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Virtual Elimination of PCBs, Mercury, and Persistent Toxics from the Pulp and Paper Industry in the Great Lakes Basin: A Role for Economic Instruments?

International Joint Commission. Virtual Elimination Task Force. Economic Subgroup

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Report of the Economic Subgroup

to the Virtual Elimination Task Force

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Disclaimer

This report to the Virtual Elimination Task Force of the International Joint Commission was prepared under the direction of the Task Force's Economic Subgroup. The statements and views presented in this report are those of VHB Research and Consulting and do not necessarily represent the views or policies of the International Joint Commission, its Boards or its committees.

The Task Force notes that some of the information contained herein has been superseded by more recent information. Also, the use of older data does not correctly reflect the name and location of some of the mills. Nonetheless, this does not detract from the main message of the report, nor its conclusions and recommendations.

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EXECUTIVE SUMMARY

This study examines the roles that economic instruments might play in achieving the "virtual elimination" of discharges of persistent toxic substances to the Great Lakes Basin Ecosystem. The specific objectives of this study are:

1. To define and assess the role of economic instruments as a means to the virtual elimination of emissions of persistent toxic substances to the Great Lakes environment.

2. To assess economic instruments as a means to achieve the virtual elimination of PCBs and mercury entering the Great Lakes environment.

3. To assess economic instruments as a means to achieve the virtual elimination of persistent toxic emissions to the Great Lakes by the pulp and paper industry in Canada and the United States.

There are many types of economic instruments for achieving environmental objectives. The emphasis in this study is on effluent charges and tradeable emissions though several other instruments are also considered (i.e. user, product and administrative charges, tax differentiation, subsidies, deposit-refunds systems and financial enforcement incentives).

Economic instruments are best seen as a complement to rather than a substitute for the traditional command and control approach. Accordingly, the study includes a brief account of the existing regulatory system for controlling toxics in the Great Lakes basin. The study also reviews several examples of the use of economic instruments in practice and concludes that, with a few notable exceptions, effluent charges have only been used to raise funds rather than to provide an incentive for abatement. On the other hand, where tradeable emissions have been used (exclusively in the United States), revenues have been low or non-existent and the incentives for more efficient and speedier abatement, provided by the instrument, have been more significant.

An evaluation framework, in the form of a decision tree, was developed for this study. The framework is general and it can used to assess the role of economic instruments for achieving environmnetal objectives in a wide range of circumstances.

The most substantive parts of the study address PCBs, mercury and all persistent toxics entering the Great Lakes Basin. Although the data for PCBs and mercury is very incomplete, it is clear that a very substantial proportion of these contaminants reach the Great Lakes through atmospheric deposition rather than direct discharge. This factor complicates any effort to achieve virtual elimination since the sources are diverse, geographically dispersed and often unknown.

Information on discharges of persistent toxics from pulp and paper mills has improved recently for Ontario owing to the monitoring requirements of MISA (Municipal Industrial Strategy for Abatement). Similar detailed information for discharges from U.S. mills is not available.

The following recommendations are based on an analysis of the information on sources of persistent toxics, on abatement technologies, process changes and costs, and on the economic prospects of the pulp and paper sector:

General

1. Efforts should continue to enhance the information on sources, abatement costs and damages that is necessary for the further appraisal and design of economic instruments.

Mercury

2. For mercury, priority should be given to economic instruments that will reduce the use of mercury in manufacturing process that are not closed cycles. Measurement of the use of mercury is far more reliable than measurement of the sources and fate of mercury discharges. A tax on mercury might be the simplest incentive to administer, though to be helpful, it would have to apply to all firms throughout Canada and the U.S. and possibly to imports from other countries as well.

3. The feasibility of a deposit/refund system for batteries containing mercury (over 30% of all mercury used in consumer products) should be investigated. In particular, the prospects for developing the necessary infrastructure should be looked at in detail.

4. Mercury emissions from electrical utilities, copper smelters and incinerators (over 85% of all industrial sources) in Canada and the U.S. could be subjected to an effluent charge if the reliability of monitoring is improved. Revenues could be used to deal with contaminated sediments in the Great Lakes basin and other bodies of fresh water.

PCBs

5. PCBs should be dealt with through regulation. There is no obvious role for the use of an economic instrument.

Pulp and Paper

6. It is in this sector that economic instruments appear to have the most to offer. Priority should be given to the detailed design and further analysis of a program of economic instruments for the pulp and paper industry consisting of:

   - Financial enforcement incentives to support regulations designed to virtually eliminate 2,3,7,8-TCDD/TCDF.

   - A tradeable permits scheme to reduce the use of chlorine.

   - An effluent charge on adsorable organic halide (AOX).

1.0 INTRODUCTION

1.1 Objectives

The main objective of this study is to provide the Joint Task Force on the Virtual Elimination of Persistent Toxic Substances with an understanding of the roles that economic instruments might play in achieving the "virtual elimination" of discharges of persistent toxic substances to the Great Lakes Basin Ecosystem.

The use of economic instruments to achieve the objectives of the Great Lakes Water Quality Agreement does not imply any change in these objectives. The purpose of this study is simply to explore whether the goal of virtual elimination can be achieved more quickly, more cheaply and/or with less social disruption by employing economic instruments than by only using more traditional forms of environmental regulation.

The specific objectives of this study are:

1. To define and assess the role of economic instruments as a means to the virtual elimination of emissions of persistent toxic substances to the Great Lakes environment.

2. To assess economic instruments as a means to achieve the virtual elimination of PCBs and mercury entering the Great Lakes environment.

3. To assess economic instruments as a means to achieve the virtual elimination of persistent toxic emissions to the Great Lakes by the pulp and paper industry in Canada and the United States.

1.2 Approach

The argument for the use of economic instruments in environmental policy is one that has long been made in the journals of the economic and legal professions. Recently, economic instruments--tradeable permits in particular-- have shown signs of becoming popular in the political and bureaucratic *milieux* as well.

However, actual experience with economic instruments to induce the reduction of emissions of wastes into the environment is quite limited. As a result, policy makers have a very limited empirical basis for deciding whether and how to make use of economic instruments for achieving environmental objectives.

Such instruments include:

- effluent charges (a fee per unit of emission)
- tradeable emissions (allowing sources to trade emissions)
- user charges (a fee per unit of service obtained)
- product charges (added to product price)
- administrative charges (paid for government approvals)
- tax differentiation (different tax rates for different activities)
- subsidies (grants, soft-loans and tax allowances)
- deposit-refund systems (refundable deposits charged on products)
- financial enforcement incentives (non-compliance fees and performance bonds)

Economic instruments can sometimes be a substitute for the more traditional regulatory approach. However, in practical terms, they should be seen as complementary to rather than a substitute for control through regulation. Indeed, one important criterion for assessing an economic instrument is its compatibility with the existing regulations. In particular, the application of any instrument to deal with persistent toxics in the Great Lakes will have to be grafted on to a regulatory system deals with similar problems in adjacent and/or competing regions that are not part of the Great Lakes system. Moreover, these regions may or may not contain sources which, through airborne dispersion, affect the Great Lakes.

The evaluation of economic instruments for achieving virtual elimination of persistent toxics is considered on two levels. First, a generalized framework for evaluation is offered that can be used to evaluate economic instruments for attaining environmental objectives under a very range of circumstances. This framework sets out the issues which should be taken into account in considering whether to make use of a particular economic instrument. For instance, an effluent charge may only be operable where emissions can be measured reliably; emissions trading may only work where a competitive market for the permits can be assured; a deposit-refund system may only be practical where used goods can easily be collected. The framework also gives some guidance as to what sort of information must be gathered in order to make a choice of policy instrument. This evaluation framework takes the form of a flow chart or "decision tree" (Figure 5.1).

While this "decision tree" sets out criteria and information requirements for decision making, it does not provide a formula for producing answers automatically. The criteria span a wide range of social, political, environmental and economic issues and the relative weights to be given to the various criteria cannot be decided in advance. Weighing the survival of one industry towns against environmental damage or either one against wider macroeconomic impacts requires a sensitivity to a wide range of considerations and should be undertaken by people who are well informed and responsible to those who will feel the consequences of any resulting decision.

The second part of the report is an attempt to show how the "decision tree" can be used to structure an evaluation of economic instruments. The merit of using economic instruments is considered with respect to three problems involving persistent toxics in the Great Lakes basin. In each case, a summary of the available information is given; then the information is reviewed using the decision tree to consider whether the use of an economic instrument might be appropriate.

1.3 Scope

The Virtual Elimination Task Force has been charged with the task of advising the International Joint Commission on the choice of a strategy for the virtual elimination of persistent toxic substances from the Great Lakes Basin Ecosystem. In developing such a strategy, the Task Force is faced with the problem that a very large number of toxic substances may be accumulating and doing harm within the Great Lakes basin.

This study focuses upon the applicability of economic instruments to a limited number of persistent toxics. Ultimately, it may be that any change in the regulatory regime should apply to all persistent toxics at once rather than be developed on a substance by substance basis. This larger question is not addressed here. A further consideration is that most attention is given in this study to effluent charges and emissions trading. The role that other instruments might play is also considered but in less detail.

In developing a virtual elimination strategy, the Task Force has chosen to focus on the eleven "Critical Pollutants" identified by the Water Quality Board of the International Joint Commission in 1985 (Table 1.1).

Table 1.1 IJC Critical Pollutants

Total polychlorinated biphenyls (PCBs)
DDT and metabolites
Dieldrin
Toxaphene
2,3,7,8- Tetrachlorodibenzo-p-dioxin (2,3,7,8- TCDD)
2,3,7,8- Tetrachlorodibenzofuran (2,3,7,8- TCDF)
Mirex
Mercury
Alkylated Lead
Benzo(a)pyrene
Hexachlorobenzene

Source: International Joint Commission, Great Lakes Water Quality Board (1987)

Each one of these critical pollutants is associated with some detrimental effect occurring in the Great Lakes basin. These pollutants have also been the subject of regulation, so that some lessons have already been learned about how they should or should not be regulated. The fact that none of these substances has yet been eliminated from the Great Lakes basin, in spite of the fact that much effort has gone into their control, may in itself be instructive.

For the purpose of evaluating economic instruments as a tool for the achievement of virtual elimination, the Task Force has proposed that the study focus upon two persistent toxic substances: PCBs and mercury. The Task Force has also proposed that economic instruments be assessed for their potential as means to induce the virtual elimination of persistent toxic emissions from the pulp and paper industry in the Great Lakes basin.

1.4 Plan of the Report

- Chapter 2 offers working definitions of a number of the terms used in this paper--"virtual elimination," "zero discharge" and "persistent toxic substance" -- and provides a description of each economic instrument considered.
- Chapter 3 describes the general nature of the regulatory framework currently being applied to control emissions of persistent toxic substances in the Great Lakes basin and discusses the limitations of that framework.
- Chapter 4 gives a brief overview of the use of economic instruments in a number of jurisdictions. Some conclusions are drawn from the experiences of these jurisdictions.
- Chapter 5 presents the general evaluation framework.
- Chapter 6 takes up the specific issue of the applicability of economic instruments to the virtual elimination of discharges of mercury to the Great Lakes basin.
- Chapter 7 does the same as Chapter 6, but for PCBs.
- Chapters 8 and 9 provide a description of the pulp and paper industry in the Great Lakes basin and consider the possibility of using economic instruments to virtually eliminate toxic discharges from pulp and paper mills.
- The study concludes with Chapter 10 which offers recommendations for the consideration of the Task Force and other interested parties.

2.0 DEFINITIONS

This chapter offers definitions of various terms and concepts that are used throughout the report.

2.1 Persistent Toxics

A persistent toxic substance is defined in the Great Lakes Water Quality Agreement of 1978 as "a substance which can cause death, disease, behavioural abnormalities, cancer, genetic mutations, physiological or reproductive malfunctions or physical deformities in any organism or its offspring, or which can become poisonous after concentration in the food chain or in combination with other substances" (toxic) and has a half-life in water of over eight weeks (persistent).

The persistence of many toxic substances is poorly understood. It can safely be said, though, that persistent toxics exist in large numbers. In 1987, the Great Lakes Water Quality Board identified the presence of 362 toxic chemicals in the waters of the Great Lakes basin. Of these 362, eleven were designated as "critical pollutants." These eleven are characterized by adverse effects on mammalian or aquatic species, bioaccumulation, and persistence at "unacceptable" levels. The eleven "critical pollutants" are also deemed by the Board to be representative of a wide variety of sources, pathways, uses, and chemical families. "Action taken for one could be expected to concurrently control; or apply to other substances with similar properties" (International Joint Commission, Great Lakes Water Quality Board 1987).

2.2 Zero Discharge

Annex 12 of the Great Lakes Water Quality Agreement of 1978 states the general principle that "the philosophy adopted for control of inputs of persistent toxic substances shall be zero discharge." No definition of zero discharge is contained in the Agreement and attempts to define it are under way. One perspective is that zero discharge is a means for achieving virtual elimination in that it refers to all controllable inputs of persistent toxics. Even if zero discharge is achieved for these inputs, other possible sources such as contaminated sediments and runoff remain.

2.3 Virtual Elimination

Article II of the Great Lakes Water Quality Agreement of 1978 states that it is the "policy" of Canada and the United States that "the discharge of...all persistent toxic substances be virtually eliminated." "Virtual elimination" has not been defined in the Agreement, nor has it been defined elsewhere. As a result, the term has come to mean very different things to different people.

According to the former Director of Water Resources at the Ontario Ministry of the Environment, Dr. Jim Bishop, representatives of industry generally take the view that "virtual elimination of a substance is reached when there is no environmental damage of any kind as a result of discharges of that substance" (Bishop 1991). This definition implies that any regulation will be based upon scientific evidence of impact on water quality.

Proponents of this view would also place the onus of proving any impact on water quality on the regulator; holding that until such onus is met, no further reductions in discharges should be required.

Environmental groups, on the other hand, take the view that the word "virtual" is used in the Agreement only to indicate that the total elimination of persistent toxic substances from the Great Lakes Basin Ecosystem is not being proposed. Total elimination being made impractical by the fact that some persistent toxics occur naturally in the Lakes as well as by the difficulty of removing from the Lakes the large quantities of toxic substances already released.

In this view, "virtual elimination can only be achieved by preventing any additional discharge of these (persistent toxic) substances (i.e. by implementing a zero discharge strategy)..." (National Wildlife Federation and Canadian Institute for Environmental Law and Policy, 1991).

In the absence of any agreed upon definition of "virtual elimination," it is recognised that a fairly wide range of goals for the abatement of persistent toxics may yet emerge. However, for the purposes of this study, it is assumed that, as a goal of environmental policy, virtual elimination means that concentrations of persistent toxics in all discharges to the Great Lakes should approach zero.

2.4 Economic Instruments

Following Organization for Economic Cooperation and Development (OECD 1989), economic instruments can be classified as charges, subsidies, deposit-refund systems, market creation and financial enforcement incentives.

2.4.1 Charges

Traditionally, the use of the environment for waste disposal has been "free" in the sense that no financial payment is required. This is one explanation for the excessive use of the environment as a depository for wastes of all kinds. By imposing a charge on discharges of wastes into the environment all methods for reducing the burden on the environment (e.g. process change, reduction, recycling, reuse and waste treatment) can become cheaper than waste disposal.

Further, such a charge on effluent not only provides an immediate economic incentive for reductions in the discharge of wastes into the environment, but it can also provide an added incentive for the development of new, cleaner production processes and more effective waste treatment technologies. The precise nature of the economic incentives offered depend on the type and level of charge imposed. Charges can be classified into four types, effluent charges, user charges, product charges and administrative charges:

- **Effluent Charges** are charges paid on discharges into the environment and are based on the quantity and/or quality of discharged pollutants. Effluent charges are normally expressed as $/unit of effluent discharged. The rate may vary according to the quality of the discharge as measured by the concentration of contaminants or toxicity.

- **User Charges** are payments for the costs of collective or public treatment of effluents. User charges are normally expressed as $/unit of effluent treated. The rate may vary according to the quality of the discharge as measured by the concentration of contaminants or toxicity.

- **Product Charges** are charges added to the prices of products which are polluting when manufactured or consumed or for which there is an organised disposal system. (A similar approach is to impose lower tax rates on products which are less damaging to the environment so to encourage their use.)

- **Administrative Charges** are payments for services provided by the authorities such as for registration of certain chemicals or for the certification of waste treatment facilities.

2.4.2 Subsidies

Subsidies provide financial assistance to encourage changes in behaviour, i.e. actions to reduce pollution. Subsidies can take the form of grants (non- repayable), soft loans (at reduced interest rates) and tax allowances (e.g. accelerated depreciation on pollution control equipment.) The role of subsidies in achieving virtual elimination is not considered in any detail in this study.

2.4.3 Deposit/Refund Systems

A surcharge is imposed on a product that is refunded when the product is returned to an approved centre for proper treatment, reuse and/or disposal.

2.4.4 Emissions Trading [1]

There are several ways in which markets can be created whereby "rights" to dispose of wastes into the environment can be bought and sold. In its simplest form, a limit is placed on the total quantity of wastes that can be emitted into the environment from all sources. After an initial allocation of this total quantity of wastes among sources has been made by a regulatory agency (e.g. by fiat or auction), the various sources are allowed to trade their allotted emissions. Such trades may be subject to additional restrictions to provide a further level of environmental protection. After a trade has been made, each source's permit is modified to reflect its new, allowable emission limit. Under different approaches, a reallocation of permitted quantities can take place within a plant, within a firm or among different firms or other sources.

2.4.5 Financial Enforcement Incentives

There are two major types of financial enforcement incentives:

- **Non-Compliance Fees** which are imposed when polluters do not comply with certain regulations. If these fees are proportional to the degree of non- compliance, as measured by discharges in excess of the authorized level, they become equivalent to an effluent charge imposed above some limited level of discharge.

- **Performance Bonds** are payments to authorities in expectation of compliance with regulations. The payments are refunded when compliance is achieved.

[1] Emissions trading is sometimes referred to as a system of tradeable permits, marketable permits, tradeable rights or emission rights. These terms are all synonyms.

3.0 THE REGULATION OF PERSISTENT TOXICS IN THE GREAT LAKES

The purpose of this chapter is to provide a brief description of the existing approach taken to regulating the discharge of persistent toxics into the Great Lakes with special reference to the pulp and paper sector.

3.1 Canada

Canadian water pollution regulation rests on two pillars: general prohibitions on the discharge of pollutants to any watercourse; and individualized, negotiated agreements between dischargers and regulatory authorities on exemptions from the general prohibition, which define permissible end of the pipe effluent loadings. Both Canadian federal and Ontario provincial law place general prohibitions on the discharge of harmful substances to surface waters. In Ontario, these laws are enforced primarily by the provincial government.

While large numbers of industrial and municipal dischargers continue to produce effluents which are toxic to marine life, prosecutions do not normally follow. For instance, in 1988, nearly three decades after the passage of the Federal Fisheries Act which requires that effluent be non-lethal to fish, 12 of 18 pulp and paper mills discharging to the Great Lakes basin still produced an effluent that is acutely lethal to fish.

In many cases lack of prosecution is due to the fact that the discharger has negotiated an individualized "Control Order" which defines permissible effluent loadings and often specific technologies to be used to achieve those limits. These agreements are, however, often violated without attracting prosecution. The permissible loadings defined by Control Orders often permit high discharge rates of conventional pollutants and often place no restrictions on the discharge of persistent toxic substances. Effluent quality standards can vary greatly from source to source, even within an industry. Control Orders for pulp and paper mills show particularly great variation.

It is only very recently that the province of Ontario has begun to develop a detailed and systematic list of the toxic substances which are being discharged to its surface waters. Once it has determined what is going into its surface waters, Ontario intends, under its Municipal-Industrial Strategy for Abatement (MISA), to define the Best Available Treatment Technologies Economically Achievable (BATEA) for each of nine industrial sectors and for municipal sewage treatment plants. Attainable discharge limits based on BATEA for each sector will then be used by the province to write regulations setting abatement limits on all dischargers in Ontario.

In the near future, the Canadian Federal Government intends to tighten its standards for discharges of conventional pollutants from pulp and paper mills. The Federal Government intends to require kraft mills to restrict emissions of dioxins and furans to a non-detection level by 1994. The rule would also restrict total organochlorine discharges. By 1992, Ontario will limit kraft mill organochlorine discharges to 1.5 kg per tonne of production.

3.2 United States

United States water pollution control policy is based upon the application of an administratively selected control technology to achieve plant and industry-specific effluent limits. Effluent standards are determined by industrial category and subcategory: the U.S. paper industry is divided into 33 subcategories. For each category, the U.S. Environmental Protection Agency (U.S. EPA) selects the best practical control technology available for the reduction of conventional pollutants as well as the best available technology for the abatement of priority pollutants. Effluent standards are then based on the performance that these technologies are expected to produce.

In addition, more stringent effluent limitations can be placed on point sources in order to achieve selected water quality standards. The United States has set as a national goal the attainment of swimmable and fishable waters. The attempt to achieve this goal along with the objectives of individual states comprise the basis for media-quality based restrictions on discharges.

Effluent limits set according to the lower of these two criteria become the basis for discharge permits which must be held by anyone discharging pollutants to water. These permits are normally issued by state pollution control agencies, although unless it waives the right, the U.S. EPA may review individual permits for compliance with its guidelines and requirements. Enforcement of compliance with the terms of the permits is done both by self-reporting and on-site inspections.

The U.S. EPA is currently engaged in a review of technology-based effluent limits for all pulp, paper and paperboard mills in the United States. Best Practicable Technology (BPT) and Best Conventional Pollutant Technology Control (BCT) effluent limits for the regulation of traditional pollutants are under review for all mills. Best Available Control Technology (BAT) and New Source Performance Standards (NSPS) effluent limits for priority pollutants released from mills which bleach pulp with chlorine are also under review. Pretreatment standards for chlorine bleaching mills which discharge to sewage treatment plants are being reconsidered. The U.S. EPA will decide whether to revise existing regulations as well as whether to regulate dioxins, furans and organochlorine compounds. Final new rules are not expected to be promulgated until mid-1995.

There are several other regulatory initiatives that will have an impact on toxics in the Great Lakes. Under the Great Lakes Critical Programs Act of 1990 uniform water quality standards are to be prepared for the U.S. by June 1992. Draft standards will be published in the Federal Register in June 1991. States are to adopt water quality standards at least as strict as the federal standards by June 30, 1992. The Great Lakes Critical Programs Act also sets deadlines for the completion of Remedial Action Plans in the U.S. and for the Lake Michigan Management Plan. Lake cleanup plans are to be incorporated into state water quality plans by 1993 or 3.5 years after designation.

On February 7, 1991 the U.S. EPA announced its Industrial Toxics Project. Under this project, 17 toxic chemicals have been identified on the basis of seriousness of effects, actual exposure levels, high release volume and recognised potential for reducing releases. (Mercury is included but PCBs are not.) The goal of this voluntary program is to achieve a one third reduction in total releases and transfers (to sewage treatment plants and landfills) of these 17 chemicals by 1992 and a one half reduction by 1995 against a 1988 baseline. A 90% voluntary reduction earns a six-year deferral of Clean Air Act technology-based standards.

The emissions targeted under this program are 73.3% to air, 19.7% off-site transfer, and 7.0% to "other media" and over 600 companies have been asked to participate. A total of 1,402 million pounds of chemicals are involved, including mercury releases of 320,000 pounds. The pulp and paper industry's contribution is 98 million pounds.

3.3 Problems With the Current Regulatory Framework

The most striking aspect of the current state of toxic substance control regulations is the contrast between the very large numbers of chemical substances which may cause human or environmental health effects and the very small number of toxic substances whose release is even monitored let alone regulated.

The pace at which regulations are currently developed is in some measure to blame. Many years tend to pass between the first recognition that a substance may be doing significant harm and the actual implementation of controls. Add to this the fact that virtual elimination has to this day not been achieved for a single persistent toxic substance being discharged to the Great Lakes, and a troubling picture of the state of current regulation emerges.

At some point, the methods of regulation currently used in Canada and the United States will have to be adapted to the dramatic growth in the number of chemicals and the number of sources of chemicals that need to be regulated.

Most new regulatory proposals, such as Ontario's Clean Air Program and MISA Program and the U.S. Clean Air Act continue to rely primarily upon the detailed prescription of pollution control technologies or plant-specific emission standards based upon a standard believed by government officials to be achievable with the use of a specific control technology.

These new proposals continue to perpetuate the use of a method of regulation known as "direct regulation" or "command and control." Direct regulation effectively requires governments to take part in decisions about the more detailed aspects of plant design and redesign, production technology, product design and waste treatment technology at every regulated facility. In practice, regulators end up engaged in months or years of negotiation over the development of complex process changes and plant specific rules. Then they are required to defend their decisions at administrative appeals and in court actions.

As virtually every major industrial process involves the release of some toxic substances, the task of the regulator -- if the task is taken seriously -- is overwhelming. Governments have not had, nor are they likely ever to have, the resources to involve themselves in so much detailed decision-making across such a wide range of production processes. The cost to regulated industries of having to win specific governmental certification of their choices of production processes and technologies is also potentially very high.

The use of economic instruments has been proposed as a way to induce environmental improvement without having regulators become bogged down in the finer details of individual firms' decision-making processes. This report now turns to review the ways in which such economic instruments might be put to use.

4.0 ECONOMIC INSTRUMENTS IN PRACTICE

4.1 Overview

Economic instruments are now widely used in environmental regulation. In a survey of 14 countries in the Organization for Economic Cooperation and Development, done in 1986 and 1987, the use of 153 different instruments was identified (OECD 1989). Charges, emissions trading, and other economic instruments are currently being considered for application to a wide variety of environmental problems. Appendix A provides a summary of the OECD 1989 survey in tabular form.

The application of most of these instruments to the problem of achieving "virtual elimination" of a toxic substance is, however, quite limited. Most of the instruments identified are used largely for financial reasons -- to raise money to pay for administration of programs or to pay for cleanups. These money-raising instruments have a limited incentive effect.

Of those measures which are explicitly designed to have an incentive effect, most have been applied to shift consumption activities in gradual ways. For instance tax differentiation has been imposed between leaded and unleaded fuel or between more and less energy-efficient vehicles; and product charges and refundable deposits have been applied to containers, car hulks and batteries.

While effluent charges have been applied to direct discharges of effluents from major industrial and municipal sources, in every instance but two (i.e. for water pollution control in the former West Germany and the Netherlands) these charges have been too low to have any significant effect on discharges. Even in the West German case, where these incentives have been the most successful, charges are levied at only about one quarter of average abatement costs.

The one form of economic instrument which has been applied to a pollutant for the specific purpose of reducing discharges to a negligible level is emissions trading. In the United States, emissions trading has been used to bring about a rapid decrease in the level of lead in automotive fuel and it is currently being used to reduce emissions of ozone depleting substances.

The use of economic instruments to cover administrative program costs, to reduce the use of materials whose production creates pollution and to reduce the disposal of potentially harmful products such as mercury-containing batteries may prove of no small assistance in achieving the "virtual elimination" of persistent toxic discharges to the Great Lakes basin. But the dramatic reductions in discharges which are necessary to achieve "virtual elimination" can only be brought about by the systematic application of either direct regulation or economic instruments, or a combination of the two, to all of the major sources of a given persistent toxic.

This chapter takes a closer look at five applications of economic instruments from which lessons can be learned regarding the potential effectiveness of these instruments for achieving "virtual elimination." While effluent charges have not been demonstrated to be able to produce the necessary reductions in and of themselves--if only because no government has yet been prepared to institute an effluent charge high enough to induce such a result -- the German water pollution effluent charges do provide an example of an instance where charges have at least helped to encourage a significant degree of pollution reduction. In addition to effluent charges on discharges to water in West Germany, three applications of emissions trading are reviewed: to reduce lead in gasoline, to reduce the release of ozone depleting substances, and to control BOD (biological oxygen demand) discharges into the Fox River, Wisconsin. A brief outline of the emissions trading provisions of the U.S. Clean Air Act is also included.

4.2 Effluent Charges in West Germany

The West German effluent change scheme was announced in 1976 and implemented in 1981. It applies on a nationwide level to any effluent source, although it is applied by provincial ("Laender") authorities.

