

# Lake Champlain Economic Database Project



**Lake Champlain  
Basin Program**

## Potential Applications of Economic Instruments for Environmental Protection in the Lake Champlain Basin

Prepared by  
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for  
Lake Champlain Management Conference

March 1993

**POTENTIAL APPLICATIONS OF ECONOMIC INSTRUMENTS  
FOR ENVIRONMENTAL PROTECTION  
IN THE LAKE CHAMPLAIN BASIN**

Prepared for  
The Lake Champlain Management Conference

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Anthony Artuso  
with assistance from Holmes and Associates

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This technical report is the fourth in a series of reports prepared under the Lake Champlain Basin Program. Those in print are listed below.

#### **Lake Champlain Basin Program Technical Reports**

1. *A Research and Monitoring Agenda for Lake Champlain.* Proceedings of a Workshop, December 17-19, 1991, Burlington, VT. Lake Champlain Research Consortium. May, 1992.
2. *Design and Initial Implementation of a Comprehensive Agricultural Monitoring and Evaluation Network for the Lake Champlain Basin.* NY-VT Strategic Core Group. February, 1993.
3. (A) *GIS Management Plan for the Lake Champlain Basin Program.* Vermont Center for Geographic Information, Inc., and Associates in Rural Development. March, 1993.  
  
(B) *Handbook of GIS Standards and Procedures for the Lake Champlain Basin Program.* Vermont Center for Geographic Information, Inc. March, 1993.  
  
(C) *GIS Data Inventory for the Lake Champlain Basin Program.* Vermont Center for Geographic Information, Inc. March, 1993.
4. (A) *Lake Champlain Economic Database Project. Executive Summary.* Holmes & Associates. March 1993.  
  
(B) *Socio-Economic Profile, Database, and Description of the Tourism Economy for the Lake Champlain Basin.* Holmes & Associates. March 1993  
  
(C) *Potential Applications of Economic Instruments for Environmental Protection in the Lake Champlain Basin.* Anthony Artuso. March 1993.  
  
(D) *Conceptual Framework for Evaluation of Pollution Control Strategies and Water Quality Standards for Lake Champlain.* Anthony Artuso. March 1993.

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The Economic Database Study is a survey of existing data and national literature intended to provide an overview of economic and demographic characteristics, and market-based approaches to facilitate water pollution control and prevention. Specific calculation of economic impacts of proposed actions will usually require additional information and data to apply principles from this compilation of existing data and literature to the Champlain Basin. In particular, current Lake Champlain Basin Program research in the areas of agriculture, recreation and fisheries will provide underlying data needed for refined estimates of costs and economic impacts of potential management actions.

March 1993

# Table of Contents

<b>Project Description and Introduction .....</b>	<b>1</b>
Research Objectives and Methodology .....	1
<b>1.0 Strengths and Weaknesses of Alternative Regulatory Instruments .....</b>	<b>2</b>
1.1 Objectives of Environmental Regulation .....	2
1.2 Alternative Regulatory Instruments .....	4
1.2.1 Command and Control Regulation .....	4
1.2.1.1 Technology Standards .....	5
1.2.1.2 Concentration Standards and Nontransferable Discharge Limits .....	6
1.2.2 Economic Instruments for Environmental Protection .....	7
1.2.2.1 Discharge Fees .....	8
1.2.2.2 Transferable Discharge Permits .....	9
<b>2.0 Case Studies .....</b>	<b>16</b>
2.1 Discharge Fees .....	<b>16</b>
2.1.1 The Agences Financieres de Bassin in France .....	16
2.1.2 Water Associations and Effluent Fees in Germany .....	17
2.1.3 The Dutch System of Effluent Charges .....	19
2.3.4 Sewer Surcharges in the U.S. ....	20
2.2 Transferable Discharge Permits .....	21
2.2.1 Emissions Trading and the Clean Air Act .....	21
2.2.2 Phosphorus Control in the Dillon Reservoir, Colorado .....	24
2.2.3 Nutrient Reductions in the Tar-Pamlico River Basin, North Carolina .....	26
2.2.4 Biological Oxygen Demand in the Fox River, Wisconsin .....	28
2.2.5 Maine's Watershed Planning Program .....	29
2.2.6 Sewer Access Rights - Escondido, California .....	30
<b>3.0 Application of Economic Instruments: Lessons from Theory and Practice .....</b>	<b>32</b>
3.1 Discharge Fees .....	32
3.1.1 Other Applications of Discharge Fees and Related Economic Incentives .....	33
3.2 Transferable Discharge Permits .....	35
3.2.1 An Illustrative Example .....	36
3.2.2 Trading Rules, Market Administration, Monitoring and Enforcement .....	38
3.2.3 Other Applications of Transferable Permits .....	42
<b>4.0 Potential Applications of Economic Instruments for Environmental Protection in the Lake Champlain Basin .....</b>	<b>43</b>

## Table of Contents

4.1 Initial Allocation of Discharge Permits .....	44
4.2 Trading Rules and Guidelines .....	45
4.3 Administration, Monitoring and Enforcement .....	46
4.4 Discharge Fees .....	47
4.5 Other Applications of Economic Instruments .....	47
4.6 Suggestions for Further Research .....	48
<b>Appendix A - Annotated Bibliography</b>	<b>A-1</b>
<b>Appendix B - Case Study Documents</b>	<b>B-1</b>

**NOTE:** Appendix B available for use at Lake Champlain  
Basin Program office only.

## **Project Description and Introduction**

This report is the third of four volumes developed under the Lake Champlain Management Conference (LCMC) project: Economic Database for the Lake Champlain Basin. The project was intended to provide the Lake Champlain Basin Program (LCBP) with the following information: an accurate, accessible economic database for the entire basin; a description of economic sectors closely related to the lake; a literature review and analysis of the use of economic instruments for environmental protection; and a framework for the evaluating pollution control strategies. The four volumes of the report are listed below.

Volume I: Summary Report

Volume II: Socio-Economic Profile, Database, and Description of the Tourism Economy for the Lake Champlain Basin

Volume III: Potential Applications of Economic Instruments for Environmental Protection in the Lake Champlain Basin

Volume IV: Conceptual Framework for Evaluation of Pollution Control Strategies and Water Quality Standards for Lake Champlain

## **Research Objectives and Methodology**

This phase of the project summarizes and interprets a review of the literature on innovative approaches to environmental regulation. The focus of the analysis was on the applicability of market mechanisms and economic incentives for protection of environmental quality in the Lake Champlain basin. Research was conducted through the library systems of Cornell University, Harvard University, and the University of Vermont. Relevant literature was identified through multiple keyword queries of electronic databases, on-line catalogs, and periodical abstracts containing references to several million journal articles, books, reports, government documents, and conference proceedings. Particular attention was provided to obtaining case studies or other empirical investigations of alternative regulatory approaches for control of point and nonpoint sources of water pollution. Telephone interviews were also conducted with public officials to obtain additional detail on four of the case studies identified in the literature. Complete references and brief abstracts of seventy of the most relevant publications obtained in the search process are contained in Appendix A.

Section 1 of this volume summarizes the objectives of environmental regulation and the theoretical strengths and weaknesses of alternative regulatory mechanisms. Section 2 presents ten case studies of the use of discharge fees and transferable discharge permits for environmental protection and pollution control. Section 3 integrates theoretical and empirical insights from the literature review with lessons drawn from the case studies. Section 4 presents specific applications of economic instruments that should be given further consideration in the development of a pollution control program for the Lake Champlain Basin, recommends a process for policy development, and outlines critical areas for further research.

## **1.0 Theoretical Strengths and Weaknesses of Alternative Regulatory Instruments**

### **1.1 Objectives of Environmental Regulation**

From the perspective of economic theory the two primary objectives of environmental policy are efficiency and equity. A secondary, or more accurately second best, objective of environmental regulation is cost-effectiveness.

- ♦ An efficient environmental policy maximizes the aggregate level of net benefits in comparison with all other available policy options.
- ♦ An equitable policy fairly distributes the costs and benefits of environmental protection among affected individuals and organizations.
- ♦ A cost-effective policy achieves a given environmental objective at least cost.

