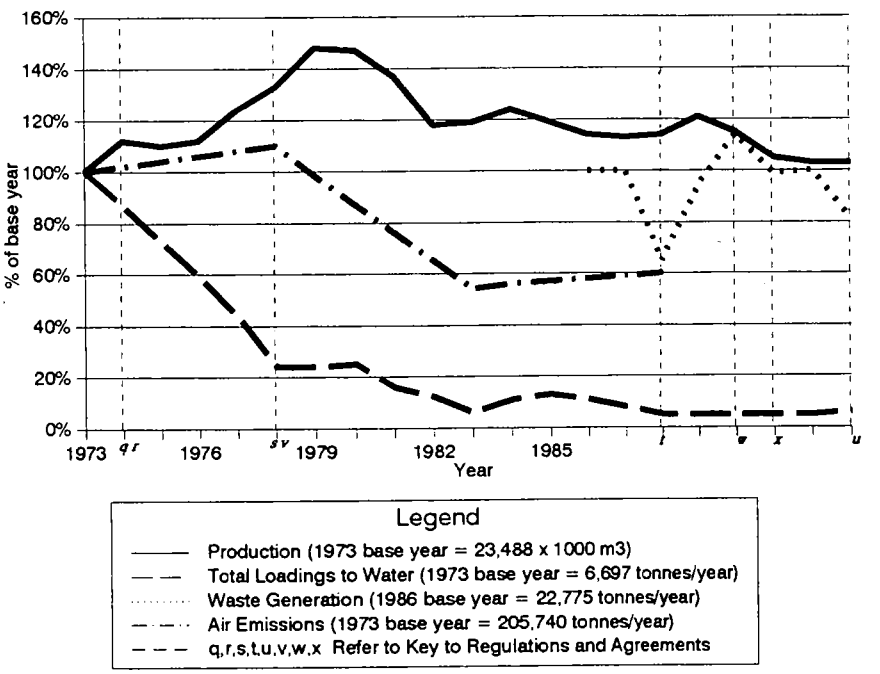
4.3.4 Summary of Results

In this section trends in total loadings to each environmental media are plotted against production data.

Exhibit 4.11 demonstrates that:

- overall, pollutant loadings appear to have fallen over the past several decades at the same time that production never fell below base year levels, and in 1979 reaching 150 % of base year levels;
- total pollutant loadings to water fell significantly from 1973 to 1993 at the same time that production was increasing. Pollutant loadings to water fell approximately 95 % over base year levels;
- total air emissions have fallen to 60 % of base year levels based on data provided by CPPI studies; and
- between 1986 and 1989 there does not appear to be any relationship between off-site waste generation and production. From 1989 to 1993 waste generation follows trends in production closely.

Exhibit 4.11
Petroleum Refining Industry
Production vs Total Loadings



Note: Waste Generation refers to hazardous and liquid industrial wastes treated off-site.

5.0 The Iron and Steel Industry

5.1 Sector Overview

The iron and steel industry is an important part of Canada's economy. The industry had shipments of $7.7 billion in 1990 and wages and salaries of $2.4 billion were paid out to a total of 62,000 employees.

Ontario accounts for the large part of the Canadian iron and steel industry. Close to 75 % of national shipments, value added, employees and wages and salaries are accounted for by the Ontario industry. In 1990, Ontario had shipments of $5.9 billion and employed almost 40,000 persons. The industry is an important component of the Ontario manufacturing sector. In 1990, the iron and steel industry accounted for about 3 % or 4 % of total Ontario manufacturing.

Exhibit 5.1 below illustrates the importance of the iron and steel sector in Ontario.

Exhibit 5.1
The Iron and Steel Industry in Canada and Ontario, 1990

Variable	Canada	Ontario	% Ontario/Canada	All Ontario Manufacturing	% Iron and Steel /Ontario Manufacturing
Shipments	$7.7 Billion	$5.9 Billion	77	$195.0 Billion	3
Value Added	$2.7 Billion	$2.0 Billion	74	$68.5 Billion	3
Employees	39,120	29,565	76	945,930	3
Wages/ Salaries	$1.7 Billion	$1.3 Billion	76	$31.3 Billion	4

Source: Statistics Canada, 1993.

Note: Statistics are based on SIC 291 "Primary Steel Industries"

5.2 The Iron and Steel Industry: Environmental Impact of Production and Consumption of the Industry's Products

Presented in this section is a brief overview of the pollutants associated with the production and use of iron and steel.

The purpose of presenting this information is to illustrate the impact the industry may have on the environment.

The information presented is a preliminary assessment of the pollutants associated with the industry.

5.2.1 The Production Process[20]

In the basic iron and steelmaking process, coal is converted to coke which is then combined with iron ore and limestone in blast furnaces to produce iron. The iron is then converted into steel in either oxygen or electric arc furnaces. The steel is then converted into a wide variety of final products.

The principal raw materials of the iron and steel industry are: coal, limestone and dolomite, and iron bearing materials (iron ore and pellets).

Iron and steelmaking can be divided into the following process categories:

- cokemaking;
- sintering;
- ironmaking;
- steelmaking;
- continuous casting;
- cold forming;
- hot forming;
- salt bath descaling; and
- acid pickling.

Each of these categories and the types of pollutants produced in each is described briefly.

Cokemaking

Cokemaking operations involve the production of metallurgical coke in coking ovens. The coke is one of the basic materials needed for the operation of ironmaking blast furnaces. Figure 5.1 presents a simplified schematic of the cokemaking process and the resulting pollutants.

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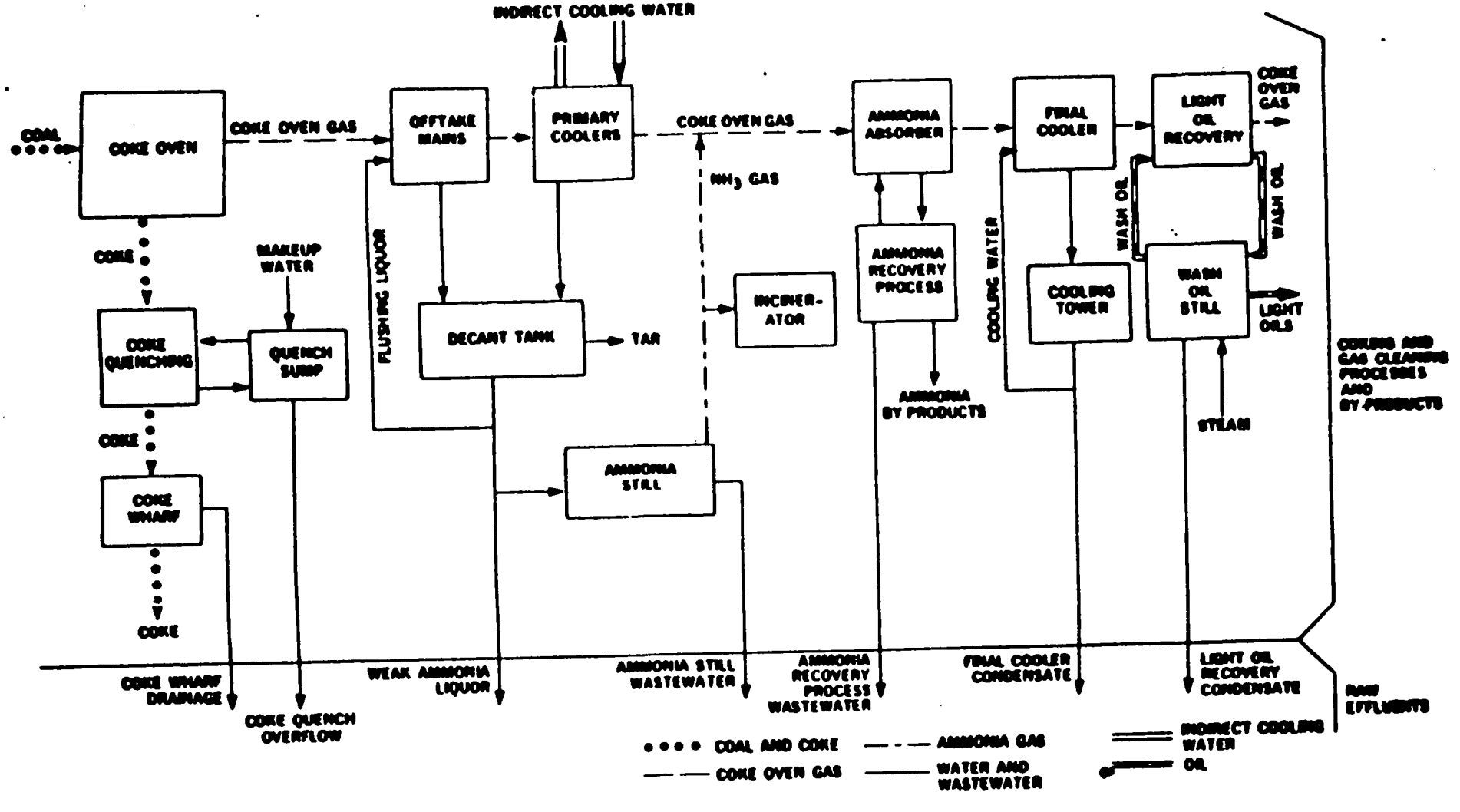
[20]. Information in this section is drawn primarily from the following document:

Environment Ontario, *The Development Document for the Effluent Monitoring Regulation for the Iron and Steel Sector*, Queen's Printer for Ontario, June 1989.

Figure 5.1
Process Flow Diagram of By-Product Coke Manufacture



Source: MISA: The Development Document for the Effluent Monitoring Regulation for the Iron and Steel Sector, Ontario Ministry of the Environment

Sintering

Sintering is the production of an agglomerate which is used as one of the feed materials in the iron and steelmaking process.

Wastewaters are produced in this category as a result of scrubbing of dust and gases. Cooling of the sinter may also generate pollutants.

Ironmaking

Ironmaking operations involve the reduction of iron ore in the presence of limestone and coke in large cylindrical blast furnaces. Figure 5.2 provides a schematic of a blast furnace process flow. Pollutants can result from: the scrubbing of gases produced in the blast furnace, cooling of slag, and air cleaning systems.

Steelmaking

Steelmaking is conducted in basic oxygen and electric arc furnaces. Blast furnaces combine iron ore, limestone and coke to produce molten iron which is then refined in a basic oxygen furnace to produce steel. Electric arc furnaces melt scrap or direct reduced iron to produce steel.

The fumes, smoke and waste gases generated during this part of the production process must be cleaned prior to release resulting in wastewater.

Continuous Casting

The continuous casting process is used to produce semi-finished steel products directly from molten steel.