Originally the scheme applied to five pollutants and pollutant groups: oxygen depleting substances, high-organic-content solids, low-organic content solids, mercury and cadmium; as well as to discharges toxic to fish. In 1989, AOX (adsorbable organic halide), chromium, nickel, lead and copper were also included.

Every discharger of a regulated pollutant is required to have a permit. Fees are assessed per "damage unit" (19.20 European Currency Units (ECU) or 40 deutsch mark (DM) or $16.70 U.S.) and damage units are calculated for each regulated category. However, the actual fee paid also varies according to whether the discharger meets a federally set minimum standard for its type of facility.

TABLE 4.1 Effluent Charges for Water Pollution in West Germany, 1989

Discharge Level	Fee Paid
Over standard	1.0 x Expected discharge*
75-100% of standard	0.5 x Standard
50-75% of standard	0.5 x Actual discharge
Under 50% of standard	No fee
Use "state of the art technology"	0.2 x Expected discharge*

*If "expected discharge" is exceeded, a corrective payment is required. Source: O.E.C.D. (1989)

West German water quality is believed to have improved significantly since 1976. By 1981, after a long introduction period, 10% of dischargers met federal minimum standards. By 1987, roughly 50% of dischargers were meeting those standards.

While the treatment cost of German dischargers averages about four times higher than applicable charges, suggesting that direct regulation is the moving force behind the improvements, the charges do exceed many firms' marginal abatement costs. A number of large dischargers are known to have exceeded minimum requirements to achieve reduce payable fees and one third of all affected municipalities claim that the charge was their main reason for intensifying wastewater treatment. In 1986, the charge system produced ECU 135 million (U.S.$ 111 million), about half of which was spent on administration of the program.

According to the Economic Council for Europe (ECE) Council of Experts, the German system results in a saving of one third in comparison with a system of uniform abatement.

4.3 Emissions Trading in the United States

In the mid-1970s the U.S. EPA introduced an emissions trading program designed to minimize the cost of attaining air pollution standards under the Clean Air Act. Seven types of non-hazardous contaminants are now regulated under this Act: particulates, sulphur dioxide, carbon monoxide, nitrogen oxides, ozone, lead and volatile organic compounds. The Act allows for four kinds of trades:

- **Netting:**
  An internal trade where plants making modifications or additions can avoid various technological and administrative requirements by reducing emissions 'rom other points within the same plant. By 1989, 5,000 to 12,000 netting transactions had taken place bringing savings estimated at more than U.S.$1 billion.

- **Offset Trading:**
  New sources entering a "non-attainment area" must arrange for an even greater reduction from existing sources in the same area. By 1986 at least 2,000 offset transactions had occurred (only 10% external), bringing savings of at least U.S.$25 million.

- **Bubbles:**
  An imaginary bubble is placed over multiple emission points in one or many plants or firms in an air quality district. The total emissions for the bubble is fixed and the controls at each source can be adjusted to meet the total emissions in the most cost-effective way. In practice, most bubbles are applied to individual plants and sometimes two. 89 State bubbles had been approved by 1986, with savings estimated at U.S.$435 million.

- **Banking:**
  An existing firm earning emission reduction credits can save them for later use or sale. By 1986 only five state banking systems had been approved by the U.S. EPA.

One Canadian commentator (Environment Canada 1990) has observed that trading works best if:

- trading is introduced at the start of a program;
- the rules are stable, clear and comprehensively specified;
- firms are allowed to freely use internal or external trading to meet all emission requirements;
- the approval process is kept as simple as possible;
- at the introduction of the program the baseline emissions for a source do not exceed actual emissions;

- baseline emissions are defined in terms of quantities not rates;
- actual emissions are calculated in a manner not subject to interpretation;
- a market is established whereby buyers and sellers or permits can easily identify each other;
- a banking program is established and banking regulations are designed that encourage external trading;
- the banking is secure - there is no danger that the credits will be devalued.

4.4 United States: Lead in Gasoline

Perhaps the most clear cut example of an economic instrument being successfully used to reduce emissions to a desired level is that of the U.S. program to reduce gasoline lead content.

Before 1982, United States gasoline lead limits were enforced on a refinery by refinery basis: each refinery's gasoline output had to meet an individualized average lead content standard. In 1982, the U.S. EPA promulgated a rule which permitted refiners to produce gasoline with a lead content higher than their original limit, if they could buy the right to do so from another refiner who would produce gasoline with a lower lead content.

In early 1985, a new U.S. EPA rule required that, between early 1985 and January 1986, gasoline lead content be reduced from 1.1 to 0.1 grams per gallon, with a midpoint of 0.5 grams per gallon to be achieved in mid-1985. The rule permitted refineries which reduced lead content ahead of schedule to save any excess rights for use or sale during 1986 and 1987.

During 1985, refiners actually banked 10.6 billion grams of lead rights. Between 10 and 20% of all available rights were traded during each quarter of 1985. (Hahn and Hester, 1989) It has been estimated that these lead trades resulted in a saving of over 20% of the cost of meeting the rule (U.S.$ 226 million)(NERA 1990).

What is most interesting about this example is that it is an instance in which trades did actually occur at about the expected rate (U.S. EPA had estimated trades of about 8 million grams), (U.S. EPA 1985.) Banking and trading were considered to be desirable, in this case, because some smaller refineries would have had a much harder time than most in meeting the U.S. EPA schedule for reductions. It was felt that U.S. EPA was faced with a choice of: 1) delaying the implementation of the rule so that all refiners could meet the standard; 2) bring the standard into effect according to the same schedule and accept that some refiners would pay much higher costs and possibly go out of business (although U.S. EPA was of the view that no refiner would be put out of business by having to meet the standard by January 1986) (U.S. EPA 1985); 3) allow trading. (There is no indication that a variable timetable for meeting a direct regulation standard was considered).

In comparison with lead, the levels of banking and trading of emissions under the old U.S. Clean Air Act (superseded in 1990) have been far more modest (Hahn and Hester, 1989). It is interesting, therefore, to consider the reasons why they were so effective in this particular case.

For one thing, trading was virtually unconstrained and administrative requirements were minimal. This compares with the very substantial restrictions and long administrative delays for Clean Air Act trades (Dudek and Palmisano, 1988). This is not necessarily to suggest that these restrictions are unreasonable. They may well be necessary to ensure that the emissions banked represent emissions actually reduced rather than "paper credits" or for keeping emissions below a standard which would normally be required by variability in performance of a pollution control system.

Also of importance is the fact that the right being traded could only be used for a limited time and the market for the ultimate product, leaded gasoline, was rapidly diminishing. As a consequence, sale of a right did not in any way surrender the right of a seller to expand future production of the product for which the market was growing, i.e. unleaded gasoline. This situation can be contrasted with trades under the Clean Air Act where sellers might be risking restricting their future ability to expand. (However, each market is different. For example, there are other, more significant barriers to competition in North American electricity markets so that trades in rights to emit SO_2 and NOx are unlikely to be restricted merely to protect future opportunities to expand production.)

4.5 United States: Potential Ozone Depleters

Emission trading by producers and importers of chlorofluorocarbons (CFCs) was implemented by the United States in the spring of 1988. Permits were allocated on the basis of historical data on production and imports. Permits were given away, apparently because the U.S. EPA did not believe that it had the authority to auction them.

Permits required vary with the ozone depleting potential of the substance involved. Each permit is good for one year and the number of permits available will decline on a regular basis over time.

The gradual restriction of the availability of CFCs is likely to result in an increase in the value of the CFC permits. It is interesting to note that the United States has sought to recapture some of this windfall by placing a tax on the permits. In theory, as long as the tax is less than the market price of the permits, CFC prices and use levels will not be affected and the tax will effectively transfer some or all of the windfall to the government.

4.6 Wisconsin: Fox River Biological Oxygen Demand

Early in 1981, the Wisconsin Department of Natural Resources instituted regulations allowing the transfer of BOD (biological oxygen demand) discharge permits among ten pulp and paper mills and four municipalities located along a 22 mile stretch of the Fox River.

In many respects, the choice of a permit trading approach seemed perfectly suited to the chosen setting. Marginal abatement costs varied widely between dischargers; each discharger also had a number of options for producing incremental reductions in BOD discharge. On the basis of studies which concluded that biological oxygen demand (BOD) control costs could be lowered by 40% (producing a predicted annual saving of $6.7 million per year), permits were issued to ten pulp and paper mills and to four municipalities.

The results of this experiment have, however, proved disappointing. One trade was made in 1981. Since then there have been no further trades. The unwillingness of dischargers to trade has been attributed both to the design and administration of the trading structure (permits expire after five years, discharge rights may be sold only upon demonstration that no additional abatement technology can be installed by the seller, administrative approval of trades is slow) (Hahn and Hester, 1989) and to the unwillingness of business competitors to give up permits which may be necessary to future expansion (OECD 1989).

5.0 AN EVALUATION FRAMEWORK

5.1 Outlining the Approach

The literature on economic instruments commonly uses several standard criteria to evaluate the instruments and systems of direct regulation which they are intended to complement or replace. These criteria include: their capacity to meet environmental objectives, the level and distribution of compliance costs, administrative practicality and compatibility with the existing institutional framework.

It is usually difficult to reach conclusive results as to the instrument(s) of choice from an evaluation in terms of these criteria. Much depends on the specific environmental problems to be addressed and the circumstances within which the instruments are expected to operate. A feature of the present study is that it is focused on a specific set of contaminants in a well- identified region for which the environmental objectives are reasonably clear: virtual elimination of persistent toxics.

A second and related consideration is that the study is intended to assist in deciding whether and in what way economic instruments can help in achieving virtual elimination of selected contaminants. Rather than simply list the strengths and weaknesses of each candidate instrument, an approach has been developed which shows how the evaluation criteria bear on the choice of which instrument to use. The next section describes a "decision tree" which systematically evaluates the options through a series of linked questions. Depending on the yes or no answers to the questions, the selection of direct regulation or any one of a number of economic instruments is indicated.

To be clear, it is not the purpose of the decision tree to show how the selection of a regulatory option, i.e. types of direct regulation of one of several economic instruments ought to be made. Neither is it the purpose to show how decisions actually are made. Rather, the decision tree is simply a way to organise the issues and criteria into a framework that is helpful for comparing the alternative regulatory options. Obviously, the actual selection of an economic instrument cannot be reduced to a relatively simple set of questions to which yes or no answers can be given. However, the advantage of the decision tree approach is that it shows how the various considerations can be prioritized and, depending on the circumstances, helps determine the suitability of a particular instrument or approach. Also, the decision tree is general enough to be of use in evaluating the role that economic instruments might play in achieving environmental objectives under a very wide range of circumstances only some of which are relevant to the specific toxics considered in this study.

In the next section an explanation is given of how the decision tree operates. The discussion proceeds along each branch of the tree in turn. In later chapters, the main considerations that emerge from the decision tree are used to evaluate the application of the economic instruments to the virtual elimination of mercury, PCBs and persistent toxics from the pulp and paper industry.

5.2 The Decision Tree

Figure 1 shows the decision tree. It consists of 13 pairs of questions (Q1 to Q13) and sets of criteria (C1 to C13) upon which answers to the questions depend. The decision tree is intended to be applied on a contaminant-by- contaminant basis. This section of the report should be read with frequent reference to Figure 1.

❐ **Question 1: Is Virtual Elimination the Objective?**

The first question to decide is whether virtual elimination is the appropriate regulatory objective for a particular contaminant.

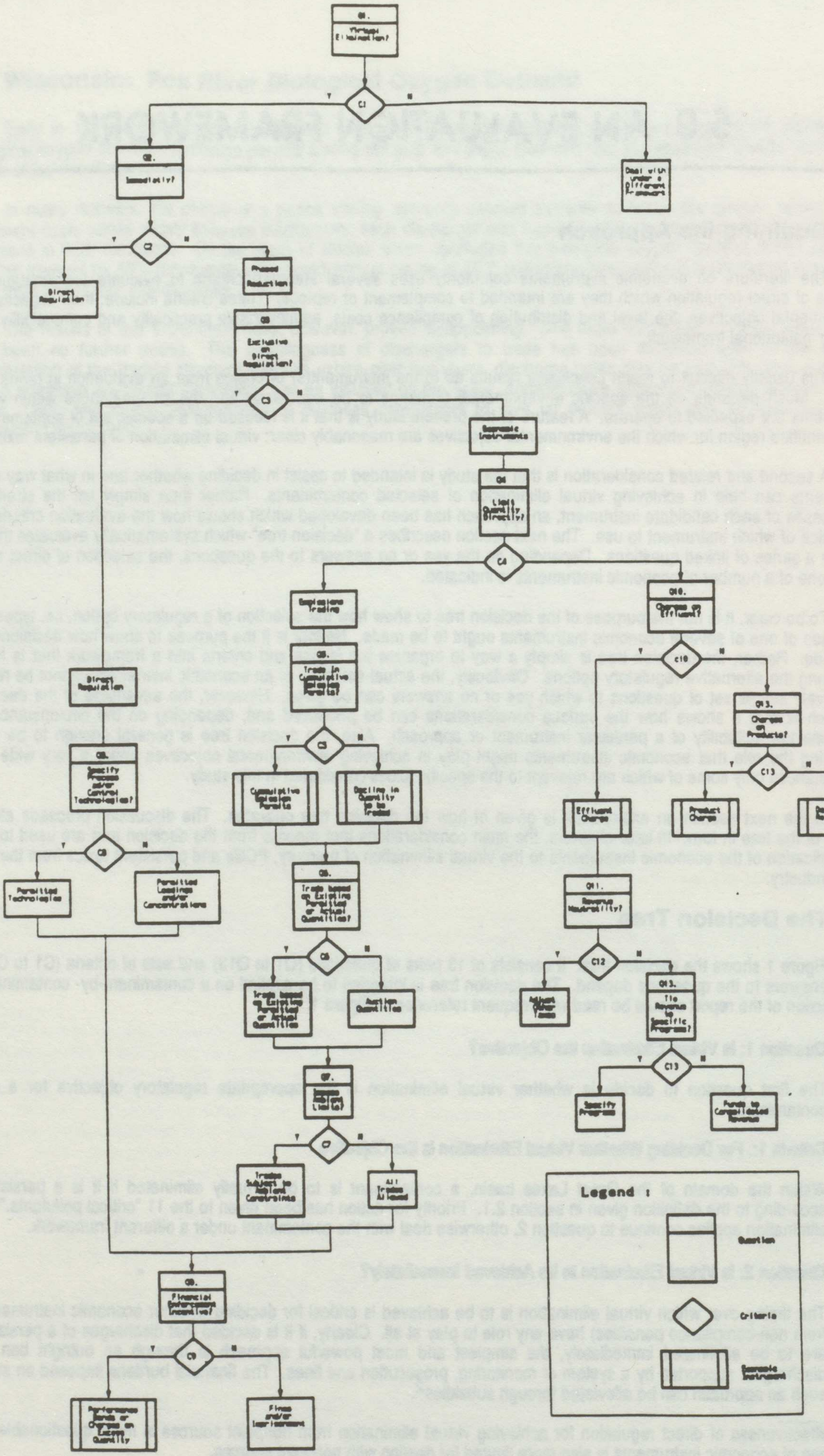
Criteria 1: For Deciding Whether Virtual Elimination is the Objective

Within the domain of the Great Lakes basin, a contaminant is to be virtually eliminated if it is a persistent toxic according to the definition given in section 2.1. Priority for action has been given to the 11 "critical pollutants." If virtual elimination applies continue to question 2, otherwise deal with the contaminant under a different framework.

❐ **Question 2: Is Virtual Elimination to be Achieved Immediately?**

The timing over which virtual elimination is to be achieved is critical for deciding whether economic instruments (apart from non-compliance penalties) have any role to play at all. Clearly, if it is decided that discharges of a persistent toxic are to be eliminated immediately, the simplest and most powerful approach is through an outright ban on such discharges, supported by a system of monitoring, prosecution and fines. The financial burdens imposed on sources by such an approach can be alleviated through subsidies[2].

[2]The effectiveness of direct regulation for achieving virtual elimination from nonpoint sources is more questionable but then the scope of economic instruments is also more limited for dealing with nonpoint sources.



Q1.
Virtual Elimination?
C1
Y
N
Q2.
Immediately?
Deal with under a Different Framework
C2
Direct Regulation
Phased Reduction
Exclusive on Direct Regulation?
C3
Economic Instruments
Q4
Limit Quantity Directly?
C4
Emissions Trading
Q10.
Charges on Effluent?
C10
Q5.
Trade in Cumulative Emission Permits?
Direct Regulation
Q13.
Charges on Products?
C5
Cumulative Emission Permits
Decline in Quantity to be Traded
C13
Effluent Charge
Product Charge
Deposit Refund
C8
Permitted Technologies
Permitted Loadings and/or Concentrations
Q11.
Revenue Neutrality?
C12
Auction Quantities
Adjust Other Taxes
Q13.
Tie Revenue to Specific Programs?
C13
Specify Programs
Funds to Consolidated Revenue
C7
All Trades Allowed
Legend
Question
Criteria
Economic Instrument
Q9.
Financial Enforcement Incentive?
C9
Performance Bonds or Charges on Excess Quantity
Fines and/or Imprisonment

There is one circumstance in which a tax (effluent charge or tradeable emissions) is self-evidently inferior to a standard (direct regulation). This is where the pollutant is so damaging that an outright ban on its use is called for...Alternatively, there is such uncertainty that we decide it is too risky to use the pollutant. This situation fits a number of ecotoxins and food additives.

(Pearce and Turner, 1990: 107)

❒ **Criteria 2: For Deciding Whether Virtual Elimination is to be Achieved Immediately**

The pace at which virtual elimination is to be achieved will be determined largely by the health and environmental risks which continued discharge of a contaminant into the Great Lakes environment is expected to bring. Additional considerations include the magnitude and impact of compliance costs and the opportunity for learning from experience as virtual elimination is approached. At present, although the use of some substances has been banned in Canada and the U.S (e.g. Mirex) no contaminants that are in industrial products have been completely banned from entering the Great Lakes. By implication, there is no regulatory requirement in Canada or the United States for prohibition of the discharge of any persistent toxic into the Great Lakes environment.

In Figure 1, the outcome "direct regulation" (with no role for economic instruments) follows from a "yes" to question 2. A "no" response calls for a phased reduction in discharges and the means for achieving this reduction is pursued in question 3.

❒ **Question 3: Should Exclusive Reliance be Placed on Direct Regulation?**

The review in Chapter 3 of economic instruments in practice showed that the use of economic instruments for achieving environmental objectives, as distinct from raising revenue, has been limited. Regulatory agencies throughout the world have traditionally relied on direct regulation, usually with economic instruments in a supporting role or in no role whatsoever. A crucial question that must be addressed therefore, is whether to rely on direct regulation for achieving virtual elimination of persistent toxics?

Criteria 3: For Deciding Whether Exclusive Reliance Should be Placed on Direct Regulation

The usual preference for direct regulation over economic instruments is based on a number of factors, some of which are very relevant to an evaluation of economic instruments as a means for achieving virtual elimination of persistent toxics. These factors provide criteria for helping decide whether reliance on direct regulation alone is the best way to achieve virtual elimination.

<u>Familiarity</u>
All parties to regulation: politicians, civil servants, industry, environmental interest groups and the general public are familiar with a regulatory approach that sets standards and enforces them through approvals, prosecutions and fines. If a certain type of behaviour is unwanted, most people think in terms of information/education programs to secure voluntary compliance and legislated limits to oblige those responsible to change their ways. Apart from deposit/refund systems for returnable bottles, people have a very limited experience with economic instruments as tools of public policy and probably think that the term refers only to these deposit/refund systems and to subsidies.

Despite the fact that in Canada and the United States people are exposed to the decision making power of the market, the idea of using economic instruments, such as an effluent charge or emissions trading, is alien to most people and lacks immediate and obvious appeal. Moreover, by taking away some of the decision making authority of those administrators currently responsible for giving approvals under existing systems of direct regulation, economic instruments may be seen as a threat to the very people without whose support they are unlikely to be implemented.

For all these reasons, familiarity with direct regulation is seen as a reason for continuing to rely on it for achieving environmental objectives. Against this, however, is the record of direct regulation which has seldom met the objectives set for it, and the growing interest in various quarters in economic instruments as a way of promoting the achievement of environmental and economic objectives.

<u>Symbolism</u>
Not only are people familiar with direct regulation but they think that it conveys the right message: something as threatening to the environment and health as the discharge of persistent toxics should be declared for what it is, i.e. dangerously anti-social and anti-environmental, and should be declared illegal and punishable in the courts. In other words, whether or not direct regulation works effectively, it carries the message people want to hear. Offering polluters the opportunity to buy their way out of reducing their discharges is anathema to such people and they are not prepared to entertain the possibility that the environment might be better served through economic instruments. The oft heard but inappropriate use of the term "license to pollute" as a description of an effluent charge testifies to this problem. After all,

a "Certificate of Approval or a Discharge Permit" really is a license to pollute. Economic instruments merit a different label. Nonetheless, the symbolic role played by direct regulation should not be under estimated and any use of economic instruments to achieve virtual elimination will likely have to be accompanied by direct regulation to cover abnormal occurrences such as leaks and spills, but also to give the right message.

Monitoring Requirements
It is sometimes believed that the monitoring requirements for economic instruments exceed that for direct regulation. This is a moot point. In the case of the virtual elimination of persistent toxics it is likely that both direct regulation and most types of economic instruments require that discharges be monitored. In general, if a monitoring system is sufficient to support a successful prosecution then it should also be sufficient for an effluent charge or emissions trading. However, there are several possible exceptions to this position which could favour reliance on direct regulation:

- One or a few cases of non-compliance with a regulation can be sufficient to support a prosecution whereas an effluent charge requires that discharges over a period of time be estimated and for this a statistically valid sampling procedure should be used;

- If emissions are traded, the regulatory authority has to monitor the trades as well as the individual discharges;

- A regulation can require the installation of certain types of equipment for reducing discharges. The presence or absence (but less so the operation of) this equipment can more easily be monitored than the discharges themselves.

With non-point sources of persistent toxics, monitoring of discharges can be impossible or very costly. The use of chemicals such as mercury or PCBs can be limited through direct regulation or charges on the use of the chemical rather than, or as well as, on its disposal. Except in the case of complete and immediate prohibition (where direct regulation again has the advantage) the monitoring requirements for each approach are similar.

Administrative Requirements
The administrative requirements for direct regulation are well known. Administration of economic instruments is less well understood though much can be learned from the more limited experiences of the various jurisdictions that have made use of them. Some proponents of economic instruments believe that they are administratively simpler than direct regulation, especially if attempts are made in direct regulation to achieve a cost-effective outcome. The amount and type of information on abatement costs required by the regulatory agency that wishes to minimize total compliance costs, if available at all, can only be obtained and analyzed at considerable cost. (This point is explored further under the heading of cost minimization.)

Flexibility
Depending on the mode of direct regulation, it can be an extremely flexible approach that takes account of each individual source's circumstances as well as such factors as the condition of the receiving water body and local climatological conditions. The system of direct regulation in Ontario has given ample opportunities for firms and municipalities to negotiate their compliance programs with the Ministry of the Environment. This is a strength and a weakness of the system. It is a strength because it allows the Ministry to be sensitive to the ability of a firm or municipality to pay for the required level of control with due consideration being given to the impact of the sources' emissions on the environment. It is a weakness because it lends itself to manipulation resulting in unacceptable delays in the achievement of the Ministry's environmental protection objectives.

Recent initiatives in Ontario such as the Municipal Industrial Strategy for Abatement (MISA) program and proposed revisions to Regulation 308 under the Ontario Environmental Protection Act have been designed to emphasize prevention rather than abatement and to increase the likelihood of compliance by restricting opportunities for individual circumstances to be allowed for. This change in approach has required some forfeiture of the flexibility that was characteristic of the older system of regulation.

Proponents of economic instruments stress that one of the advantages of these instruments is that they introduce a degree of flexibility that is beyond the scope of any system of direct regulation. For example, emissions trading systems limit total loadings but sources are able to determine their own share of this total by buying and selling the right to discharge contaminants into the environment. Further, new firms entering an area must obtain an appropriate quantity of tradeable emissions by purchasing them from those who hold them. This ensures that total loadings do not increase without the regulatory agency having to intervene. (Contrast this with direct regulation where a new entrant will add to total loadings even if LAER (lowest achievable emission rate) standards are met unless the regulatory agency specifically reduces the allowable discharges at one or more existing sources to offset these additional loadings.)

Effluent charges bring a different type of flexibility. Sources can select their own level of discharge but must pay accordingly. Some critics of effluent charges believe that this offers too much flexibility but this is less of a problem if the regulatory agency retains the option of raising the effluent charge to secure whatever level of total discharges is required.

Certainty of Results

One consideration which has traditionally favoured the use of direct regulation is the belief that such regulations bring a degree of certainty that economic instruments lack. However, for a number of reasons expectations that required limits set by regulation will be met have often been frustrated in practice. These include: a lack resources devoted to monitoring and enforcement, a reluctance to prosecute, unfavourable decisions in the courts, low penalties, and a concern about the socio-economic consequences of high compliance costs. Nevertheless, the perception that direct limits set by regulation bring assured results remains and should be considered when a decision about direct regulation is being made.

It is not only the public that wants to see direct regulation. Such regulations can reduce the uncertainties facing dischargers who like to know what is being required of them. At the same time, this desire to know "the rules of the game" can also make it difficult for the politicians and administrators to change the rules even when new evidence suggests that such changes are justified.

Cost Minimization

Perhaps the strongest argument against relying too much on direct regulation is that it is not cost effective. The argument that economic instruments are cost effective is directly related to the flexibility of these instruments that was described above. Under a conventional permitting system it can easily happen that two sources of the same contaminant face different marginal (i.e. incremental) costs of reducing discharges. By allowing the source for which costs are higher to increase its level of discharge and requiring the other, lower cost source to reduce its level of discharge from both sources, the same combined level of discharge can be maintained but at a reduced total cost.

To achieve an economically efficient allocation of discharges through direct regulation requires that the administration has detailed knowledge of control costs at each source. However, if the sources are allowed to trade permits, the sources themselves, who only have to know their own costs of control, will determine whether permit trading is to their mutual advantage. If it is, the savings in total costs will be realized without intervention by the administration.

A similar argument can be made in favour of effluent charges. Faced with an effluent charge per unit of emission, sources can be expected to reduce their emissions as long as it is cheaper to do so than to simply pay the effluent charge. Providing different sources face the same effluent charge, they will all tend to reduce their emissions to the point that the incremental costs of doing so are equal to the effluent charge and therefore equal to each other. This result will minimize the total costs of reducing the combined emissions from all sources that are subject to the effluent charge since no reduction in the total cost of emission reduction could be achieved by transferring emissions from one source to another.

The degree to which economic instruments will, in practice, reduce the costs of meeting an environmental objective depends upon many factors not least of which is the variation in incremental reduction costs among the various sources subject to control. The greater is the variation in these costs, the greater will be the potential savings from tradeable permits and effluent charges. In the event that these costs are very similar, there will be little or no advantage in using an economic instrument to meet an environmental objective.

Technological Progress

Although efforts have been made to make direct regulation "technology forcing" by requiring increasingly high levels of performance, there remains a concern that, for the most part, direct regulation actually discourages the development of new technologies. One argument is that, for contaminants of greatest concern, regulatory agencies require sources to meet standards at least equal to the best treatment technology available. Therefore, the development of a new, expensive technology by a firm may actually penalize the firm if it is obliged to install it. Since the cost of new technologies cannot be predicted in advance of their development, firms have little incentive to invest resources into developing technologies which may turn out to be costly to implement.

A corollary to this argument is that firms other than the sources themselves may respond well to direct regulation which insists on the use of the best available technology since it assures them of a market for new technologies if regulatory agencies can be convinced of their efficacy.

Economic instruments seem to have a considerable advantage over direct regulation in stimulating the development and adoption of new technologies. Sources with tradeable emissions or those paying an effluent charge can make or save money by reducing discharges. Knowing this, they have an ongoing incentive to find ways and means of reducing their discharges and one such means is the development of new technologies. Similarly, firms in the business of developing new technologies can expect to find a ready market for products or processes which reduce emissions.