As illustrated in Figure 1, an efficient regulatory program would seek to improve or protect environmental quality up to the point where the cost of eliminating the next unit of pollution (the marginal cost) equals the benefit obtained from controlling one more unit of pollution (the marginal benefit). The ability to achieve an efficient environmental policy outcome, where marginal costs and benefits are equal, assumes that all polluters have the incentives, flexibility, and information necessary to achieve the same marginal costs of pollution control. Some regulatory strategies are more likely to meet these requirements than others. However, even if a pollution control program is economically efficient, in that it maximizes the net benefits to society, the program may still be considered unacceptable if the net benefits are not distributed in some equitable manner.

Although an efficient pollution control program requires the use of the most cost-effective control strategy, the reverse is not necessarily true. Developing a pollution control program that is cost-effective does not require an analysis of the net benefits of alternative policy objectives. It only requires a comparison of the costs of alternative means of achieving a given environmental quality objective. Cost-effectiveness analysis is most appropriately employed when the policy objective has already been established by executive order, legislative action, citizen referendum, or some other means. If the environmental objective has already been chosen, the issue is simply how to achieve that objective at least cost.

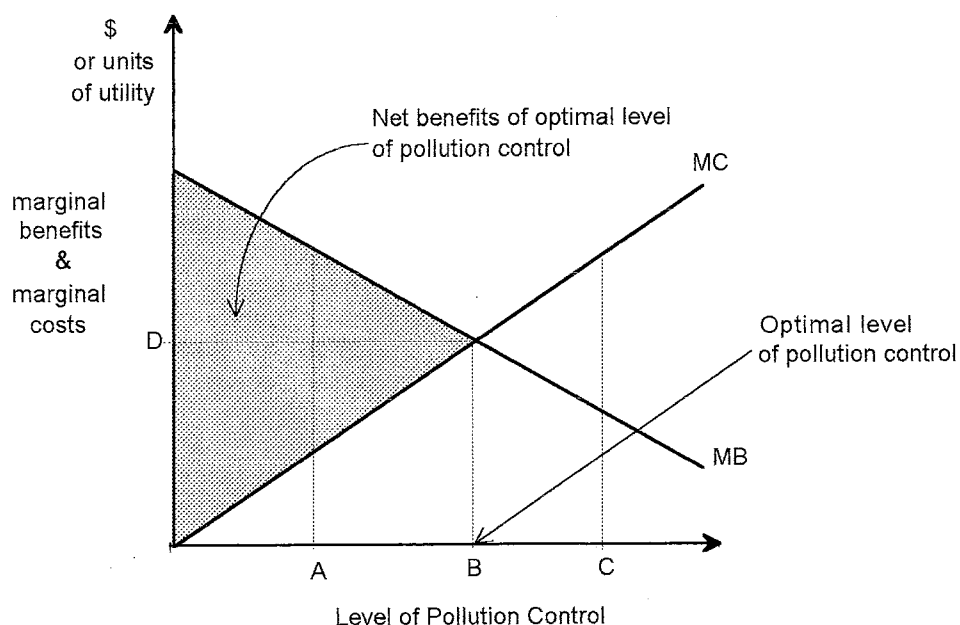
In addition to efficiency, equity and cost-effectiveness, other administrative, political, and dynamic issues should be evaluated in developing a pollution control strategy. These include:

- Feasibility and costs of administration, monitoring and enforcement.
- Public understanding and support.
- Conformance with the existing regulatory and legal framework.
- Flexibility in response to changing circumstances.

This volume concentrates primarily on analyzing the potential cost-effectiveness and equity of alternative regulatory mechanisms for water quality protection in the Lake Champlain basin. Volume 4 of this project addresses the question of how to estimate the benefits and costs of water quality control for Lake Champlain in order to develop efficient water quality standards. Both volumes also discuss issues of implementation, administration, and financing of environmental protection programs.

Figure 1

# The Economically Efficient Level of Pollution Control



## Notes to Figure 1

The optimal level of pollution reduction occurs where marginal costs (MC) are equal to marginal benefits (MB). The shaded area above the MC curve and below the MB curve represents the net benefits of pollution reduction up to the optimal level of control. At a lower level of pollution control (point A), marginal benefits exceed marginal costs and net benefits can be increased by increasing the degree of pollution control. At a greater than optimal level of pollution reduction, marginal benefits are less than marginal costs and total net benefits can be increased by decreasing the degree of pollution control.

Assuming all dischargers attempted to minimize costs or maximize profits, a discharge fee equal to point D would lead to the optimal level of pollution control. Similarly, if transferable discharge permits were issued in an amount that required pollution control equivalent to point B, the market price for a one unit discharge permit would be equivalent to D which is the marginal cost of pollution control at point B.



## 1.2 Alternative Regulatory Instruments

Environmental quality objectives are normally expressed in the form of maximum pollutant concentrations known as ambient standards. Ideally, any given set of standards would only be adopted after comparison with the costs and benefits of alternative environmental quality objectives. Unfortunately, it is often quite difficult to estimate the public health, recreational, commercial, and aesthetic benefits of improvements in environmental quality. Uncertainty regarding the value of these benefits often leads policy makers to simply adopt environmental quality standards based on public health or aesthetic criteria without any formal evaluation of costs and benefits associated with achieving that standard.

Even if a formal cost benefit analysis is not performed, the pollution control program should still seek to be cost-effective (i.e. minimizing the total costs of achieving whatever standards have been established), while ensuring an equitable distribution of the costs and benefits of the program. In the past, pollution control strategies intended to achieve some ambient standard of environmental quality have relied primarily on mandatory regulatory requirements combined with legal action, and in some cases financial penalties, for non-compliance. This approach has often been referred to as command and control regulation. As described below, most command and control regulatory approaches do not seek to equalize the marginal control costs of all polluters and therefore can lead to costly inefficiencies. In recent years, environmental regulators have sought to reduce the cost and improve the effectiveness of environmental programs through the use of a more flexible set of economic incentives and market mechanisms.

### 1.2.1 Command and Control Regulation

Beginning with the Clean Air Act of 1970, environmental regulation has traditionally followed a command and control approach. Legislation and subsequent administrative regulations have attempted to specify exactly what types of pollution control technologies must be implemented and/or defined the degree of pollution reduction that must be achieved at specific types of facilities. There is no theoretical conflict between command and control regulation and cost-effectiveness. If policy makers have complete information on pollution control technologies and control costs it is possible to construct a set of regulatory requirements that achieve a given level of pollution reduction at least cost. Firms with relatively high control costs would be required to reduce their pollution by a smaller amount than firms with relatively low control costs.

Unfortunately, regulators rarely have reliable, detailed information on the marginal control costs of all sources of a particular pollutant. In addition, command and control approaches are ill equipped to deal with the distributional issues that can arise from imposing different control requirements on similar pollution sources. This has led to the widespread use of uniform standards in environmental regulation. Uniform standards can take the form of requiring the use of a specific control technology, requiring all dischargers to reduce their emissions to a specific concentration level, or mandating a uniform percentage reduction in pollution from all sources.

### 1.2.1.1 Technology Standards

It is possible to differentiate between two types of technology standards. The first requires implementation of a specific control technology, and is referred to in this report as explicit technology standards. The well known requirement that municipal treatment facilities employ a minimum of secondary treatment is a characteristic example of an explicit technology standard. The second type of technology standard, more accurately referred to as a technology-based standard, simply imposes a certain discharge limit that is theoretically achievable with a given control technology. Technology-based standards are discussed in this report under the heading of concentration standards and discharge limits.

One of the apparent benefits of explicit technology standards for pollution control is their simplicity. If the required technology is explicitly identified in the legislation and/or pursuant regulations, there can be no confusion over what is necessary for compliance. It is also a simple matter for the regulatory agency to monitor compliance with the regulations. However, this simplicity is bought at a price. Explicit technology standards are a fairly blunt instrument. They leave little flexibility to fine tune the level of control at different locations or to adapt to different economic circumstances. Due to local differences in the ecology of the control region, and geographic differences in the location of dischargers, as well as population and economic changes over time, explicit technology standards are likely to provide either excessive or insufficient levels of pollution control. As outlined below explicit technology standards also achieve any given level of pollution control at much higher cost than other regulatory approaches.