Cold Forming

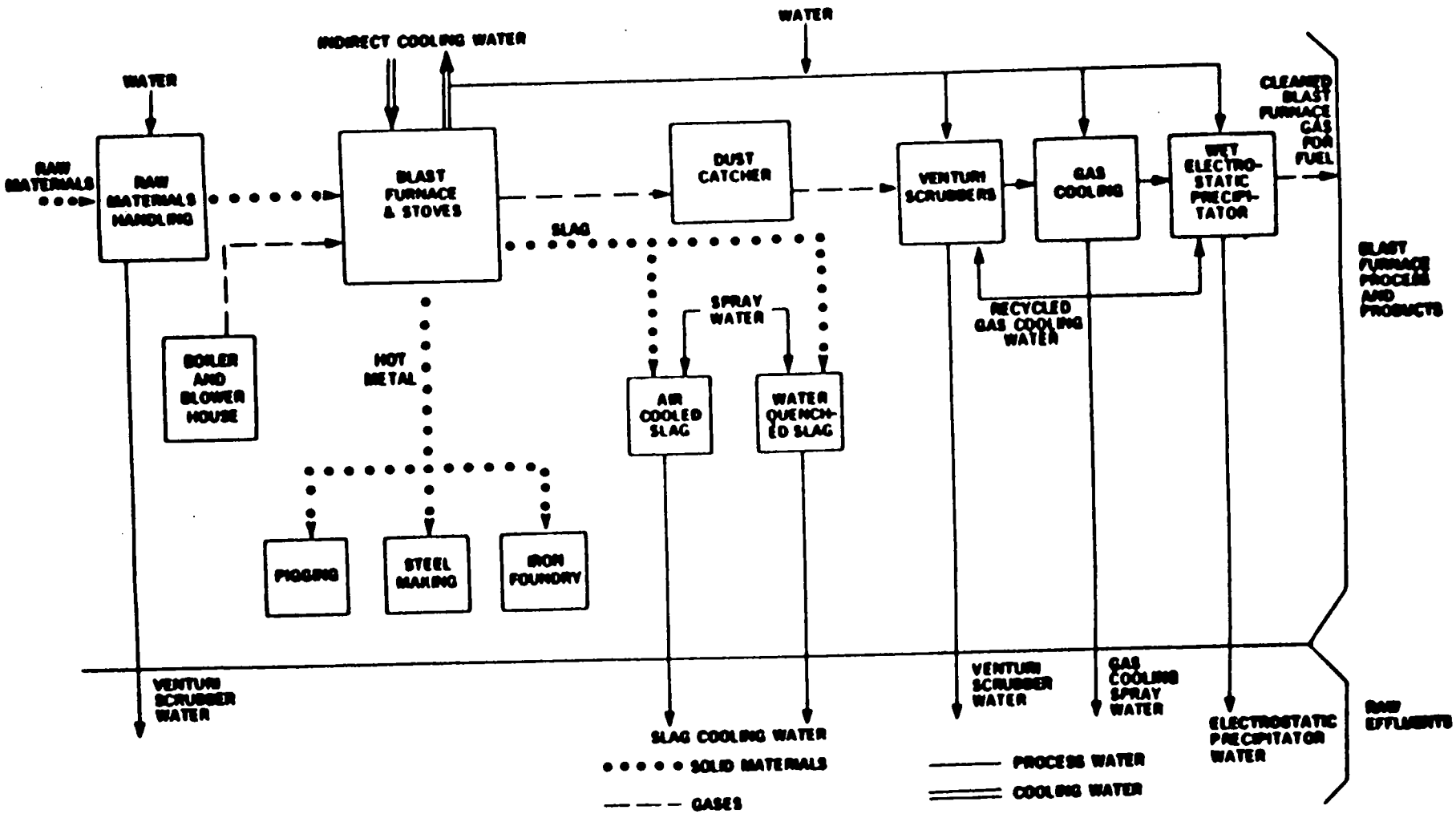
Cold forming is divided into two operations: cold rolling and cold tube forming. Cold rolling is used to reduce the thickness of steel products. Emulsified oils are the major pollutants in wastewater from this operation.

Cold tube forming involves forming flat steel strips into hollow cylindrical products.

Hot Forming

Hot forming involves transforming hot steel into semi-finished and finished products. A number of different forming mills and processes are used in hot forming. Wastewaters are produced from cleaning scale off the hot steel, cooling the hot steel, and the scrubbing of fumes from the cleaning of the steel.

Figure 5.2
Process Flow Diagram of Blast Furnace Operations



Source: MISA: The Development Document for the Effluent Monitoring Regulation for the Iron and Steel Sector, Ontario Ministry of the Environment

Salt Bath Descaling

Salt bath descaling is simply the removal of scale from specialty steel products by processing the products in molten salt solutions.

Acid Pickling

Acid pickling is the process of chemically removing oxides and scale from the steel. Spent pickle liquor, and the rinsewaters are the major pollutants from this operation.

The wastewaters associated with the iron and steel industry may contain ammonia, cyanide, phenols, oil and grease, suspended solids, benzene, and heavy metals. Air emissions include conventional pollutants such as sulphur dioxide and nitrogen oxide. The predominant type of hazardous and liquid industrial waste generated by the industry is emulsified oil.

5.2.2 The Products

Iron and steel are used in virtually every facet of modern society. The shipments of rolled steel products are shown in Exhibit 5.2 below. The major consuming industries are: petroleum refining, construction, appliances, automotive and packaging. Use of the products can impact the environment in a variety of ways. For example, steel is used in the production of automobiles. Automobiles then release emissions to the environment. What part steel plays in the total impact on the environment is difficult, if not impossible, to determine.

One immediate impact of steel on the environment stems from its disposal. The disposal of steel to landfills has decreased over the past decade. While the iron and steel industry has traditionally relied upon scrap metal as an important input with the introduction of recycling programs throughout Ontario, the percentage of steel recovered has increased. Approximately 30 % of the iron and steel industry's raw material is now composed of recycled scrap steel.

Discussions with representatives of the Recycling Council of Ontario revealed that data on the ultimate fate of steel not recovered is difficult to determine. The data are held confidentially by firms disposing of the material.

Dofasco is currently working on a life-cycle analysis of the steel industry. This information was not available at the time this report was prepared.

Exhibit 5.2
Canadian Mill Shipments of Rolled Steel Products (000 of tonnes)

	1981	1982	1983	1984	1985	% Share in 1985
Ingots and semis	996.8	525.0	747.7	585.2	368.8	3.2
Wire rods	987.2	898.0	1,024.9	1,077.3	1,047.6	9.0
Rails and heavy structural shapes	839.7	412.1	458.6	520.1	531.9	4.6
Track Material	68.0	57.2	50.0	68.3	49.1	0.4
Concrete reinforcing bars	681.0	542.7	526.4	475.8	564.3	4.8
Other hot rolled bars	1,022.0	753.1	850.9	1,153.5	1,137.2	9.8
Cold finished bars	95.0	68.3	90.0	113.1	118.5	1.0
Structural shapes	520.7	331.6	387.9	458.7	497.0	4.3
Plate	1,802.8	1,122.6	1,014.6	1,414.1	1,476.3	12.7
Hot rolled sheet, strip	2,274.3	1,998.9	2,112.7	2,809.2	2,740.4	23.5
Cold reduced sheet, strip, other and coated (including tin plate)	1,761.0	1,709.5	1,784.4	1,797.3	1,918.0	16.4
Galvanized sheets	950.7	930.2	949.6	1,072.9	1,212.3	10.4
Total	**11,999.3**	**9,349.2**	**9,997.6**	**11,545.4**	**11,661.5**	**100.0**

Source: Ministry of the Environment - Industry Profile: Ontario Iron & Steel Producers, November 1987. Exhibit 2

5.3 Relationships between Industrial Production and Pollutant Loadings

The illustration of the historical relationship between pollutant loadings and production in the iron and steel sector is based on four major facilities in Ontario. Trends in production and pollutant are based on data for these four facilities only. Total production and pollutant loadings of the Ontario industry would be higher than the figures presented in this report.

5.3.1 Pollutant Loadings to Water

The IMIS database was used to illustrate trends in pollutant loading from the iron and steel sector for the years 1977 to 1989. MISA data exist for the industry but could not be obtained before this report was completed. Future reports in this project will contain illustrations of the trends in pollutants loading to water versus production for the years 1977 to 1992.

Trends in the following pollutants are illustrated in this section:

- phenols;
- oil and grease and TSS;
- ammonia;
- cyanide; and
- iron.

The exhibits on the following pages reveal that loadings of all these pollutants fell during the period 1977 to 1989 while production remained relatively constant.

Exhibit 5.3
Iron and Steel Industry
Production vs Phenols

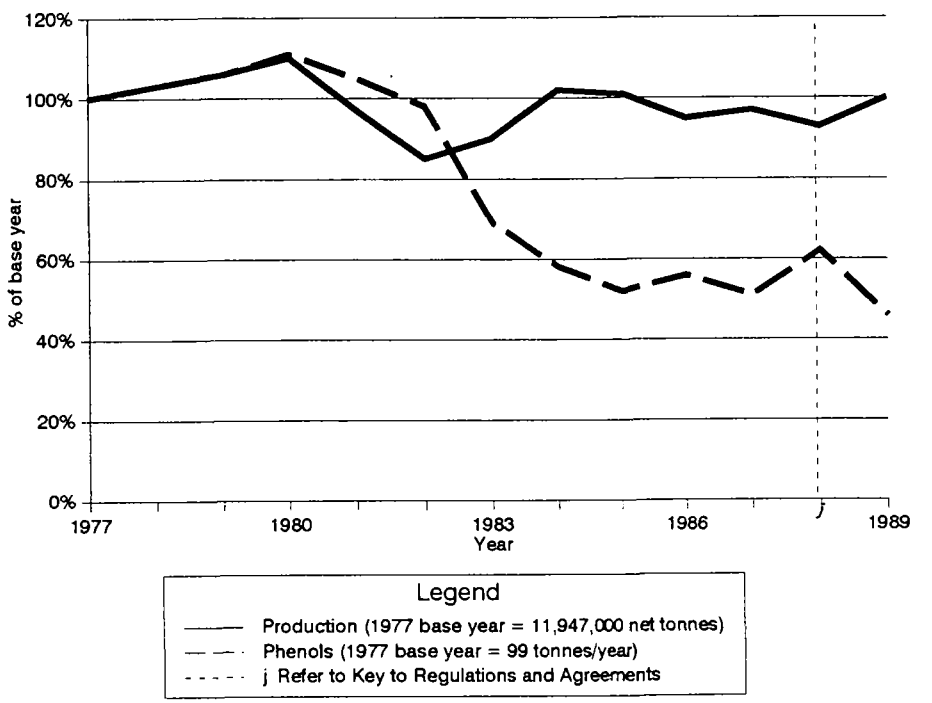


Exhibit 5.3 reveals that from 1977 to 1980 loadings of phenols matched production almost exactly. However, since 1980, phenol loadings fell to less than 50 % of base year levels while production remained relatively constant, except in 1982 when it fell to about 85 % of base year levels.

Exhibit 5.4
Iron and Steel Industry
Production vs Oil and Grease and TSS

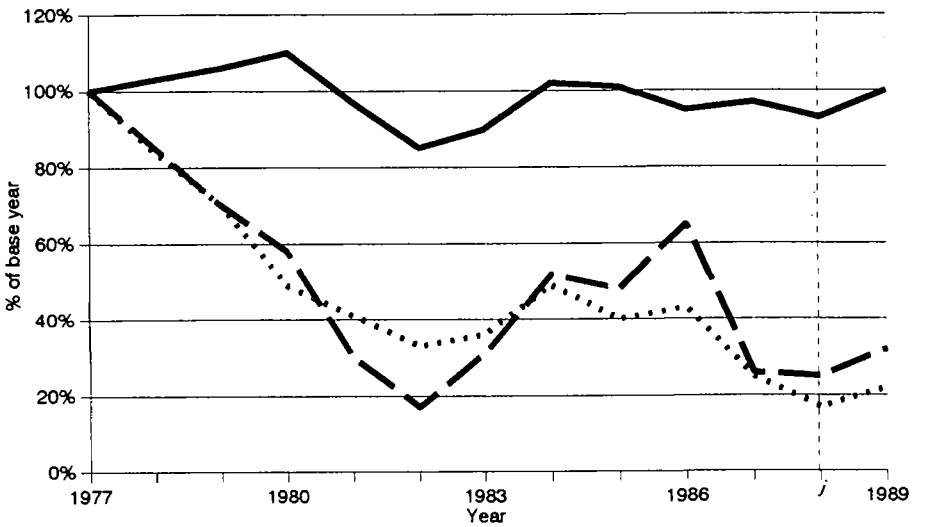


Exhibit 5.4 shows that by 1989 suspended solids and oil and grease fell to 20 % and 30 % of base year levels respectively. These two pollutants show some interesting trends over the period 1977 to 1989. By 1982, suspended solids had fallen to about 35 % of base year levels and oil and grease to about 20 %. Following 1982, however, loadings of both pollutants began to rise consistent with a rise in production over 1982 levels. By 1986, oil and grease loadings were back up to over 60 % of base year levels and suspended solids were over 40 % of base year levels. Interestingly, production had actually declined slightly in 1986 relative to 1985 levels. Following 1986, declines in both pollutants occurred until 1988, when a slight increase took place, again consistent with an increase in production over 1988 levels.