Incentives for Virtual Elimination

This discussion of criteria for deciding whether exclusive reliance should be placed on direct regulation for achieving virtual elimination began with several reasons why direct regulation may be favoured over economic instruments. The discussion then considered arguments that suggest that economic instruments may have advantages over exclusive reliance on direct regulation: cost minimization and a stimulus for technological development being the most important. There is one more reason for including economic instruments in a program to achieve virtual elimination of persistent toxics: that is they may allow virtual elimination to be achieved more rapidly. There are two reasons why this is so.

Firstly, under direct regulation where firms in very different financial situations may be required to incur similar, high compliance costs, there may be a concern that some plants will be forced to close if virtual elimination is achieved too rapidly and so the reduction schedule is set according to what the highest cost abater can afford. When emissions trading is allowed such sources can buy cheaper abatement at other, lower cost sources thereby reducing the financial obstacle to a more rapid approach to virtual elimination.

Secondly, the traditional reliance on permits, monitoring, inspections, prosecutions, convictions and court imposed penalties, with each stage subject to considerable uncertainties and possible delays, has generally failed to bring compliance with environmental objectives at the rate expected. An effluent charge of sufficient magnitude or an emissions trading system based on a declining total loading could greatly increase the incentives for compliance. One reason is that under direct regulation there is little or no incentive to control discharges beyond the permitted level if to do so adds to costs. With emissions trading or effluent charges there is always a financial gain to be made from further reductions.

As stated earlier, the choice is not necessarily between direct regulation and economic instruments, only between an exclusive reliance on direct regulation and other approaches. As subsequent stages in the decision tree will show, financial enforcement incentives can be grafted on to a system of direct regulation which underlines the fact that, in reality, the choice will be between exclusive reliance on direct regulation and some mix of direct regulation and economic incentives. (Allowing emissions to be traded does very little per se for ensuring compliance and even with an effluent charge direct sufficiently high to offer a real incentive for reduction, direct regulation will still be required to deal with unusual events such as leaks and spills.)

At this point, the decision tree branches either to direct regulation as the only tool for achieving virtual elimination or to economic instruments to play a major role in achieving virtual elimination. Even if it is decided that direct regulation should be relied upon as the primary component in a regulatory program, the decision tree subsequently considers the role that financial enforcement incentives could play. On the other hand, if the arguments in favour of some form of economic incentive for achieving virtual elimination seem compelling when applied to a specific case, then the selection of economic instruments at this branch in the tree should not be seen as irrevocable. If further analysis of the economic options reveals that, while promising, they are unsuitable for any of a number of reasons which will soon come to light, then reversion is still possible.

To continue, therefore, with the analysis, it is assumed that a negative answer is given to question 3: i.e. there will not be exclusive reliance on direct regulation. (Question 12 pursues the direct regulation option assuming that a positive answer is given to question 3.)

❐ Question 4: Should the Total Quantity of Emissions be Limited Directly?

The main difference between emissions trading and an effluent charge is whether the regulatory agency sets the total quantity or unit price of emissions. Under an emissions trading system, the regulatory agency establishes a limit on total allowable emissions and the market in tradeable emissions sets their price (and therefore the price of discharging an additional unit). Under an effluent charge, the regulatory agency sets the price of discharging an additional unit of emission and the sources themselves decide on their discharges.

In principle the two schemes are symmetrical and can be used to achieve the same results although the distributional implications may be very different depending on what mechanism is used for the initial allocation of the tradeable emissions and what is done with any funds received by the government.

When a decision has been taken to achieve virtual elimination over a period of time it is to be expected that a timetable for achieving virtual elimination will be established. Such a timetable may be restricted to an endpoint by which time virtual elimination is to be achieved. It may also include milestones, expressed in terms of reducing the quantity and/or concentration of discharges, so that progress towards the ultimate goal can be monitored. However, even this approach does not require that the discharges be limited directly. This is a matter about which a decision must be made.

Criterion 4: For Deciding Whether the Total Emissions Should be Limited Directly

The most important criteria for deciding whether waste emissions should be limited directly (i.e. at interim, declining non-zero levels on the way to virtual elimination) relate to what is known about a) the emission reduction cost functions[3] in material and energy inputs in production, different technologies, differences in the age and condition of equipment, differences in plant size and differences in operating efficiency and the damage function[4].

[3] The emission reduction cost function (which is somewhat broader in scope than a control or abatement cost function) is a quantified relationship between reductions in emissions and costs. The function will be different for each reflecting differences in material and energy inputs in production, different technologies, differences in the age and condition of equipment, differences in plant size and differences in operating efficiency.

[4] A damage function is a quantified relationship between a cause and a consequence. The cause might be the level of discharge of ambient concentration and the consequence might be the increased incidence of mortality or morbidity in any living species.

If the emission reduction cost functions are relatively steep, small variations in the allowable total (i.e. from all sources) emissions can have a dramatic effect on the costs of compliance which will be reflected in the prices of tradeable permits. An effluent charge has the advantage in this case by avoiding unduly high emission reduction costs without sacrificing much in terms of the resulting level of total emissions.

However, if the damage function displays the existence of critical thresholds above the level of virtual elimination, a strong case can be made for limiting emissions below these thresholds in the approach towards virtual elimination. For example, once the concentration of a persistent toxic is reduced below one such threshold, some uses of the water may be considered safe. In this case, considerable benefits could be obtained prior to virtual elimination providing the total level of emissions is reduced below this critical level. Responses to an effluent charge can only be estimated and may prove to be insufficient to meet the interim threshold. There may be delays before this is known and it may be administratively difficult, if not impossible, to raise the effluent charge quickly to secure the desired result.

In contrast, an emissions trading system can be geared directly to the achievement of interim thresholds and can give somewhat greater assurance that they will be met. It only requires that the total permitted level of emission be reduced from one threshold level to the next until virtual elimination is achieved. (In most cases such thresholds, if they exist at all, are more likely to exist in a relationship between ambient concentration and effect rather than quantity or quality of emissions and effect. This detracts somewhat from this advantage of emissions trading over effluent charges.) Furthermore, the market price of the tradeable emissions will reveal useful information on the costs of compliance as the objective is achieved.

The absence of evidence of thresholds and/or indications of steeply rising discharge reduction cost functions will indicate that an effluent charge may be more suitable than emissions trading for achieving virtual elimination. Another consideration that may favour effluent charges is the absence of a large enough number of sources to ensure competition in the emissions trading market. From an economic standpoint, the benefits of trade are more likely to be achieved the more competitive is the market. This general principle from economic theory applies to trades in emissions as much as to trade in any other good or service. Therefore, consideration should be given to the likely number and relative strength of the likely participants in an emissions trading market. Possibilities for using the ownership of tradeable emissions to restrict new entrants and limit competition should a matter of concern. Even if a persistent toxic emanates from a large number of diverse sources, not all of these sources will necessarily be able to participate in a permits market. It may be especially difficult to design a system which can involve non-point sources (e.g. agricultural and urban runoff, long range transport) and/or point sources for which no-one is responsible (e.g. some sedimentary and groundwater sources).

Whereas economic considerations call for a large number of potential buyers and sellers who are free to make whatever trades are in their mutual interests, there can be environmental reasons for restricting the trade in emissions even though the total level of discharge is unaffected. For example, if there is a concern that the combined discharges within a sub-region may become excessive either trading zones will have to be established, which reduces market competitiveness, or all trades will have to be subjected to checks that specified levels of local discharges and/or ambient concentrations are not exceeded. By requiring administratively imposed limits of this sort the possibilities for trade are reduced and transaction costs are increased, again lessening the gains from trade. (This feature of an emissions trading system is pursued further in question 7.)

As this discussion has shown, many considerations have a bearing on whether emissions trading or effluent charges are more appropriate for achieving virtual elimination, assuming that some form of economic instrument is to be selected. The option of using an effluent charge or some other form of charges system (deposit/refund or product charges) is taken up under question 9. At this point, it is assumed that emissions trading is indicated and the consequences of selecting such an instrument are explored.

❐ Question 5: Should There be Trade in Cumulative Emission Permits?

There are two main ways of designing a system of emissions trading to achieve virtual elimination. The first way requires the regulatory agency to progressively limit the total quantity of tradeable emissions available. This can be accomplished by issuing permits for a fixed period of time after which the allowable emissions are revised downward until the total quantity is consistent with virtual elimination however it is defined.

A second method described by Tietenberg (1985) is for the regulatory agency to issue permits that must be retired when they are used. The number of permits issued corresponds to the total allowable discharge between the time the system is initiated and virtual elimination is achieved. Tietenberg refers to this as a system of cumulative emission permits.

> *The permits themselves do not have a time dimension; the holder has complete freedom when to emit. However, ... cumulative emission permits do not regulate emission rates; they limit total emissions (tons rather than tons per year) ... In this market the permits are an exhaustible resource; once used they are withdrawn from circulation.*
>
> (Tietenberg 1985: 29)

Tietenberg discusses a cumulative emission permit system in the context of "uniformly mixed accumulative pollutants." For pollutants that mix uniformly location does not matter. If mixing is not uniform then the scheme may have to be modified by imposing additional constraints on trades at the sub-regional level.

For the case that Tietenberg does consider he shows that the standard result obtained from the theory of exhaustible resources (Hotelling 1931) applies to the price of a cumulative emission permit and to the total quantity of emissions per year providing competition prevails. This result is that as the unused permits diminish over time, the real price of a permit will rise at a rate equal to the rate of interest and the quantity emitted in each year will decline until virtual elimination is achieved. (Technical change can modify this result.)

Criteria 5: For Deciding on trade in Cumulative Emission Permits

The apparent simplicity of cumulative emission permits is most obvious when the contaminants mix uniformly and the location of the discharges is irrelevant. Whether or not this situation applies depends on mixing patterns and on the relevant damage functions. In the absence of the necessary information it may be wise to assume that location does matter and that local as well as regional effects of persistent toxics are of concern.

Even when a contaminant is persistent and toxic, it seems unlikely that the effects of discharges on the ecosystem will be independent of their timing. Without additional constraints, a trading system does allow for the entire permitted quantity of a contaminant to be discharged at one time as well as in one place. Unless there is extremely high confidence in the belief that the temporal pattern of discharge has no real bearing on the ecosystem effects it would be unwise to leave decisions about timing exclusively to market forces. There is also the possibility that once all permits have been used up pressure will be brought to bear for additional permits to be issued. This possibility may be sufficient to reject this form of tradeable permits for achieving virtual elimination.

The imposition of local limits on discharges in combination with cumulative emission permits is taken up in question 7. As Figure 1 shows rejection of cumulative emission permits results in the selection of a system wherein the allowable emissions declines over time. Both systems require a method for allocating the initial allowable emissions and this is the topic of question 6.

❐ **Question 6: Should Trade be Based on the Existing Permitted or Actual Quantities?**

Under a system of tradeable emissions, where the total permitted emissions decline over time, the simplest way of initiating the system is to allow existing sources to start trading their permitted or actual quantities (whichever is less). To achieve virtual elimination the quantity of discharge allowed by a permit would have to decline over time such that a permit which allows x Kg of discharge this year will only allow a discharge of y Kg next year ($y < x$). Through this means, emissions trading could take place but eventually virtual elimination would be achieved according to the pre-determined timetable. One example of such a system is the trade in "emission reduction credits" used in the United States (see section 3.2 above).

Criteria 6: For Deciding Whether Trade Should be Based on the Existing Permitted Quantities

There are two possibly conflicting criteria to be considered in deciding this question: i) whether an initial distribution of allowable emissions is equitable and ii) whether any other initial distribution could be introduced without strong opposition from existing sources.

There are several implications of giving the right to trade existing emissions according to the existing permits. First, it converts the right to pollute into a right which has a realizable economic value. This economic value accrues to the polluters rather than to those actually or potentially exposed to the effects of the persistent toxics. Is this fair?

Second, the largest realizable economic value accrues to the largest sources. These may be the very sources that have done the least in the past to reduce their discharges. This seems like a perverse way to reward such behaviour and it may have implications for further extensions of emissions trading: sources may deliberately increase their emissions in anticipation of receiving a greater share of the tradeable emissions. (To some extent this behaviour can be avoided by distributing the tradeable emissions according to some historical level of emissions but to do so introduces additional concerns not only about the current relevance of these historical levels of emissions but also about the accuracy of the measurements.)

Third, by conferring an economic advantage on the existing sources, new firms wishing to establish themselves in the Great Lakes basin may be discouraged, even if the technologies they plan to use are less polluting than those of their competitors.

Despite the possible inequities in allocating tradeable emissions according to current permitted or actual emissions, it may be infeasible to do any thing very different (e.g. auction the emissions) owing to the opposition that this might evoke from the sources. Even if the overall advantages that emissions trading might bring is accepted by the existing sources they will be determined to reap some portion of these advantages. The most obvious form that these advantages will take is in cost reductions. However, no source can be assured of a cost reduction if, in addition to the costs of reducing emissions, they also have to pay for their initial, pre-trade share of the tradeable emissions. The possibility of imposing a tax on the level of tradeable emissions held by any source to return some of their economic value to the government may also be difficult to introduce for this reason. (The issue of what the government might do with the revenues accruing from an auction or a tax on tradeable emissions is taken up under question 11.)

Decisions about the initial allocation of the tradeable permits are inextricably tied to decisions about the level and allocation of the financial burden that such schemes involve. Whatever decision is made on this matter, and the decision tree in Figure 1 shows two possibilities, (trade based on existing permitted or actual discharge and a permits auction), the question of additional limits to protect local areas must be addressed.

❐ **Question 7: Should Limits on Trades be Imposed to Protect Local Areas?**

Additional limits to protect local areas have been imposed with respect to air emissions, where trading systems have been most extensively used. These limits are designed to ensure that ambient concentration standards are met and/or that ambient concentration levels do not increase. There may well be a concern that ambient concentrations should be limited even as virtual elimination is approached. One of the risks of trading systems is that, in the absence of special measures to protect local environments, ambient concentrations of persistent toxics in these environments may rise unacceptably.

Criteria 7: For Deciding Whether Limits on Trades Should be Imposed to Protect Local Areas

If there is evidence that shows a relationship between ambient concentrations (e.g. in sediment or in benthic communities) and effects on species higher up the food chain that is characterized by thresholds, then there are good grounds for restricting trades such that these critical ambient concentrations are not exceeded. Even in the absence of such evidence, it may be deemed prudent to prevent an accumulation of tradeable emissions at specific locations which are believed to be at risk if ambient concentrations rise. Proximity to sensitive ecological areas (e.g. wetlands, spawning areas, breeding grounds, municipal water supplies) might be reason enough to regulate trades such that ambient concentrations (or combined discharges) do not rise.

This concludes the discussion of the portion of the decision tree that deals specifically with emissions trading. (The possibility of combining financial enforcement incentives with emissions trading or direct regulation is taken up under question 13.) Previously, a "no" in response to question 4 (should quantities be limited directly?) would have lead to the selection of effluent charges (or some other charges system) for achieving virtual elimination once it was decided that exclusive reliance on direct regulation was unwise. There are several questions and criteria for evaluating the role that charges might beginning with question 8.

❐ **Question 8: Should an Effluent Charge be Imposed on Emissions?**

In principle, an effluent charge can be used to achieve virtual elimination. This can be accomplished by increasing the level of the charge to induce greater and greater reductions in the quantity and/or concentration of emissions. An announcement that the effluent charge will be raised periodically, say every year, until virtual elimination is achieved may hasten the process since the expectation of an ever increasing effluent charge will justify a greater level of expenditures to reduce emissions than an effluent charge which may or may not be raised in the future.

Criteria 8: For Deciding if an Effluent Charge Should be Imposed on Emissions?

If virtual elimination is the goal but the precise path towards it is unimportant (or there is insufficient information to know what the path should be) then an effluent charge that increases over time may be preferable to emissions trading. First, the administrative requirements of an effluent charge may be more modest. (For the reasons given in response to question 7, the local environment may only be adequately protected if trades are regulated.) Second, an effluent charge is not weakened if only a few sources, which may not compete effectively in an emissions trading market, are involved. Sources large or small, many or few, all have to pay the charge and will all have an economic incentive to reduce their discharges.

Third, an effluent charge will generate revenues. Question 9 examines whether this is an advantage or not. It is certainly one reason why governments are taking a fresh look at effluent charges and may make them more acceptable than emissions trading in which no revenues accrue to the government. (If the emissions "rights" are auctioned revenues will be generated but, as discussed under question 6, such a scheme may be difficult to introduce.)

It should be noted that the apparent simplicity of an effluent charge may be confounded by a need to impose different charge rates for different contaminants, different concentrations, different locations (to take account of local conditions), different times of the year (to take account of the seasonality of ecosystem processes), as well as different total quantities of emission (to take account of non-linear damage functions.) Also, the requirement to pay an effluent charge in addition to abatement costs may have adverse effects on a sector's competitiveness. A concern with this possibility may limit the level of the effluent charge below that which is required to induce the required reductions in emissions.

The final consideration to be considered is whether or not emissions can be monitored reliably enough to support an effluent charge. Monitoring is also required for direct regulation but it may be less demanding to determine if a source is in compliance with a specified level of emission than the precise level of emission. Furthermore, if self-monitoring is used there would be an increased incentive for under reporting than with direct regulation since every unit reported would add to a source's costs.

Despite these complications, an effluent charge has the potential to be an extremely powerful tool in the arsenal of instruments aimed at virtual elimination. What to do with the revenues is the next question if charges are to be considered further.

A negative answer to this question does not necessarily entail a rejection of all systems of charges. One possibility is a charge on specific materials to discourage their use. This possibility is addressed in question 11. For now, an affirmative answer is assumed and the issue of what, if anything, to do with the possible revenues from an effluent charge is considered.

❐ Question 9: Should an Effluent Charge be Revenue Neutral?

The success of an effluent charge to achieve virtual elimination of persistent toxics will be marked by the disappearance of any substantial revenues. However, before that point is reached the potential revenues from a system of effluent charges could be considerable. Hence, the interest of some governments in "green taxes."

The danger in using an effluent charge to raise revenues is that the achievement of virtual elimination will conflict with a government's revenue requirements and this might make it difficult or even impossible to continually raise the charge until all toxic emissions are eliminated.

An effluent charge can be revenue neutral (i.e. generate no additional revenues for government) if a commitment is made to adjust other tax rates downwards so that total government revenues remain unchanged. In practice this may be difficult to do because it requires adjustments to the rates from what they would otherwise have been in the absence of an effluent charge and this is a matter of speculation not fact.

One approach to revenue neutrality that should be analyzed very carefully before implementation is to reimburse the sources that pay the effluent charge through some form of subsidy to help defray the costs of reducing emissions. The danger with this approach is that the subsidy may undermine rather than reinforce the very incentives for action that an effluent charge is supposed to offer.

Criteria 9: Should An Effluent Charge be Revenue Neutral?

Revenue neutrality is important if revenue generation threatens to compromise the effectiveness of an effluent charge. It may also be a helpful feature in persuading sources to accept an effluent charge because total revenues paid to government will not be affected. (Municipal sources may be problematic in this regard.)

Revenue neutrality may be a definite handicap if revenue generation is one of the main reasons why a broad constituency supports the introduction of an effluent charge. In such circumstances, an effluent charge may still be very effective in inducing some reduction in discharges though other instruments will be needed to go all the way to virtual elimination.

If revenue neutrality is rejected a decision must be made about what to do with the funds generated which is the topic of question 10.

❐ Question 10: Should Revenue be Tied to Specific Programs?

The revenues from an effluent charge (or from auctioned emission "rights") can be tied to specific government expenditures or go into the consolidated fund as one of many categories of revenue out of which government funds its programs.

Criteria 10: For Deciding if Revenue Should be Tied to Specific Programs

Opinion polls indicate that "green taxes" may be the only type of new taxes that the public will pay without much resistance. However, the same polls also indicate that the public wants to know how the funds will be spent. If these polls show a widely held view that will endure then revenues may have to be tied to specific programs if there is to be an effluent charge on persistent toxics.

On this question it should be remembered that traditionally government revenues and expenditures have been separated for two important reasons: i) decisions about revenues and expenditures are often subject to different criteria, and ii) there is no guarantee that the revenues required by a program bear any relation to the level of funds that might come from an effluent charge. Also, if a program becomes dependent on an effluent charge as a source of funds then those responsible for the program or beneficiaries of the program may become extremely distressed at the prospect of their funding drying up as virtual elimination is achieved and the revenue from the effluent charge approaches zero.

The final step in the decision tree goes back to question 10 which asked if a charge should be put on the effluent. Previous questions examined the implications of a positive response to this question. Question 13 examines those of a negative response.

❐ Question 11: Should a Non-Refundable Charge be Placed on Specific Products?

If effluent monitoring is too unreliable or too expensive to support an effluent charge, or their is a risk that a charge will result in intermedia transfers, a reasonable alternative can be a charge on a product that is used as an input to production providing that it is closely correlated with the emission of the unwanted persistent toxic. (For example, a charge imposed on the use of mercury or PCBs will discourage their use and encourage a search for alternatives.) Alternatively, a deposit/refund system on products that can cause a release of persistent toxics (e.g. batteries) can be useful for ensuring reuse, recycling and proper disposal.

The problem with charges on inputs is that they provide very little incentive for improved management of a material once it has been purchased (except to make internal recovery and reuse marginally more attractive.) In particular, input charges do not directly penalize the action that is to be deterred which is the discharge of persistent toxics into the environment. Therefore, their effectiveness is thought to be less than that of an effluent charge though their range of application may be greater. Non-point sources are seldom amenable to an effluent charge but they can sometimes be effectively discouraged with a charge on specific products. A charge on toxic chemicals used in agriculture is but one example.

Product charges can also be imposed at the point of sale to final consumers. Ideally, such a charge would be related to the quantity of persistent toxics discharged at all stages of production, consumption and disposal of the product. However, unless an extremely detailed schedule of charges is used, which differentiates not only by product but also by production process, a product charge will generally be too remotely related to the emission of persistent toxics to be effective for achieving virtual elimination.

Criteria 11: For Deciding Whether a Non-Refundable Charge Should be Placed on Specific Products

The main criteria for deciding this question are whether effluent monitoring is problematic and whether there is a close correlation between the quantity of a product purchased (either as an input or final consumption) and the quantity of a persistent toxic released. If a high proportion of a persistent toxic entering the Great Lakes environment comes from non-point sources then a charge on specific products could be useful in achieving virtual elimination. Also, some non-point sources such as agricultural runoff, may be responsive to product charges even when effluent charges are impractical.

Similar issues relating to revenue neutrality as were discussed under an effluent charge also apply to a charge on specific products. One way of imposing such a charge that avoids revenue is through a deposit/refund system.

A deposit/refund system imposed on products which contain persistent toxics can help ensure that the materials are recovered and reused and then ultimately disposed of in a comparatively safe manner by physical and chemical treatment, incineration or in a secure landfill. These measures all help eliminate persistent toxics from entering the environment.

The main criterion for assessing the suitability of a deposit/refund system for persistent toxics is whether the requisite infrastructure exists or can be created. Care must be taken to ensure that the various steps in the system can be undertaken safely without risking unwanted and possibly large discharges of the contaminants into the environment.

This concludes the section of the decision tree that deals with economic incentives except in the form of financial enforcement incentives. These are a possibility in conjunction with direct regulation or tradeable emission permits. Question 12 reverts to a further consideration of direct regulation assuming that the conditions for economic instruments, particularly emissions trading and effluent charges are not met.

❐ Question 12: Should Process and Control Technologies be Specified?

Regulations can be promulgated that limit the allowed quantity that a source may discharge into the Great Lakes environment. Such regulations leave it to the individual sources to determine how they will meet the limits imposed on them. This is the approach usually followed by the U.S. Environmental Protection Agency. Another approach is to have regulations which specify those processes (including raw materials and product characteristics) and/or control technologies that are allowed or prohibited.

The first approach allows a greater range of choice to the sources subject to regulation which lowers overall compliance costs. It also makes clear that responsibility for meeting the regulations rests unambiguously with the sources. This clarity can be lost if official governmental approval is given for the adoption of a process or control technology which later proves inadequate. Under these circumstances, sources may request and be granted an exemption from a non-compliance penalty on the grounds that these actions received government approval.

A second reason why regulations that specify process or control technologies can be ineffective is that, unless equipment is properly operated and maintained, it may not perform to expectations. Additional regulations and compliance incentives may be required to ensure that this problem does not arise.

Despite these drawbacks, there are situations when regulations specifying technologies are appropriate. First, it may be costly or technically impossible to adequately monitor emissions of some persistent toxics especially as the goal of virtual elimination is approached and emission quantities become very small. This is not a problem when technologies are specified. Second, if sources do not have the necessary expertise for selecting processes and control technologies, and there is concern that bad choices cannot easily be reversed, requiring approval of these technologies may be appropriate. Third, measures to avoid spills may best be mandated, and fourth, it may be advisable to restrict the adoption of technologies which simply transfer toxics to other media.

Criteria 12: To Decide Whether Process and Control Technologies Should be Specified

The economic rationale for allowing sources to make their own selection of process and control technologies, subject to regulated limits on emissions, is compelling. Nevertheless, if discharges cannot be monitored to the level required for enforcement or if the administration has more expertise on the various technologies which cannot easily be transferred to sources, then the technologies should be specified in the regulations. To do so may bring a more assured approach to achieving virtual elimination providing responsibility for non-compliance does not pass to the government if approved technologies do not work as well as planned.

Whatever is decided at this point, there remains the potential role for financial enforcement incentives. This is the issue raised in question 13.

❒ **Question 13: Should Financial Enforcement Incentives be Used?**

Financial enforcement incentives can replace or complement the more traditional penalties of fines and imprisonment. Two such financial enforcement incentives are performance bonds and emission charges imposed only on excess quantities.

Performance bonds already exist in some jurisdictions (see Chapter 4). They are intended to remove any financial incentive that sources may have for not complying with a regulation. Charges on excess emissions work the same way except that they can only be applied when regulations specify discharge limits rather than technologies. (Performance bonds can be effective in both cases). Unlike a performance bond, the amount of the excess charge is closely related to the extent of the non-compliance as measured by the excess emission.

As with most economic instruments, there is always a question of what to do with any revenues that accrue to the government. This question was raised in connection with the auctioning of tradeable emissions, and will be looked at in more detail in response to question 11. One feature of financial enforcement incentives is that their effectiveness is inversely related to the revenues that they generate. If they work as intended so that sources comply with their permitted limits, they generate no revenue at all.

Criteria 13: For Deciding Whether Financial Enforcement Incentives Should be Used?

Since the main rationale for economic non-compliance penalties is to improve compliance rates, the main criterion for deciding on their use is whether compliance rates have historically been inadequate. Of course, a satisfactory record in the past is no guarantee that stronger non-compliance penalties will not be required as progress is made towards virtual elimination. If nothing else, the incremental costs of compliance can be expected to rise as the level of discharge declines so that a stiffening of non-compliance penalties may be required to induce an ever declining level of emission.

This completes the discussion of the decision tree and the evaluation framework that it offers. A summary of the main points arising from this evaluation framework is given in Table 5.1. In the following chapters, the applicability of economic instruments for achieving virtual elimination if mercury, PCBs and several persistent toxics from the pulp and paper industry is examined using the questions and decision criteria discussed in this chapter.