In order to provide regulators with some flexibility in designing pollution control programs, a technological standard may be only vaguely specified in environmental law. But providing this flexibility can bring its own set of problems. For example, state and federal legislation may simply require the use of best available or best practicable control technologies. Individual regulatory reviews and administrative rulemaking are then necessary in order to determine just what constitutes the best available or practicable technology for specific types of facilities. Whether it leads to an explicit technological requirement or the establishment of technology based discharge limits, this detailed technology review process can be time consuming and expensive. It is also prone to administrative disagreements and litigation by environmental and industry groups.

Another problem with explicit technology standards is the stifling effect they can have on innovation and technological improvement. Once an explicit technology standard has been adopted, there are no incentives, and there may even be disincentives, for dischargers to adopt new more effective or less expensive technologies. Moreover, because of the time, expense, and political difficulties involved in setting technology standards, once they are implemented they are difficult to change. The net result is a significant delay in the development and implementation of new pollution control technologies.

An even more serious deficiency with explicit technology standards is that they are often imposed without a full consideration of their costs and benefits. In many cases, if the technology is available and its adoption will not cause serious economic hardship, regulatory programs will require the use of that technology at all relevant facilities. This can lead to a situation where control costs far exceed benefits. Several studies have indicated that pollution control programs that rely on technology based standards have some of the worst benefit-cost ratios (Luken 1990, Freeman 1991).

In addition to their failure to consider both the costs and benefits of pollution control, the poor economic performance of technology standards can also be attributed to their disregard for variations in the marginal pollution control costs of regulated facilities and operations. Facilities with high costs of installing the required technology or meeting the specified emissions limit must still comply with the same requirements as facilities with low compliance costs.<sup>1</sup> Any given environmental outcome could be achieved at less cost by requiring higher levels of control from the facilities with the lowest control costs. In addition, at certain sites, it may be possible to achieve a given level of pollution control less expensively through the use of a different control technology. By prohibiting any variations in the degree or type of pollution control measures employed at different facilities, explicit technology standards increase the total costs of pollution control programs.

#### 1.2.1.2 Concentration Standards and Nontransferable Discharge Limits

As indicated above many technology-based standards are ultimately translated into a set of discharge concentration limits. For example, a requirement that all wastewater facilities ensure that their effluent does not exceed a phosphorus concentration of 1.0 milligrams per liter is an example of a concentration standard. Although often based upon what can be achieved through the use of the best available or practicable technology, concentration standards normally provide dischargers with the flexibility to choose what technology to actually employ. Allowing this flexibility can be expected to result in a more cost effective control program and provide dischargers with some incentive for the development and adoption of less expensive control technologies. However, setting emissions concentration limits rather than simply requiring the use of a specific technology can increase regulatory costs by requiring more detailed permitting reviews and more frequent monitoring of pollution discharges.

One problem shared by fixed concentration standards and explicit technology standards, is that they both ignore differences in control costs between facilities. All dischargers of a particular type or size are likely to be required to achieve the same level of pollutant concentrations in their emissions regardless of the relative costs of meeting that standard. Regulatory agencies may attempt to reduce the costs of meeting a particular environmental quality objective by setting more stringent emission standards for facilities with relatively low control costs and more lenient standards for facilities with relatively high control costs. However, this assumes that regulators have reliable information on which to make these distinctions. As the number and type of dischargers increases, the costs of obtaining detailed, reliable information on the pollution control costs of all dischargers rises rapidly. Even if adequate information can be obtained at a particular point in time, changes in economic conditions and development of new technologies can significantly alter the relative marginal costs of pollution control from various sources. Due to economic and technological change, what was once determined to be a cost-effective pollution control strategy may no longer achieve pollution reductions at least cost.

Another problem common to both emission concentration limits and explicit technology standards, is that economic or demographic growth can cause the need to continually tighten the standard in order to maintain a given environmental quality target. New emission sources or

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<sup>1</sup> Throughout this report the terms "discharger" and "facility" are used to refer to both point and nonpoint sources of pollution.

increases in emissions from existing sources can result in increases in the total volume of pollutants, even though all dischargers continue to meet or exceed their concentration limits. This dilemma has plagued regulatory efforts to control mobile sources of air pollutants. Even though catalytic converters and cleaner fuels have greatly reduced the concentration of pollutants emitted by cars and trucks, increases in the number of vehicle miles logged on roadways in the U.S. has repeatedly postponed the achievement of air quality standards in many regions. Similarly, twenty years after the passage of the Clean Water Act many regions of the country, have experienced continued declines in water quality due to increases in the number and volume of point and nonpoint sources of pollution.

The difficulty of achieving or maintaining environmental quality objectives through the use of discharge concentration standards has often required regulators to allocate an acceptable level of pollution discharge among existing sources. Permits issued to existing sources specify a maximum amount (volume or mass) of specific pollutants that can be discharged over a given period of time. For example, the permit issued to Facility A might indicate it can discharge a maximum of one thousand pounds of phosphorus per month. This permitting approach ostensibly gives regulators direct control over total discharges, at least from existing sources. If dischargers expand their level of operations they must implement more stringent controls to remain within their discharge limits.

Unless the nontransferable discharge limits are tailored to account for the unique circumstances of each source of pollution in the control region, marginal pollution control costs will be higher for some dischargers than for others. Consequently, the total cost of the control program will be higher than it needs to be. In addition, to accommodate economic or population growth while still meeting environmental quality standards will require frequent reallocations of permitted discharge levels. This reallocation can be made by regulatory fiat or it can occur through a market-like trading program. In many cases, regulators do not have the information and/or political support necessary to achieve the most cost-effective reallocation. In addition, regulators are unlikely to force a reallocation simply as a result of operational or technological changes that alter the relative control costs of existing dischargers. A market-based system provides incentives for both existing and new sources of pollution to negotiate cost saving reallocation of discharge permits without regulatory intervention.

### 1.2.2 Economic Instruments for Environmental Protection

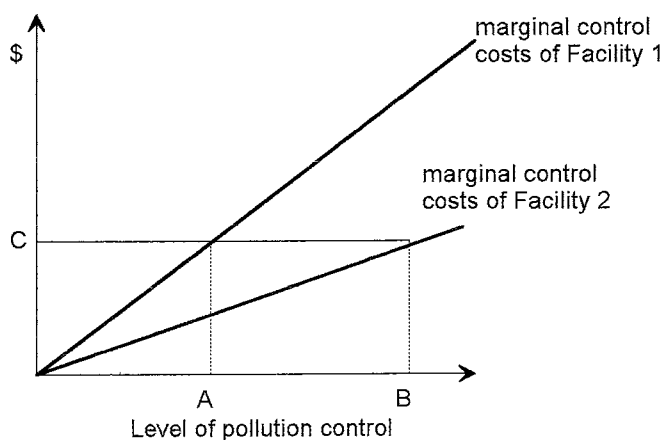
There are many forms of economic instruments that can be devised to promote environmental protection. With only minor conceptual damage they can generally be divided into two categories. The first category is defined by the use of direct monetary incentives or disincentives intended to promote environmentally beneficial behavior or reduce environmentally harmful activities. Discharge fees, pollution taxes, subsidization of environmentally benign technologies, and deposit-refund systems would all depend on the use of direct monetary incentives. The second type of economic instrument relies on the creation of markets for common property natural resources such as air, water or biological diversity. This category of economic instruments would include transferable or marketable discharge permits, transferable development rights, and the creation of transferable boating, fishing, harvesting, or other resource use rights.

### 1.2.2.1 Discharge Fees

The basic rationale for using discharge fees as an environmental policy instrument is to provide polluters with a price signal that indicates the cost to society of each unit of pollution. If a discharger's marginal pollution control costs are less than the discharge fee, profits could be increased by reducing pollution discharges until the cost of eliminating one more unit of pollution was just equal to the discharge fee. In an ideal system, the revenues raised from the discharge fees would be utilized to reimburse parties who sustained damages from discharges of pollution.