Exhibit 5.5
Iron and Steel Industry
Production vs Ammonia

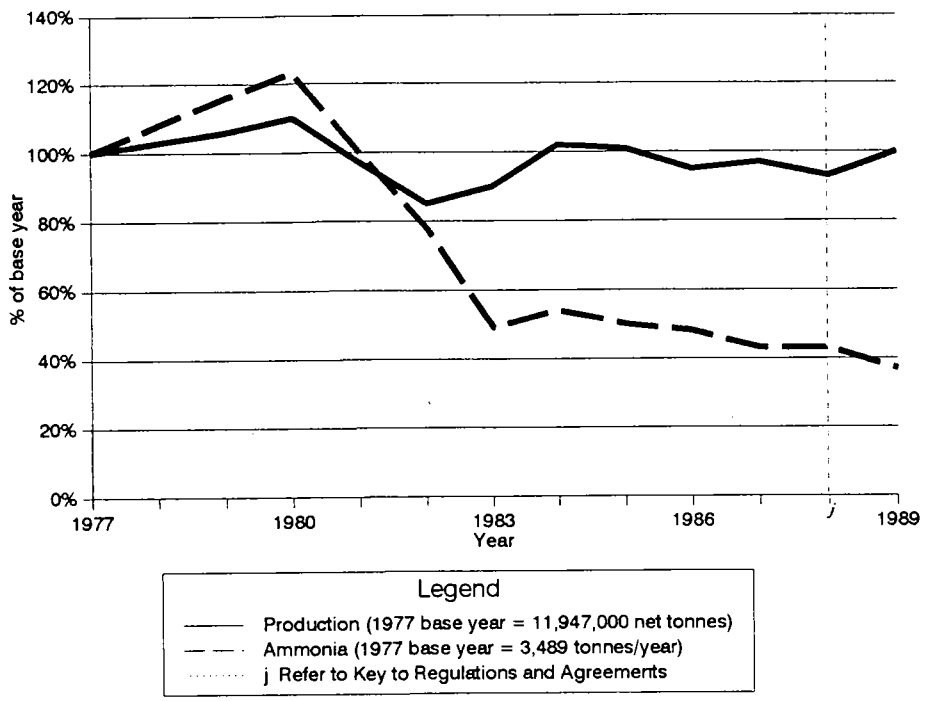


Exhibit 5.5 illustrates that loadings of ammonia decreased to just under 40 % of base year levels by 1989. During the period 1977 to 1980, loadings actually rose 20 % at the same time production increased by about 10 %. Following 1980 levels of both production and ammonia fell. Following 1982, however, loadings of ammonia continued to decline while production rose back up to base year levels.

Exhibit 5.6
Iron and Steel Industry
Production vs Cyanide

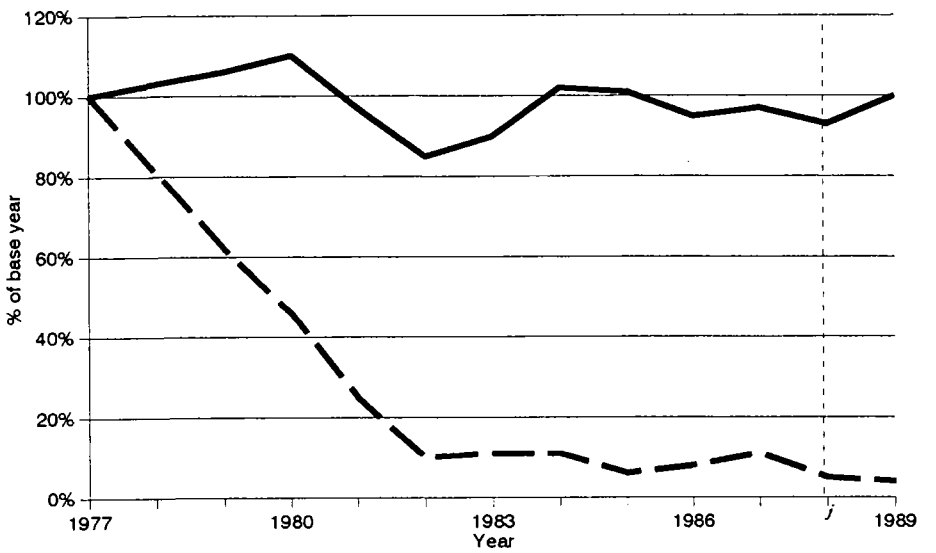


Exhibit 5.6 shows significant declines in the loadings of cyanide by the iron and steel industry relative to production levels. Total loadings decreased steadily to about 5 % of base year levels by 1989.

Exhibit 5.7
Iron and Steel Industry
Production vs Iron

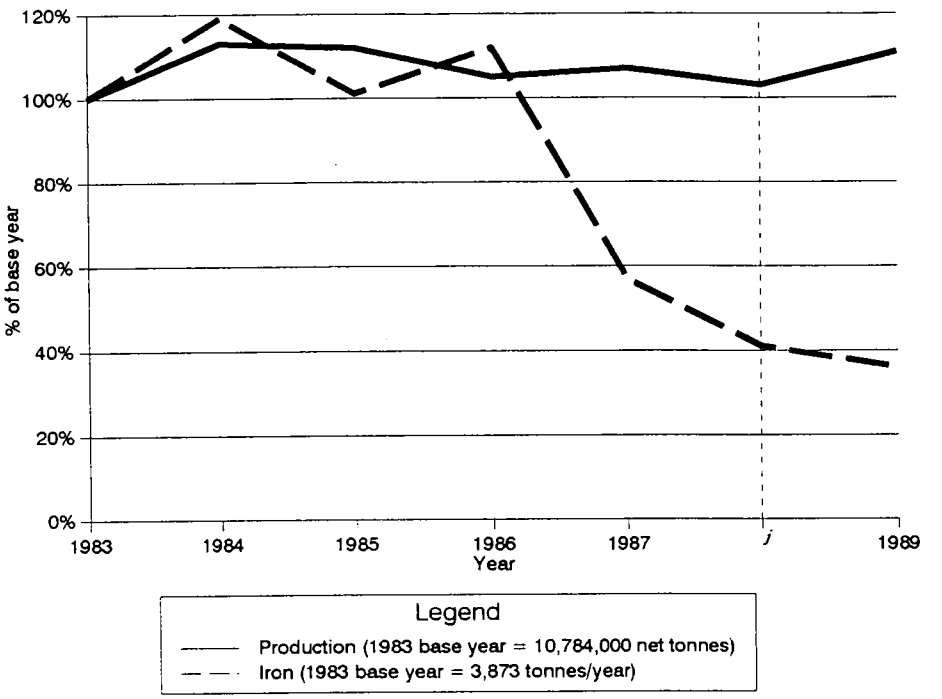


Exhibit 5.7 illustrates the trends in loadings of iron versus production. Note that the base year used is 1983, not 1977. The exhibit reveals that during the mid-1980's loadings increased, consistent with increases in production. In 1986, however, loadings began to fall while production remained relatively constant. By 1989 iron loadings decreased to under 40 % of base year levels.

5.3.2 Pollutant Loadings to Air

Trends in the following pollutants are illustrated:

- SO_x;
- NO_x;
- particulates;
- CO; and
- VOCs.

The exhibits on the following pages show the relationship between industrial production and pollutant loadings to air for the iron and steel industry.

It should be noted that the MOEE is currently working with the Canadian Environmental Steel Association to revise the estimates presented in this report.

Exhibit 5.8
Iron and Steel Industry
Production vs SOx

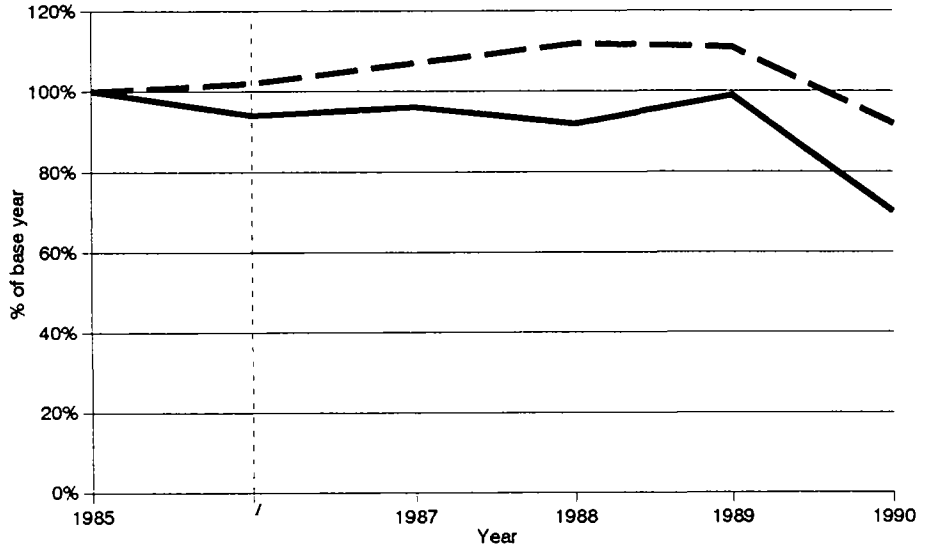


Exhibit 5.8 reveals that production remained relatively constant until 1989 when a 30 % drop occurred by 1990. At the same time, SO_x emissions were rising. By 1989 SO_x levels rose 15 % over base year levels. In 1990, SO_x fell below base year levels for the first time, accompanied by the significant decline in production levels. Recall that emission factors are used to calculate most of the air emissions. This ties industrial activity directly to air emissions.