TABLE 5.1A Summary of Evaluation Framework (*Questions 1 to 3*)

QUESTION	DIRECT REGULATION	ECONOMIC INSTRUMENT	ANSWER
1. IS GOAL VIRTUAL ELIMINATION?			Yes, already decided

Continued

TABLE 5.1A Summary of Evaluation Framework (*Questions 1 to 3*, continued)

QUESTION	DIRECT REGULATION	ECONOMIC INSTRUMENT	ANSWER
2. **AT ONCE?**	If done at once, outright ban simplest	Financial burdens can be alleviated with subsidies	No, not at once so can use economic instruments. (Here, subsidy would not encourage increased production)
3. **USE DIRECT REGULATION EXCLUSIVELY?**	Stakeholders are familiar with direct regulation. Growing sense that direct regulation is not achieving goals. Leaves more authority with current decision-makers.	Increasing interest in using economic instruments	
	Gives appearance of firm action	Gives appearance of putting environment up for sale. Arguable, just putting an explicit price on what is already being sold or given away, implicitly	
		May require more extensive monitoring, if there is: •a need to demonstrate statistically the likelihood of a continuing violation over a period of time •a need to monitor trades as well as discharges •technology-based regulations can be monitored simply by ensuring installation of a piece of equipment	Monitoring requirements should be similar, except in case of noted exceptions
			Nonpoint sources are difficult to monitor; may require regulatory or use charges
	Administrative requirements are well understood. More difficult to regulate cost-effectively	Administrative requirements are uncertain. Easier if goal is to regulate cost effectively	
	Negotiations allow for considerable flexibility in implementation, but may result in considerable delay	Allow decentralized decision-making about how to achieve reduction targets	

Continued

TABLE 5.1A Summary of Evaluation Framework (*Questions 1 to 3*, continued)

QUESTION	DIRECT REGULATION	ECONOMIC INSTRUMENT	ANSWER
3. (continued) USE DIRECT REGULATION EXCLUSIVELY?	Appears to give certainty of result, but track record does not bear this out. Appears to increase predictability of regulatory outcomes		
	Less cost-effective. Very difficult to administer to gain detailed knowledge of control costs	Allow equalization of marginal abatement costs. Sources have incentive to minimize costs to same marginal level. If marginal abatement abatement costs are similar for all firms, much of the advantage is lost. (Still retain advantage of speeding the process with economic instruments)	
	Development of new control technology/technique may increase abatement costs. Disincentive to innovation	Innovations will save money, so are encouraged (but in both cases, standards are set on basis of known technology)	
		Environmental objectives may be achieved more quickly as all need not move at pace of highest cost abater. Effluent charge is a bigger incentive to act than fines for non-compliance	

Continued on Table 5.1B

TABLE 5.1B Summary of Evaluation Framework (*Questions 4 to 13*)

QUESTION	DISCUSSION	CONCLUSION
4. LIMIT DISCHARGES BY QUANTITY OR MAXIMUM ABATEMENT COST	•If cost functions are steep, effluent charge gives better control over reduction charges •If damage function has critical threshold and if response to effluent charge is uncertain, may be better to fix total discharge level with a permit. However, thresholds are likely to be ambient; setting tradeable permits with an eye to ambient needs is more difficult	In principle, the two schemes are symetrical In the absence of steep costs or thresholds, effluent charges may be moresuitable. (In practice, there will be a significant level of uncertainty as to the result that will be achieved. The question becomes: is it more costly to be uncertain about the resulting level of abatement?) of abatement?)

Continued

TABLE 5.1B Summary of Evaluation Framework (*Questions 4 to 13*, continued)

QUESTION	DISCUSSION	CONCLUSION
4. (Continued) LIMIT DISCHARGES BY QUANTITY OR MAXIMUM ABATEMENT COST?	Market only works if there are enough sources to ensure competition in the market for permits May be potential to use permits to exclude new entrants. Some emitters may not be in a position to trade (nonpoint of past dumping sites)	
5. TRADE: BY GRADUAL REDUCTION OF TOTAL PERMITS AVAILABLE OR BY ISSUING ALL PERMITS AT ONCE AS AN EXHAUSTABLE RESOURCE?	In the absence of evidence to the contrary, it is safest to assume that timing and location of discharges does matter. Concern that all of pollutant may be discharged at once in one place	(This creates a significant burden on the use of any economic instrument. Any reason to believe that cumulative permit is particularly burdened?)
6. TRADE: BASE AS CURRENT PERMITTED OR CURRENT ACTUAL DISCHARGE?	Should economic value of permit go to the class of polluters? And, in particular, to the biggest polluters? May discourage new entrants too. It may be impossible to do anything else due to opposition from existing sources. Could impose a tax on the permits to recover some of the value	(Could auction the permits)
7. TRADES: LIMIT TO PROTECT LOCAL AREAS?	May wish to ensure that local thresholds are not exceeded	
8. EFFLUENT CHARGES: USE THEM?	If the precise path toward virtual elimination is unimportant (or indeterminable), a gradually increasing effluent charge may be preferable. Will require less administration. Market size won't matter. The more a charge has to be refined to account for variations in local or ambient effects or time or year, etc., the harder it will be to implement. Requiring dischargers to pay a fee over and above abatement costs involves a redistribution of income which will be resisted. Monitoring requirements may be higher	
9. EFFLUENT CHARGES: REVENUE NEUTRAL?	May have political consequences -- affecting group/budget	

Continued

TABLE 5.1B Summary of Evaluation Framework (*Questions 4 to 13*, continued)

QUESTION	DISCUSSION	CONCLUSION
10. EFFLUENT CHARGES: USE TO FUND SPECIFIC PROGRAMS?	Revenues required by a given program may end up differing from revenues received. Revenue shortfall when goal achieved	(Tax could be instituted to raise revenues notwithstanding virtual elimination by direct regulation)
11. USE NON-REFUNDABLE PRODUCT CHANGES?	Spread net too widely. Don't focus on discharge. Makes sense only where monitoring discharge is difficult, e.g. nonpoint. If a high proportion of sources are nonpoint, may be useful. Deposit/refund option would avoid putting burden on nondischarger and be non-revenue raising. Re: deposit/refund: How easy will it be to set up the necessary infrastructure?	(Does cost of further monitoring exceed cost of casting net too wide?)
12. SPECIFY PROCESS/ CONTROL TECHNOLOGY?	Problems: Less range of choice likely leads to higher compliance costs. Still needs to ensure proper operation, maintenance of equipment. Advantages: If monitoring is difficult; if sources have less expertise than government in selecting technologies; may need to mandate spill avoidance	
13. USE FINANCIAL INCENTIVES?	Examples are performance bonds and emission charges on excess quantities. Excess charge is more closely tied to level of exceedance	

6.0 ECONOMIC INSTRUMENTS AND VIRTUAL ELIMINATION OF DISCHARGES OF MERCURY

At one time, the discharge of mercury to the Great Lakes basin was almost entirely from chlor-alkali plants. These plants were frequently located near pulp and paper mills, due to those mills' need for bleaching chemicals. Brine was electrolyzed in mercury cells to produce chlorine as well as sodium hydroxide and hydrogen.

Today, nearly all of the old chlor-alkali plants have either closed or they have been converted to non-mercury cell processes and the few plants that continue to use the old process have reduced their mercury emissions markedly. However, mercury levels in fish are still a matter of concern in many areas of the Great Lakes basin (International Joint Commission 1989) and further reductions in discharges of mercury to the basin are being sought.

In the early 1970s, reducing mercury discharges seemed a straightforward matter. In Canada, for instance, chlor-alkali plants were required to limit their mercury discharges to a certain quantity per tonne of chlorine production capacity. For other industries, mercury discharges became a matter to be considered in the granting of discharge permits. The first section of this chapter will indicate that achieving further reductions in mercury discharges will be more complex.

The mercury which is now entering the Great Lakes basin comes from diverse sources the relative importance of which is poorly understood. Contaminated sediments, the legacy of past discharges, are certainly a prominent source. Deposition from the air is also important, apparently accounting for about three quarters of depositions resulting from ongoing human activity. The main source of emissions of mercury to the air is its evaporation from a wide variety of mercury-containing finished products such as batteries, paints, electrical switches, dental supplies, control instruments and lights. The incineration of products in which mercury has been used, in particular batteries, is also a significant source of emissions. The combustion of coal also releases substantial quantities of mercury to the air. Mercury discharged directly to water appears to be entering the basin mainly through sewage treatment plants. The sources of the mercury entering sewage treatment plants are not well known.

The control of the discharge of mercury, considered in the second section of this chapter, can be achieved in a number of ways. Many local mercury contamination problems can probably be cleared up by remediation of sediments in a few locations -- particularly near the sites of the old chlor-alkali plants. The non-essential use of mercury in products such as paint and batteries is currently virtually unregulated. These uses could be reduced and ultimately ended entirely. Incinerators and coal-fired power plants could install more effective pollution control devices to reduce mercury as well as other metal emissions.

6.1 Sources of Mercury

Estimates of the quantity of mercury discharges into the Great Lakes from industry (direct discharges), sewage treatment plants, and atmospheric deposition are summarized in Tables 6.1 (all lakes) to 6.7 (for each lake and the St. Lawrence River). It is important to realize that these data are far from complete and are not considered to be very accurate. Nevertheless, the overall picture that emerges is believed to be reasonable and is of some use in assessing the role that economic instruments could play in achieving virtual elimination of mercury discharged into the Great Lakes.

TABLE 6.1 Sources of Mercury Discharges to the Great Lakes Basin (Total)

SOURCE	Tonnes/year Dolan 1985	Kilograms/day Dolan 1985	Kilograms/day Dolan 1988	Percentage Dolan 1985
INDUSTRIAL DIRECT	0.05			0%
SEWAGE TREATMENT PLANT	1.23			12%
ATMOSPHERIC DEPOSITION	8.08			76%
TRIBUTARIES	1.27			12%
TOTAL FOR AVAILABLE DATA	10.63			100%

Data Sources: Dolan 1990; STORET database, U.S. EPA; TRI Toxic Release Inventory, U.S. EPA

On the basis of the available data, it is apparent from Table 6.1 that atmospheric deposition is a major source of mercury deposition in the Great Lakes[5]. At the same time, direct industrial discharges of mercury are extremely low and sewage treatment plants also make only a modest contribution. Much the same pattern is shown for each individual lake.

The total discharge of 10.6 tonnes estimated for 1985 is known to be an underestimate of the actual total. For example, Dolan (personal communication) reports with some confidence an individual estimate of 4.6 tonnes/year of mercury entering lake Ontario from the Niagara river in 1985. Much of this amount is believed to come from contaminated sediments in the river. Unfortunately, no data on sedimentary sources of mercury are available though much of the mercury entering from tributaries could come from sediments. Similarly, data for non-point sources of mercury are also lacking so the overall significance of the sources for which data are available remains in question.

Tables 6.2 to 6.7 suggest that the individual sources of mercury are widely scattered. This is true of the sewage treatment plants and the atmospheric sources. (Though it should be noted that in Lake Erie, where information for a large number of sewage treatment plants is available, six plants account for most of the mercury discharges.) Glass et al. (1990) indicate that the incineration of municipal refuse is a significant source of the atmospheric deposition of mercury in the Great Lakes[6] incinerators in the U.S. and ten in Ontario. Five U.S. and one Canadian incinerator in the region have capacities over 18,000 kg/hr of waste. The U.S. National Emission Standard for Hazardous Air Pollutants (NESHAPS) allows 3,200 g/day of mercury to be emitted to air by a sewage sludge incinerator. European domestic garbage has been found to contain an average 3-4 g of Hg/tonne, about 50% of which is accounted for by used batteries (Reimann 1986). Some individual countries, such as Denmark, however, separate dry-cell batteries from household wastes through a collection system operated through the retail outlets where the batteries are sold.

TABLE 6.2 Sources of Mercury Discharges to the Great Lakes Basin (Lake Superior)

SOURCE		Tonnes/year Dolan 1990	Kilograms/day STORET	Kilograms/day STORET 1988	Percentage Dolan 1990
INDUSTRIAL DIRECT/INDIRECT		0.00			0%
-Michigan	Callahan Mining			0.0001	
	White Pine Copper		0.0079		
-Minnesota	U.S. Steel - Mtn.			0.0008	
-Ontario	James River (Marathon)		0.0004		
	TEC-Corunna			0.0001	
SEWAGE TREATMENT PLANT		N/A			N/A
-Minnesota	Western Lake Superior			0.400	
ATMOSPHERIC DEPOSITION		2.64			78%
TRIBUTARIES		0.74			22%
-Ontario	Black Sturgeon		0.092		
	Little Pic		0.065		
	Nipigon		1.296		
	Pic		0.113		
	White		0.220		
Wisconsin	Nemadji		0.231		
TOTAL FOR AVAILABLE DATA		3.38			100%

Data Sources: Dolan 1990; STORET database, U.S. EPA; TRI Toxic Release Inventory, U.S. EPA

6.1.1 Sources of Atmospheric Deposition of Mercury

The importance of atmospheric deposition of mercury in the Great Lakes requires that the likely sources of this deposition be identified if the relevance of economic instruments is to be properly assessed. Table 6.8 provides information on

5 This finding was discussed with a senior official at the Ontario Ministry of the Environment who believed it to be correct. However, the Ministry has very little information on the sources of this atmospheric deposition.

6 Detroit-Windsor/Port Huron-Sarnia Air Pollution Advisory Board (1991) estimates that region's mercury air emissions to total 94 tonnes/year. Much of this comes from incinerators: 1,678 incinerators in the U.S. and ten in Ontario. Five U.S. and one Canadian incinerator in the region have capacities over 18,000 kg/hr of waste. The U.S. National Emission Standard for Hazardous Air Pollutants (NESHAPS) allows 3,200 g/day of mercury to be emitted to air by a sewage sludge incinerator.

mercury emissions for the U.S.[7] seem far too low. What emerges from Table 6.8 is that anthropogenic sources of air emissions of mercury (650 tonnes/year) exceed emissions from natural sources (500 tonnes/year). The use of finished goods (352 tonnes/year, most of which comes from paint and electrical equipment), coal fired power stations (113 tonnes/year), municipal and sewage sludge incinerators (68 and 36 tonnes/year, respectively) account for almost 90% of the total anthropogenic sources. Although similar data do not exist just for the Great Lakes basin it is likely that a similar pattern of emission sources exists there too.

TABLE 6.3 Sources of Mercury Discharges to the Great Lakes Basin (Lake Michigan)

SOURCE		Tonnes/year Dolan 1990	Kilograms/day STORET	Kilograms/day STORET 1988	Percentage Dolan 1990
INDUSTRIAL DIRECT		0.00	0.0251		0%
-Michigan	Hitachi Magnetic		0.0018		
-Wisconsin	Bergstrom Paper		0.0153		
	J.I. Case		0.0059		
	Waupaca Foundry		0.0021		
SEWAGE TREATMENT PLANT		0.40			23%
-Wisconsin	Neenah Menasha		0.6400		
	Racine		1.1000		
ATMOSPHERIC DEPOSITION		1.29			74%
TRIBUTARIES		0.05			3%
-Indiana	Burns		0.019		
	Trail		0.123		
TOTAL FOR AVAILABLE DATA		1.74			100%

Data Sources: Dolan 1990; STORET database, U.S. EPA; TRI Toxic Release Inventory, U.S. EPA

TABLE 6.4 Sources of Mercury Discharges to the Great Lakes Basin (Lake Huron)

SOURCE		Tonnes/year Dolan 1990	Kilograms/day STORET	Kilograms/day STORET 1988	Percentage Dolan 1990
INDUSTRIAL DIRECT		N/A			N/A
SEWAGE TREATMENT PLANT		N/A			N/A
ATMOSPHERIC DEPOSITION		2.15			91%
TRIBUTARIES		0.21			9%
-Ontario	French		0.203		
	Mississauga		0.157		
	Nottawasaga		0.027		
	Saugeen		0.071		
	Severn		0.084		
	The Cut		0.038		
TOTAL FOR AVAILABLE DATA		2.36			100%

Data Sources: Dolan 1990; STORET database, U.S. EPA; TRI Toxic Release Inventory, U.S. EPA

7 Similar data was obtained for Ontario from Jacques (1987) but are not considered very reliable. The estimated totals of five tons per year from Ontario and 31 tonnes per year from Canada seem far too low.

TABLE 6.5 Sources of Mercury Discharges to the Great Lakes (Lake Erie)

SOURCE		Tonnes/year Dolan 1985	Kilograms/day STORET 1985	Kilograms/day STORET 1988	Percentage Dolan 1985	Kilograms/day TRI 1988
INDUSTRIAL DIRECT/INDIRECT		0.00			0%	
-Indiana	Gridcraft		0.0001			
	Stanscrew		0.0001			
-Ohio	BP Oil-Oregon					0.3113
	LCP Chemical-Ashtabula					0.0075
	Summitt Comm. Fish		0.0017			
-Pennsylvania	Gunnison Bros. Tannery		0.0000			
	Malinckrodt-Erie (to STP)					0.3113
SEWAGE TREATMENT PLANT		0.80			36%	
-Michigan	Algonac		0.0000			
	Detroit		0.6200			
	Port Huron		0.0200			
-Ohio	Akron		0.1100			
	Archbold		0.0000			
	Ashtabula		0.0000			
	Avon Lake		0.0100			
	Bedford		0.0100			
	Bedford Heights		0.0000			
	Bellevue		0.0000			
	Berea		0.0100			
	Blufton		0.0000			
	Bowling Green		0.0000			
	Brookpark		0.0000			
	Bryan		0.0000			
	Bucyrus		0.0100			
	Clyde		0.0000			
	Conneant		0.0000			
	Cuyahoga		0.0500			
	Defiance		0.0100			
	Delphos		0.0100			
	Elyria		0.0000			
	Findlay		0.0200			
	Fostoria		0.0000			
	Geauga Co., Macfarlane		0.0200			
	Kent		0.0000			
	Lake Co., Mentor		0.0100			
	Lake Co., Madison		0.0000			
	Lakewood		0.0100			
	Lima		0.0200			
	Lorain, East Side		0.1100			
	Lucas Co.		0.0100			
	Medina Co. (#1)		0.0000			
	Medina Co. (#2)		0.0000			
	Middleburg Heights		0.0100			
	Milan		0.0000			
	Montpelier		0.0000			
	Napolean		0.0000			
	North Olmstead		0.0000			
	North Royalton		0.0000			
	N.E. Ohio, Region #1		0.0000			
	N.E. Ohio, Region #2		0.0900			
	N.E. Ohio, Region #3		0.1100			
	N.E. Ohio, Region #4		0.0400			
	Norwalk		0.0100			
	Oak Harbor		0.0000			

Continued

TABLE 6.5 Sources of Mercury Discharges to the Great Lakes (Lake Erie, continued)

SOURCE		Tonnes/year Dolan 1985	Kilograms/day STORET 1985	Kilograms/day STORET 1988	Percentage Dolan 1985	Kilograms/day TRI 1988
Ohio, continued						
	Ohio Water Development Authority		0.0000			
	Oregon		0.0000			
	Ottawa		0.0000			
	Painesville		0.0000			
	Pemberville		0.0000			
	Perrysburg		0.0100			
	Port Clinton		0.0000			
	Ravenna		0.0000			
	Sandusky		0.0100			
	Solon Central		0.0000			
	Spencerville		0.0000			
	St. Marys		0.0000			
	Summit Co., #1		0.0100			
	Summit Co., #2		0.0000			
	Toledo Bay		0.3800			
	Twinsburg		0.0100			
	Upper Sandusky		0.0500			
	Vermillon		0.4000			
	Wapakoneta		0.0000			
	Willard		0.0000			
Michigan	Warren		0.0200			
ATMOSPHERIC DEPOSITION		1.20			54%	
TRIBUTARIES		0.24			11%	
-Ontario	Big Otter		0.029			
	Grand		0.231			
	Sydenham		0.165			
	Thames		0.231			
TOTAL FOR AVAILABLE DATA		2.24			100%	

Data Sources: Dolan 1990; STORET database, U.S. EPA; TRI Toxic Release Inventory, U.S. EPA

TABLE 6.6 Sources of Mercury Discharges to the Great Lakes (Lake Ontario)

SOURCE		Tonnes/year Dolan 1985	Kilograms/day STORET 1985	Kilograms/day STORET 1988	Percentage Dolan 1985	Kilograms/day TRI 1988
INDUSTRIAL DIRECT		0.03			3%	
-New York	Abex		0.0000			
	Dupont		0.0908	0.0000		
	Eastman Kodak		0.0000	0.0000		
	Hooker		0.0029	0.0030		
	New York State Electric & Gas					
	- Milliken G.S.		0.0016	0.0253		
	- Somerset G.S.			0.0861		
	Rochester Gas & Electric					
	- (Indirect)			0.3709		
	- (Direct)			0.0002		
	GMC - Fisher Body			0.0001		
	Evans Chemetics			0.0001		

Continued

TABLE 6.6 Sources of Mercury Discharges to the Great Lakes (Lake Ontario, continued)

SOURCE		Tonnes/year Dolan 1985	Kilograms/day STORET 1985	Kilograms/day STORET 1988	Percentage Dolan 1985	Kilograms/day TRI 1988
INDUSTRIAL DIRECT, continued						
New York	Goulds Pumps			0.0004		
	Allied Chemical			0.0009		
	Oneida Limited			0.0011		
	SCA Chemical SVC			0.0007		
	Clark Specialty			0.3796		
	Olin - Niagara Falls					0.0037
	Olin - N.F. (to STP)					0.0299
	Occidental - N.F.					0.0062
	Occidental - N.F. (to STP)					0.0012
	LCP Chem - Solvay					0.1370
	LCP Chem - Solvay (to STP)					0.0112
SEWAGE TREATMENT PLANT		0.03			3%	
New York	Amherst		0.0100	0.0100		
	Niagara Falls		0.0700	0.0400		
	Field Mem. WPCP			0.0700		
	Lockport			0.0100		
	Syracuse			0.0900		
	Niagara Co.			0.0200		
	Oswego West			0.0300		
	Webster PWS PH			0.0100		
ATMOSPHERIC DEPOSITION		0.80			90%	
TRIBUTARIES		0.03			3%	
Ontario	Don		0.010			
	Etobicoke		0.006			
	Humber		0.020			
	Twelve Mile		0.274			
	Welland Ship		0.298			
TOTAL FOR AVAILABLE DATA		0.89			100%	

Data Sources: Dolan 1990; STORET database, U.S. EPA; TRI Toxic Release Inventory, U.S. EPA

TABLE 6.7 Sources of Mercury Discharges to the Great Lakes Basin (St. Lawrence River)

SOURCE		Tonnes/year Dolan 1985	Kilograms/day STORET 1985	Kilograms/day STORET 1988	Percentage Dolan 1985
INDUSTRIAL DIRECT		N/A			N/A
-New York	St. Joe Mineral		0.0000		
-Ontario	C.I.L.		0.0433		
SEWAGE TREATMENT PLANT		N/A			N/A
ATMOSPHERIC DEPOSITION		N/A			N/A
TOTAL FOR AVAILABLE DATA		N/A			N/A

Data Sources: Dolan 1990; STORET database, U.S. EPA; TRI Toxic Release Inventory, U.S. EPA

TABLE 6.8 Estimated Sources of Air Emissions of Mercury in the U.S. (tonnes/year)

SOURCE		EMISSION (tonnes/year)	YEAR
Natural		500	1991
Mercury Mining and Smelting		<1	1983
Fossil Fuel Combustion	Utility coal	113	1985
	Industrial coal	18	1985
	Commercial/residential coal	1	1985
	Utility oil	1	1985
	Industrial oil	3	1985
	Commercial/residential oil	3	1985
Smelting	Copper	41	1980
	Lead	5	1980
	Zinc	5	1980
Incinerators	Sewage sludge	36	1980
	Municipal waste	68	1986
Battery Manufacture		1	1982
Mercury Recovery Retorts		<1	1982
Mercury Chlor-Alkali Plants		3	1983
Use of Finished Goods		352	1980
TOTAL ANTHROPOGENIC SOURCES		650	
TOTAL ALL SOURCES		1,150	

Source: Bloxam 1991

One important feature of air emissions of mercury is that different forms of mercury have very different deposition rates. In particular, elemental mercury may stay in the air for many months, so that distant, even global sources can be as important to local sources in determining how much mercury is deposited into the Great Lakes from the air. According to Bloxom (personal communication) the importance of extra-regional reductions in mercury emissions is indicated by a high proportion of elemental mercury releases. Table 6.9 shows that all of the mercury released from the use of finished products is elemental. At the other end of the spectrum, only 25% of mercury from municipal solid waste falls into this category.

TABLE 6.9 Speciation of Mercury by Source

SOURCE	ELEMENTAL HG (gaseous)	BIVALENT HG (gaseous)	PARTICULATE HG
Finished Products	100%	0%	0%
Power Generation/Industrial Coal Burning	75	20	5
Non-ferrous Smelting	90	10	0
Chlor-Alkali Production	45	45	10
MSW	20	75	5

Source: Dornier 1990.

6.1.2 The Use of Mercury in Canada and the United States

From the above analysis, the way in which mercury is used has emerged as a major determinant of the quantity of this persistent toxic that ultimately finds its way into the Great Lakes. Estimates of the use of mercury in Canada or any of its sub-regions are not available. However, quite detailed estimates do exist for the U.S. as displayed in Table 6.10.

6.3 Applicability of Economic Instruments

This section considers the application of economic instruments to achieve the virtual elimination of mercury entering the Great Lakes based on the information given above. The analysis follows broadly the analytical framework of Chapter 5 but concentrates on the issues most pertinent to mercury.

It is clear that mercury is an appropriate candidate for virtual elimination in that it is a persistent toxic and has been identified as a critical pollutant by the GLWQB. While efforts to reduce the discharge of mercury into the environment have a long history in Canada and the U.S., no generalized prohibition has been introduced. A phased reduction of mercury discharged into the Great Lakes reflects an attempt to find a balance between protection of the environment and the benefits obtained from the use of mercury in modern economies.

There are two considerations which affect any attempts through direct regulation or economic incentives to achieve virtual elimination of mercury discharge into the Great Lakes:

- the available data for mercury on uses (especially in Canada), sources, quantity discharged and quantity entering the Great Lakes is very partial and unreliable;

- much of the mercury entering the Great Lakes is transported by air from sources outside the Great Lakes basin.

Any effective approach to reducing mercury in the Great Lakes must begin with a better appreciation of where the mercury is coming from than the information currently available allows. Furthermore, any scheme to achieve virtual elimination of mercury discharged into the Great Lakes will have to be applied to jurisdictions that are outside of the Great Lakes basin. Conceivably, national programs in Canada and the U.S. might be required just to solve a regional problem. However, reductions in mercury discharges anywhere in the two countries might well bring benefits that would justify programs that are continental in scope.

Although precise quantitative information is unavailable, it is clear from the tables presented earlier in this Chapter that mercury is used in a wide range of industrial and agricultural sectors. Much of the mercury ends up in finished products en route to the environment unless the products are recycled and the mercury recovered, or they are disposed of in secure landfills. This suggests that there is likely to be very substantial differences in the costs of reducing the mercury emanating from these various sources. Also, it is possible that there are good prospects for substitutions to be made and for new technologies that can be developed to reduce the use of mercury and its discharge into the environment. As explained in Chapter 5, these considerations: large differences in discharge reduction costs and possibilities for technological developments, provide important grounds for using economic instruments to achieve virtual elimination.

6.3.1 Emissions Trading or an Effluent Charge?

The main criterion suggested in Chapter 5 for choosing between these two types of economic instruments concerned the shapes of the discharge reduction cost functions and the damage functions. Based on the limited information available, and given the general downward trend in mercury use suggested by Table 6.11, there is no compelling reason to select emissions trading over an effluent charge, or vice versa. Both instruments can help secure a continuing reduction in mercury discharges.

The competitiveness of an emissions trading market is not likely to be a problem, providing the scheme extends to sources outside the Great Lakes basin, which it would have to do for it to be effective in eliminating air deposition into the Lakes. Even if such a scheme was restricted at the outset to the larger sources (coal fired power stations, copper smelting, incinerators and possibly, sewage treatment plants) there are plenty of these to ensure a reasonably competitive market in emissions.

Cumulative emission permits are unlikely to be suitable for mercury and local concentrations of mercury in air may well have to be regulated through ambient air quality standards enforced through court action. (The same would apply if an effluent charge on mercury emissions is implemented.)

In practice, familiarity with emissions trading in the U.S., and their proven success in cost-effectively reducing the lead in gasoline, may make this approach more readily acceptable than effluent charges. However, based on what is currently known about mercury and its sources, there is no obvious reason to think that an effluent charge would not be just as effective as emissions trading. (The reduction of lead in gasoline could probably have been achieved just as well with an effluent charge that increased with time.)

One possible advantage of an effluent charge on mercury is that there is an obvious use of the funds should it be agreed that the use of such funds be decided in advance. Much of the mercury in the Great Lakes is believed to come from contaminated sediments some of which could possibly be dredged, treated and/or disposed of in a secure landfill. This is a costly procedure that must be undertaken with great care since dredging can stir up the sediments and aggravate the problem. However, the possibility of using revenues from an effluent charge to further eliminate mercury from the Great Lakes could be attractive. (Revenue from auctioned permits could also be used for this purpose.)