Assuming that pollution control can be increased or decreased in small increments, and that dischargers seek to maximize profits or minimize costs, a properly structured discharge fee system will not only be cost-effective but will also achieve an economically efficient level of pollution control. Pollution control is achieved cost-effectively since all dischargers will reduce their pollution until their marginal control costs equal the discharge fee. As illustrated in Figure 2, dischargers with initially lower marginal costs of pollution control will reduce their pollution by a proportionately greater amount than dischargers with initially higher marginal control costs. An economically efficient level of pollution control will be achieved if the fee is established to achieve an equilibrium level of pollution control where the benefits of an additional unit of pollution reduction are equal to the cost of reducing pollution by an additional unit.

Figure 2 Effect of Discharge Fees on Facilities with Different Control Costs



**Notes to Figure 2**

If a discharge fee of C dollars is charged for each unit of pollution, the cost minimizing level of pollution control for Facilities 1 and 2 are points A and B respectively.

Very few if any actual discharge fee systems approach the theoretical ideal outlined above. One of the more serious practical problems with the use of discharge fees for pollution control is determining the "price level" that will achieve the optimal level of pollution control. If the regulatory agency has perfect information on the marginal control costs of all sources of pollution and the benefits of all levels of pollution control, it is a simple matter to set the fee at the intersection of these two curves (as shown in Figure 1). In reality, perfect information is never available and regulators must employ a process of trial and error. The fee might be established based upon the best information available and then raised if the desired level of pollution control is not met or lowered if the pollution control target is exceeded.

Due to the difficulty of estimating the marginal costs and benefits of pollution control, the associated problem of adjusting the fee to achieve the target level of pollution control, and the political difficulty of imposing a significant fee on well organized sectors of society, most discharge fee systems are utilized in conjunction with other pollution control measures. For example, a set of technology standards or effluent concentration limits might be established and a fee imposed for any remaining discharges. Rather than trying to equate the fee revenue with the costs imposed by the pollution discharge, such hybrid approaches use discharge fees primarily to recover the operating, capital, and financial assistance costs of the pollution control program. However, even as part of this kind of hybrid system, the discharge fee can still provide incentives for increased pollution control if it is based upon the volume, concentration, or chemical composition of the pollution discharge.

#### 1.2.2.2 Transferable Discharge Permits

Various terms are used in the literature when referring to pollution control systems that allow trading of permitted levels of pollution from one source to another. These terms include transferable discharge permits, marketable discharge rights, pollution trading, and transferable discharge allocations. Many existing regulatory programs that allow for the transfer of permitted discharges from one source to another, use terms such as pollution reduction credits to emphasize that the objective of the program is to reduce or control pollution to acceptable levels. This report will generally utilize the term transferable discharge permits (TDP's) when referring to pollution control systems that allow trading of permitted levels of pollution. However, in the case studies of Section 2, the actual terminology utilized by each program will generally be followed in this report.

The first steps in establishing a TDP system are essentially the same as those previously described for an ambient standards approach to environmental protection. First, a set of environmental quality standards are adopted, hopefully after considering the costs and benefits of achieving those standards. Next, the total pollution discharges that can be permitted without violating the standards are calculated, and then this permitted level of pollution is allocated to the various sources of pollution in the control area. Once the initial allocation of permissible levels of pollution has been completed, TDP systems differ from traditional regulatory approaches by promoting cost-saving transfers of discharge permits from one source to another.

For example, suppose that two facilities (Facility 1 and Facility 2) discharge the same quantity of a particular pollutant and the initial allocation of discharge permits requires both facilities to reduce their discharges by fifty percent. If pollution discharges can be reduced at a

lower per unit cost at Facility 2 than at Facility 1, the owners of these two facilities could reduce their net pollution control costs by transferring discharge permits from Facility 2 to Facility 1. As shown in Figure 3, Facility 1 will have an incentive to limit its own level of pollution control, and to pay Facility 2 to increase its pollution control, until either the marginal pollution control costs at the two facilities are equal, or the required aggregate level of pollution reduction has been achieved. By allowing facilities to transfer discharge allocations, the net pollution control costs to society can be reduced.<sup>2</sup> To facilitate cost saving transfers of discharge permits, the permits should be denominated in standardized transferable units such as pounds per year, and the guidelines governing permissible trades should be clearly defined.

To illustrate the benefits of TDP systems more clearly, it may be instructive to add some quantitative detail to the example outlined above. Assume Facility 1 can reduce its pollution discharge for a total cost of  $\$1000 \times (p1)^2$ , and assume that Facility 2 can reduce its pollution for a total cost of  $\$500 \times (p2)^2$ , where  $p1$  and  $p2$  are the percentage reductions in pollution discharged at Facilities 1 and 2 respectively. If both facilities are required to reduce pollution discharges by fifty percent, then the total costs of pollution control would be \$3.75 million as summarized in Table 1 below.

Table 1 Example of Pollution Control Costs of Uniform Nontransferable Discharge Allocation

	Non-Transferable Discharge Allocation	Cost of Pollution Reduction
Facility 1	50% of prior discharge	$1000 \times (50)^2 = \$2.5 \text{ million}$
Facility 2	50% of prior discharge	$500 \times (50)^2 = \$1.25 \text{ million}$
Total	50% of total discharges	\$3.75 million

Given the differences between the pollution control costs of Facility 1 and Facility 2, requiring both facilities to reduce their discharges by an equal amount is not the most cost-effective or equitable means of achieving any given pollution control target. As indicated in Table 1, a uniform level of pollution reduction results in control costs for Facility 1 that are twice as high as those of Facility 2.

Regulators could achieve a fifty percent reduction in total pollution discharges at least cost simply by requiring Facility 2 to reduce its pollution by two thirds while demanding only a one third reduction in pollution discharges from Facility 1.<sup>3</sup> Unfortunately, under this least cost

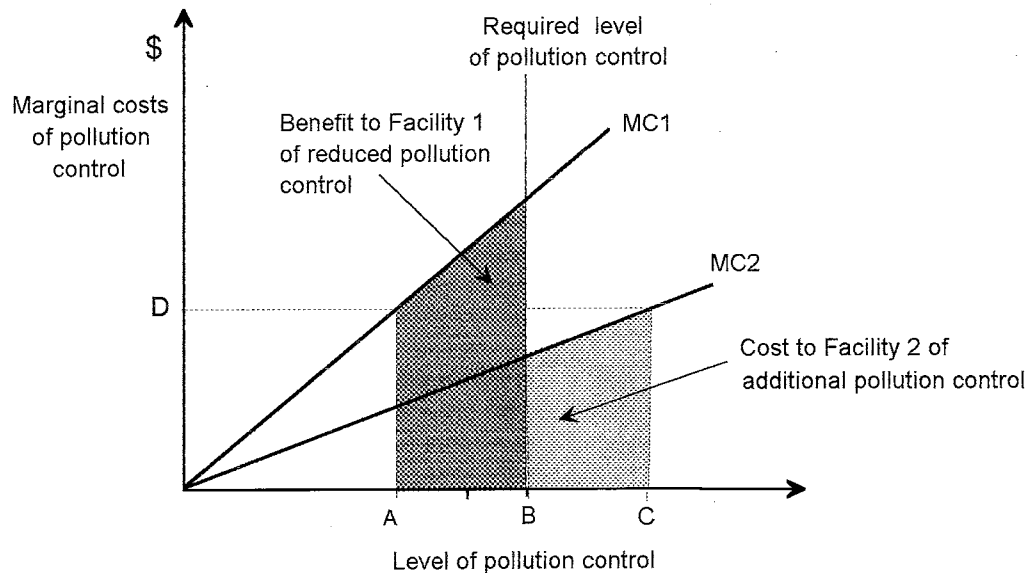
<sup>2</sup> It is important to note that the potential cost savings of TDP systems diminish as the overall regulatory requirements approach the maximum technically feasible level of pollution control. In the extreme case, if the desired environmental quality standards can only be met by *all* dischargers reducing their pollution as much as is technically possible, then there will be no opportunity for one discharger to pay another to make additional pollution reductions.