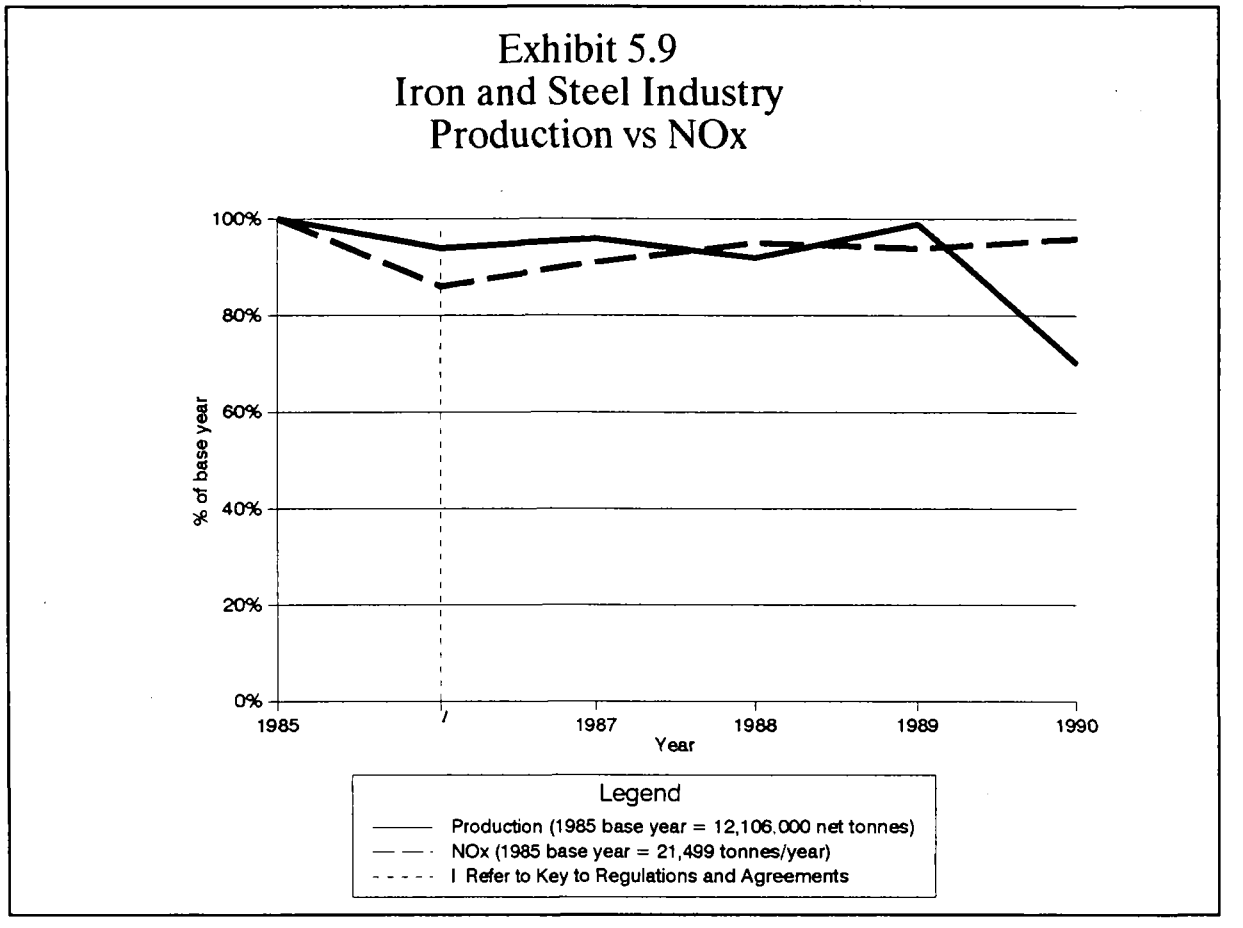


Exhibit 5.9 reveals that loadings of NO_x fell between 1985 and 1986 but then rose again and by 1990 were almost at base year levels. During this period production remained relatively constant, until a significant drop in 1990, to 70 % of base year levels. No accompanying decline in NO_x occurred in 1990.

Exhibit 5. 10
Iron and Steel Industry
Production vs Particulates

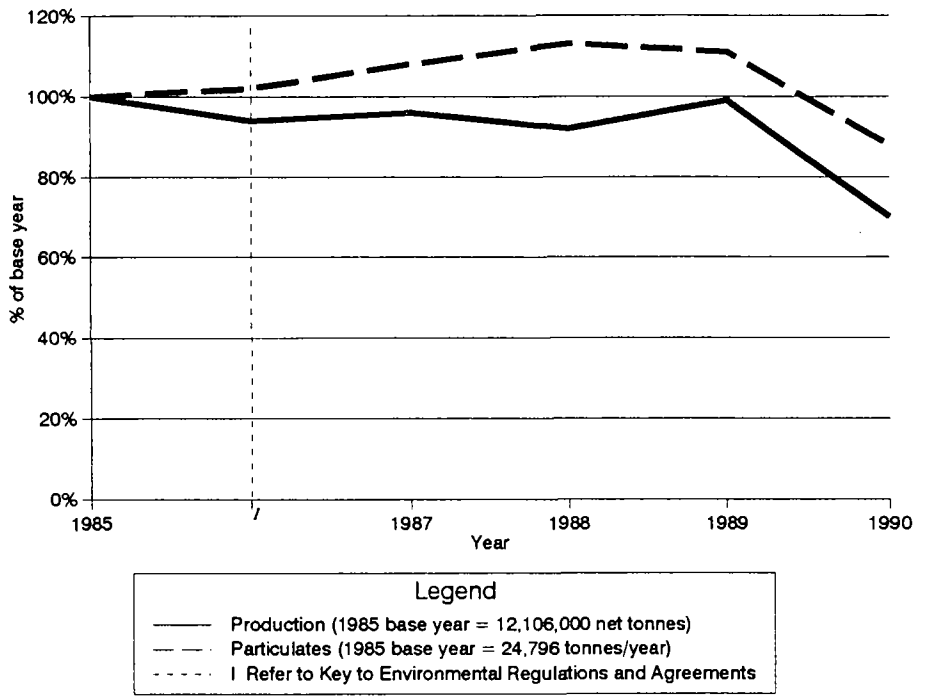


Exhibit 5.10 shows particulate loading rising at the same time production was decreasing. Loadings of particulates did not fall below base year levels until 1990 when a significant reduction in production also took place.

Exhibit 5.11
Iron and Steel Industry
Production vs Carbon Monoxide

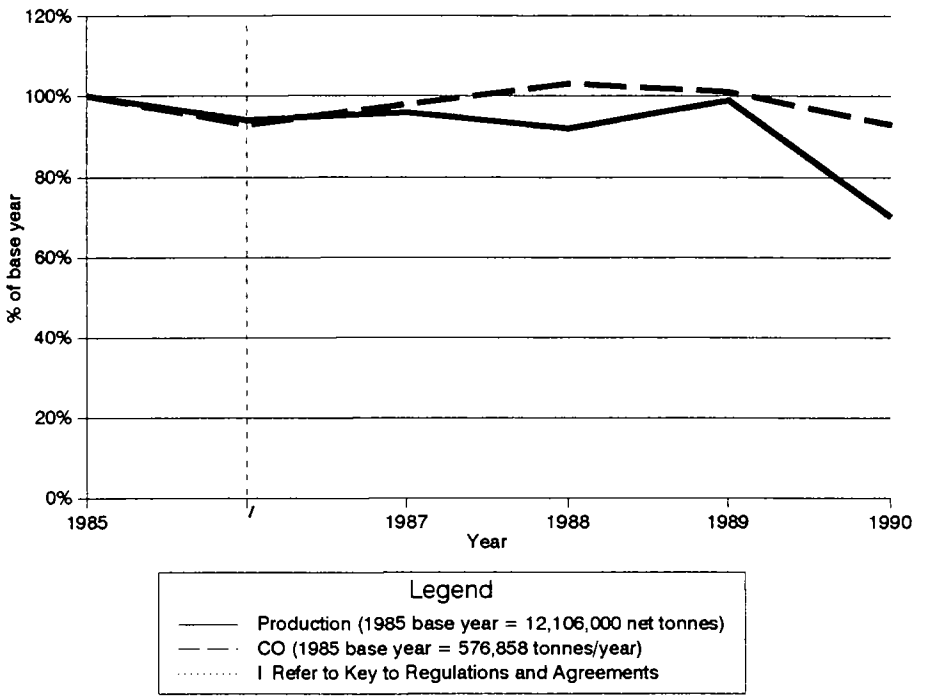


Exhibit 5.11 shows that production and carbon monoxide loadings followed relatively similar trend patterns between 1985 and 1990, except for a rise in carbon monoxide levels in 1988 when production decreased.

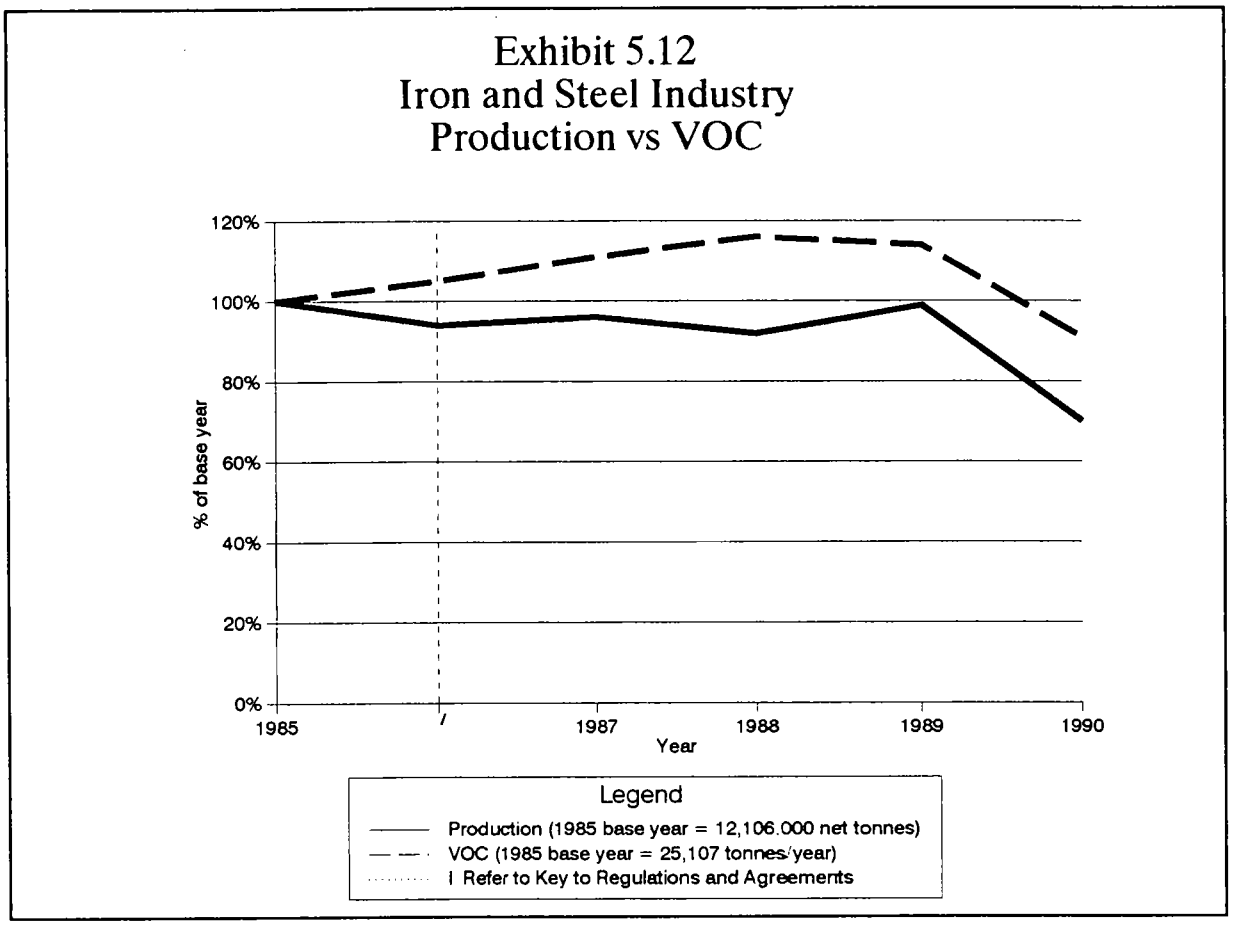
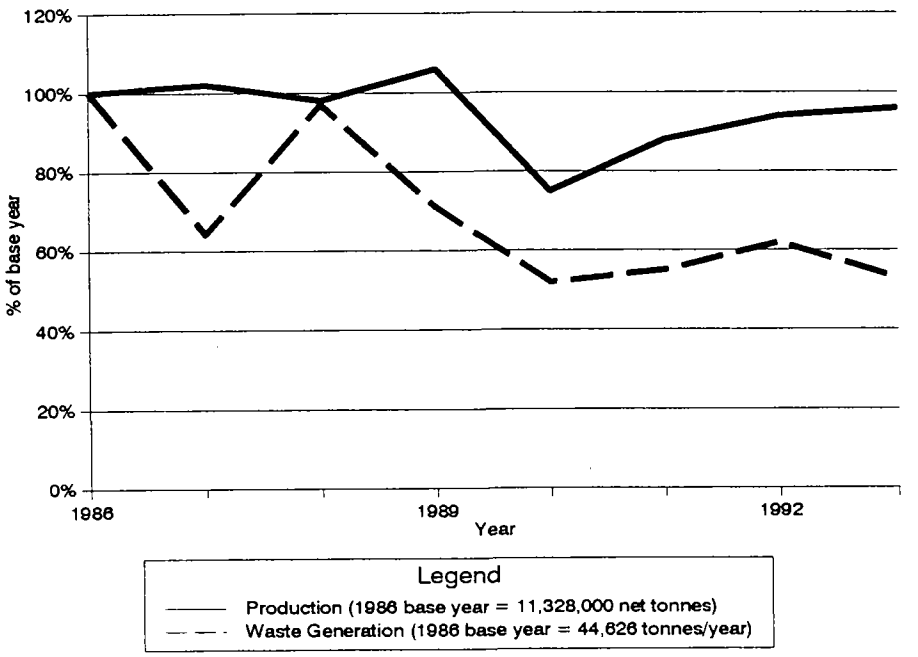


Exhibit 5.12 again shows loadings of VOC rising at the same time production was decreasing. Further work with the industry will be necessary to understand these results.