6.3.2 Tradeable Input Permits and Product Charges

The previous discussion of emissions trading and effluent charges was predicated on an assumption that steps can and would be taken to dramatically improve the reliability of information on sources of mercury entering the Great Lakes. In the absence of such data, all regulatory approaches which focus on the discharge of mercury will suffer. An alternative which should be considered is to apply economic instruments to the use of mercury. Two options are: tradeable permits or product charges to reduce the use of mercury in manufactured products. Table 6.10 shows that a relatively small number of product categories account for most of the mercury consumption in the U.S. with batteries alone, accounting for about one third of the total. A system of tradeable input permits similar to that used to eliminate lead in gasoline could also be effective in this case. Similarly, a charge on the use of mercury would also stimulate a reduction in its use.

Finally, the possibility of a deposit/refund system for some types of products containing mercury should be considered. In Toronto, for example, a limited infrastructure for returning used batteries for proper disposal is already in place and is operated entirely on a voluntary basis. It would have to be substantially expanded and regulated to cope with a comprehensive deposit/refund system just for batteries. If the system was extended to other products the complexity of the infrastructure required could greatly increase.

6.3.3 Financial Enforcement Incentives

Effective direct regulation of mercury discharges to achieve virtual elimination is handicapped by the same data problems as the use of emissions trading and effluent charges. However, if these problems are solved and the advantages of these economic instruments found not to be compelling, there may still be a role for financial enforcement incentives to increase the likelihood that regulated sources will, in fact, comply, with the increasingly stringent discharge limits that will be required to achieve virtual elimination.

7.0 ECONOMIC INSTRUMENTS AND VIRTUAL ELIMINATION OF DISCHARGES OF PCBs

Polychlorinated biphenyls (PCBs) are odourless, colourless organic chemical compounds synthesized from the reaction of biphenyl with anhydrous chlorine. Characterized by a high degree of stability and resistance to heat and pressure, PCBs make excellent lubricants and hydraulic fluids for industrial processes such as aluminum die casting where high pressures are exerted. In addition, PCBs have been found useful as insulating fluids in transformers and capacitors, as plasticizers where flame resistance is required, as constituents of ink and paints, as hardeners in metallurgical processes and even as dust suppressants.

It has been estimated that by the late 1960s, when PCB use reached its highest levels, about 61% of U.S. use was in "closed" electrical systems, 13% was used in "nominally closed" processes (largely hydraulic fluids) and 26% of use was in "open" systems (for instance, ink) (Lamay 1990).

Since that time, growing concern over the health effects of long term exposure to PCBs has lead to increasing restriction upon their production and use. By the late 1970s the manufacture, importation and resale of PCBs were banned in Canada and the United States (exemptions were and are available for narrowly defined research uses). The storage and disposal of PCBs is also strictly controlled in both countries. However, the use of PCBs in materials or equipment where they are already in service continues to be permitted. In Ontario alone, as of 1989, there were 7,800 tonnes of high-level PCBs and 13,300 tonnes of low level PCBs in service, and 11,000 tonnes of PCBs in storage (Dillon 1989). Equivalent estimates for the United States have not been found.

The quantities of PCBs entering the Great Lakes Basin Ecosystem have fallen significantly over the past decade. Levels of PCBs found in Great Lakes fish and aquatic mammals have also been decreasing. But these declines appear to be levelling off at undesirably high levels. Fish in all of the Great Lakes continue to be found with PCB levels exceeding the Great Lakes Water Quality Agreement objective (0.1 mg/kg) (International Joint Commission) Great Lakes Water Quality Board 1989). Concern over the continuing presence of PCBs throughout the Lakes has led regulators to seek further reductions in their discharge.

In deciding how to reduce discharges of PCBs to the Great Lakes basin, regulators first have to identify where the PCBs are coming from. The answer to this question is far from clear. PCBs are slightly heavier than water, and so past discharges have left large quantities of PCBs deposited on river and lake bottoms. About 50% of PCBs now entering the Great Lakes are probably releases from those sediments. A further 30% are probably reaching the Lakes by means of airborne deposition. Volatilization of fluids leaked from transformers, electrical power generation and industrial fuel combustion are believed to be among the main sources of emissions of PCBs to the air. The final 20% are attributed to direct discharges and unknown sources. Probably less than 5% of discharges are directly from point source discharges to water, although this low number is at least in part attributable to very low levels of monitoring. The next section of this chapter provides further detail on the rather ragged state of knowledge of PCB discharges.

7.1 Sources of PCBs

Estimates of the quantity of PCBs discharged into the Great Lakes from industry (direct discharges), sewage treatment plants, and atmospheric deposition are summarized in Tables 7.1 to 7.7. The data are not considered complete or very accurate but they do give some idea of the various sources.

Table 7.1 shows that, according to Dolan (1985), atmospheric deposition of PCBs accounts for about 60% of the total. The more recent IJC report (1988) gives a different impression and attributes 28% to atmospheric deposition which is considered to be a more reasonable estimate. Unfortunately, this report does nor provide estimates of the sources that account for the remaining 72%.

TABLE 7.1 Sources of PCBs to the Great Lakes (Total)

SOURCE	Tonnes/year Dolan 1985	Tonnes/year IJC 1985	Tonnes/year WQB 1989	Percentage Dolan 1985	Percentage IJC 1988
INDUSTRIAL OUTFALLS	0.04			3%	
SEWAGE TREATMENT PLANTS	N/A		0.15	N/A	
ATMOSPHERIC DEPOSITION	0.81	1.944		62%	28%
TRIBUTARIES	0.45			35%	
OTHER		5.043			72%
TOTAL FOR AVAILABLE DATA	1.30	6.987		100%	100%

Sources: Dolan 1985; IJC 1988

TABLE 7.2 Sources of PCBs to the Great Lakes (Lake Superior)

SOURCE		Tonnes/year Dolan 1985	Tonnes/year IJC 1988	Kilograms/day Dolan 1985	Percentage Dolan 1985	Percentage IJC 1988
INDUSTRIAL DIRECT		0.00			0%	
-Wisconsin	American Can			0.0041		
SEWAGE TREATMENT PLANTS		N/A			N/A	
ATMOSPHERIC DEPOSITION		0.12	0.545		80%	90%
TRIBUTARIES		0.03			20%	
-Ontario	Little Pic			0.029		
	Pic				0.048	
OTHER				0.061		10%
TOTAL FOR AVAILABLE DATA		0.15	0.606		100%	100%

Data Sources: Dolan 1985; IJC 1988

TABLE 7.3 Sources of PCBs to the Great Lakes (Lake Michigan)

SOURCE		Tonnes/year Dolan 1985	Tonnes/year IJC 1988	Kilograms/day Dolan 1985	Percentage Dolan 1985	Percentage IJC 1988
INDUSTRIAL DIRECT		0.03				
-Wisconsin	Badger Die Cast			0.0000		
	Bergsrtom Paper			0.0024		
	Fort Howard Paper			0.0492		
	Kimberly Clark			0.0025		
	Scott Paper			0.0040		
	Wisconsin Tissue			0.0261		
SEWAGE TREATMENT PLANTS		N/A				
ATMOSPHERIC DEPOSITION		N/A	0.397			58%
OTHER			0.288			42%
TOTAL FOR AVAILABLE DATA		0.03	0.685			100%

Sources: Dolan 1985; IJC 1988.

TABLE 7.4 Sources of PCBs to the Great Lakes (Lake Huron)

SOURCE		Tonnes/year Dolan 1985	Tonnes/year IJC 1988	Kilograms/day Dolan 1985	Percentage Dolan 1985	Percentage IJC 1988
INDUSTRIAL DIRECT		0.01			2%	
Michigan	GMS-Chev Metal			0.0118		
	GMS-Chev Motor			0.0048		
SEWAGE TREATMENT PLANTS		N/A			N/A	
ATMOSPHERIC DEPOSITION		0.56	0.496		90%	78%
TRIBUTARIES		0.05				8%
-Ontario	Saugeen			0.039		
	Severn			0.108		
OTHER			0.140			22%
TOTAL FOR AVAILABLE DATA		0.62	0.636		100%	100%

Data Sources: Dolan 1985; IJC 1988

TABLE 7.5 Sources of PCBs to the Great Lakes (Lake Erie)

SOURCE	Tonnes/year Dolan 1985	Tonnes/year IJC 1988	Kilograms/day Dolan 1985	Percentage Dolan 1985	Percentage IJC 1988
INDUSTRIAL DIRECT	0.00			0%	
-Michigan Ford Wixom			0.0001		
SEWAGE TREATMENT PLANTS	N/A			N/A	
ATMOSPHERIC DEPOSITION	0.12	0.328		57%	13%
TRIBUTARIES	0.09			43%	
-Ontario Big Otter			0.020		
Grand			0.125		
Thames			0.080		
Kettle			0.010		
OTHER		2.192			87%
TOTAL FOR AVAILABLE DATA	0.21	2.520		100%	100%

Data Sources: Dolan 1985; IJC 1988

TABLE 7.6 Sources of PCBs to the Great Lakes (Lake Ontario)

SOURCE	Tonnes/year Dolan 1985	Tonnes/year IJC 1988	Kilograms/day Dolan 1985	Percentage Dolan 1985	Percentage IJC 1988
INDUSTRIAL DIRECT	N/A			N/A	
SEWAGE TREATMENT PLANTS	N/A			N/A	
ATMOSPHERIC DEPOSITION	0.01	0.178		3%	7%
TRIBUTARIES	0.28			97%	
-Ontario Don			0.009		
Etobicoke			0.005		
Humber			0.016		
Twelve Mile			0.367		
Welland Ship			0.364		
[Niagara River]			[10.541]		
OTHER		2.362			93%
TOTAL FOR AVAILABLE DATA	0.29	2.540		100%	100%

Data Sources: Dolan 1985; IJC 1988;
Note: OTHER attributed but non-allocable to listed sources.

TABLE 7.7 Sources of PCBs to the Great Lakes (St. Lawrence)

SOURCE	Tonnes/year Dolan 1985	Tonnes/year IJC 1988	Kilograms/day Dolan 1985	Percentage Dolan 1985	Percentage IJC 1988
INDUSTRIAL DIRECT					
-New York Chev Motor			0.0001		
SEWAGE TREATMENT PLANTS					
ATMOSPHERIC DEPOSITION					
SEDIMENTS					
GROUNDWATER					
TRIBUTARIES					

The importance of tributary loadings of PCBs is suggested by some estimates of PCB pathways into Lakes Michigan that are summarized in Table 7.8.

TABLE 7.8 PCB Pathways to Lake Michigan

Pathways	Kg/year	Percent
Tributaries (include sediment releases and direct dumping)	1,150	75.0
Atmospheric	380	24.7
Direct Discharges to Lake (industry & STPs)	5	0.3
TOTAL	1,535	100.0

Source: National Wildlife Federation and Canadian Institute for Environmental Law and Policy (1991).

According to Lamay (1990), 76.4% of all tributary loadings to Lake Michigan is "sediment-bound" and so considered to be deposited to the Lake from the sediments as opposed to from current discharge sources. No individual discharger to Lake Michigan is releasing more than 2 kg/year. A further breakdown of Lake Michigan tributary loadings is given in Table 7.9.

TABLE 7.9 Lake Michigan Tributary Loads

Pathways	Kg/year	Percent
Fox	520	38.0
Grand Calumet	191	14.0
Kalamazoo	114	8.4
Waukegan	20	1.5
TOTAL	845	61.2%*

* Note that Sheboygan Harbor, whose sediments are heavily contaminated with PCBs, has been omitted, "because of clean-up activities already under way. Source: National Wildlife Federation and Canadian Institute for Environmental Law and Policy 1991.

7.1.1 Sources of Atmospheric Deposition of PCBs

Atmospheric deposition accounts for a smaller proportion of total PCBs entering the Great Lakes than for mercury. However, it is still sufficiently important to examine its origins. Tables 7.10 to 7.12 gives estimates of air emissions of PCBs in Ontario and Eastern N. America.

TABLE 7.10 Air Emissions of PCBs in Ontario and Eastern North America in 1985 (kg/yr)

Emission Category	Ontario	Eastern North America
Stationary Fuel Combustion	6.9	446
Solid Waste Incineration	1.2	42
Open Sources	36.9	517
TOTAL	45.0	1,005

Source: Ortech 1990

TABLE 7.11 Ontario Air Emissions of PCBs in Detail, 1985 (kg/yr)

CATEGORY/SECTOR		POINT	AREA	TOTAL	RANK
Stationary Fuel Combustion	Electrical Power Generation	6.8		6.8	2
	Industrial Fuel Combustion		0.1	0.1	6
	Sub-Total	6.8	0.1	6.9	
Solid Waste Incineration	Municipal Waste Incineration	0.4		0.4	5
	Sewage Sludge Incineration	0.3	0.5	0.8	4
	Industrial Waste Incineration	0.0		0.0	7
	Commercial Institutional Waste Incineration		0.0	0.0	8
	Sub-Total	0.7	0.5	1.2	
Open Sources	Transformer Leakage		33.6	33.6	1
	Municipal Refuse-Landfill		3.3	3.3	3
	Sub-Total		36.9	36.9	
TOTAL		7.6	37.4	44.9	

Source: Ortech 1990

TABLE 7.12 Eastern North America Emissions of PCBs in Detail, 1985 (kg/yr)

CATEGORY/SECTOR		EMISSION
Stationary Fuel Combustion	Electrical Power Generation	337.6
	Industrial Fuel Combustion	108.1
	Sub-Total	445.7
Solid Waste Incineration	Municipal Waste Incineration	11.2
	Sewage Sludge Incineration	3.6
	Industrial Waste Incineration	6.9
	Commercial/Institutional Waste Inc.	3.0
	Waste Oil Combustion	17.0
	Sub-Total	41.5
Open Sources	On-site Incineration	8.2
	Transformer Leakage	440.5
	Municipal Refuse-Landfill	68.7
	Sub-Total	517.4
TOTAL		1,004.7

Source: Ortech 1990

Data for 1989 from the U.S. EPA Toxic Release Inventory Data (TRI) shows that total air emission releases from "Lake Michigan States", (Western Michigan, Wisconsin, Indiana and Illinois) totalled 8.56 kg/yr. TRI includes only manufacturing facilities that produce, process or use over 10,000 lbs of one of the 332 TRI listed chemicals or over 50,000 lbs of all TRI chemicals combined. These data are presented in Table 7.13.

Given the estimated air emissions of 350 kg/yr (Lamay 1990) these point source loadings in the TRI account for under 3% of atmospheric loadings.

Lamay cites an estimate by Murphy et al (1985) that the contribution of MSW plants, due to the lack of restriction on burning of materials containing small quantities of PCBs (such as carbonless copy paper, capacitors on fluorescent light ballasts, starting capacitors on refrigerator and washing machine motors) is .25 kg/yr per stack. Lamay (1990), without knowing the actual number of incinerators in the region, estimates total MSW emissions at about 120 kg/yr with 13-117 kg/yr deposited to Lake Michigan. Sewage sludge incinerators are estimated to emit 50 kg/yr of which 0-12.5 kg/yr enter Lake Michigan.

TABLE 7.13 Air Emissions of PCBs in the Lake Michigan States

STATE	FACILITY	RELEASE (kg/yr)
Illinois	SCA Chemical Services	1.09
	Album, Inc.	.09
	AMCE International	.18
	Northwestern Waste Energy	5.40
Wisconsin	City of Sheboygan Department of Public Works	.54
	Intercommunity Incinerator Dist.	.63
	City of Waukasha	.18
Indiana	East Chicago Municipal	.18
	Swift Adhesive	.27
	TOTAL	8.56

Source: TRI; Lamay 1990

7.2 The Control of PCB Discharges

Proven chemical and incineration technologies are available to remediate and treat PCB liquids and solids, industrial wastewater, and groundwater. Technologies are also available to treat soil contaminated with PCBs but these are expensive. PCB contaminated sediment is more difficult to treat and effective technologies have not yet been demonstrated on a large scale. Removal and treatment of subsurface contamination may not be technically feasible.

Prevention rather than treatment is likely to be the most cost-effective approach for reducing PCBs entering the Great Lakes. This requires a reduction in the use of PCBs and the elimination of stocks in storage.

7.3 Applicability of Economic Instruments

As in the previous chapter on mercury, this section follows the analytical framework of Chapter 5 in assessing the role that economic instruments might play in achieving the virtual elimination of PCBs entering the Great Lakes.

PCBs are one of the 11 critical pollutants identified by the IJC and, as a persistent toxic that bioaccumulates in fatty tissue, the goal of virtual elimination applies. Indeed, the ban on the production, importation and sale of PCBs in Canada and the United States in the late 1970s demonstrates the commitment that governments in both countries have made to eliminating PCBs from the environment. However, as the previous sections have shown, significant quantities of PCBs continue to enter the Great Lakes environment from a variety of sources, the most important of which are believed to be from contaminated sediments in tributaries and deposition from the air.

Even though there is ample opportunity to improve the data on PCB loadings entering the Great Lakes, and such improvements are a pre-requisite for introducing any type of economic instrument, it is unlikely to affect the overall picture which shows that the majority of PCB sources are not readily amenable to economic instruments. The single largest category of PCB loadings in the Great Lakes is from contaminated sediments which may account for 50% or more of total loadings. These sources are beyond the control of economic instruments and direct regulation unless the sediments are the legal property or responsibility of a corporation, municipality or individual. This is seldom the case.

An unknown proportion of the tributary loadings, perhaps as much as 25% of total loadings, come from point source discharges. These could be amenable to economic instruments if detailed information on them was available.

Some 25-30% of total PCB loadings in the Great Lakes come from air emissions. Transformer leakages and municipal landfills are believed to represent about 50% of these emissions and these could not easily be controlled through economic instruments. Stationary fuel combustion, especially for electrical power generation, creates about 45% of the total air emissions and incineration takes care of most of the remainder. Economic instruments could be applied to these last two categories of sources but their combined contribution to the total PCB loadings is only about 15% of the total. Most of the remaining PCBs entering the Great Lakes appear to come from municipal sewage treatment plants which might also respond to control through economic instruments.

In summary, therefore, less than 40% (possibly much less) of the total PCB loadings in the Great Lakes can even be considered as potentially suitable for control through economic instruments assuming that far better data than are currently available could be obtained on the specific point sources responsible. Furthermore, as with mercury, the situation is complicated by the fact that many of the sources of airborne emissions of PCBs are situated outside of the Great Lakes basin.

In view of the fact that PCBs are no longer permitted to be manufactured, imported or resold anywhere in Canada or the United States (with minor exceptions for research) there is no need to rely on economic instruments to provide incentives to develop less harmful substitutes or alternative production processes. Likewise, there is little opportunity for economic instruments to capitalize on differences in abatement costs for PCBs given that strict controls on emissions are already in existence. The problem seems to be those of monitoring and enforcement which would not be lessened by the introduction of tradeable permits or effluent charges.

Given the current state of knowledge it seems that the greatest reductions in discharges can probably be achieved by cleaning up the more severely contaminated Great Lakes basin sediments. However, such clean ups are currently quite expensive. Accelerating the removal of PCBs from electrical equipment through regulation, supported by fines or financial enforcement incentives, would also reduce future emissions significantly providing the PCBs so removed are disposed of effectively. The exemption allowing wastes containing under 50 parts per million of PCBs to be exempted from strict PCB disposal controls, found in both in Canadian and U.S. law, could be removed. Other reductions could be achieved by tighter control of direct discharges to water and discharges to sewage treatment plants, strict quality control at PCB destruction facilities and other currently permitted "closed" system uses of PCBs could be restricted or eliminated. Actions such as these can be best be implemented through direct regulation.

In summary, even if better data on sources were available, the prospects for using economic instruments to achieve the virtual elimination of PCBs in to the Great Lakes, except in a supporting role of financial enforcement incentives, seems limited.

8.0 AN ECONOMIC PROFILE OF THE PULP AND PAPER INDUSTRY IN THE GREAT LAKES BASIN

The pulp and paper industry has historically been characterized by slow, steady market growth and limited technological innovation. Recently, however, the industry has been showing signs of moving into a period of rapid technological change.

The "globalization" of pulp and paper markets, involving free trade between Canada and the United States as well as the emergence of low cost third world producers is bringing heavy pressure on the industry to become more efficient. The advanced age and relatively small scale of Ontario's pulp and paper facilities make them particularly vulnerable to these pressures.

The need to reduce acute and persistent toxic emissions from pulp and paper mills will require this industry to make significant process changes. In particular, new chlorine-free bleaching technologies may have to be adopted. New air and water pollution control equipment will also have to be purchased.

Growing pressure from governments and consumers to increase the recycled fibre content of paper products is increasing the need for mills which can reuse waste papers. In combination with demand for reduction in the over all use of packaging materials, the demand for recycling may also reduce the market for pulp and paper products made with virgin fibres.

While the need to adapt to new circumstances will create financial risks, it will also present innovative pulp and paper producers with great opportunities. Currently many companies, particularly those operating in Canada, are suffering the effects of a recession, but on the whole the industry is believed to be generally sound and healthy (Pulp and Paper, January 1991; U.S. Department of Commerce 1990; Value Line, January 1991). Companies are believed to be in a position to make the investments that will be necessary to survive in a global, ecologically sustainable market.

8.1 Pulp and Paper Industry Products

Pulp, paper and board making constitute the most important sector of the North American forest products industry, in terms of tonnes of product as well as dollar value. The sector also serves the lumber and plywood manufacturing sectors as a market for by-products of their production.

For most purposes, pulping processes can be categorized as either chemical or mechanical, although the two processes are sometimes used in combination. The levels of use of these methods of pulping in the United States, Canada and the rest of the world can be seen in Tables 8.1, 8.2 and 8.3, respectively.

Mechanical pulping involves turning wood into fibre by means of grinding or beating. Between 85 and 95% of the wood furnished to a mechanical process is actually used in the product. As a result of retaining most of the wood content, individual fibres retain a high lignin content and are relatively stiff. The resulting pulp has relatively few contact points between fibres and so produces paper with a relatively low strength.

Chemical pulping can produce a relatively strong product from virtually any sort of wood. Lignin and some hemicelluloses are removed from the wood by chemical pulping, producing more flexible and better bonding fibres. Typical kraft pulp uses about 45 to 55% of the wood furnished to the process. Softwoods produce stronger kraft pulp than do hardwoods.

Mechanical pulp is characterized by its opacity, ink absorbtivity, resilience and stiffness. These characteristics make mechanical pulp desirable as a source of newsprint (typically containing 80 to 100% mechanical pulp), printing and writing papers (including supercalendered magazine paper), lightweight coated papers (typically containing 30 to 60% mechanical pulp), and folding carton boards (normally 30 to 50% mechanical pulp).

Semichemical pulp is used mainly for corrugating medium. Semichemical pulp is desirable for this use due to its ability to resist compression and crushing.

Recycled fibre has most commonly been used as a furnish for packaging papers and boards. It is also used in sanitary and creped papers. The use of recycled furnish for making newsprint is rapidly increasing. Some use is now also being made of recycled fibre in printing papers.

Chemical pulp is distinguished by its length and strength and is used as a reinforcement fibre in nearly all paper and board grades. Softwood chemical pulp is stronger than hardwood pulp. Hardwood chemical pulp, on the other hand is slightly cheaper and has good surface formation characteristics. About 50% of chemical pulp used worldwide is bleached.

TABLE 8.1 United States Woodpulp, Paper and Paperboard Production and Capacity
(Thousands of Short Tons)

	1987	1989	1990 (est.)	1990 (max. capacity)	1991 pract.
WOODPULP					
Dissolving & Special Alpha	1,311	1,425	1,301	1,495	1,495
Chemical Pulp, Paper Grades	48,293	50,181	50,640	52,518	54,510
Sulphite, bleached	1,269	1,554	1,565	1,433	1,433
Sulphite, unbleached	171	(incl. in bleached)		189	189
Kraft and Soda, unbleached	21,442	21,648	21,914	23,020	23,671
Kraft, bleached and semibleached	25,411	26,979	27,100	27,876	29,217
Semichemical	4,246	4,363	4,409	4,929	4,964
Groundwood and Thermomechanical	5,700	6,029	6,292	7,327	7,585
Total Woodpulp	60,239	61,998	62,643	66,265	68,554
PAPER					
Newsprint	5,842	6,088	6,499	6,808	7,123
Groundwood Printing and Converting	1,498	1,743	1,751	1,808	1,877
Coated Papers	6,860	7,215	7,312	8,499	8,903
Uncoated Free Sheet	10,966	11,081	11,498	12,403	13,022
Tissue	5,301	5,636	5,733	5,972	6,127
Packaging & Industrial Converting	4,955	4,925	4,669	5,475	5,600
Other	1,798	N/A	N/A	N/A	N/A
Total Paper	36,876	38,256	39,009	42,649	44,342
PAPERBOARD					
Unbleached Kraft Paperboard	18,898	19,490	19,996	21,482	22,409
Solid Bleached Paperboard	4,406	4,521	4,474	4,838	5,051
Semichemical Paperboard	5,536	5,691	5,708	6,003	6,010
Combination Furnish Board	8,601	8,754	8,742	10,029	10,370
Total Paperboard	37,442	38,456	38,921	42,352	43,840
GRAND TOTAL	134,557	138,710	140,573	151,266	156,736

Source: Lockwood-Post 1990

TABLE 8.2 Canada Paper and Paperboard Production and Capacity
(Thousands of Short Tons)

	1987	1989	1990 (est.)	1990 (max. capacity)	1991 pract.
WOODPULP					
Dissolving & Special Alpha	266	301	254	278	278
Chemical Pulp, Paper Grades	13,890	13,738	12,792	15,368	15,838
Sulphite, bleached	500	458	455	530	530
Sulphite, unbleached	1,428	1,335	1,156	1,422	1,389
Kraft, unbleached	1,624	1,481	1,345	1,720	1,720
Kraft, semi-bleached	10,338	10,464	9,836	11,696	12,199
Semichemical	389	374	433	565	565
Mechanical	10,764	11,538	11,784	13,760	14,609
Total Woodpulp	25,328	25,965	25,271	29,971	31,290

Continued

TABLE 8.2 Canada Paper and Paperboard Production and Capacity (continued)
(Thousands of Short Tons)

	1987	1989	1990 (est.)	1990 (max pract. capacity)	1991
PAPER					
Newsprint	10,653	10,667	10,400	12,161	12,744
Printing & Writing	2,927	3,515	4,076	4,453	4,696
Kraft Packaging Papers	625	579	567	576	594
Tissue & Specialty	503	537	535	722	752
Total Paper	14,708	15,298	15,578	17,912	18,786
PAPERBOARD					
Containerboard	2,154	2,143	2,244	2,483	2,507
Boxboard	818	803	783	1,005	1,073
Total Paperboard	2,972	2,946	3,027	3,488	3,580
GRAND TOTAL	43,008	44,209	43,876	51,371	53,656

Source: Lockwood-Post (1990)

TABLE 8.3 Global Share of Production. Papermaking Raw Materials, 1985

Raw Material	Share (%)
Chemical pulp, softwood	32
Chemical pulp, hardwood	13
Mechanical pulps (mainly softwood)	16
Semichemical pulps (mainly hardwoods)	4
Recycled fibre	22
Chemicals, fillers, synthetic fibres	7
Pulps from non-woody plants	6
TOTAL	100%

Source: Ebeling 1987

Table 8.4 indicates the levels of global consumption of various sorts of paper and paperboard products. Tables 8.1 and 8.2 may also be referred to for levels of production of those products within the United States and Canada.

TABLE 8.4 Total Global Consumption of Paper and Board, 1985

Paper Board Grand	Consumption (million tons/year)
Printing and Writing	49
Newsprint	28
Soft Tissue Paper	11
Sack Paper	6
Total Paper (55%)	105
Linerboard	30
Corrugating Medium (fluting)	15
Total Board (45%)	86
GRAND TOTAL	190

Source: Ebeling 1987

8.2 The Economic Significance of the Pulp and Paper Industry

8.2.1 Ontario

The pulp and paper industry is one of Ontario's most important industries. In the past several years the industry's growth has been slower than that of the provincial economy as a whole, resulting in a decline in the industry's share of total provincial production and employment. Nevertheless, changes in demand for its products still have widespread implications for the Ontario economy. In particular, communities in Northwestern Ontario and along the shore of Lake Superior are heavily dependent upon pulp and paper production

- Employment

In 1985, the "Paper and Allied Industries," comprised of pulp, paper and paperboard makers as well as manufacturers of asphalt roofing, directly employed approximately 41,000 people in Ontario. This amounts to approximately 1.2% of the Ontario workforce. Of these, approximately 20,000 were employed in the pulp and paper sector, 11,000 were employed in the specialty and fine paper sector (not included in pulp and paper), 10,000 were employed in the paperboard and bag sector and 600 were employed in asphalt roofing manufacture (Coke 1988).