<sup>3</sup> The least cost mix of pollution control between the two facilities can easily be determined by solving the following optimization problem.

$$\begin{aligned} \text{Min. } & 1000 \times (p1)^2 + 500 \times (p2)^2 \\ \text{s.t. } & p1 + p2 = 100 \text{ and } 0 < p1, p2 < 100 \end{aligned}$$

Figure 3

### Cost Savings From Transfer of Discharge Permits



#### Notes to Figure 3

Assume Firm 1 and Firm 2 discharge equal amounts of pollution and both are required to reduce their discharges to point B, either directly or by paying other firms to achieve additional pollution control. Since the marginal costs of pollution control of Firm 1 (MC1) are greater than those of Firm 2 (MC2), the two firms could negotiate a mutually beneficial transaction. Firm 1 would reduce its required level of pollution reduction equivalent to point A, by paying Firm 2 to increase its pollution control by an equivalent amount, from point B to point C. At points A and C the marginal costs of pollution control for the two firms are both equal to \$D and there are no incentives for further transactions.

The benefit (avoided cost) of this lower level of pollution control to Firm 1 is represented by the shaded region under the MC1 line between points A and B. The costs of additional pollution control to Firm 2 are equivalent to the shaded region under the MC2 line between points B and C. It is easy to see from the figure that the benefits exceed the costs. After the transaction is completed the combined level of pollution control would still equal point B, but the total cost of achieving that level of pollution reduction would be lower than if both firms had to directly achieve pollution reductions equivalent to point B.



approach, the distribution of pollution control costs between the two facilities is still quite uneven, as shown in Table 2.

Table 2 Least Cost Nontransferable Discharge Allocation

	Non-Transferable Discharge Allocation	Cost of Pollution Control
Facility 1	2/3 of prior discharge	$1000 \times (1/3 \times 100)^2 = \$1.1 \text{ million}$
Facility 2	1/3 of prior discharge	$500 \times (2/3 \times 100)^2 = \$2.2 \text{ million}$
Total	1/2 of prior discharge	\$3.3 million

One of the principal strengths of TDP systems is the ability to approach a least cost solution while still ensuring a fair distribution of costs. Continuing with the above example, regulators could achieve a fifty percent reduction in pollutant discharges at least cost by allocating to Facilities 1 and 2 any combination of transferable discharge permits that equates to a fifty percent average reduction. Mutually beneficial transfers of discharge permits between the two facilities would result in a final allocation that required Facility 1 to reduce its discharges by one third and Facility 2 to reduce its discharges by two thirds. By selecting the appropriate initial allocation, regulators could ensure an equal distribution of control costs between the two facilities. For example, if the regulatory agency initially allocates transferable discharge permits to Facility 1 equal to 58.3% of its baseline discharges and transferable permits to Facility 2 equal to 41.6% of its baseline discharges, mutually beneficial transactions between the owners of the two facilities would result in a cost effective final allocation and an equal distribution of costs as summarized in Table 3 below.<sup>4</sup>

Table 3 Distribution of Costs for Sample Transferable Discharge Permit Allocation

	Initial Discharge Allocation	Purchase (Sale) of Discharge Permits	Final Discharge Allocation	Direct Pollution Control Costs	Costs (Revenues) of Purchase (Sale) of Permits	Total Cost
Facility 1	58.3% of prior discharges	8.3% of prior discharges	66.6% of prior discharges	\$1.1 million	\$.55 million	\$1.65 million
Facility 2	41.6% of prior discharges	(8.3%) of prior discharges	33.3% of prior discharges	\$2.2 million	\$ (.55 million)	\$1.65 million
Total	50% of total discharges	No net change	50% of total discharges	\$3.3 million	No net change	\$3.3 million

<sup>4</sup> The distribution of costs presented in Table 3 are based on the assumption that the price paid by Facility 1 for each 1% increase in pollution control by Facility 2 is equal to the equilibrium marginal cost of both facilities (i.e. Price = MC =  $2000 \times (33.3) = \$66,600$ ). In a market with many buyers and sellers, competition would be expected to keep the price of discharge permits close to the marginal cost of pollution control. However, with just one buyer and one seller, imperfect information or unequal bargaining skills could result in a price that differs from the competitive equilibrium.

The preceding example is intended to illustrate that regulatory programs based on nontransferable discharge allocations require public officials to choose between minimizing total pollution control costs and achieving an equitable distribution of those costs. However, regulatory programs that employ transferable discharge permits can simultaneously achieve these two important objectives. The ability to buy or sell discharge permits provides dischargers with incentives to engage in trades until their marginal costs of pollution control are equivalent to the price at which they can purchase an additional (one unit) discharge permit. As a result of these transactions, the final distribution of discharge permits will approach the least-cost pollution control strategy, regardless of the initial allocation of permits.<sup>5</sup> Consequently, the regulatory agency can utilize the initial allocation of transferable discharge permits as a means of achieving an equitable distribution of pollution control costs, without increasing the total costs of the pollution control program.

Another strength of TDP systems that is illustrated by the previous example is the ability to directly control the aggregate level of pollution control. Assuming effective monitoring and enforcement, the regulatory agency can achieve any reasonable pollution control objective by issuing the appropriate level of discharge permits. Technological and economic changes will continually affect the market value of the tradeable permits which will in turn promote cost-effective reallocations of the permits among both existing and new sources of pollution. In contrast, environmental regulatory programs that depend on discharge fees, technology standards, or concentration limits, only indirectly control the aggregate level of pollution discharges. With any of these other regulatory instruments, changes in the level of economic activity, new development, or a miscalculation in the appropriate level of the discharge fee can cause actual pollution discharges to deviate from the targeted level. As illustrated in Figure 4, the importance of maintaining direct control over the level of pollution discharge depends on how rapidly pollution control costs or environmental damages increase as the deviation from the targeted level of environmental quality increases.

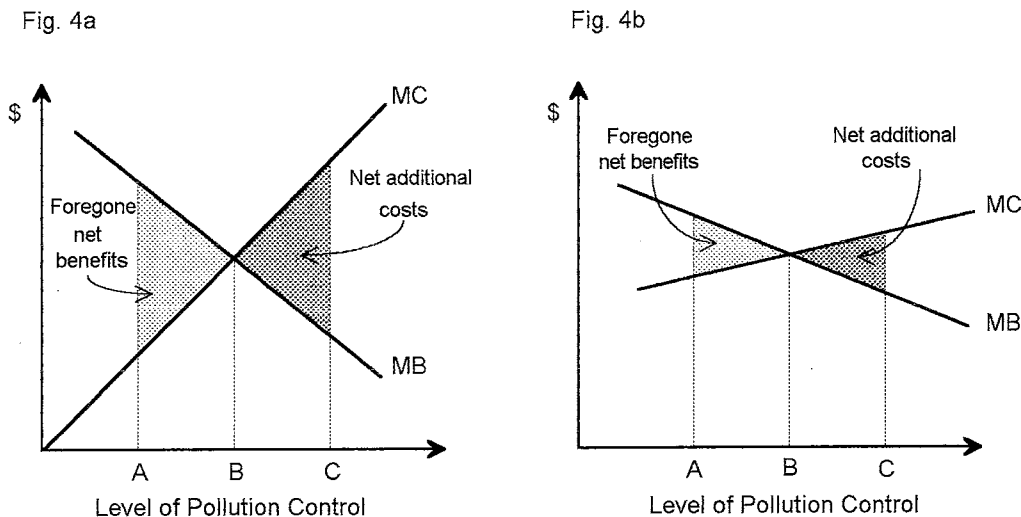
Although TDP systems do provide direct control over the aggregate level of pollutant discharges, an unrestricted trading system can result in excessive concentration of pollutants in a localized area within the control region. It should be noted that other regulatory instruments including uniform discharge fees as well as technology and concentration standards can also result in excessive localized concentrations of pollutants. With certain "global" pollutants such as greenhouse gases or chloroflourocarbons, the location of dischargers is relatively unimportant. However, for "local" pollutants such as biological oxygen demanding wastewater or the air pollutants that lead to ground level ozone, the concentration of dischargers in a localized area can be a more serious problem. Many pollutants have both global and local characteristics; both the total discharge of pollutants in the control area and the location of those discharges are of concern. In order to avoid localized pollution "hot spots", it may be necessary to place certain restrictions on trading and/or require something other than a one to one ratio for trades between certain locations. These considerations will be discussed in greater detail in Section 3 of this volume.