5.3.3 Hazardous and Liquid Industrial Waste Generation

The Ontario Generator Registration Database (OGRD) data are used to illustrate trends in waste generation for the years 1986 to 1993. Total waste generation is plotted against industrial production. Recall that caveats about using OGRD data noted earlier in this report.

Exhibit 5.13
Iron and Steel Industry
Production vs Waste Generation



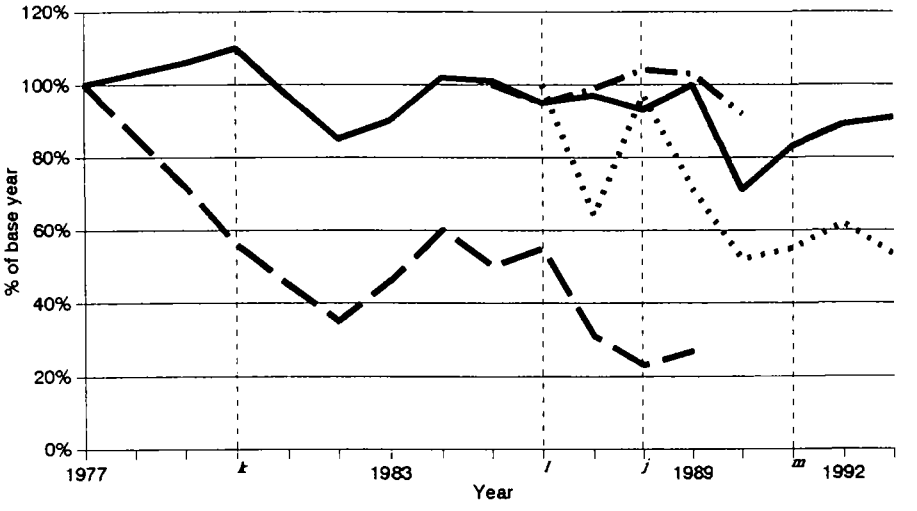
Note: Waste Generation refers to hazardous and liquid industrial wastes treated off-site.

Exhibit 5.13 illustrates little relationship between production and waste generation between 1986 to 1988. Beginning in 1989, a relationship begins to emerge. In 1989 declines in production were matched by even larger declines in waste generation. From 1990 to 1992, an increase in production occurs at the same an increase in waste generation takes place. Following 1992 waste generation actually declined while production continued to rise. By 1993, waste generation was 50 % of base year levels.

5.3.4 Summary of Findings

Exhibit 5.14 on the following page plots total pollutant loadings to each environmental medium against production data.

Exhibit 5.14
Iron and Steel Industry
Production vs Total Loadings



Legend

- Production (1977 base year = 11,947,000 net tonnes)
- Loadings to Water (1977 base year = 41,584 tonnes/year)
- Waste Generation (1986 base year = 44,626 tonnes/year)
- Air Emissions (1985 base year = 699,897 tonnes/year)
- j,k,l,m Refer to Key to Regulations and Agreements

Note: Waste Generation refers to hazardous and liquid industrial wastes treated off-site.

Exhibit 5.13 illustrates that:

- the total pollutant loadings to water fell to about 30 % of base year levels from 1977 to 1989;
- air emissions trends closely resemble trends in production except in 1988 and 1989 when they increased while production was decreasing; and
- except for a spike in 1988, waste generation fell relative to production.

6.0 The Electric Power Generation Industry

6.1 Sector Overview

The electric power generation sector is an important Ontario industry. In 1990 the industry generated revenues of $ 11.5 billion in Ontario, 45 % of all Canadian revenues. The industry employed 31,551 persons, paying out salaries and wages of $1.5 billion.

For the purposes of this study, the analysis was limited to Ontario Hydro nuclear and thermal generating stations. Ontario Hydro is a provincial crown corporation that in 1987 supplied 95 % of the electricity consumed in Ontario[21].

Exhibit 6.1
The Electric Power Generation Industry in Canada and Ontario, 1990

Variable	Canada	Ontario	% Ontario/Canada
Employees	78,849	31,551	40
Wages	$3.6 Billion	$1.5 Billion	42
Revenue	$25.4 Billion	$11.5 Billion	45

Source: Statistics Canada, 1993.

6.2 The Electric Power Generation Industry: Environmental Impact of Production and Consumption of the Industry's Product

Presented in this section is a brief overview of the environmental impact associated with the production and consumption of electric power.

The purpose of presenting this information is to illustrate the total impact the industry may have on the environment.

The information presented is a preliminary assessment of the environmental impact associated with the industry.

[21]. The Ontario Ministry of Environment and Energy, *The Development Document for the Draft Effluent Monitoring Regulation for the Electric Power Generation Sector*, August 1989, p. A - 16.

6.2.1 The Production Processes[22]

Electrical generation is a relatively straightforward principle: an electric current is produced in a copper wire if the wire is moved quickly through the field between two magnets. In large electrical generators many loops of wire are placed around the circumference of a machine. Electromagnets are spun around this machine and the create electricity as the magnet fields alternate.

This is the basic technique used to produce electricity at both hydraulic and thermal generation stations. Each of the types of generating stations are described below.

Hydraulic Generation

Hydraulic stations use only the force of falling water as their "input". The force of falling water is used to turn turbines, which in turn drive electrical generators.

Thermal Generation

In thermal electrical generation, high-pressure steam is used to turn turbines, which in turn drive the electrical generators. There are two methods used to produce the steam necessary to drive the turbines:

- fossil fuels are burned to create high pressure steam which is used to turn turbines which in turn drive electrical generators; and
- uranium oxide is used as a fuel in nuclear generating stations to produce steam which drives the turbines and electrical generators.

Figures 6.1, 6.2 and 6.3 provide illustrations of the different methods of producing electricity.

The various processes employed in electric power generation result in a variety of pollutants. Figures 6.4 and 6.5 illustrate the generation of wastewaters at fossil-fuel and nuclear generating stations. The wastewaters can include both conventional and toxic pollutants. Conventional pollutants that may be present include, oil and grease, suspended solids, nitrogen, acids and dissolved solids. Toxic contaminants include metals, phenols, and chlorinated hydrocarbons.

The electric power sector is one of the largest emitters of air pollutants. Ontario Hydro is the largest industrial generator of NO_x in Ontario and the second largest generator of SO_x.[23]

The electric power sector is not a significant generator of conventional hazardous wastes. Note that

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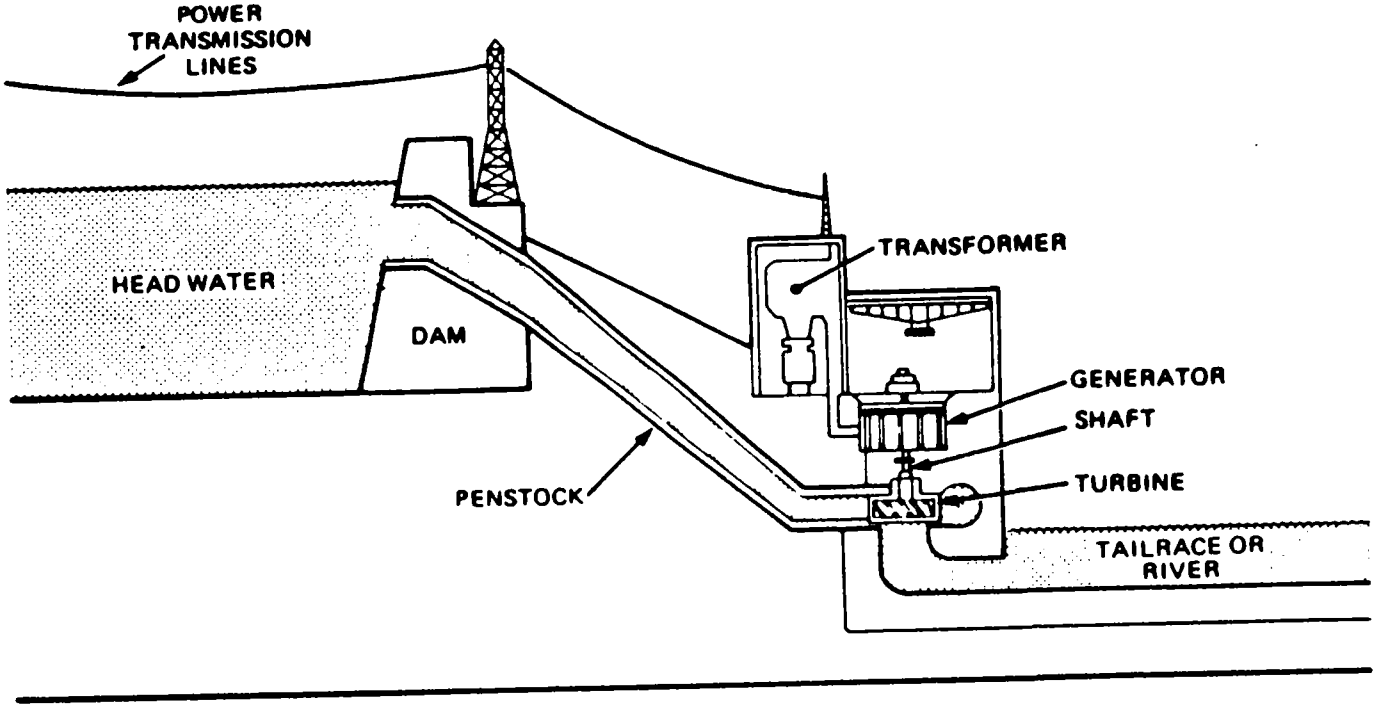
[22]. Information in this section is drawn primarily from the following report:

Environment Ontario, *The Development Document for the Draft Effluent Monitoring Regulation for the Electric Power Generation Sector*, Queen's Printer for Ontario, 1989.