Employment in the Paper and Allied Industries has been declining slightly over the past twenty years. This change is largely attributable to the modernization of the pulp and newsprint making sectors. Statistics Canada estimates that a further 57,000 jobs are indirectly stimulated by the Ontario Paper and Allied Industries (Coke 1988).

- Provincial Gross Domestic Product

The Paper and Allied Industries contributed about C$2.5 billion to the province's total manufacturing value-added in 1985. Of this, about C$1.5 billion came from the pulp and paper sector, C$534 million from production of fine and specialty papers (not included in pulp and paper), C$431 million from the paperboard and paper bag sector and C$61 million from asphalt roofing manufacture.

Approximately 2.7% of the Ontario Provincial Gross Domestic Product has historically been generated by the Paper and Allied Industries (Coke 1988).

- National Paper and Allied Industries

In 1987, Ontario produced 24% of the total value of Canadian pulp and paper shipments (C$4.2 billion), as well as 23% of the value added and 25% of total national employment in the industry (Canadian Pulp and Paper Association 1989).

- Exports

In 1985, Canadian exports of pulp and paper products earned C$10.3 billion dollars. C$5.4 billion (C$1.1 billion from Ontario) came from the export of newsprint, C$3.4 billion (C$0.5 billion from Ontario) from the sale of pulp and C$1.5 billion (C$0.5 billion from Ontario) from the sale of other paper and paperboard products (Coke 1988).

- Regional Economies

Nearly half of the value added by the Paper and Allied Industries in Ontario is created in Cental Ontario, while about one quarter is generated in Northwestern Ontario. About ten percent each are produced in the Northeast and East of the province. About three percent of total value-added is generated in the Southwestern portion of the province. However, over 70% of all manufacturing activity in the Northwest and about 20% of that in the Northeast is generated by the Paper and Allied Industries.

Employment created directly by the Paper and Allied Industries is distributed across the province in proportions almost identical to those for the generation of value added. Similarly, over 60% of manufacturing employment in the Northwest of Ontario is in the Paper and Allied Industries, as is about 15% of Northeastern manufacturing employment (Coke 1988).

Within the larger region currently being studied at the Ontario Class Environmental Assessment for Timber Management on Crown Lands (all of Northern Ontario but for the north most portions of Kenora and Cochrane Districts and bordering Southern Ontario Counties where there is significant logging activity), the Paper and Allied Industries are the third largest private sector employer, the second largest source of income, and first in terms of value of sales per full-time employee (Table 8.5).

8.2.2 United States

Detailed information on the importance of the pulp, paper and paperboard industries to the regional economies of the Great Lakes states was not found. As a whole, the United States pulp, paper and paperboard industries employed 195,000 people, and produced value added equal to U.S.$23 billion, from shipments of a total value of U.S.$27 billion (U.S. Department of Commerce 1990).

In Michigan, during 1987, the production of Paper and Allied Products directly created 20,600 jobs (3% of state total), produced U.S.$1.7 billion dollars in value added (3% of state total) and shipped U.S.$3.6 billion worth of products (2.5% of state total) (U.S. Department of Commerce 1990).

In Wisconsin, in 1987, the Paper and Allied Products Industry employed 43,000 people (8% of state total), produced U.S.$3.9 billion in value-added (12% of state total) and shipped products with a value of U.S.$8.8 billion (13% of state total) (U.S. Department of Commerce 1990).

TABLE 8.5 Direct Economic Contribution to the Area of the Undertaking for the Ontario Class Environmental Assessment of Timber Management, Made by the Forest, Mining and Primary Metals, Tourism and Fur Industries, 1986

		EMPLOYMENT (person-years)	VALUE OF SALES VALUE OF SALES OR EXPENDITURES ($C-millions)	VALUE OF SALES PER FULL-TIME EQUIVALENT ($C-000s)
Forest Industry	Logging	7,470	985	132
	Forestry Services	3,865	60	16
	Wood Industry	9,500	1,215	128
	Paper & Allied Industries	15,045	2,430	162
	Total	35,880	4,690	131
Mining and Primary Metals	Mines	15,745	2,475	157
	Primary Metals	13,335	1,665	125
	Total	29,080	4,140	142
Tourism	Total	27,100	1,310	48
Fur Industry	Total	700	14	20

Source: Peat Marwick 1989

In Ohio, during 1987, the production of the Paper and Allied Products Industry employed 30,000 people (3% of state total), produced U.S.$1.9 billion in value-added (3% of state total) and shipped products with a value of U.S.$4.4 billion (3% of state total) (U.S. Department of Commerce 1990).

In New York, during 1987, the production of Paper and Allied Products employed 40,000 persons (3% of state total), created U.S.$2.2 billion in value-added (3% of state total) and produced shipments worth U.S.$4.8 billion dollars (3% of state total) (U.S. Department of Commerce 1990).

While the Michigan pulp and paper industry is located entirely within the Great Lakes basin, only a part of Wisconsin, Ohio and New York's pulp and paper production facilities are within that area. In Illinois, Indiana and Minnesota, only a small portion of pulp and paper industry facilities are located in the Great Lakes basin.

Table 8.6 indicates the total levels of pulp, paper and paperboard production in the region which includes the Great Lakes basin, as well as giving an indication of the importance of the region to the U.S. pulp and paper industry as a whole.

TABLE 8.6 Paper, Paperboard and Woodpulp Production, North Central Region (Thousands of Short Tons, 1987)

	Paper	Paperboard	Pulp
North Central	8,076	4,949	4,647
Total U.S.	36,134	36,990	62,357

Source: Lockwood-Post (1990)

8.3 Industry Structure

Production facilities in the pulp and paper sector tend to be very large due to the capital intensive nature of new capacity construction. Environmental, energy and automation costs per unit of output are generally lower in larger mills. Increasingly, logging, pulping and papermaking facilities are being integrated to take advantage of economies in transport and materials costs.

Investment in such large integrated facilities carries an inherently high investment risk not easily borne by smaller companies (Table 8.7). In addition, the high capital costs of these large facilities leave them relatively inflexible in the face of demand changes induced by the business cycle. As a consequence of these factors, the North American pulp and paper industry shows strong signs of increasing concentration of ownership. This is particularly true of the pulp and newsprint sectors of the industry.

TABLE 8.7 Capital Cost of Pulp and Paper Facilities, 1984 (1984 U.S. dollars)

Facility Type		Facility Size (tons/day)	Cost (1984 U.S.$)
Pulp Mill	Unbleached kraft	1,000	338,500,000
	Bleached kraft mill	1,000	414,500,000
	Bleached sulfite	1,000	407,100,000
	Thermomechanical	1,000	171,800,000
Paper Mill	Newsprint	1,000	254,000,000
	Fine paper	1,000	280,100,000

Source: Tillman 1985

Competitive efforts in the industry tend to focus on reducing manufacturing prices and offering discounts on publicly advertised prices. There has historically been little competition for technical leadership in the industry. The industry is characterized by relatively old technology. Pulp and paper industry products are also considered by the industry to be more or less substitutable within each product grade. It is not entirely clear why the pulp and paper industry has shown so little competitiveness in distinguishing products. A number of factors are cited as possible explanations: the industry's basic technology is relatively old and available to anyone; customers consider the producers' products within each category to be close substitutes; markets are well established and growing steadily, showing consumers' contentment with the types of products they are receiving.

Low levels of technological innovation and new product creation are also ascribed to a number of other causes. In particular: high capital risks involved in applying new manufacturing processes-- as developing a production technology from laboratory testing to bench scale, pilot scale, prototype and finally established use typically is a long (5 to 10 years) and costly process; reductions in cash flows resulting from the fact that the pulp and paper industry had about ten lean years before a profit jump in the late 1980s. The fact that equipment and process development tends to be by equipment builders rather than the pulp and paper industry may also be of significance.

The different sectors of the pulp and paper industry reflect varying degrees of concentration.

- Newsprint

The North American newsprint market can be characterized as oligopolistic. Ten firms control 67% of newsprint capacity and six companies control 47% (McCubbin 1990). A total of 62 mills are operated in North America by 31 companies.

Increased use of recycled newsprint will offer significant opportunities for new entrants. New recycling mills can be located close to urban areas and are economical to build on a smaller and less expensive scale. This may well attract new entrants into newsprint production.

Short term overcapacity of virgin fibre newsprint capacity may prevent producers from using their oligopoly situation to pass on price increases in the short term. But in the longer run, oligopolistic conditions should allow producers to pass on a significant portion of environmental control costs.

- Market Pulp

Market pulp production is also characterised by an oligopolistic structure. Within Canada 28 market kraft pulp producing mills are controlled by "roughly 20" companies (McCubbin 1990). Across North America, levels of concentration similar to those in the newsprint sector are found: The top five companies in the industry control 39% of market share and the top ten companies control 59% (Pulp and Paper, October 1990).

Capital costs of building an optimally sized new kraft pulp mill, which would produce 1200 tonnes of pulp per day, are in the area of C$1.4 billion (McCubbin 1990). This is a significant barrier to entry. Environmental control costs may also contribute to the difficulty of entry. In addition, a mill must have access to a very large area of forest, over a long period of time. In Northern Ontario, McCubbin estimates that an optimally sized pulp mill would require access to about 63,000 acres of forest every year.

- Printing and Writing Papers

The printing and writing papers sector is far less homogeneous than the newsprint and pulp sectors, producing a wide variety of product types. However, market niches within this larger sector tend to be dominated by small numbers of companies. For instance, in the North American market for coated free-sheet paper (used in magazines, catalogues, commercial printing and some books) three companies hold 53% of the market share, the largest five hold 66% and the top ten companies hold 99% (Pulp and Paper, July 1990).

U.S. production in this sector is far larger than Canada's. Trade between Canada and the United States in this sector is relatively small, although this may be attributable to the past existence of significant tariff barriers.

- Other Sectors

Like the printing and writing sector, the rest of the pulp and paper industry shows a significant level of diversity while at the same time small numbers of companies dominate the production of individual products (Table 8.8).

TABLE 8.8 Market Share in Selected U.S. Pulp and Paper Markets

MARKET AND LEADING PRODUCER		MARKET SHARE	TOP FIVE MARKET SHARE	TOP TEN MARKET SHARE	TOTAL MARKET CAPACITY (000 short T/y)
Kraft Paper	Stone Container	23.1%	69.0%	96.0%	2,745
Bleached Paperboard	International Paper	19.7%	65.4%	92.4%	4,838
Kraft Linerboard	Stone Container	14.0%	49.7%	78.4%	20,339
Tissue	Scott Paper	19.1%	75.1%	92.2%	6,113
Corrugating Medium	Georgia-Pacific	19.5%	47.9%	67.9%	8,200

Source: Pulp and Paper, various issues.

- Companies

The overall North American pulp and paper market is spread across a moderately large number of companies (Table 8.9). These are, however, large and often regionally very influential. The market power of these companies is significantly magnified by the fact that the industry is fractured into a large number of specialty paper and board manufacturing sectors. Each of these sectors tends to be dominated by a small number of producers.

TABLE 8.9 The 20 Largest North American Paper Companies, 1989
(millions of U.S. Dollars)

		PAPER AND ALLIED PRODUCTS SALES	TOTAL SALES	RANK BY TOTAL SALES
1.	International Paper	9,224.0	11,378.0	1
2.	James River	5,950.0	5,950.0	4
3.	Kimberly-Clark	5,577.1	5,733.6	5
4.	Stone Container	5,165.3	5,329.7	6
5.	Scott Paper	5,065.6	5,065.6	8
6.	Georgia-Pacific	4,042.0	10,171.0	2
7.	Champion International	4,037.0	5,163.2	7
8.	Great Northern Nekoosa	3,754.3	3,863.1	11
9.	Weyerhaeuser	3,723.4	10,105.6	3
10.	Noranda Forest	2,434.1	4,111.5	10
11.	Boise Cascade	2,380.4	4,338.0	9
12.	Union Camp	2,147.9	2,761.3	13
13.	Westvaco	2,077.8	2,284.1	16
14.	Mead	2,048.5	4,612.1	12
15.	Canadian Pacific Forest Products	1,996.6	2,429.0	15
16.	MacMillan Bloedel	1,532.0	2,764.9	12
17.	Domtar	1,515.2	2,124.2	17
18.	Temple-Inland	1,506.7	1,894.2	18
19.	Bowater	1,450.0	1,450.0	20
20.	Abitibi-Price	1,323.0	2,751.4	14

Source: Lockwood-Post 1990

Ownership of individual pulp and paper companies is more widely held in the United States than in Ontario. In Ontario, control of pulp and paper companies tends to be held by small numbers of investors (Table 8.10). Some of the larger U.S. companies have dominant shareholders: the Stone family hold 25% of Stone Container, Warren Buffett and Laurence Tisch have taken sizeable positions in Champion International, the Weyerhaeuser family maintains a significant stake in Weyerhaeuser -- but most of the larger U.S. companies appear to be widely held.

TABLE 8.10 Ownership of Ontario Pulp and Paper Mills, 1990

Mills	Principal Shareholders		
Abitibi Price	Olympia and York	-	78%
Beaver Wood Fibre	Georgia Pacific	-	100%
CPFP (Thunder Bay Mills)	Canadian Pacific	-	85%
Domtar	Public	-	56%
	Quebec Government	-	44%
E.B. Eddy	George Weston	-	100%
Fraser	Noranda	-	100%
James River (Marathon Mill)	James River	-	80%
	Buchanan	-	20%
Kimberly Clark of Canada	Kimberly Clark	-	100%
Macmillan Bloedel	Noranda	-	50%
Quebec & Ontario Paper	Chicago Tribune	-	100%
St. Marys Papers	Private	-	75%
	Rauma Rapola	-	25%
Trent Valley Paperboard		-	N/A

Source: McCubbin 1990

Table 8.11 indicates which of these companies are operating mills in the Great Lakes basin and gives some description of the mills.

TABLE 8.11 Pulp, Paper and Paperboard Mills in the Great Lakes

LOCATION AND MILL		RECEIVING WATER	MILL TYPE	PROD. (t/d)	TREATMENT	NOTES
			LAKE SUPERIOR BASIN			
Ontario						
Thunder Bay	Abitibi-Price Fine Papers	Thunder Bay Harbour	Groundwood	125	P	Total, 442 t/d fine and coated papers
Thunder Bay	Abitibi Price, Ft-William	Thunder Bay	Groundwood CMP	235 135	P	Total, 383 t/d newsprint
Thunder Bay	Abitibi-Price, Thunder Bay	Thunder Bay	Groundwood Sulphite	320 120	P	Total, 442 t/d newsprint
Thunder Bay	CPFP	Kaministikwia River	Groundwood Sulphite Kraft	910 300 1,300	P	Total, 1,170 t/d newsprint
Red Rock	Domtar Packaging	Nipigon Bay	Kraft Groundwood Semi-bleached kraft	600 150 50	P	Total, 600 t/d linerboard 200 t/d newsprint
Terrace Bay	Kimberly-Clark	Jackfish Bay	Kraft	1,200	P, S	Total, 1,200 t/d bleached kraft pulp
Marathon	James River	Peninsula Harbour	Kraft	440	P	Total, 440 t/d bleached kraft pulp
Wisconsin						
Superior	Superior Fibre (Subs. of Georgia-Pacific)	Lake Superior	Defibrating	140	P: Closed system	Hardboard, 140 t/d
Ashland	James River	Chequamegon Bay	Deink and Bleach	65	P, S	Tissue, Napkings, 65 t/d
Michigan						
Ontonagon	Stone Container	Ontonagon River	Semi-chemical	575	P, S	Corrugating Medium, 550 t/d
Munising	Kimberly-Clark	Lake Superior	(Paper Mill)		P	Specialty Papers, 98 t/d

P = Primary; S = Secondary; t/d = tonnes/day

Continued

TABLE 8.11 Pulp, Paper and Paperboard Mills in the Great Lakes (continued)

LOCATION AND MILL	RECEIVING WATER	MILL TYPE	PROD. (t/d)	TREATMENT	NOTES
		LAKE MICHIGAN BASIN			
Wisconsin					
Green Bay Fort Howard Paper	Fox River	Deinking	N/A	P,S	Industrial and personal service paper, ? t/d
Green Bay Green Bay Packaging	Fox River	Semi-Chemical (NSSC)	220	P: Closed system	Corrugating medium, specialty board, 410 t/d expanding to 700
Green Bay James River	Fox River	Sulphite	160	P, S*	Tissue, towel, napkin 470 t/d
Green Bay Proctor & Gamble Paper	Fox River	Sulphite Groundwood	(idle) (idle)		Tissue, household paper
De Pete Nicolet Paper (Division of International Paper)	Fox River	(Paper Mill)		P	Specialty kraft papers 140 t/d
Kaukauna Thilmany Pulp and Paper (Division of International Paper)	Fox River	Kraft	420	P, S	Kraft, converting and coated papers, 550 t/d
Kimberly Midtec Paper	Fox River	Groundwood	180	P, S	Book and specialty papers, 1,140 t/d
Appleton Kerwin Paper (Subsidiary of Riverside Paper)	Fox River	Bleach & Deink		P, S**	Fine papers, 120 t/d
Combined Locks Appleton Papers	Fox River	Chemi-mechanic	200	P, S	

LOCATION AND MILL		RECEIVING WATER	NOTES
	LAKE MICHIGAN BASIN, CONTINUED		
Wisconsin and Michigan			
Neenah, WI	Kimberly Clark	Fox River	About 5-10 miles upstream of Appleton
Menasha, WI	Wisconsin Tissue Mills	Fox River	About 5-10 miles upstream of Appleton (opposite Neenah)
Neenah, WI	Bergstrom Paper	Lake Butte Des Mortes	Above Lake Oshkosh, thence to Fox River
Neenah, WI	Kimberly Clark	Little Lake Butte Des Mortes	Above Lake Oshkosh, thence to Fox River
Shawano, WI	Shawano Paper	Wolf River	Distant tributary of Fox; over 70 miles upstream of Oshkosh
Peshtigo, WI	Badger Paper	Peshtigo River	A few miles upsatream; into north end of Green Bay
Oconto Falls, WI	Scott Paper	Oconto Paper	About 15 miles upstream; into northern part of Green Bay
Minominee, MI	Minominee Paper	Monominee	At mouth of Green Bay, north end
Marinette, WI	Scott Paper	Monominee	Opposite Menominee
Niagara, WI	Niagara	Monominee	Over 60 miles upstream of Marintette
Dickenson County, MI	Champion	Trib. to Menominee	In same general areas as Niagara
Manistique, MI	Manistique Pulp & Paper	Manistique River	North end of lake
Escanaba, MI	Mead	Escanaba River	Top of Green Bay
Filer City, MI	Packaging Corp. of America	Lake Michigan	East-central lake
Kalamazoo, MI	Brown	Kalamazoo River	About 40 miles upstream of east side of lake
Kalamazoo, MI	Allied Paper	Portage Creek	Ostego & Plainwell are 10-15 miles downstream of Kalamazoo
Ostego, MI	Mead	Kalamazoo River	
Ostego, MI	Menasha	Kalamazoo River	
Plainwell, MI	Plainwell Paper	Kalamazoo River	
Watervliet, MI	Waterliet Paper	Paw Paw River	South-east side of lake
Niles, MI	French Paper	St. Joseph River	About 25 miles from southeast corner of lake

P = Primary; S = Secondary; t/d = tonnes/day; * S at joint municipal/industrial plant; **S at municipal plant

Continued

TABLE 8.11 Pulp, Paper and Paperboard Mills in the Great Lakes (continued)

LOCATION AND MILL		RECEIVING WATER				NOTES
		LAKE HURON BASIN				
Ontario and Michigan						
Sault Ste. Marie, ON	St. Marys St Marys Paper	Groundwood River		220	P	Total, 350 t/d specialty Groundwood
Espanola, ON	E.B. Eddy Forest Products	Spanish River	Kraft	1,040	P, S, 02	Total, 900 t/d bleached kraft 120 t/d specialy, 20 t/d fine
Sturgeon Falls, ON	Macmillan-Bloedel	French River	NSSC	200	P	124 km to Lake Huron via Lake Nipissing, 200 t/d corrugating medium
			Mechanical	110		110 t/d hardboard
Cheboygan, MI of Mackinac	Proctor and Gamble Paper Products	Cheboygan River				Just southeast of Straights
Alpena, MI	Abitibi	Thunder Bay River				West side of lake
Alpena, MI	Fletcher Paper	Thunder Bay River				
		LAKE ERIE BASIN				
Ohio and Michigan						
Port Huron, MI	Port Huron Paper	Black River				Into St. Clair River; over 70 miles to Lake Erie
Palmyria, MI	Simplex Industries	River Raisin				South of Detroit; over 40 miles inland
Gypsum, OH	U.S. Gypsum	Lake Erie				Near Sandusky
Chagrin Falls, OH	Chase Bay	Chagrin River				Eastern edge of Cleveland

LOCATION AND MILL		RECEIVING WATER	MILL TYPE	PROD. (t/d)	TREATMENT	NOTES
		LAKE ONTARIO BASIN				
Ontario						
Thorold	Beaver Wood Fibre	Twelve Mi. Creek	(Paperboard)		P	Produce 273 t/d paperboard from purchased waste paper
Thorold	Domtar Construction	Twelve Mi. Creek				
St. Catharines	Domtar Fine Paper	Twelve Mi. Creek	(Fine Paper)		P	Produce 200 t/d fine paper from purchased pulp and waste
Thorold	Fraser	Twelve Mi. Creek	(Fine Paper		S	
Thorold	Quebec and Ontario Paper	Twelve Mi. Creek	TMP	460	P	Produce 600 t/d newsprint
			Deinking	540	S	
St. Catharines	Kimberly Clark	Old Welland Canal	(Tissue/Fine)		P	Produce 50 t/d tissue, 35 t/d 1/2 t/d fine paper
Trenton	Domtar Pkg.	Trent River	Semi-chemical	130	Liq. recovery	Produce 282 t/d corrug. medium
Trenton	Trent Valley Paperboard	Trent River	(Paperboard)		P	Produce 250 t/d paperboard from recycled paper & board

P = Primary; S = Secondary; t/d = tonnes/day;

Continued

TABLE 8.11 Pulp, Paper and Paperboard Mills in the Great Lakes (continued)

LOCATION AND MILL		RECEIVING WATER	MILL TYPE	PROD. (t/d)	TREATMENT	NOTES
		LAKE ONTARIO, CONTINUED				
Ontario, continued						
Camden East Twp.	Strathcona Paper	Napanee River	(Box board)		P, S	Produce 165 t/d box board from waste paper & board
New York						
Lyons Falls	Georgia-Pacific	Black River				Over 70 mi. upstream of Watertown
Lyonsdale	Burrows Paper	Moose River				Just upstream of Lyons Falls
Deteriet	St. Regis Paper	Black River				About 30 miles upstream of lake
Croghan	Latex Fiber	Beaver River				Flows into Black River about 15 mi. upstream of Deteriet
Brownville	Latex Fiber	Black Riover				At river mouth
Richland	Schoeller Technical	Salmon River				Southeast corner of lake
Volney	Armstrong Cork	Oswego River				About 10-15 miles upstream of Oswegho and lake
Oakfield	U.S. Gypsum	Whitney Creek				Between Buffalo and Rochester, about 20 miles south of lake
		ST. LAWRENCE RIVER BASIN				
Ontario						
Cornwall, ON	Domtar	St. Lawrence River	Kraft	400	P	Produces 600 t/d fine paper, 200 t/d paperboard
New York						
Gouvernour	Groveton Papers	Oswegatchie River				Over 50 miles upstream of St. Lawrence in at Ogdensburg
Newton Falls	Newton Falls	Oswegatchie River				Over 30 miles upstream of Gouvernour
Potsdam	Potsdam Paper	Raquette River				About 15 miles upstream through Messina'
Norfolk	Simplicity Pattern	Raquette River				About 10 miles upstream of Norfolk

P = Primary; S = Secondary; t/d = tonnes/day;

While the pulp and paper industry already appears to be fairly concentrated, further consolidation may lie ahead. Many Canadian mills are well below optimum size and use relatively antiquated equipment (Tables 8.12 and 8.13). Many of those are also not integrated with pulp producers (and so are vulnerable to significant pulp price fluctuations). As tariffs continue to decline and as environmental costs go up, these smaller operations will be vulnerable.

TABLE 8.12 Age of Newsprint Machines Operating in Canada, the United States and Scandinavia, 1983.

DATE COMMENCED OPERATION	CANADA	UNITED STATES	SCANDINAVIA
Prior to 1950	58%	28%	7%
1950 to 1970	19	45	50
After 1970	23	27	43

Source: Sinclair (1990)

TABLE 8.13 Annual Production Capacity of Canadian, U.S. and Scandinavian Newsprint Machines, 1983

TONNES PER YEAR	CANADA	U.S.A.	SWEDEN	FINLAND	NORWAY
Under 100,000	50%	15%	0%	30%	40%
100,000 to 150,000	35	55	20	30	40
Over 150,000	15	30	80	40	20

Source: Sinclair (1990)

It should be noted that, the size and concentration of the pulp and paper industry may prove advantageous to the industry if it is forced into large capital expenditures. If producers are able to influence market prices, the costs of environmental protection measures are relatively more likely to be passed on to paper and board consumers rather than being absorbed entirely by producers.

- Ownership of Forests

In Ontario forest land used in timber production is owned almost entirely by the provincial government. Allocation of timber rights is normally non-competitive and involves long term supply arrangements. The province deals with a number of large purchasers who do not seem strongly motivated to compete with one another. The high levels of capital invested in production facilities creates strong incentives to bid only for cutting rights on nearby lands.

The fees paid to the government for timber cutting rights, known as stumpage, have historically been too low to cover provincial forest management costs. According to Atkin (1988), the Ontario government lost C$139 million or C$4.79 per cubic meter of timber harvested in the province during the fiscal year 1986-87. Stumpage revenues equalled C$85 million while forest management expenditures equalled C$224 million. Stumpage fees charged to pulp mill owners in Ontario varied between C$1.04 and $4.55 at that time.

The government has been criticized for not monitoring harvesting activities more closely (Atkin 1988). Ontario is heavily reliant upon information provided by the forest industry on actual harvesting practices. Inspection of and quality control over reforestation efforts has also been insufficient to prevent a significant level of tree crop failure. However, Ontario does appear to have adequate forest supplies to meet current levels of growth in the fibre needs of the pulp and paper industry (Atkin 1988).

Private ownership of forest land plays a much more significant role in the United States than in Canada. Originally, all of the forest land was publicly owned in the U.S. but over the years ownership shifted to private ownership in many areas. Since about World War I the are of forest land in the U.S. has roughly stabilized and large shifts in the future are not expected. (Clawson 1979)

8.4 Pulp and Paper Market Trends

Pulp and paper markets will have overcapacity for several years in all but some coated paper and uncoated free sheet grades. While total U.S. industry capacity is expected to grow at a compound annual rate of 2.9% over the next three years, product consumption is expected to grow by about 2% per year over the next five years (Value Line 1991 and U.S. Department of Commerce 1991). Overall prices are expected to be restrained by recent and continuing increases in capacity. The share that Ontario producers will take of any market expansion will be affected by fluctuations in the price of the Canadian dollar.

- Pulp

High inventories, increasing capacity including significant growth in low cost South American pulp production, decreasing operating rates (percentage of capacity actually used) and slipping prices characterize the current state of the pulp production business.

Chemical pulps sales are also increasingly being cut into by sales of mechanical pulps. New developments in the production of mechanical pulps, also known as "alphabet pulps" because of the confusing array of acronyms used to describe the various pulping processes (CTMP, chemi-thermomechanical pulping; TMP, thermomechanical pulping; RMP, refiner mechanical pulping; and others), have increased their quality and well as the cost effectiveness of their production.

Secondary fibres will also be used increasingly. The relatively low costs of secondary and mechanical pulp fibre will create continuing pressure to keep prices low.

Pulp shipments are expected to increase by about 1% in 1991 and about 2% per year over the next five years. Demand for high quality bleached pulp, in particular the Northern Bleached Softwood Kraft produced in Ontario, should be strong due to growing demand for high grades of printing and writing paper.