One area where economic instruments such as TDP systems and discharge fees are generally perceived to be superior to other forms of environmental regulation, is in providing incentives for cost reducing innovation. This advantage is most obvious in comparison to explicit technology standards. If a specific technology is required by law, there is little room for

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<sup>5</sup> An initial allocation of permits that provides one or two dischargers with a near monopoly could prevent attainment of a least cost outcome.

**Figure 4** Costs of Deviating From Optimum Level of Pollution Control



**Notes to Figure 4**

Figure 4a illustrates that if the marginal costs and/or benefits of pollution control vary significantly in the vicinity of the optimum level of pollution control, then deviating from the optimum will result in significant additional costs or foregone benefits. Conversely, Figure 4b shows that if marginal costs and benefits are relatively constant in the vicinity of the optimum level of pollution control, then the costs, or foregone benefits, of deviating from the optimum control level will not be as large.

innovation. But even in comparison with nontransferable discharge limits or concentration standards, discharge fees and TDP's generally offer greater incentives for innovation.

The increased incentives for innovation offered by discharge fees and TDP's can be illustrated with two simplified examples. In the first case, a new technology increases the percentage of pollutants that can be removed from the waste stream but does not reduce the cost of lower levels of pollution control. A firm that is already in compliance with maximum concentration standards for its discharge has no incentive to adopt this more effective technology. This is not the case with discharge fees or TDP's. If a new technology enables additional pollution reductions at a lower per unit cost than the discharge fee or the market price of discharge permits, dischargers can reduce their total costs by adopting the new technology. A different type of technology improvement might reduce per unit control costs at any level of pollution control. In this case discharge fees and TDP programs will again offer greater incentives to adopt the technology than fixed regulatory requirements. When faced with either per unit discharge fees or the opportunity to sell discharge permits, a reduction in the per unit costs of pollution control offers the potential for savings not only on the current level of pollution control but also on further pollution reductions.

Perhaps the most serious concern regarding TDP systems, is that they are more difficult to monitor and administer than uniform regulatory requirements. When compared with explicit technology standards this is almost certainly the case. Monitoring compliance with a regulation that requires use of a specific technology requires little else besides determining if the technology has been installed and is functional. Monitoring discharge permits, tradeable or otherwise, requires periodic analysis of the emissions or effluent of the facility to ensure it does not exceed the permitted level. In addition, a system of tradeable permits requires administration of the trading system. Regulations governing permissible trades must be developed and a system must be implemented that ensures all trades are recorded on the books of the regulatory agency.

A pollution control program based on nontransferable discharge limits obviously avoids the difficulties of defining and monitoring permissible trades. However, if the nontransferable permits specify a maximum concentration for each discharger, then increases in economic activity and population will require the development of a revised set of discharge limits in order to ensure continued achievement of environmental quality objectives. The political difficulty of continually revising existing discharge permits may make it difficult to accommodate economic growth without jeopardizing environmental quality. With a system of tradeable permits, economic and demographic growth does not require continual revision of discharge permits by the regulatory agency. New or expanding facilities must simply purchase from existing dischargers a sufficient amount of the permitted discharge rights previously allocated by the regulatory agency.<sup>6</sup>

Much of the foregoing discussion of TDP systems implicitly assumes that an efficient market for discharge permits will develop. This liberal assumption was made in order to illustrate the theoretical strengths of a TDP system. In general, the participation of many buyers and sellers will tend to increase the competitiveness and therefore the efficiency of a market for discharge permits. Nevertheless, even if there are many sources of pollution in a region, the regulatory agency must exercise some care in the initial allocation of discharge permits and in the ongoing administration of the TDP program in order to ensure a reasonably efficient and equitable market outcome. The requirements for the development of an efficient market for discharge permits are discussed further in the following sections of this volume.

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<sup>6</sup> With either transferable or nontransferable permits, the regulatory agency could also choose to withhold a portion of the environmentally acceptable discharge permits for future allocation to new or expanding facilities. Although this approach provides some flexibility in accommodating economic growth, there is a price to be paid for this benefit. If the regulatory agency withholds a portion of the allowable permits, existing dischargers will receive lower discharge permit allocations and therefore will have higher pollution control costs. These issues are discussed in more detail in Sections 3 and 4.

## **2.0 Case Studies**

This section summarizes ten case studies of the use of discharge fees and transferable discharge permits for environmental protection. While all of the case studies except one are related to the protection of water quality, variations of the economic instruments examined in this section have been utilized to protect a wide range of natural resources and environmental amenities. Other applications of these instruments that might be considered in the Lake Champlain Basin, in addition to water quality protection, will be discussed in Sections 3 and 4.

### **2.1 Discharge Fees**

The use of discharge fees for the control of water pollution has a long history of application particularly in Western Europe and to a limited degree also in the U.S. The most instructive examples of the use of discharge fees as a policy instrument for water quality control can be found in France, Germany and the Netherlands. Similar, although somewhat less ambitious, systems of sewer surcharges exist in many parts of the U.S. In each of these case studies the use of discharge fees must be understood as part of a larger regulatory program that includes self-regulation, voluntary agreements, development of consensus among affected parties, and in many cases traditional technology standards or discharge limits.

#### **2.1.1 The Agences Financieres de Bassin in France**

France has been utilizing a system of economic incentives for water quality control for almost thirty years. In 1964 the national 'Law on Water' was passed by the French parliament, which introduced three principles into management of water resources in France (Kaczmarek 1990). First, water resource management must be conducted within the framework of major watersheds as opposed to political boundaries. Second, management of water resources must be conducted with the active participation of all affected parties including representatives of local communities, industries, farmers, fishermen, and recreational users as well as provincial and national representatives. Finally, each entity that causes water pollution or uses water should have to pay for their degradation or use of the resource. Based upon these three principles, six water basin agencies (Agences Financieres de Bassin) were created in 1966, each responsible for management of one of the major watersheds in the country. The Law on Water and subsequent decrees and administrative clarifications provides the water basin agencies with authority to impose discharge fees on all municipal and industrial point sources of water pollution.

The water basin agencies are effectively governed by a board of representatives of all industries, municipalities, and water user groups within the river basin. The central government, through the Ministry of the Environment, is also represented on the governing boards. The governing board must approve the schedule of fees to be levied on all dischargers as well as define the duties and activities of the basin agency within the fairly general national guidelines defined in the Law on Water. The basin agencies themselves are highly professional institutions employing over 200 administrators, engineers, and technicians. The agencies monitor discharges necessary to collect the fees, enforce certain pollution control agreements, and

provide technical assistance for water supply and pollution control planning. However, the water agencies are not directly responsible for the construction or operation of wastewater treatment facilities.

The discharge fees paid by all point sources of pollution are based on the characteristics and volume of the wastewater discharge. Pollutants for which charges are assessed include suspended solids, biological oxygen demand, chemical oxygen demand, organic nitrogen, and total phosphorus (Opschoor and Vos 1989, 37). The charges vary within a particular river basin depending on location. Upstream dischargers normally pay more than those located downstream. Small, municipal dischargers pay a fee based upon the typical discharge of one inhabitant equivalent multiplied by the population served. These municipalities can reduce their fees if they demonstrate that their actual discharges are lower than the estimated amounts based on the inhabitant equivalents. For most large municipal and industrial treatment facilities, fees are based on the actual level of pollution monitored by the agency.