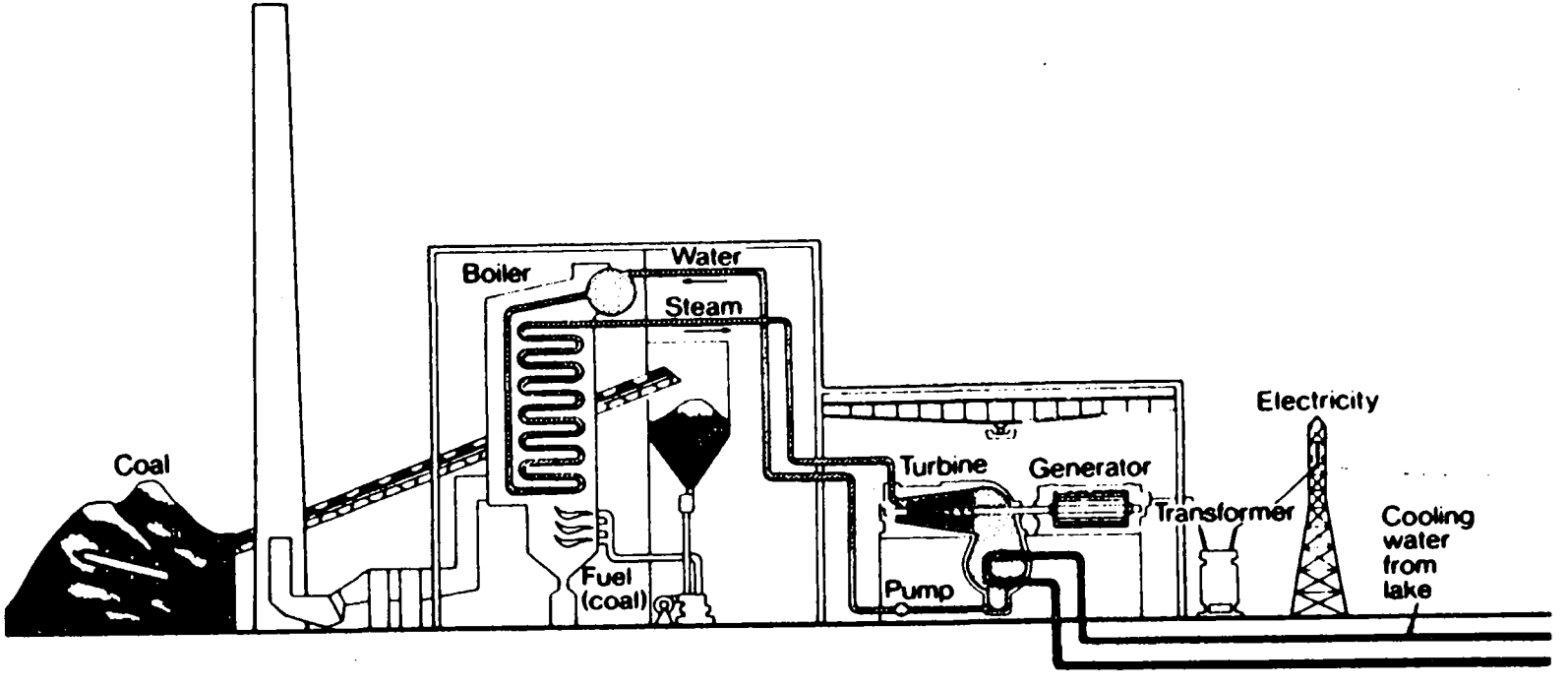
[23]. Senes Consultants Ltd, *Countdown Acid Rain, Future Abatement Strategies, prepared for the Ontario Ministry of Environment and Energy*, April 1991.

Figure 6.1
Cross-sectional View of a Typical Hydraulic Generating Station



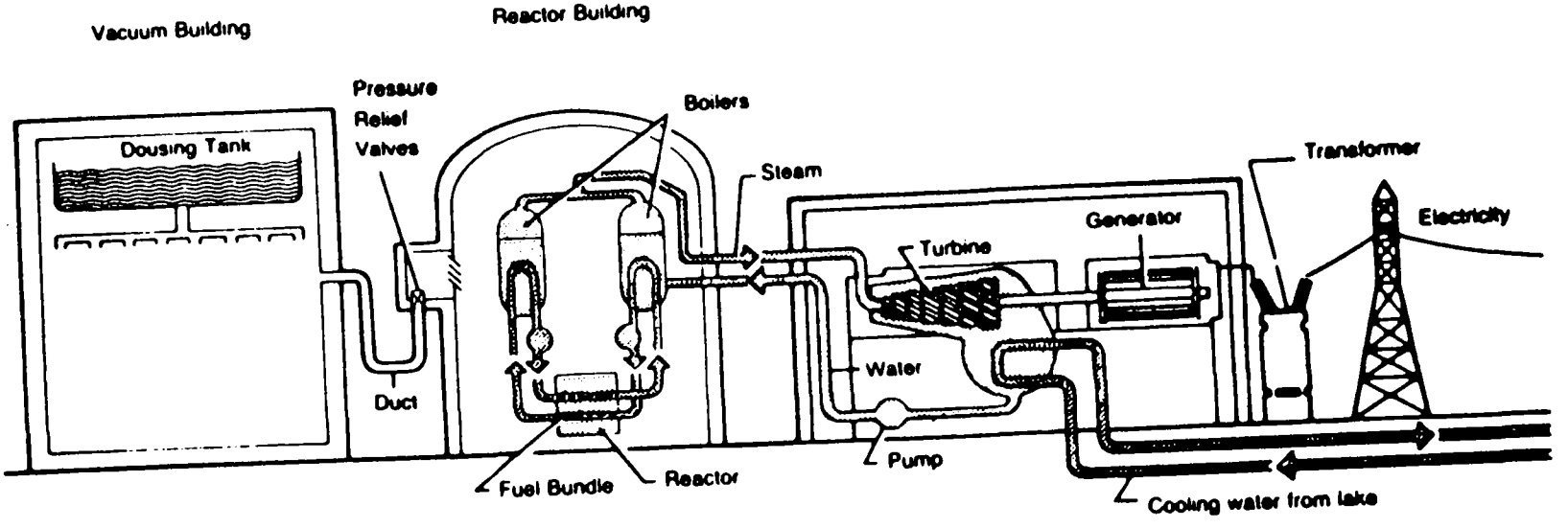
Source: MISA: The Development Document for the Draft Effluent Monitoring Regulation for the Electric Power Generation Sector, Ontario Ministry of the Environment

Figure 6.2
Cross-sectional View of a Typical Fossil-fuelled Thermal Generating Station



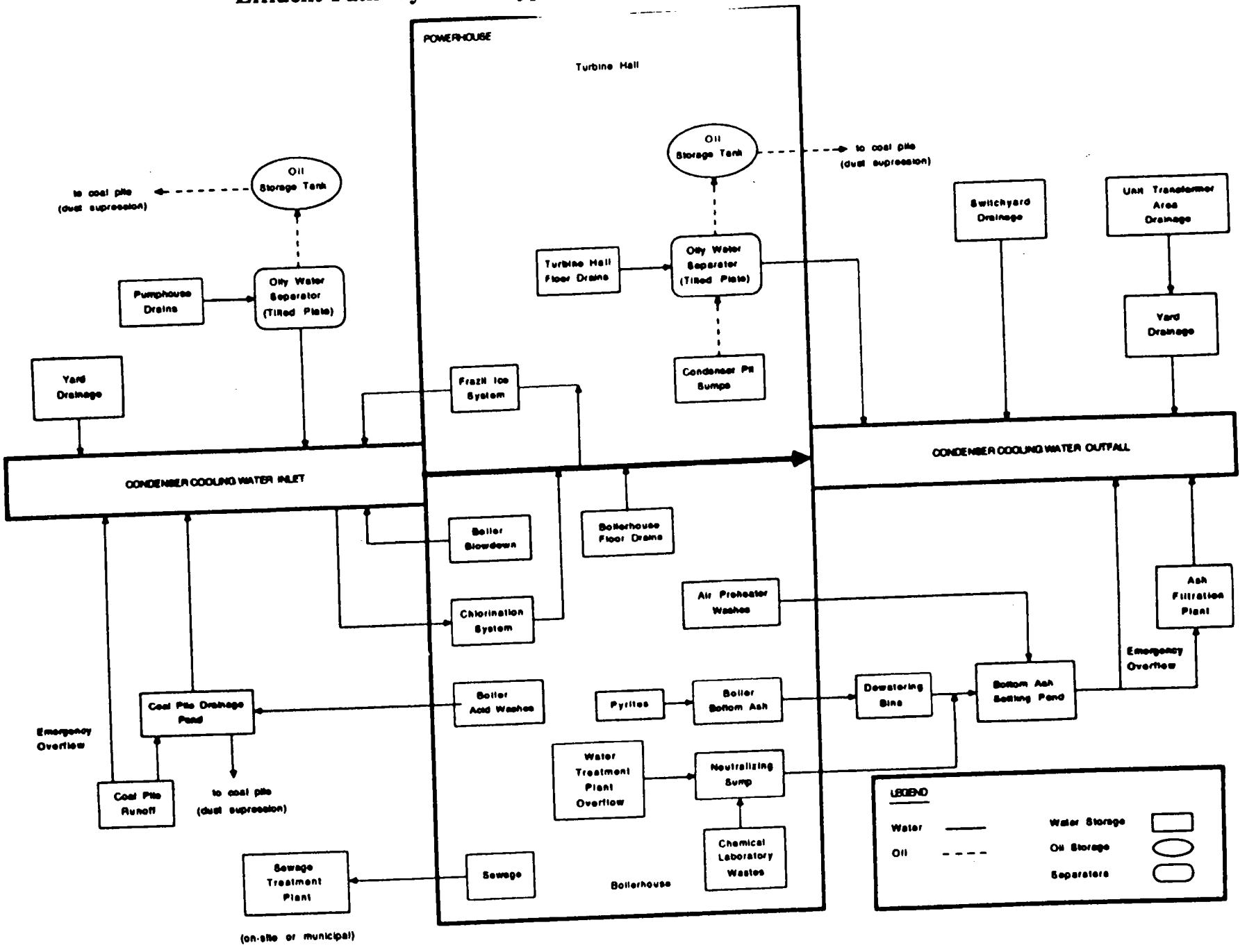
Source: MISA: The Development Document for the Draft Effluent Monitoring Regulation for the Electric Power Generation Sector, Ontario Ministry of the Environment

Figure 6.3
Cross-sectional View of a Typical Nuclear-Powered Thermal Generating Station