Employment levels in the sector are expected to decline slightly or stay constant.

- Paper and Paperboard

Overall sales in this sector are expected to increase by 2.5% in 1991 and by 2.3% per year over the next five years. Coated paper, representing 20% of U.S. paper shipments, has been in strong demand recently. However, increases in capacity will exceed growth and should lead to flat or declining prices in the short term. Uncoated free sheet paper, representing 29% of U.S. paper shipments, contains at least 90% kraft fibre, and its use has also been growing faster than overall growth in paper consumption. Consumption of uncoated free sheet paper is expected to grow 2.9% in 1991. This compares with projected GNP growth of under 2%. Newsprint production, representing 17% of U.S. paper production, is flat with little increase foreseen in newspaper uses.

In general, while the recession is likely to remain throughout 1991, the industry is expected to recover and resume steady growth over 1992-93. By the year 2001, global virgin fibre use is expected to rise worldwide by 35 million tons and waste paper use is expected to rise by 55 million tons (Uutela 1990).

Areas in which growth in the demand for virgin fibre is expected are: printing and writing papers, with an increase of 23 million tons (nearly two thirds of the expected increase in demand); linerboard and fluting, 6 million tons (largely unbleached pulp); cartonboards, 3 million tons; newsprint, 2 million tons; tissue, 2 million tons. Demand for use of virgin pulps in unbleached grades is expected to decline by about 2 million tons (Uutela 1990).

This increase in the demand for virgin fibre pulp will benefit both chemical and mechanical pulp producers. If current trends continue, most of the increased demand will be met by bleached kraft pulps, but increasingly stringent pollution controls may encourage a shift to modern mechanical pulp production.

Demand for mechanical pulp will grow moderately and new mechanical pulping capacity will be constructed largely to produce combined recycled and thermomechanical pulp furnish (replacing sulfite-groundwood furnishes).

- Markets for Ontario Producers

The main markets for Ontario pulp and paper products are the Northeastern and North central United States and Ontario. Exports to the United States consume 56% of Ontario pulp and paper production. Another 41% is consumed within Ontario. Only 3% of Ontario production leaves North America. (Andersen 1988; 1986 figures)

Per capita consumption of pulp and paper products has grown substantially during the past decade. U.S. demand for newsprint has grown from 44 kilograms per person in 1981 to 51 kilograms per person in 1987 (14%). Demand for printing and writing paper in the United States has grown from 58 to 80 kilograms per person (27%) over the same period.

Ontario supplies about 13% of the 12.3 million (metric) tonne United States newsprint market, shipping about 1.6 million (metric) tonnes in 1987. Ontario's share of the U.S. newsprint market has declined from about 15% in 1981. Ontario consumes about 0.6 million tonnes of newsprint.

Ontario supplies about 3% of U.S. printing and writing paper demand, or about 0.5 million tonnes.

Population growth is an important determinant of demand for pulp and paper products. In the United States, the population is expected to grow at a rate of 0.72%/year, producing a population increase of 22 million people between 1988 and 2000, resulting in a total population of 267 million in 2000. In Canada, population is expected to increase at a rate of 0.85% per year, producing a population increase of about 3 million over the same period for a total, in the year 2000, of 29 million inhabitants.

- Production Costs

Current pulp and paper mills are capital intensive and have fairly constant running costs. This means that mill operations are not easily adjustable to market conditions. To the extent that new, less capital intensive pulping technologies can be developed, the volatility of profit levels which characterizes the industry could be reduced.

Andersen (1988) has estimated the cost of production of pulp and newsprint (Tables 8.14 and 8.15). In combination with Table 8.16, which indicates commodity prices in the U.S. market, these tables indicate in rough way the potential profitability of the industry. Costs of environmental control can also be considered in the context of these figures.

TABLE 8.14 1986 Newsprint Production Costs per Metric Tonne

	ONTARIO	CANADA	UNITED STATES	U.S	SWEDEN	SWEDEN
Wood Costs*	C$157	C$155	US$93	C$109	SK1,061	C$222
Energy	74	77	75	88	538	112
Labour	120	113	67	79	408	85
Other	65	68	80	94	425	89
Total Mill Cost	416	413	315	370	2,432	508
Corporate	24	27	16	19	115	24
Delivery	75	86	27	32	381	80
Total Delivered Cost	515	526	358	421	2,928	612
Expressed in Canadian $	515	526	421	421	612	612
C$1 assumed =			US$0.85		SK4.78	

* includes purchased kraft pulp
Source: Anderson 1988

Note: If the Canadian dollar was worth 80 cents U.S., as in 1986, the equivalent cost of U.S. production would be $449. At a Canadian dollar worth 70 cents U.S., costs would be about equal.

TABLE 8.15 1986 Kraft Pulp Production Costs per Metric Tonne

	Eastern Canada (Hardwood)	Eastern Canada (Softwood)	Interior B.C. (Softwood)	U.S. South (Softwood) (C$)	Sweden (Softwood) (C$)
Wood Costs	C$150	C$206	C$146	C$134	C$360
Energy	35	30	38	34	17
Chemicals	47	55	51	42	40
Labour	58	62	61	53	58
Other Materials	45	45	52	48	42
Mill Cost	335	398	348	312	517
Delivery	44	44	80	59	33
Total Delivered Cost	379	442	428	370	551

Canadian Dollar = U.S.$0.85 = SK4.78. If C$= U.S.$.80, U.S. cost = C$394.
Source: Andersen (1988)

TABLE 8.16 Commodity Prices (U.S. $ per Metric Tonne)

	1986	1988	1990
Newsprint	$545	$650	685
Market Pulp (Bleached Softwood Northern Kraft)	450	725	800
Groundwood Printing Paper (directory)	735	850	
Printing and Writing Paper (bond)	725	925	

Sources: Andersen (1988) and Pulp and Paper various issues

Profit levels in the pulp and paper industry have historically been low relative to other manufacturing industries. Given the level of risk involved in the industry, this is also an important influence on levels of investment in the industry.

In the immediate future, industry profit levels will be particularly low. Over the rest of 1991 many companies are expected to show low profits or losses. A return to more normal profit levels is expected in 1992 and 1993 as slack created by recently created overcapacity is taken up by a steady increase in demand (Value Line 1991).

8.5 Capital Spending

The recent downturn in pulp and paper industry cash flows has led to significant cuts in plans for capital spending in the industry. However, capital spending plans continue to be high in comparison to the levels of the past ten years. According to a survey done by Pulp and Paper at the end of 1990 (Pulp and Paper, January 1991. All figures in this section are derived from that survey), U.S. companies currently have plans to invest U.S.$17.0 billion in mill improvements, which is 5.5% less than was planned a year earlier. In Canada, companies have plans to invest C$10.2 billion on mill improvements over the next two years. This is 21.1% less than spending plans made at the end of 1989. Relatively deeper cuts to Canadian investment plans are attributed to weakness in markets for Canada's two most important products, newsprint and market pulp, as well as the high value of the Canadian dollar.

These proposed capital expenditures are broken down as follows (see also, Tables 8.14 and 8.15). Startups of new mills and new equipment in the U.S. account for U.S.$7.1 billion in 1990, falling to U.S.$5.7 billion in 1991, U.S.$2.4 billion in 1992 and U.S.$1.4 billion in 1993. In Canada, startups consumed C$4.6 billion in 1990, and will shrink to C$3.2 billion in 1991, C$1.4 billion in 1992 and C$1.0 billion for 1993 and beyond. This is a reversal from strong increases in investment in new facilities over the past few years.

Spending driven by environmental concerns, in contrast, is expected to rise significantly. In the U.S., spending on environmental improvements to old mills will account for 11.1% of all new capital spending. This is up from 6.9% in 1990 and 5.0% in 1989. In Canada, environment related investments are projected to rise to 24.9% of all planned investments, up from 15.9% in 1990 and 5.5% in 1989. Canadian costs are driven by the need to install secondary treatment, already in place at U.S. mills, as well as by the same pressure as exists in the U.S. to reduce toxic emissions.

Of U.S. environment related spending over 1990-92, U.S.$1.1 billion will be for water quality improvements (up 54% from 1990), U.S.$758 million will be for air quality improvements (up 51.1%) and U.S.$74 million will be spent to manage solid waste (up 25.8%). In Canada, water quality related spending will total C$1.9 billion (up 18.9% from 1990, but up over 500% from 1989), C$562 will be spent on air pollution control (up 45.4%) and spending on solid waste disposal will be C$68 million (down 2.9%). These figures may be an underestimate of planned environmental spending in the sense that construction of new mills and introduction of more modern production equipment is often at least partially driven by the need to meet tighter environmental controls.

In the U.S., pulp mill expansion and modernization will consume U.S.$6.2 billion, or 41% of total 1990-92 capital spending. None of the major capacity expansion projects planned to come into production between 1990 and 1992 are located in the Great Lakes region. However, a 200 (short) ton deinking mill for market pulp production will be completed by Fox River Fibre at Kaukauna, Wisconsin in 1991.

In Canada, C$4.5 billion will be spent on pulp mill expansion and modernization, of which C$776 million will be spent in Ontario. With the possible exception of a proposed new 150,000 (metric) tonne per year CTMP proposed by Shin Ho Canada for Thunder Bay and the recently postponed 178,500 (metric) tonne per year proposed expansion of the James River-Marathon kraft mill at Marathon, Ontario, the Atlantic Packaging Mill which is about to open, is the only planned major capacity expansion on the Ontario side of the Great Lakes basin.

While virgin newsprint production capacity is in excess of requirements, demand for secondary fibre caused by solid waste disposal problems across the continent is creating a rush to develop recycled fibre capacity. A 250,000 (short) ton per year recycled containerboard mill is planned by Dunkirk Containerboard for Dunkirk, New York (on Lake Erie) and Jefferson Smurfit intends to build a 250,000 (metric) tonne recycled newsprint mill at an unspecified location in New York state. Start up dates have not been announced for the latter two projects. In Ontario, Atlantic Packaging Products will complete a new recycled tissue (35,000 metric tones per year) and recycled newsprint (150,000 metric tonnes per year) mill in Whitby, on Lake Ontario in 1991. Abitibi-Price has also announced plans to add deinking capacity to its newsprint operations at Thunder Bay, Ontario.

Construction of new paper machines will require 31% of U.S. spending between 1990 and 1992. Many of these new mills are being constructed in the Great Lakes basin. In 1990, an 80,000 (short) ton per year recycled tissue mill was opened by Chesapeake at Menasha, Wisconsin. Fort Howard paper is also planning construction of a new recycled tissue mill at Green Bay and Lake Superior Paper has proposed to add a new paper machine at Duluth, Minnesota. Canadian expenditures on new paper machines are expected to total C$1.3 billion over the 1990-92 period, with C$245 million of that sum being spent in Ontario. Canadian Pacific Forest Products is replacing two older machines with a 240,000 metric tonne per year paper machine (net capacity addition will be 60,000 tpy).

Spending on paper machine modifications and improvements in the United States will amount to U.S.$2.5 billion over 1990-92 (up 3.9%). In Canada, expenditures on machine modifications over the same period will total C$725 million, of which C$206 million will be spent in Ontario.

U.S. containerboard capacity is being increased largely by rebuilding old machines. Installation of a new technology known as wide-nip presses allows expansion at far lower than could be achieved by building new facilities. Green Bay Packaging, at Green Bay, Wisconsin is the only Great Lakes mill currently undergoing such modification.

Power plant improvements will cost U.S.$1.1 billion (down 22.5%) over the 1990-92 period in the United States. Lower energy costs are seen as the reason for declining spending in this area. The purchase of cogenerated power from private producers has been a significant factor in keeping power costs low. In Canada, energy production investment over the same period will total C$559 million, of which C$151 million will be spent in Ontario.

TABLE 8.17 U.S. and East North Central Region Capital Expenditures for 1990-92+, By Type of Facility (in U.S.$000)

		East North Central		Total U.S.	
Production -Related Expenditures	Wood/Fibre	11,900	(4%)	284,624	(100%)
	Pulping	255,941	(4%)	6,165,478	(100%)
	New Machines	875,000	(19%)	4,670,314	(100%)
	Machine Modification	416,666	(17%)	2,451,789	(100%)
	Energy	174,250	(17%)	1,053,542	(100%)
	Miscellaneous/Plant	129,233	(25%)	512,727	(100%)
	Total	1,862,990	(12%)	15,138,474	(100%)
Environmental Spending	Water	109,905	(10%)	1,055,489	(100%)
	Air	20,135	(3%)	758,350	(100%)
	Solid Waste	7,785	(11%)	74,131	(100%)
	Total	137,825	(7%)	1,887,970	(100%)
Grand Total		2,000,815	(12%)	17,026,444	(100%)

Source: Pulp and Paper (January 1991)

TABLE 8.18 Ontario Reported Capital Expenditures for 1990-92+, By Type of Facility (in C$000)

		Ontario		Canada	
Production-Related Expenditures	Wood/Fibre	12,100	(4%)	301,775	(100%)
	Pulping	775,829	(17%)	4,471,525	(100%)
	New Machines	245,000	(19%)	1,320,200	(100%)
	Machine Modification	205,530	(28%)	724,561	(100%)
	Energy	151,250	(27%)	559,061	(100%)
	Miscellaneous/Plant	1,500	(1%)	252,241	(100%)
	Total	1,391,209	(18%)	7,629,363	(100%)
Environmental Spending	Water	119,601	(6%)	1,893,684	(100%)
	Air	16,020	(3%)	561,830	(100%)
	Solid Waste	510	(1%)	67,835	(100%)
	Total	136,131	(5%)	1,527,340	(100%)
Grand Total		1,527,340	(15%)	10,152,712	(100%)

Source: Pulp and Paper (January 1991)

- Trends in Mill Modernization

The age of North American and, in particular, Canadian newsprint machines has already been noted in Table 8.11. Most of the pulp and paper mills in the Great Lakes basin are comparatively small and are older than might be desirable. Overcapacity and generally weak long term performance have encouraged modernization of existing plant over new mills. In future, priority will be placed on increasing the scale of production facilities as well as on modernizing production equipment to make more efficient use of wood supplies. Mills will also emphasize the production of higher value grades of paper, the use of recycled fibres and the use of low-effluent technologies.

The market share of mechanical pulp share is expected to increase significantly. This will occur as a result of a number of advantages which mechanical pulping processes have over chemical pulping. Mechanical pulping makes relatively efficient use of fibre, using about 90% of all fibre going into the mill, as opposed to about 50% for chemical pulping. The capital cost of constructing a new mechanical mill is about 50% of that of a new chemical pulp mill. Mechanical pulping capacity can also be added in smaller increments than can chemical pulping capacity.

Improvements in the strength characteristics of mechanical pulps may allow a reduction in paper basis weight, which would mean that less material would have to be used to produce a given product. The high strength of the newer mechanical pulps also means that there will normally be no need to add any semi- bleached softwood pulp to reinforce it for newsprint use, as was required for earlier mechanical grades.

Mechanical mills are also more amenable to automation, producing lower labour costs, and they are better able to meet more stringent environmental regulations. Chlorine bleaching is not necessarily required, reducing dioxin, furan and organochlorine emissions and total levels of releases of conventional and acutely toxic substances are significantly lower than with chemical pulping (largely because more fibre is used and less is released as effluent). Already mechanical pulp is often the least expensive virgin furnish for newsprint.

Technological advances in mechanical pulping and use of recycled fibre (including declining manufacturing costs) and chemical pulp overcapacity may induce innovation to decrease chemical pulping manufacturing costs. Capacity increases at chemical pulp mills are likely to be restricted to expansion of existing mills.

As a result of these developments, the use of wood has become significantly more efficient. Much of the recent growth in pulp and paper manufacturing has been accomplished simply by increasing the use of logging and wood mill residues. Integration of sawmilling and pulping mills makes use of wood wastes easier and more economical. Improvement in the quality of mechanical pulping also promises to reduce wastage of wood fibre. Better paper machines are also reducing the need for pulp and paper strength, which will allow papers to be lighter in weight.

Changes to bleaching technologies are considered in Chapter 9.

8.5.1 Impact of recycling

Atkin (1988) estimates that Canada's paper recovery rate is under 30%. In the United States the recovery rate is estimated to be 42%. These figures compare with an 82% recovery rate in Japan (93% of all newsprint and 75% of container grade paper). If Japanese levels of recovery could be achieved in North America, the effect on markets for virgin paper could be dramatic.

Worldwide use of recycled fibre is expected to grow from 75 million tons in 1988 to 100 million tons in 1996 and to 130 million tons by 2001. This would mean that recycled fibre would account for 41% of all fibre use in the year 2001 (Uutela 1990).

In general, because mixing recycled fibre into paper threatens the strength of the resulting paper product, recycling will increase the use of long-fibre rather than short-fibre pulps. This is something of an advantage for the Northern Bleached Softwood Kraft pulp produced in the Great Lakes basin and in Ontario in particular. However, improvements to mechanical pulping techniques as well as innovations in the production of fibre-bonding chemicals may reduce this advantage.

The different sectors of the pulp and paper industry will be affected in diverse ways by the increased use of recycled fibre.

- Newsprint

Major changes are coming to North American newsprint production due to an increase in the demand for post-consumer waste content in newspapers. As a consequence of the fact that discarded newspapers make up approximately 6-7% of all solid waste disposed of in North American landfills, many jurisdictions are acting to reduce the disposal of old newspapers. A number of U.S. states have already passed or are in the process of passing minimum secondary fibre requirements for locally sold newspapers. Toronto is seriously considering a 30- 50% secondary fibre requirement for all newspapers sold in street vending machines.

Approximately 8-15% of recycled newsprint ends up as sludge after deinking. The remaining 85-92% is reusable. As it is technically feasible for newsprint to be produced entirely from old newspapers the potential reduction in demand for virgin fibre newsprint of an increase in recycled content is dramatic. Northern Ontario newsprint mills will suffer the additional problem that waste newsprint is generated largely in the United States (Canada consumes only about 1.1 of the 10 million tons of newsprint that it is capable of producing annually); the cost of shipping that waste paper to Thunder Bay or Marathon may be prohibitive.

In practice, mills are expected to operate with something closer to 50% waste paper. Waste paper collection may also continue to leave a significant portion of used newspapers uncollected (the Canadian Pulp and Paper Association projects that old newspaper collection efficiency will increase to 46% in 1993--up from 25% in 1989 and 11% in 1988; U.S. recovery is projected to be 52% by 1995--up from 38% in 1989). But the threat to distant, old newsprint mills is unmistakeable.

• Printing and Writing Papers

Only a small increase in the use of wastepaper is seen for supercalendered or lightweight coated papers. The demand for high brightness and good printability qualities currently makes the incorporation of waste papers into these grades difficult. Advertisers and other users continue to demand higher quality standards from these papers.

Opportunities for the sale of recycled papers in this sector are for listing paper, envelope paper, paper for "a small, environmentally conscious part of the business papers market, largely for public authorities" (Uutela 1987).

However, the pure potential for recycling of printing and writing paper sis high. According to the Canadian Pulp and Paper Association, 3.7% of the solid waste stream in North America consists of these high fibre quality papers. A significant upgrade of collection of these papers, in particular from office waste streams, could provide the furnish necessary to produce a high quality recycled writing or printing paper.

• Tissue

The use of wastepaper is already high in the manufacture of tissue grades. In future, waste paper is expected to be used across a wider range of tissue grades and the overall use of secondary fibres in tissue-making is expected to increase significantly. As a result, many virgin fibre based tissue mills are expected to be required to invest in deinking plants.

• Linerboard and Fluting

Kraft liner is expected to include a higher proportion of old corrugated containers as more waste material becomes available. The number of grades of linerboard may also increase to accommodate the various types and qualities of wastes which will become available.

• Cartonboards

Recycled fibre is already heavily used in cartonboard production. Growing interest in waste grade folding cartonboard may lead to the development of new waste-based grades. At the same time, the use of virgin fibre is actually increasing at the high-end of the cartonboard market, due to a demand for brighter appearance and improved performance characteristics. A growing market for liquid packaging boards also favours virgin fibre. Generally, food packaging legislation currently inhibits the use of recycled fibre for food packaging.

• Wastepaper Business

A growing demand for waste paper content is encouraging suppliers to secure supplies of waste paper. This is improving wastepaper business prospects as well as creating further demand for waste paper collection. An increase in sorting at source will also improve waste paper quality and value. The long term prospect is for far greater price stability, particularly as mills try to lock in supplies of wastepaper. In the short term, until adequate mill capacity is available, increasing numbers of waste separation and recycling programs may produce an oversupply of some grades of paper.

The export of old wastepaper from U.S.A to Canada is expected to provide new opportunities. High quality old corrugated cardboard and deinking grades of waste paper may also be imported to North America to help meet demand.

• Equipment and Chemical Suppliers

Wastepaper deinking is expected to increase significantly worldwide. Much of the growth will be at U.S. and Canadian newsprint mills. As a result, demand for deinking chemicals is forecast to grow by 8 to 10 percent per year. Fibre cleaning and upgrading equipment will also be in demand, as will improvements to paper machines to accommodate waste paper.

9.0 ECONOMIC INSTRUMENTS AND THE VIRTUAL ELIMINATION OF PERSISTENT TOXIC DISCHARGES FROM THE PULP AND PAPER INDUSTRY

9.1 The Pulp and Paper Industry Persistent Toxics Problem: Emission Sources

The pulp and paper industry discharges a wide range of toxic substances to the environment. Most prominent among these discharges are the class of substances known as organochlorines. Normally measured as adsorbable organic halide (AOX), chlorinated organics include large numbers of known toxins as well as a wide range of poorly understood substances.

Of the organochlorines, two highly toxic dioxin and furan cogeners 2,3,7,8- tetrachlorodibenzo-p-dioxin (2,3,7,8- TCDD) and 2,3,7,8- tetrachlorodibenzofuran (2,3,7,8-TCDF) have been singled out by the International Joint Commission as "Critical" pollutants in the Great Lakes basin. This Chapter focuses on the possibilities of using economic instruments to virtually eliminate the discharge of those two substances and AOX in general.

The critical substances list of the IJC is intended to be representative of classes of pollutants and sources of pollution in the Great Lakes basin. In this case, the presence of 2,3,7,8- TCDD/TCDF is associated with the presence of other persistent toxins (Table 9.1). Emissions of dioxins and furans as well as organochlorines in general are associated only with those mills at which chlorine is used to bleach pulps. Normally these are kraft mills, although chlorine is also used to brighten sulfite and other pulps.

The number of mills using significant quantities of chlorine in the Great Lakes basin is relatively small (Table 9.2). Notably, with the exception of two mills in Thunder Bay, each of these mills discharges to a different area of the Lakes and no two mills are known to impact on any one particular area.

TABLE 9.1 Priority Pollutants Detected in Ontario Kraft Mill Effluents, 1990

	FREQUENCY OF DETECTION (%)	AVERAGE CONCENTRATION (µg/L except dioxin/furan ng/L)	E.B. EDDY ESPANOLA	JAMES RIVER MARATHON
PERSISTENT BIOACCUMULATIVE SUBSTANCES				
Total Tetra- Furans	67%	.14	.03	.49
Total Octa- Dioxins	54	.20	ND	.60
Nickel	43	11.09	31.50	8.33
2,4,5- Trichlorotoluene	35	.15	ND	.01
Camphene	34	5.36	ND	3.08
Mercury	33	.09	ND	.68
Hexachlorobenzene	30	.15	ND	.01
Pentachlorobenzene	23	.09	ND	ND
1,2,4,5- Tetrachlorobenzene	20	.02	ND	.01
Total Hexa-7- Dioxins	19	.02	ND	.18
Total Penta- Furans	19	.04	ND	.29
Total Tetra- Dioxins	19	.03	ND	.07
1,2,3,4- Tetrachlorobenzene	15	.02	ND	ND
Total PCB	13	.03	ND	ND
Fluoranthene	11	.42	ND	.40
Pentachlorophenol	11	.17	.18	.20
Total Penta- Dioxins	11	.00	ND	.04
1,2,3,5- Tetrachlorobenzene	9	.03	ND	.01
Pyrene	9	.25	ND	ND
Total Hexa-6- Furan	9	.01	ND	.08
Total Octa- Furan	7	.01	ND	.05
Total Hexa-6- Dioxin	7	.01	ND	.07

Continued

TABLE 9.1 Priority Pollutants Detected in Ontario Kraft Mill Effluents, 1990 (continued)

	FREQUENCY OF DETECTION (%)	AVERAGE CONCENTRATION (µg/L except dioxin/furan ng/L)	E.B. EDDY ESPANOLA	JAMES RIVER MARATHON
PERSISTENT BIOACCUMULATIVE SUBSTANCES, CONTINUED				
2,3,7,8- Tetra- Dioxin	6	.00	ND	.02
Total Hexa-7- Furan	6	.01	ND	.06
Chrysene	4	.05	ND	ND
Anthracene	2	.03	ND	ND
Benz(a)anthracene	2	.02	ND	ND
GENERAL PARAMETERS		In mg/L		
Adsorbable Organic Halide (AOX)	100	21.75	8.49	55.66
BOD, 5 day	100	131.14	18.30	203.67
Total Suspended Solids	100	65.00	29.36	41.78
ACIDS				
Dehydroabietic	85	.47	.01	.06
Chlorodehydroabietic	68	.09	.00	.25
Isopimaric	68	.14	.00	.06
Dichlorodehydroabietic	66	.06	.00	.07
Pimaric	66	.04	.00	.03
Abietic	64	.23	ND	.14
Oleic	64	.08	.01	.14
Neoabietic	60	.19	.00	.09
Levopimaric	35	.01	ND	.06
OTHER PARAMETERS		In µg/L		
Chloroform	100	437.71	17.08	1,126.67
Aluminum	100	1,834.52	930.31	258.40
Phenol	47	19.20	.25	1.93
Bromodichloromethane	8	.26	ND	ND
2,4,6- Trichlorophenol	51	4.56	3.47	ND
2,4- Dichlorophenol	51	2.08	.37	ND

Source: Ontario Ministry of the Environment 1991

TABLE 9.2 Chlorine Using Mills in the Great Lakes Basin

MILL AND LOCATION		2,3,7,8 TCDD (PPQ)	2,3,7,8 TCDF (PPQ)	Total PCDD (pg/L)	Total PCDF (pg/L)	NOTES
Potlatch	Cloquet MN Lake Superior	24	46	n.a	n.a.	Municipal secondary treatment.
CPFP	Thunder Bay ON Lake Superior	ND*	ND*	190	60	Process only 52% kraft.
Abitibi-Price	Thunder Bay ON Lake Superior	ND*	ND*	4,780	1,230	Bleached groundwood papers.

Continued

TABLE 9.2 Chlorine Using Mills in the Great Lakes Basin (continued)

MILL AND LOCATION		2,3,7,8 TCDD (PPQ)	2,3,7,8 TCDF (PPQ)	Total PCDD (pg/L)	Total PCDF (pg/L)	NOTES
Domtar	Red Rock ON Lake Superior	ND*	ND*	240	ND	Process 6% bleached.
Kimberly-Clark	Terrace Bay ON Lake Superior	ND*	ND*	690	410	
James River-Marathon	Marathon ON Lake Superior	ND*	ND*	960	970	
Mead Paper	Escanaba MI Lake Michigan	ND	51	n.a	n.a.	
Champion International	Quinessec MI Lake Michigan	9	66	n.a.	n.a.	Oxygen delig. being installed.
Scott Paper	Muskegon MI Lake Michigan	ND	42	n.a.	n.a.	Effluent discharged by spray irrigation
James River	Green Bay WI Lake Michigan	19	72	n.a.	n.a.	Municipal secondary treatment.
E.B. Eddy	Espanola Lake Huron	ND*	ND*	ND	30	Oxygen delig'n and other measures.
Domtar	Cornwall. ON Lake Ontario	ND*	ND*	200	40	Flow diluted by newsprint effluent.