A significant portion of the revenues raised by the discharge fees is utilized to provide grants and subsidized loans for the installation of water pollution control equipment at municipal treatment plants or factories within the basins. In 1988 over 80% of the revenues of the water basin agencies were devoted to grants and low interest loans for pollution control projects. (Kaczmarek 1990). The per unit rate of the fee imposed on both municipal and industrial discharges is reduced if certain pollution control equipment is installed, with the degree of reduction depending on the efficiency of the control equipment or process. In addition, the discharge fees are supplemented by a system of negotiated pollution control contracts between firms and the national Environment Ministry. The negotiated contracts normally require rapid implementation of certain pollution control measures in exchange for suspension of the discharge fees while these measures are being installed (Harrison and Sewell 1980).

Since 1976, the level of charges imposed by the water basin agencies has risen steadily as was initially intended by national decree. After accounting for inflation, the total receipts of the waster basin agencies increased by approximately 75% from 1976-1990. During this same period, total point source discharges of toxics, biochemical oxygen demand, and suspended solids were reduced by approximately 40% (Kaczmareck 1990).

Recently, the Ministry of the Environment introduced a bill to the French parliament that would widen the role of the basin agencies in water quality protection. (Gaines and Westin 1991, 56-57) In particular the bill would expand the application of the discharge fees to include pesticides and nutrient discharges from various agricultural activities. The bill also authorizes the collection of stormwater fees based upon the area of impervious surfaces within each basin such as parking lots, roof surfaces, roads etc. It is not clear from the published literature whether the French parliament has authorized this expanded system of discharge fees.

### 2.1.2 Water Associations and Effluent Fees in Germany

The German system of water quality control balances federal, state, and local involvement and combines the use of discharge concentration limits with a set of discharge fees. Many of Germany's Genossenschaften, or regional water associations, have been in operation since the early twentieth century. All municipal and industrial point source dischargers within a particular watershed or river basin are required to join the water associations. One of the main purposes of the water associations is to comply with state and federal water quality requirements

through the construction and operation of regional treatment, flow management, and in-stream aeration facilities. Capital and operating expenditures of the water associations are funded through an effluent fee on all members. The fees are based upon the chemical characteristics of the discharge. Voting power within the water associations is proportionate to the percentage of the overall budget paid by each member.

By the late 1960's, there was a growing consensus that the water associations were not providing adequate protection of the nation's water resources. In particular, massive fish kills in the Rhine during the summer of 1969 provided clear evidence of the need for additional measures to improve water quality. Political support for the use of economic incentives for environmental management emerged in Germany at about this same time. During the early 1970's, initial legislative proposals for water pollution control envisioned a system of effluent charges that would have pleased most theoretical economists. The proposed fees were to be based on the estimated damage caused by pollution discharges (Brown and Johnson 1984). However, pressure from some lander (states) and industries yielded a more moderate charge system that operates in tandem with technology-based standards. Nevertheless, the resulting system includes a set of discharge fees explicitly based on the assumption that pollution dischargers cause damages to other users of the water body and that discharge fees can be utilized to provide incentives for pollution control.

Under the 1976 Waste Water Charges Act, the federal government is responsible for formulation of minimum water quality goals and technology-based standards for municipal and industrial discharges as well as the determination of the annual level of the charges. The lander are responsible for the implementation and enforcement of the discharge fees. Revenues from the fees can be used by the lander only to cover the administrative and enforcement costs of their water quality programs and for providing financial assistance for public and private water pollution control activities. Although the Charges Act was passed in 1976, the fees were not imposed until January 1981. This time lag was intended to provide dischargers with an opportunity to implement pollution control programs.

The national system of discharge fees covers several types of pollutants including settleable solids, oxidizing substances, mercury, cadmium, and lead. Fees must also be paid by municipalities for discharge of untreated stormwater (Gaines and Westin 1991, 96). Municipal and industrial wastewater treatment facilities that exceed the minimum effluent standards set by federal authorities receive a fifty percent discount on the discharge fees (Opschoor and Vos 1989, 39). The discharge fee will be partially waived for a period of three years during construction of a new treatment facility. During this period the fee is based on the treatment efficiency expected after completion of the new facility.

The level of effluent charges imposed under the German system is generally perceived to be too low to achieve water quality objectives in the absence of technology based standards (Opschoor and Vos 1991; Gaines and Westin 1991; Brown and Johnson 1984). However, a German government study estimated that the combined effluent charge/technology standards approach is approximately one third less expensive than a system based solely on uniform standards. In addition, based upon the original legislation, the fees are scheduled to continue to increase through 1999 and further increases are under discussion. As the discharge fee rates continue to rise, their incentive effect will increase accordingly.

### 2.1.3 The Dutch System of Effluent Charges

The Netherlands is a small country, roughly the size of the states of Maryland and Delaware combined. But it has one of the highest population densities in the world, is highly industrialized, and has a highly productive agricultural sector. By the late 1960's, the combination of population density and high levels of industrial and agricultural production had resulted in extremely poor surface water quality throughout many parts of the country. These conditions led to the passage in 1970 of the Pollution of Surface Waters Act which initiated the Dutch system of water quality charges.

Water pollution control in the Netherlands is a coordinated effort involving the State Water Authority, regional Water Boards, and local governments. Municipalities provide local wastewater collection and in some cases treatment of domestic and industrial discharges. However most of the treatment facilities are owned and operated by the regional Water Boards. These Boards have authority to assess fees on all dischargers to their facilities and on any direct dischargers to surface waters in their region. Households and small firms pay a standard charge and larger firms are charged according to the content and volume of their monitored effluent. In addition, certain farming operations that discharge directly to surface waters are also subject to discharge fees. The charge rate applied by the Water Boards is based on the level of biological oxygen demand, suspended solids, toxic substances, and heavy metals found in the wastewater discharge. In addition to the discharge fees levied by the regional Water Boards, the State Water Authority charges the Water Boards and any industries for direct discharges into state waters. The fees collected by the State Water Authority are utilized to provide financial assistance to the Water Boards and industries for pollution control investments. As with the French and German systems, the Dutch discharge fees were deliberately introduced at a low level and increased gradually over time. However, the Dutch water charges are currently much higher on a per capita basis than those in France or Germany (Opschoor and Vos 1989, 42).

Although the discharge fee system was originally intended simply as a device by which the Water Boards could finance the construction and operation of treatment facilities, the fees are now recognized as having a significant incentive effect. From 1970 to 1980, industries had reduced the level of organic pollutants in their discharges by two thirds and nearly half of the remaining organic pollution was removed by newly constructed regional treatment facilities (Bressers 1988). Although these reductions are impressive, they cannot simply be attributed to the use of discharge fees. In Dutch water quality policy, discharge fees coexist with traditional discharge permits and informal contracts between the Water Boards and industrial and municipal dischargers.

Bressers (1988) has performed statistical analyses of the factors contributing to the reduction of industrial water pollution over this period in an attempt to determine which policy instrument has had the greatest impact. Utilizing multiple regression and partial correlation techniques, Bressers compared regional differences in pollution abatement with regional differences in discharge fees and permits issued by the Water Boards. Regional variations in the discharge fees were found to account for the greatest proportion of the variation in the level of industrial pollution abatement, even after accounting for the effects of regional differences in industrial structure. In addition, Bressers presents the results of several surveys of Water Board officials and industrial engineers and executives. Both groups ranked discharge fees higher than permits or enforcement actions in motivating industries to reduce their discharges of organic pollutants (Bressers 1988, 27-31).



The third policy instrument of the Water Boards, informal negotiations, appears to be most effective in coordination with its other powers. One Water Board official was quoted by Bressers as saying "When I'm going to have a talk with a company about the abatement of their discharges, I always take my pocket calculator along. I calculate their potential savings on charges and invariably get an interesting conversation started" (Bressers 1988, 29).

#### 2.3.4 Sewer Surcharges in the U.S.

There is a long history of experience with discharge fees for suspended solids, biological oxygen demand and some other water pollutants in the U.S. These fees have usually been referred to as sewer surcharges and are applied to nonresidential facilities that discharge wastewater to municipal sewer systems. The essential purpose of the surcharges has almost invariably been to recover the additional costs of wastewater treatment and sludge management that are imposed by highly concentrated industrial effluent. Nevertheless, the charges have presented firms with incentives to reduce the volume and/or concentration of their discharges. One of the most detailed analyses of actual responses of firms to these surcharges can be found in *Pollution Pricing* by Hudson, Lake and Grossman (1981).