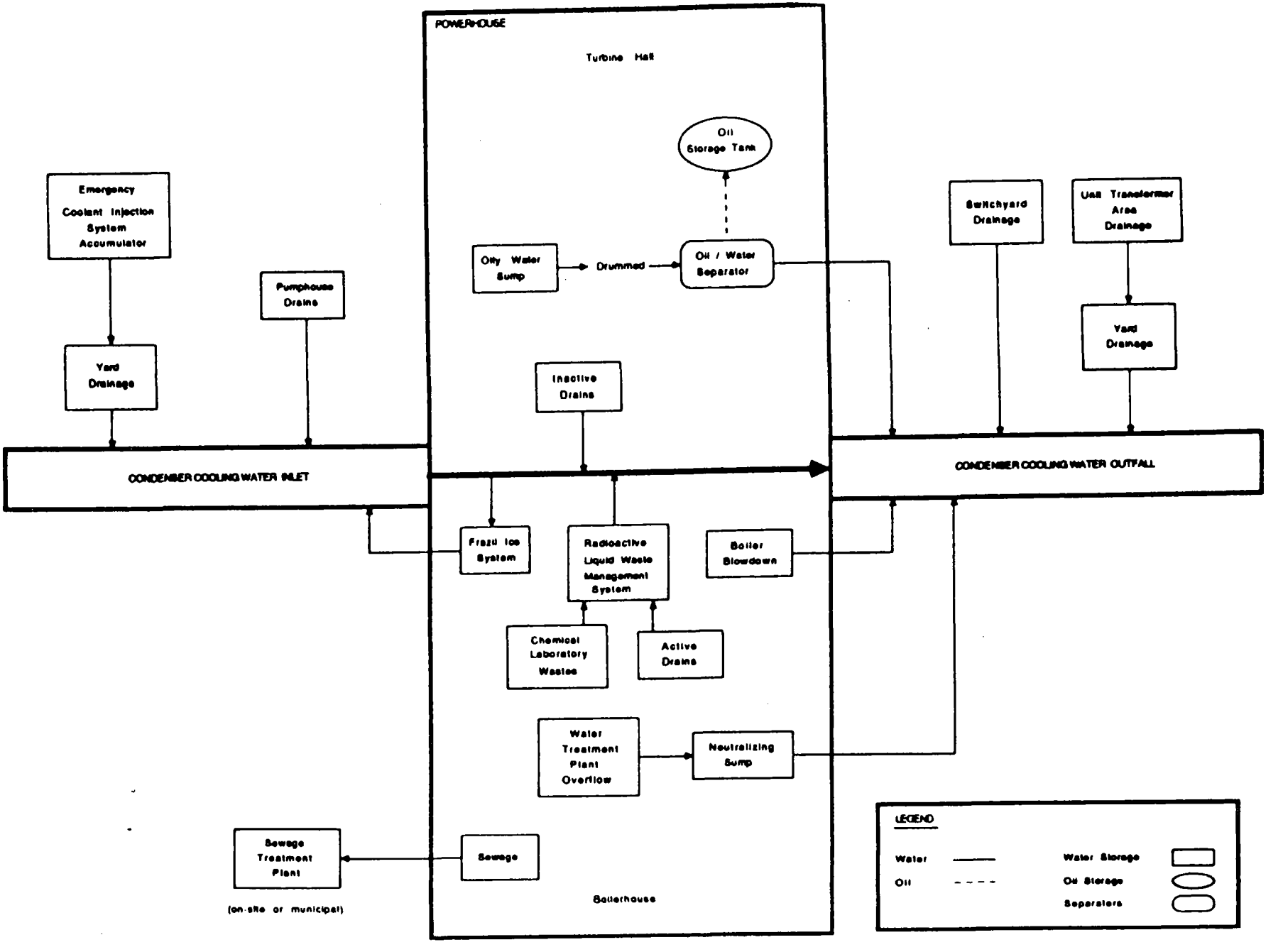
Source: MISA: The Development Document for the Draft Effluent Monitoring Regulation for the Electric Power Generation Sector, Ontario Ministry of the Environment

Figure 6.4
Effluent Pathways for a Typical Fossil-fuelled Thermal Generating Station



Source: MISA: The Development Document for the Draft Effluent Monitoring Regulation for the Electric Power Generation Sector, Ontario Ministry of the Environment

Figure 6.5
Effluent Pathways for a Typical Nuclear-powered Thermal Generating Station



Source: MISA: The Development Document for the Draft Effluent Monitoring Regulation for the Electric Power Generation

this does not include radioactive wastes produced by nuclear generating stations. Typical wastes produced by the sector include waste crankcase oils and other waste oils. These oils are mainly from machinery and transformers.

6.2.2 The Products

Electricity is used in virtually every aspect of modern society. Electricity itself is environmentally benign. It is the uses to which the electricity is put that have an impact on the environment. Therefore, no analysis of the impact electricity itself has on the environment is possible.

6.3 Relationships between Industrial Production and Pollutant Loadings

6.3.1 Pollutant Loadings to Water

As noted earlier in this report, the only "pollutants" for which historical data exist for the electric power generation sector are temperature rise and pH. These pollutants offer little insight into any trends in pollutant loadings to water. No analysis of the relationship between these pollutants and production is undertaken.

6.3.2 Pollutant Loadings to Air

The FRED database is used for measuring trends in pollutant loadings to air by the iron and steel industry. The following pollutants are included:

- SO_x;
- NO_x;
- particulates;
- CO; and
- VOCs.

Data on SOx, NOx and particulates are provided to the MOEE by Ontario Hydro. Emissions of VOC and CO for this sector are estimated by the MOEE.

For the electric power generation sector, five thermal generating stations are used to illustrate trends in production versus pollutant loadings to air.

Exhibit 6.2
Electric Generation Industry
Production vs SO_x

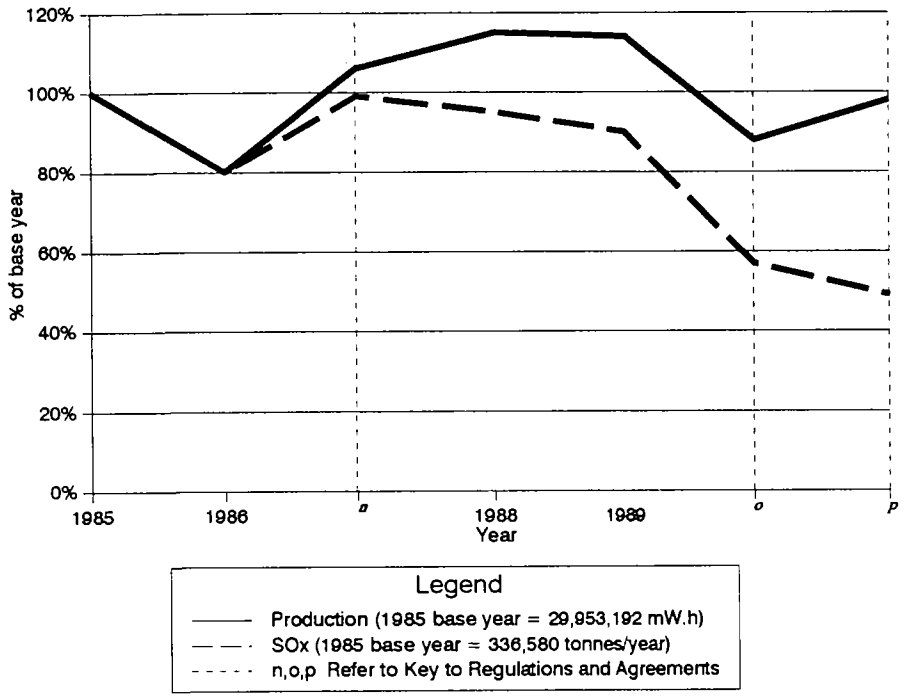


Exhibit 6.2 illustrates that between 1985 and 1987 production and emissions of SO_x followed almost the same trend. From 1987 to 1989, however, production increased at the same time emissions were decreasing. From 1989 to 1990 both production and emissions declined relative to base year levels. By 1991 SO_x emissions had fallen to 50 % of base year levels while production rose to almost 100 % of 1985 levels.

Exhibit 6.3
Electric Generation Industry
Production vs NO_x

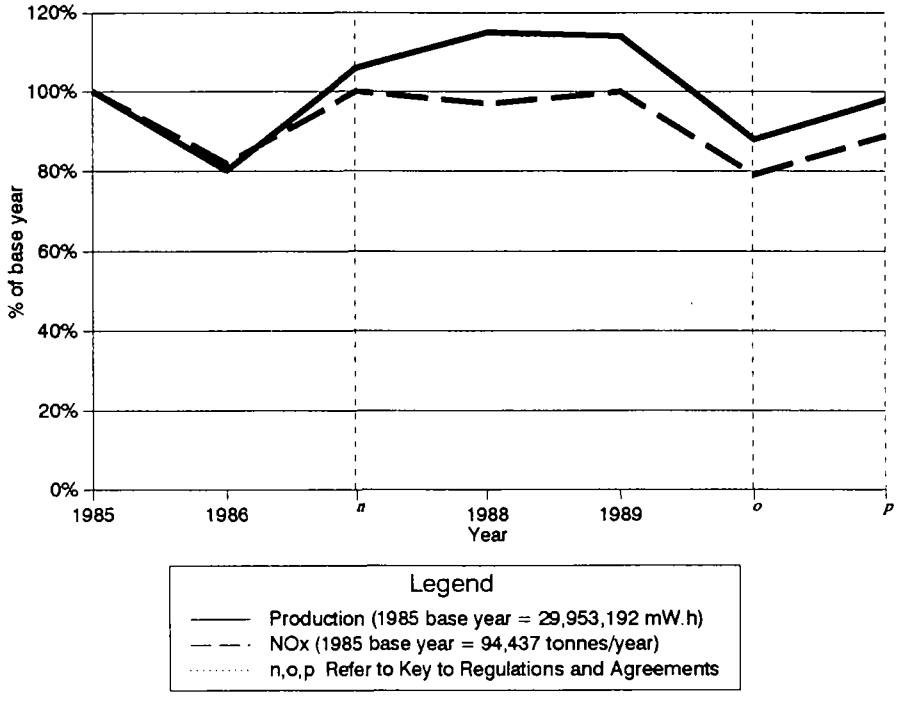


Exhibit 6.3 illustrates the relationship between production and NO_x loadings. From 1985 to 1987, trends of the two were almost exactly the same. During the period 1987 to 1989, however, production increased while emissions levelled out at base year levels. From 1989 to 1990, NO_x emissions declined in conjunction with a decline in production and rose again with production in 1991.

Exhibit 6.4
Electric Generation Industry
Production vs Particulates

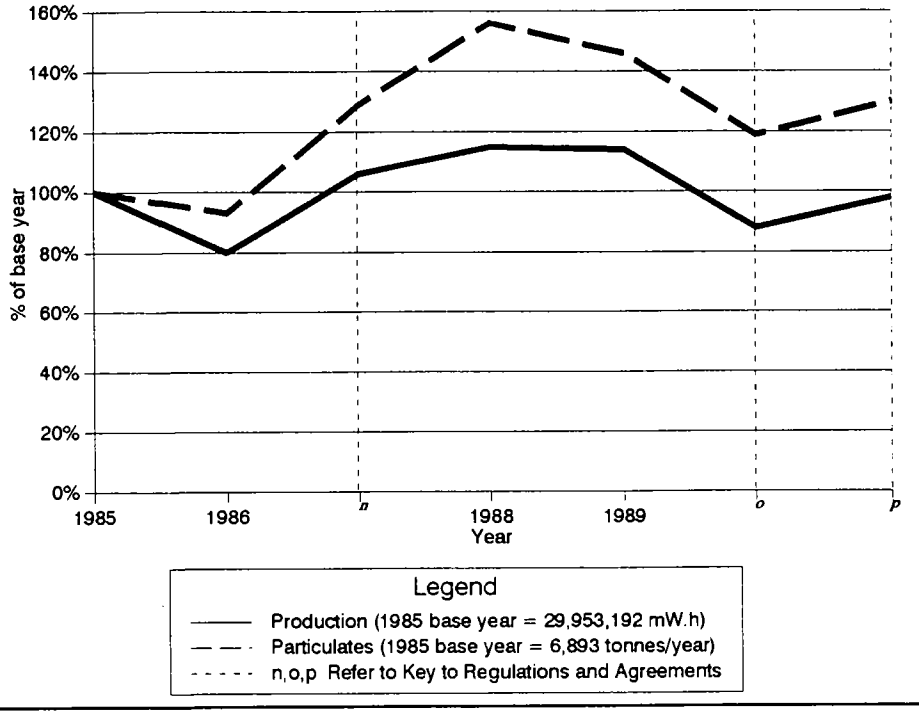


Exhibit 6.4 reveals that trends in production and particulate loadings follow the same patterns, however, increases in pollutants loadings were much greater than corresponding increases in production. From 1985 to 1986, production decreased by approximately 20% while particulate emissions fell by only 10%. From 1986 to 1989, increases in emissions were greater than corresponding increases in production. From 1989 to 1991, trends in production and particulate emissions appear to be closely related.