ND*= Not detected, but Ontario detection level
Sources: MISA (1991), NCASI (1990)

* 1 ng/L is approximately equal to 1 ppt (part per trillion)
1 pg/L is approximately equal to 1 ppb (part per billion)
1 ug/L is approximately equal to 1 ppm (part per million)

It should be noted that the pulp and paper industry persistent toxic emissions problem goes beyond the 2,3,7,8- dioxin and furan cogeners. Other dioxin and furan cogeners are also significant health risks (Table 9.3). Levels of AOX and some other toxic substances remain significant even where dioxins have been virtually eliminated. (See, for instance, E.B. Eddy, in Table 9.1)

TABLE 9.3 PCDD Toxic Equivalencies

Compound	Relative Potency
2,3,7,8- TCDD	1
Other TCDD	0.01
1,2,3,7,8- PeCDD	0.5
1,2,3,6,7,8- HxCDD	0.04
1,2,3,7,8,9- HxCDD	0.04
1,2,3,4,7,8- HxCDD	0.04
Other HxCDD	0.0004
OCDD	0

Source: Exner (1987)

Source specific information on other sources of dioxin and furan emissions to the Great Lakes has not been found, although emissions are associated with wood preserving facilities, hazardous waste sites (des Rosiers 1987), and air emissions from municipal and industrial waste incineration, residential fuel combustion and power generation (Ortech 1990). Kraft pulping black liquor recovery boilers are also significant sources of PCDDs and PCDFs (Ortech 1990).

9.2 Mill Processes and Persistent Toxic Discharges

In kraft pulping a liquid containing Na_2S and NaOH, known as white liquor, is used to separate lignin and related materials from wood cellulose fibres. The materials thus separated along with the spent cooking liquor, known at this point as black liquor, are washed away from the remaining wood cellulose and any partially cooked or otherwise unsatisfactorily bleached material is screened out. This effluent material is then treated for chemical recovery with wastes being incinerated. Black liquor not removed is ultimately discharged to the mill sewers. It is highly toxic to aquatic life and is also difficult to treat biologically.

Losses from the washing area vary widely with the quality and age of the washing and screening processes used in a mill. Older mills may have losses ten times higher than those of new mills. Spills and other plant upsets may result in from one third to one half of all black liquor releases to surrounding waters (Sinclair 1990). Accordingly, spill control procedures are of great importance in reducing emissions. Spills of any size may also incapacitate a mill's biological treatment system for a number of days.

Washed pulp is bleached to remove the remaining lignin content, typically about 7% of the fibre at this point. Normally, chlorine is used to separate out the lignin and then it is washed out with caustic sodium hydroxide. This process is then repeated, often with chlorine dioxide or hypochlorite. All of the organochlorines found in mill effluents are produced at these stages, as is approximately one half of effluent biological oxygen demand (BOD).

The level of brightness to which pulp must be bleached has a very significant effect on effluent levels. Pulp used in integrated processes is generally bleached to a brightness of 85 ISO units. Market kraft, on the other hand, is normally bleached to 90 ISO. In part this difference is accounted for by the fact that stored pulp will gradually lose some brightness. But to some extent this difference would appear to result simply from attempts to differentiate products for sales purposes rather than because of any real difference in usefulness or quality of the product (McCubbin 1990). Designing a processes for producing pulp with low organochlorine effluent levels is significantly easier if the required brightness is only 85 rather than 90.

Effluents from sulfite chemical pulping and the various forms of mechanical pulping are presume to vary proportionately with the percentage of the incoming fibre that is actually used. While this relationship is known to exist for BOD levels, there is insufficient evidence to prove that toxicity levels are actually similarly proportional. Typically, sulfite processes yield just under 50% of the wood processed, while mechanical pulping yields on the order of 90%. As a result, sulfite pulping is a far more heavily polluting process. Any additional use of chlorine in bleaching of sulfite or mechanical pulps will of course add to resulting pollution. The efficiency of chemical recovery systems in sulfite mills is also relatively lower than in kraft mills.

Recycled fibre pulping produces relatively low levels of effluent. Corrugating and board mills which recycle fibre without deinking are of little environmental concern. De-inking effluents, although not comparable to virgin mill effluents, continue to be difficult to make non-toxic.

9.3 Abatement Technologies

Proposed new Canadian regulations under the Canadian Environmental Protection Act will require that the release of 2,3,7,8- TCDD or 2,3,7,8- TCDF be prohibited above an as yet undefined level of detection. Meeting these regulations is also expected to reduce AOX discharges below 2.5 kg per tonne of product. McCubbin (1990) estimates that new Canadian Regulations relating to BOD, TSM and toxicity can be met by the installation of clarifiers, activated sludge systems or aerated stabilization basins and properly placed outfalls. He also believes that the proposed Canadian dioxin and furan regulations can be met by increasing the level of chlorine dioxide substitution in the first chlorination stage of soft wood bleaching to upwards of 70%; improving chlorination stage mixing and control equipment; as well as using certain site-specific equipment.

Abatement measures to lower or eliminate the formation of furans and dioxins emphasizes lowering the amount of chlorine used in bleaching. The problem is that reducing chlorine causes a reduction in pulp brightness. Chlorine is used for its ability to separate lignin from pulp while removing or damaging only a relatively little of the more useful cellulose. Chlorine also has a relatively low unit cost.

Bleach plant effluents typically contain between 3 and 8 kg of organochlorines per tonne of pulp production. Essentially, these concentrations are directly proportional to the levels of chlorine used in a given bleaching process. Biological treatment can reduce these quantities by between 30 and 50%. However there are some individual organochlorine compounds which are not reduced at all by biological treatment. Further reductions in effluent organochlorine levels are achievable only by reducing the level of chlorine actually used in bleaching.

The substitution of chlorine dioxide for elemental chlorine in the bleaching process produces significant reductions in organochlorine effluents, in particular dioxins and furans, while maintaining brightness levels. The E.B. Eddy mill at Espanola, Ontario has increased chlorine dioxide substitution from 10 to 50% at its 975 tonne kraft mill after determining that significant reductions in organochlorine and dioxin and furan production would result. Resulting brightness is unchanged (88+) and paper strength actually increased.

TABLE 9.4 Reductions in AOX and Dioxins and Furans from Chlorine Dioxide Substitution at E.B. Eddy, Espanola, Ontario

Chlorine Dioxide substitution level	AOX (kg/tonne) Untreated Effluent	AOX (kg/tonne) Treated Effluent	2,3,7,8-TCDD(ppt)	2,3,7,8-TCDF(ppt)
10%	3.42	1.39	2.2-3.6	7.1-11.0
28%	--	--	1.8	6.4
48%	2.31	1.15	ND	ND-6.2
52%	--	--	ND	ND
58%	1.38	0.68	ND	ND

ND = Below detection limit.
Source: Munro (1990)

Untreated effluent AOX is low due to oxygen delignification, hardwood-softwood mix, and other process modernization; treated effluent AOX is low due to primary and secondary treatment.

Chlorine dioxide substitution methods are quite well known and proven in practice. The addition of small amounts of oxygen or hydrogen peroxide into later chlorine bleaching stages can be used to reduce chlorine use and may produce organochlorine discharges to water by as much as 15 to 20%. Oxygen delignification can be used as a substitute for part of the chlorination process. Resulting reductions in organochlorine effluents are estimated at 40%.

9.4 Abatement Costs

Estimates of the costs of reducing dioxin and furan emissions to non-detection levels at Great Lakes pulp and paper mills are shown in Table 9.5. The total capital cost for dioxin and furan control in the Canadian portion of the Great Lakes basin is estimated at C$568 million and this entails no significant change in direct operating costs. In Ontario, which has a total chemical pulp production level of about 6000 tonnes per day, total costs will be C$84.7 million, or C$4.51 per ton (amortized capital cost). By product, costs will be C$4.76 for market kraft, C$4.76 for integrated kraft and C$2.03 for sulphite pulp. Adding oxygen delignification will reduce the cost of traditional external treatment systems. Capital costs and operating costs would fall in the range of 20 to 25%.

TABLE 9.5 Ontario Great Lakes Basin Dioxin /Furan Control Costs, By Mill

MILL AND LOCATION		CHEMICAL PULP PRODUCTION (Tonnes/day)	CAPITAL COST (C$ millions)	AMORTIZED CAPITAL (C$/Tonne)
Canadian Pacific Forest Prod.	Thunder Bay	1,323	8.7	$1.63
Domtar	Red Rock	50	1.3	$6.45
Kimberly Clark	Terrace Bay	1,200	16.1	$3.33
James River-Marathon	Marathon	433	14.0	$8.02
E.B. Eddy Forest Products	Espanola	910	0.0	$0.00
Domtar	Cornwall	450	1.3	$0.72
GREAT LAKES TOTAL/AVERAGE		4,366	41.4	$2.35
Average, Excluding E.B. Eddy				$2.97
CANADA TOTAL		(45 Mills)	30.808 567.6	$4.48

Source: McCubbin 1990

These costs vary considerably among companies but, in comparison with the costs of secondary treatment and other capital investments which are being planned by the industry in the near term abatement costs, they are relatively modest. Table 9.6 gives representative costs for the control costs of traditional pollutants (e.g. BOD and suspended solids). Since the costs of dioxin and furan control are relatively minor there is little reason for concern that these costs alone would be disruptive of any mill which was not already in serious financial difficulty. Indeed, far higher abatement costs than even those shown in Table 9.5 which were met by U.S. mills during the difficult times of the early 1980s did not a single operation out of business. It is not expected that these requirements would put any mill out of business either.

Furthermore, capital expenditures for abatement measures at all Ontario facilities will be reduced significantly by the possibility of fast tax write offs. This assumes that the firms have sufficient existing cash flows to use the write offs. McCubbin estimates that this will reduce actual costs to the companies by roughly 20 to 25% over and above the cost which would result where normal tax depreciation rules applied.

In the United States, revision of the Clean Water Act will involve setting similar standards for emissions of 2,3,7,8-TCDD and TCDF and the implications for the mills of the associated abatement costs are believed similar to those described for Ontario.

9.5 Applicability of Economic Instruments

As with mercury and PCBs, the contribution that economic instruments (especially emissions trading and effluent charges) can make to achieving virtual elimination of persistent toxics from pulp and paper mills in the Great Lakes basin is limited by the extent of the regulatory actions that have already been taken. In terms of the decision tree in Figure 1, Canada and the U.S. are on the verge of declaring that virtual elimination of these persistent toxics is to be achieved within a very short time frame. Hence, an outright ban (or, at any rate, no emissions above the detection level) through direct regulation is the best option. Emissions trading and effluent charges can only play a useful role if the objective of virtual elimination is to be achieved over a considerable period of time. Only then can advantage be taken of differences in control costs and the added stimulus that these instruments can give to the development of new, cost effective technologies to be developed.

In view of the fact that these contaminants have been given such high priority by the public and the regulatory agencies in both countries, and that the technical means for their virtual elimination are proven and affordable, it is unlikely that there will be any retrenchment in the urgency now being given to eliminating them from the waste streams of pulp and paper mills. Consequently, the role of economic instruments in achieving the virtual elimination of 2,3,7,8- TCDD/TCDF from pulp and paper mills may be limited to supporting compliance with regulations. Under these circumstances there would seem to be no role for emissions trading. (In any case, any proposal to allow trades in emissions of dioxins and furans would doubtless run up against immense opposition.)

An effluent charge levied on detectable emissions could be a most effective way of introducing a financial enforcement incentive and demonstrating the supportive role that economic instruments can make in achieving and maintaining the virtual elimination of persistent toxics. Such a compliance incentive should be based on the quantity discharged, not just the concentration. Since concentration will have to be measured merely to test compliance with the proposed regulations and flow measurements are common place, the imposition of a per unit charge on detected emissions of 2,3,7,8- TCDD/TCDF from pulp and paper mills should be comparatively simple to implement. The level of the per unit penalty should be at least as high as the control costs to remove any financial advantage that mills might have for not incurring the necessary costs of complying with the regulations.

One problem with defining virtual elimination in terms of concentrations is that dilution of the mill effluents offers a means of compliance even though the total loadings may still be undesirably high. This is not to say that mills will rely on dilution to meet the standards, only that it may be used as one component of a compliance strategy. An additional problem that remains is the possibility of spills and leaks that are hard to detect and may be consistent with the legal test of due diligence. These concerns can best be met by taking further steps to reduce the use of chlorine in the bleaching process.

Regulation offers one way of limiting the use of chlorine but, as usual, it suffers from the inability to make proper allowances for the different opportunities and costs of each mill. The two main possibilities for using economic instruments to reduce the use of chlorine are a chlorine tax and tradeable chlorine permits (comparable to the tradeable lead permits described in Chapter 4). These measures would not only reinforce the regulation of 2,3,7,8- TCDD/TCDF but they would also help reduce the emission of all organochlorines from pulp and paper mills.

Referring to question 4 in the decision tree and the associated criteria for deciding whether a quantity limit is preferable to a charge, there is no information to suggest the existence of thresholds in the damage functions that would favour a trading system over a chlorine tax. (Even if such information did exist, it would hardly support trading over a charge on chlorine since there is only an indirect relation between the amount of chlorine used and the amount of organochlorines in the waste stream.) On the other hand, a chlorine tax has the advantage of limiting in advance the additional costs that such a measure would impose on any mill.

A determined effort to reduce the chlorine used by mills in the Great Lakes basin could best be accomplished in a cost-effective way through a system of tradeable chlorine permits based on the proven success of the lead trading system among U.S. petroleum refineries. The total quantity of chlorine used by mills in the Great Lakes basin (Table 9.2) would be limited and this limit would decline over time according to a predefined schedule, not necessarily to zero. For simplicity and ease of acceptance by the companies concerned, the initial allotment of chlorine permits should be based on recent historical usage. The only complicating factor might be that mills outside of the Great Lakes basin would have a competitive advantage over those within the basin unless they were also to be included in the scheme. This consideration goes beyond the mandate of the IJC but could be of concern to the regulatory agencies that would have to implement the scheme and they might be advised to extend the chlorine trading market to pulp and paper mills throughout Canada and the U.S.

A system of tradeable chlorine permits would help reduce the discharge of all organochlorines into the Great Lakes basin. However, the reduction of chlorine used by pulp and paper mills is only indirectly related to the generation of organochlorines in the waste stream. A more direct application of economic instruments to this problem could be accomplished by introducing emissions trading or an effluent charge for AOX. Under an emissions trading system involving such highly toxic contaminants it would be essential to review and approve all potential trades. Furthermore, there is a great deal of variation from mill to mill in the specific organochlorines measured as AOX. Hence, trades in AOX emissions could be highly problematic in that there would be little assurance that the overall level of environmental impact does not increase when trades are made.

Finally, there is no information about the respective abatement cost and damage functions to suggest that tradeable emissions are better than an effluent charge for reducing the emission on AOX from pulp and paper mills.

For all these reasons an effluent charge on AOX that increases over time seems to be a more effective way of using economic incentives to achieve the virtual elimination of organochlorines in general as measured by AOX. Further analysis of AOX control costs will be required to estimate the level of a an effluent charge that is likely to induce any required rate of reduction in emissions.

9.6 Social, Economic and Financial Impacts

In section 9.4 it was suggested that the costs required to virtually eliminate 2,3,7,8- TCDD/TCDF from pulp and paper mill effluents were modest in comparison with the abatement costs that mills in Canada are likely to have to incur merely to deal with the traditional pollutants. Similar costs have, by and large, already been incurred by U.S. mills almost all of which have already installed secondary treatment. In both cases, therefore, it appears that these two most toxic organochlorines can be virtually eliminated without imposing significant burdens on the industry or the towns in which they are located. Far more important for the future prosperity of the mills and the towns that depend on them will be their ability to adapt to the trends in recycling that were discussed in Chapter 8.

The impact of tradeable chlorine permits and/or an effluent charge on AOX is more difficult to determine. Some mills have already taken steps to significantly reduce their use of chlorine and, hence, generation of AOX. Presumably, others can follow without incurring particularly onerous costs. The complete elimination of chlorine from bleaching may be more demanding though proven chlorine free bleaching processes exist and have been implemented in some Scandinavian mills. Much will depend on the rate at which the total level of chlorine used by the mills is reduced and the level of an effluent charge on AOX and rate at which it is increased.

While Canadian pulp and paper mills lag somewhat behind U.S. mills in terms of secondary treatment, and will incur a competitive penalty as they try to catch up, effluent standards in both countries are typically less stringent than those faced by their European, particularly Swedish competitors. Proposed AOX standards are tighter and will come into force sooner in Sweden than those proposed for Canada and the U.S. (Bemda and Graham, 1990). Since the Swedish producers already face the prospect of effluent charges, with AOX one of the parameters under consideration, the impact on Canadian and U.S. mills of such a charge is unlikely to put them at a competitive disadvantage. It may, however, divert funds from modernization, the implications of which are beyond the scope of this study.

10.0 RECOMMENDATIONS

This chapter summarizes the recommendations that have been put forward in the previous chapters. Despite the considerable effort that has gone into assembling data on emissions, abatement technologies and costs there is much that is not known especially in relation to the discharge of mercury and PCBs. The absence of this information makes it difficult to develop firm recommendations for the implementation of economic instruments for achieving virtual elimination of these selected persistent toxics in the Great Lakes basin. This factor should be born in mind since although the recommendations that are offered are not likely to cause a severe impact on the industry when considered on their own, their impact could be significant in conjunction with other requirements for abatement and the concerns expressed in Chapter 8 about the lack of competitiveness of some mills.

General

1. Efforts should continue to enhance the information on sources, abatement costs and damages that is necessary for the further appraisal and design of economic instruments.

Mercury

2. For mercury, priority should be given to economic instruments that will reduce the use of mercury in manufacturing process that are not closed cycles. Measurement of the use of mercury is far more reliable than measurement of the sources and fate of mercury discharges. A tax on mercury might be the simplest incentive to administer. though to be helpful, it would have to apply to all firms throughout Canada and the U.S. and possibly to imports from other countries as well.

3. The feasibility of a deposit/refund system for batteries containing mercury (over 30% of all mercury used in consumer products) should be investigated. In particular, the prospects for developing the necessary infrastructure should be looked at in detail.

4. Mercury emissions from electrical utilities, copper smelters and incinerators (over 85% of all industrial sources) in Canada and the U.S. could be subjected to an effluent charge if the reliability of monitoring is improved. Revenues could be used to deal with contaminated sediments in the Great Lakes basin and other bodies of fresh water.

PCBs

5. PCBs should be dealt with through regulation. There is no obvious role for the use of an economic instrument.

Pulp and Paper

6. It is in this sector that economic instruments appear to have the most to offer. Priority should be given to the detailed design and further analysis of a program of economic instruments for the pulp and paper industry consisting of:
   - Financial enforcement incentives to support regulations designed to virtually eliminate 2,3,7,8- TCDD/TCDF.
   - A tradeable permits scheme to reduce the use of chlorine.
   - An effluent charge on AOX.

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12.0 APPENDIX A: A SUMMARY OF THE O.E.C.D. (1989) SURVEY OF ECONOMIC INSTRUMENTS IN PRACTICE

ECONOMIC INSTRUMENTS IN USE (BASED ON OECD 1989; Written June 1988)

MEDIUM	COUNTRY	SINCE	PURPOSE	USE OF FUNDS	TARGET	FEE	REVENUE	EVALUATION
EFFLUENT CHARGES								
Air	France	1985	Revenue	Subsidy for air pollution control equipment (90%). Government technological research (10%). over 2,500 tonnes/year	Power generation: capacity over 50 mW. SOx or NOx discharge:	ECU 19/tonne	ECU 13 million	Charge too low to have incentive impact. Estimated that charge would have to equal ECU 1.2 billion to induce achievement of government targets. Moderate effect on innovation. About 400 plants are affected. Simple system: overhead is less than 3% of revenues.
Water	France	1969	Revenue	Operate river basin agencies. Agencies finance local and industrial effluent treatment.	Fee per unit of: 1. Suspended matter 2. Oxidizable matter 3. Soluble salts 4. Inhibitory matter (inhibits STP function) 5. Ammonia, nitrogen 6. Phosphorous (3,4 not for households)	Varies	ECU 240 million	Low incentive effect. Subsidies lower industry abatement cost by an average of 12%. Subsidies do have incentive effect on some firms. Rates have not kept pace with inflation.
Water	Germany	1981	Incentive		Fee per unit of: 1. Settling substances 2. Oxidizing substances 3. Mercury 4. Cadmium 5. Chromium 6. Nickel 7. Lead 8. Copper 9. AOX 10. Toxicity to fish	ECU 19.20/ damage unit (unit varies with substance) Fee reduced if meet or exceed standard or if use "state of the art technology" (See, text)	ECU 135 million (1984)	Average treatment costs are about 4 times average charges. There is evidence of incentive effects: Many firms have increased abatement to earn fee discounts and one-third of municipalities claim to have improved treatment in response to charge system. German water quality is said to have improved considerably since charges were put into effect.
Water	Italy	1976	Incentive		Varies with plant	Fees 9X higher if fail to comply with standards		Too little information. Charge is intended to end upon achieving full compliance with standards.

$1/Canadian = 0.65 ECU = $1/U.S. (June 1, 1987)

Continued

ECONOMIC INSTRUMENTS IN USE (BASED ON OECD 1989; Written June 1988)

MEDIUM	COUNTRY	SINCE	PURPOSE	USE OF FUNDS	TARGET	FEE	REVENUE	EVALUATION
EFFLUENT CHARGES, continued								
Water	Netherlands	1972	Revenue	Subsidy for abatement (direct dischargers). Pay full cost of STPs (indirect dischargers).	Fee per unit of: 1. BOD/COD 2. Suspendable solids 3. Toxic substances 4. Heavy metals	Households: set fee Medium-size firms: per unit, set with coefficients Large firms: direct monitoring. Pretreatment may reduce charge	ECU 473 million (1985)	Strong incentive impact on certain industries. Pollution levels for included parameters are significantly lower. Charges have risen steadily. Anticipation of further increases has a significant incentive effect. Administrative costs are low (7%).
Water	U.S.A. (Wisconsin)		Revenue	Covers 35% of state water pollution program costs.	37 substances, including mercury, PCBs	Varies	U.S.$ 1.2 million	Not a disincentive to pollute.
Waste	Belgium	1981	Incentive	All solid waste Recycled material exempt	ECU 0.02-2.15/ tonne or cu. m. Varies with type Incinerated and composted waste discounted.			
Waste	Denmark	1987	Incentive		All non-harmless waste Exemptions include demolition waste, unpainted wood and straw	ECU 5.20/tonne		
Waste	U.S.A.	1983	Revenue	Restoration of closed chemical waste sites.	Hazardous waste	ECU 1.85/ton		Little incentive.
Waste	U.S.A. (20 states)			Hazardous waste ECU 0.12/ton (WI)	Varies: to ECU 0.60/ton (MN)			

$1/Canadian = 0.65 ECU = $1/U.S. (June 1, 1987)

Continued

ECONOMIC INSTRUMENTS IN USE (BASED ON OECD 1989; Written June 1988)

MEDIUM	COUNTRY	SINCE	PURPOSE	USE OF FUNDS	TARGET	FEE	REVENUE	EVALUATION
PRODUCT CHARGES								
Medium	Country	Since	Purpose	Use of Funds	Target	Fee	Revenue	Evaluation
	Finland	1976	Incentive		Non-returnable beverage containers.	ECU 0.07 beer ECU 0.58 soft drink (in glass/metal) ECU 0.20 soft drink (other containers)	ECU 1.6 million	Market share of non-returnable bottles is low (5%). But the market for non-returnable plastic bottles is growing.
	Finland	1987	Revenue		Lubricant oils	ECU 29/tonne	ECU 3 million	Collection and reprocessing have increased.
	Finland	1972	Revenue		Crude oil and products			
	France	1981	Revenue	Infrastructure for proper disposal.	Lubricant oils	Up to ECU 6/tonne	ECU 3.8 million	Charge too low to be incentive. 70% of waste motor oil is collected. 11% of total oil sold is recycled. Administrative efficiency is high.
	Germany	1969 to 1989	Revenue	Infrastructure for proper disposal.	Lubricant oils	ECU 96/ tonne	ECU 63 million	High incentive effectiveness. Charge replaced by regulations which adequately control waste oil. System subsidization no longer seen to be necessary.
	Italy	1985	Revenue	Infrastructure for proper disposal.	Lubricant oils	ECU 3.20/tonne	ECU 2.3 million	
	Italy	1989	Incentive		Consumer plastic bags	ECU 0.06/bag		Tax equals 5X manufacturing cost. But reduction in use has been low.
	Nether-lands	1988	Revenue	Finances majority of federal environmental programs.	Gasoline (unleaded) Gasoline (leaded) Light fuel oil Lubricating oil (auto) Lubricating oil (other Heavy fuel oil/coal	ECU 0.10/ 100 litre ECU 1.74/ 100 Litre ECU 0.10/ 100 litre ECU 0.70/ 100 litre ECU 0.10/ 100 litre ECU 2.51/ 1,000 kg (rebate if install flue gas desulph.)		

$1/Canadian = 0.65 ECU = $1/U.S. (June 1, 1987)

Continued

ECONOMIC INSTRUMENTS IN USE (BASED ON OECD 1989; Written June 1988)

MEDIUM	COUNTRY	SINCE	PURPOSE	USE OF FUNDS	TARGET	FEE	REVENUE	EVALUATION
PRODUCT CHARGES, continued								
	Sweden	1973	Revenue	General revenue	Non-returnable beverage containers	ECU 0.01 to 0.03/ container	ECU 11 million	Tax too low to affect choice of containers.
	U.S.A.	1981	Revenue	Hazardous waste site clean up.	Petroleum	ECU 0.07/ bbl.(dom) ECU 0.10/ bbl.(imp)	ECU 487 million	Low charge level results in minimal effect on chemical use.
					Base chemicals	ECU 0.02- 0.09/ ton	ECU 244 million	Does not distinguish between better
					Derivatives	ECU 0.02- 0.09/ ton	ECU 52 million	or worse management.
ADMINISTRATIVE CHARGES								
	Sweden		Revenue	Regulation of polluting activities.	All polluting activities requiring permits	ECU 55 to 78/hour	ECU 3 million	Expenditures, estimated at ECU 12 million/year were expected to be balanced by revenues. But only ECU 3 million was raised. Civil servants, unused to billing for services, were either unable or unwilling to charge for full time spent. Change to a fixed yearly charge is expected.

$1/Canadian = 0.65 ECU = $1/U.S. (June 1, 1987)

Continued

ECONOMIC INSTRUMENTS IN USE (BASED ON OECD 1989; Written June 1988)

MEDIUM	COUNTRY	SINCE	PURPOSE	USE OF FUNDS	TARGET	FEE	REVENUE	EVALUATION
DEPOSIT-REFUND								
	Various EC, Canada, U.S.A. (some states)		Incentive		Beverage containers	ECU 0.06 to 0.30/ container		Initially, manufacturers encouraged container re-use to save money. Return of deposit- bottles is normally in the 80-95% range. Higher deposits are required for relatively higher priced beverages.
EMISSIONS TRADING								
Air	U.S.A.	1977	Incentive	Permits not auctioned.	Particulates, SOx, CO, O3, NO2			Imprecise emission inventories make assessment of effect on emissions highly uncertain. Cost savings, often of significant magnitude, are frequently reported. Administrative efficiency is low.

$1/Canadian = 0.65 ECU = $1/U.S. (June 1, 1987)

Continued

ECONOMIC INSTRUMENTS IN USE (BASED ON OECD 1989; Written June 1988)

MEDIUM	COUNTRY	SINCE	PURPOSE	USE OF FUNDS	TARGET	FEE	REVENUE	EVALUATION
ADMINISTRATIVE CHARGES, continued								
	Sweden		Revenue	Registration and control of pesticides.	New pesticides Pesticides	ECU 1,400 (no new active substance) ECU 5,600 (new active substance) ECU 700 (annual fee) ECU 420 (change use)	ECU 0.5 million	Nearly covers cost of registration and control (ECU 0.65 million). More personnel hired, reducing wait for permits. Yearly fee is burdensome for some highly specialized products.
TAX DIFFERENTIATION								
	Germany Nether- lands, Norway, Sweden	1985 to 1989	Incentive		Automobiles, larger or higher emitters			Phased out in 1989, when all new medium and large cars in the EC were required to meet minimum air pollution standards. Successfully used to speed application of regulation.
	Various EC		Incentive		Leaded gasoline	ECU 0.02- 0.05/ l.		In most countries, differentiation has been followed by abolition. Differentiation has had some incentive effect, easing and speeding transition to a new rule.

$1/Canadian = 0.65 ECU = $1/U.S. (June 1, 1987)

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