Exhibit 6.5
Electric Generation Industry
Production vs Carbon Monoxide

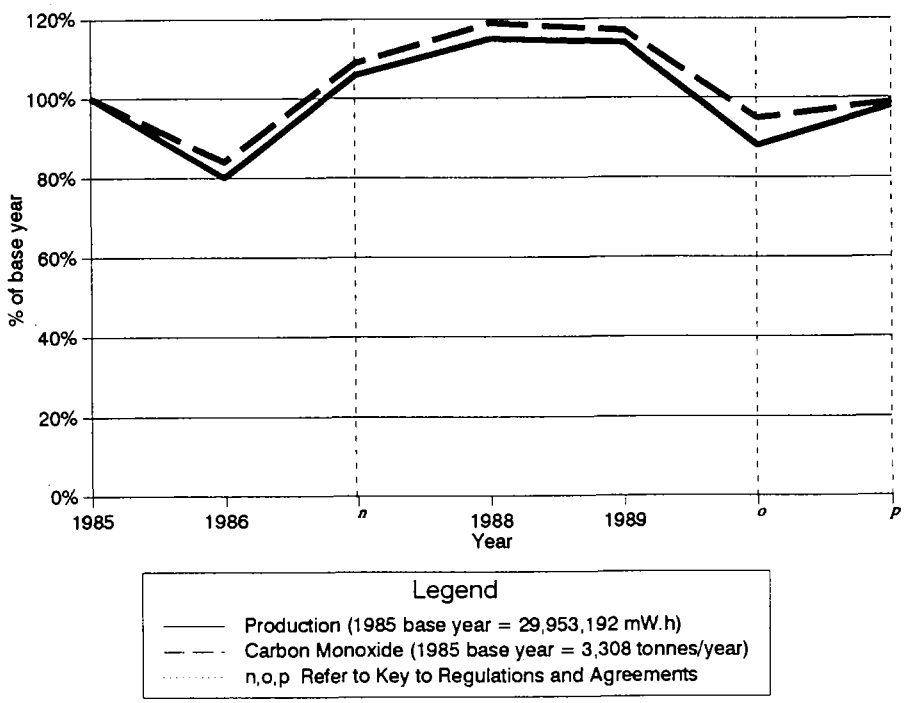
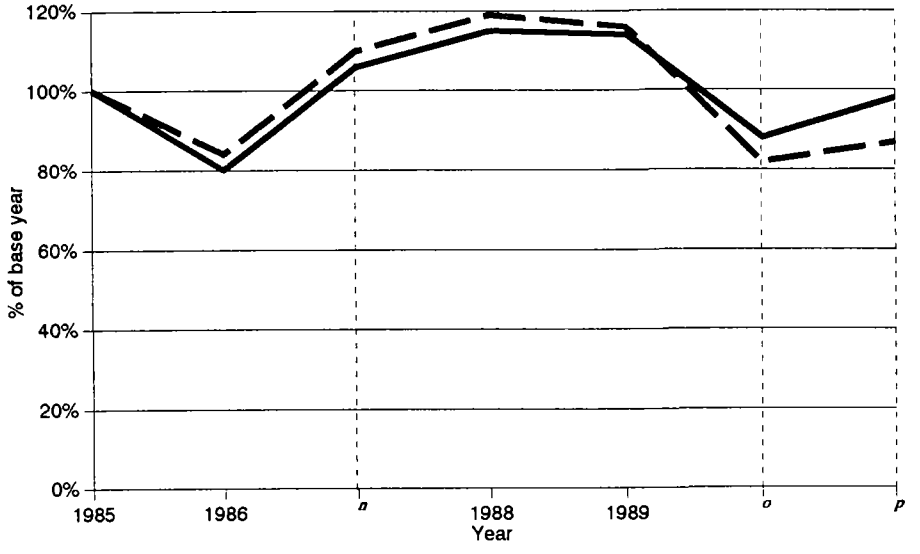


Exhibit 6.5 above and exhibit 6.6 on the following page reveal that the MOEE estimates of VOC and CO are based on emissions factors. Trends in production and emissions are shown to have almost a one-to-one relationship.

Exhibit 6.6
Electric Generation Industry
Production vs VOC

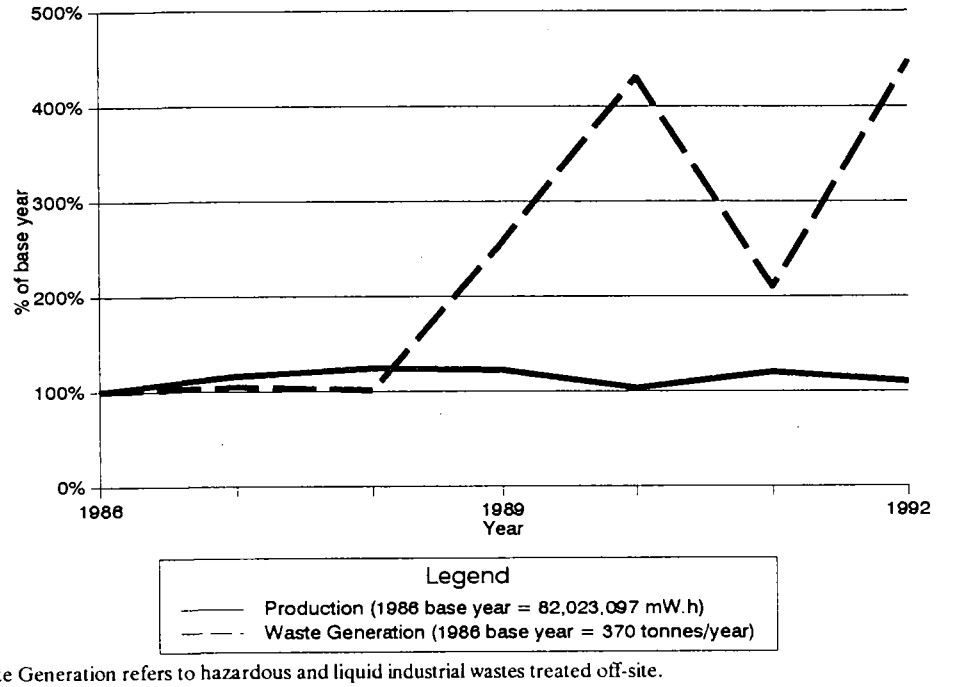


6.3.3 Hazardous and Liquid Industrial Waste Generation

The Ontario Generator Registration Database (OGRD) is used to illustrate trends in hazardous and liquid industrial wastes treated off-site for the years 1986 to 1992. Total waste generation is plotted against industrial production. Recall the caveats noted in Section 2.0 regarding the use of OGRD data for illustrating historical trends in waste generation.

The waste generation and production data presented below are for a different sample of facilities then was used for illustrating air emissions versus production. A total of 10 nuclear and thermal generating stations are included in the illustration of waste generation.

Exhibit 6.7
Electric Generation Industry
Production vs Waste Generation

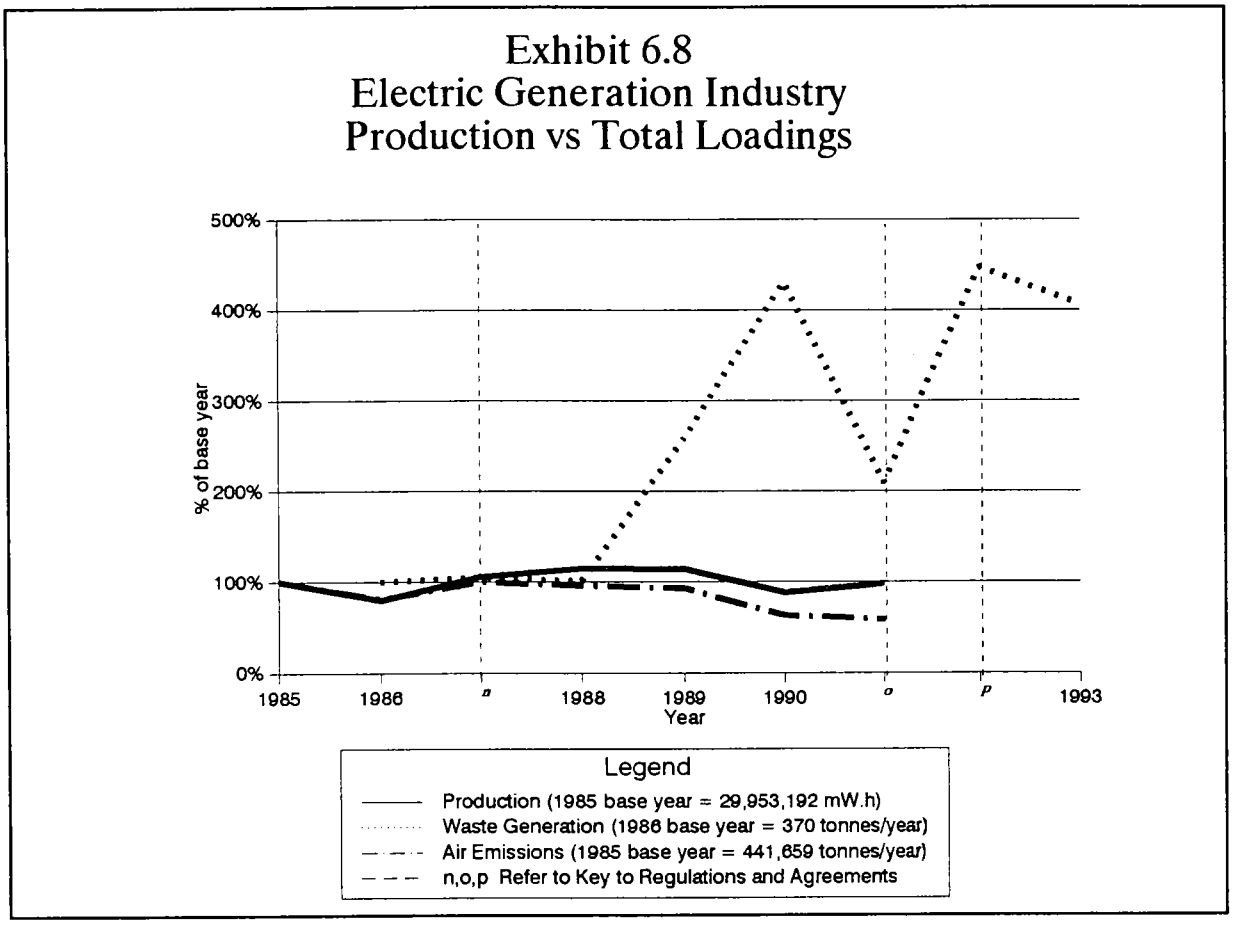


Note: Waste Generation refers to hazardous and liquid industrial wastes treated off-site.

Exhibit 6.7 reveals that there is no clear relationship between production and waste generation. While production has remained relatively constant for these facilities over the period 1986 to 1992, waste generation has fluctuated significantly.

6.3.4 Summary of Findings

In this section trends in total loadings to each environmental media are plotted against production data. Exhibit 6.8 illustrates these relationships.



The exhibit reveals that total air emissions have fallen almost 50 % over base year levels while production has remained relatively constant. The bulk of this decrease is due to reductions in SO_x emissions. Waste generation, on the other hand, has fluctuated widely.

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