Hudson et al. examined the industrial sewer charge systems in five cities: Atlanta; Dallas; Chicago; Salem, Oregon; and South San Francisco. Representatives from the responsible public agencies were interviewed regarding the objectives of their programs as well as monitoring, billing, and enforcement practices. Plant managers, engineers, and financial officers from approximately one hundred industrial dischargers in the five cities were also interviewed to determine the response of these industries to the charges. For almost all the firms interviewed, the sewer charges amounted to only a few percent of total operating costs. Nevertheless, almost all plants actively reviewed ways of reducing these charges and as a result, operational changes or capital improvements were made at most of the facilities.

Actions taken by the firms included water conservation measures, housekeeping improvements, installation of treatment facilities, and alteration of production processes. In only a few cases however, were the results of these actions equivalent to what could have been achieved with best practical technology. This is not a surprising finding since in all of the cities the charges were designed simply as a mechanism to equitably recover the relatively minor additional costs imposed on the municipal treatment works. The sewer charges would have had to be substantially higher to encourage industrial managers to install the best available control technology at their own facilities (Hudson et al. 1981, 41).

Even with the relatively low level of the charges, Hudson et al. found that many of the industrial plants made significant and innovative changes in their production processes or facilities. Almost all of the plant managers viewed the charges favorably and preferred them to direct regulations such as discharge limits or technology-based standards (Hudson et al. 1981, 46-7). This was in part because they were understood to be simply a cost recovery mechanism for the municipality as opposed to a set of incentives designed to reduce industrial pollution. The surveys conducted in the study did not uncover any instances of business closings or relocation caused by the industrial sewer charges.

## 2.2 Transferable Discharge Permits

While Western European countries have emphasized the use of discharge fees and pollution taxes, the U.S. has provided more fertile ground for exploring the potential applications of transferable discharge permits. The U.S. preference for TDP systems can be explained in part by their similarity to many existing air and water pollution control programs that are based largely on the issuance of (nontransferable) emissions or effluent permits.

Some of the earliest applications of the basic concept of transferable discharge permits were for air pollution control. Under the Clean Air Act, a system of emission offsets, bubbles, and emission reduction credits slowly developed during the 1970's and 1980's. The evolution of TDP programs under the Clean Air Act is summarized below. In addition, several case studies of more recent nutrient discharge trading programs for water pollution control are also presented.

### 2.2.1 Emissions Trading and the Clean Air Act

To understand the context in which emissions trading programs for air pollution control developed, it is useful to review the basic elements of the 1970 Clean Air Act and subsequent amendments. As a result of the 1970 Clean Air Act, the EPA was given responsibility for establishing a system of National Ambient Air Quality Standards. Primary standards were to be set for protection of human health and secondary standards were to be established in cases where the primary standards were not stringent enough to protect crops, forests, building facades, and other non-health related values. Congress required that the primary standards be uniform for all air quality control regions across the country. In addition, the 1977 amendments to the Clean Air Act required EPA and the states to "prevent significant deterioration" (PSD) of air quality in areas that met or exceeded the primary standards.

Emissions standards for mobile sources of air pollutants (cars, trucks, buses, etc.) were written into the Clean Air Act directly by Congress. However, Congress gave the EPA authority to set new source performance standards (NSPS) for all newly constructed or substantially modified stationary sources of air pollution (factories, power plants, incinerators, etc.). In general, the NSPS were established on the basis of the emissions rates that could be achieved at various kinds of stationary sources with the use of the best available control technologies (BACT). Responsibility for establishing emissions limits on all existing stationary sources of air pollutants was delegated to the states. Each state was required to develop a state implementation plan (SIP) for control of existing sources of air pollution and attainment of primary and secondary air quality standards. The SIP's needed to be approved by EPA which maintained authority to reject state SIP's if they were deemed inadequate to achieve ambient air quality standards (Portney 1991, 27-31).

The EPA's "offset" policy was developed in response to the need to permit economic growth to continue in areas that had not yet achieved ambient air quality standards. The policy was developed in the mid 1970's and formalized in the 1977 amendments to the Clean Air Act. Under the offset program, all new sources of air pollution in nonattainment areas were required to install advanced pollution control equipment and to offset any remaining emissions by reducing an equivalent amount of pollution from existing sources. Over time, the offset policy was joined by other policies for netting, bubbles, and banking of emissions of specific pollutants.

Netting allows an existing source of air pollutants that is expanding or otherwise modifying its facility to avoid the most stringent limits on the new source of emissions at the facility by reducing emissions from other sources within the same facility. For example, if a new production line is being added at a factory, less stringent emission controls might be required for that new operation in exchange for installation of additional emissions controls on existing operations at the facility.

The bubble concept is similar to netting but it is the total emissions of all facilities included within the regulatory "bubble" that must achieve the emissions standard. This allows trades of emission reduction credits from one facility to another as long as both facilities are located within the bubble and there is no net increase in total emissions. Finally, banking provides a mechanism for firms to reduce their emissions and then save these emission credits to be utilized or traded in the future (Hahn 1989. 370-2).

Since emissions trading under the Clean Air Act has been occurring across the country for more than fifteen years, there have been numerous studies of the pitfalls and progress of these trading programs (Dudeck 1988, Roberts 1988 or Portney 1991). One of the principal problems that the air emissions trading programs have had to grapple with is determining the baseline level of emissions. Other difficulties that have been encountered in emissions trading include verification of emissions reductions, differences in types of emissions involved in a trade, such as the size of particulates or the chemical species of a particular pollutant, and differences in the temporal or geographic pattern of traded emissions.

Despite these difficulties, emissions trading has resulted in substantial cost savings. One study by Hahn and Gordon (1987) reviewed the EPA and state air pollution emissions trading programs during the period 1973-85. The authors found that over nine thousand trades of emissions credits had occurred during this period, resulting in approximately \$4.4 billion in savings. However, most of these trades occurred between plants of the same firm or between smokestacks of the same plant.

Hahn and Gordon attributed the scarcity of inter-firm trades of emission credits to uncertainty over the property rights inherent in the tradeable emission credits. This uncertainty arises in part from the difficulty of establishing baseline emissions as outlined above. In addition, during the early years of the emissions trading programs, every trade had to be reviewed and approved by state and federal regulators. Delays in the review process, as well as numerous changes in the regulations governing permissible trades, increased the costs, risk, and uncertainty involved in interfirm transfers of emission reduction credits. Moreover, controversy over the rights inherent in discharge reduction credits gave firms the impression that if they "banked" credits by reducing their emissions by more than was legally required they would not be permitted to use or sell all of these credits in the future.

Several studies have concluded that the air emissions trading market could have developed more rapidly if the EPA and the states had made a greater effort to determine baseline emissions and developed clear guidelines regarding permissible trades including the use of emissions credit banks (Hahn and Gordon 1987; Dudeck 1988; Roberts 1988; Hahn 1989; Portney 1991). It is no coincidence that many of these recommendations have been incorporated into the Clean Air Act Amendments adopted by Congress in 1990. Many of the economists and policy analysts who made the original recommendations, assisted the Bush Administration and Congress in drafting the 1990 amendments.

In addition to expanding and clarifying the authorization for existing emissions trading programs, the 1990 Clean Air Act Amendments include an ambitious new emissions trading

program to control sulfur dioxide and nitrogen oxide emissions, pollutants that are precursors to acid rain. The Act divides sulfur dioxide emission controls into two phases. Phase I beginning in 1995, will control emissions of large power plants that emit more than 2.5 pounds of sulfur dioxide for every million British thermal units (BTU's) of energy produced. Phase II will cover smaller plants that emit more than 1.2 pounds of sulfur dioxide per million BTU's. Discharge permits for emissions at the maximum levels allowed under Phase I and Phase II, will be allocated at no cost to existing power plants. Owners of these plants will then have the option of reducing their emissions to the required levels, transferring emission reduction credits from another facility they own, or buying excess sulfur discharge allowances from another utility. If a utility wants to build a new plant after 1999 it will first need to accumulate enough discharge allowances to run it. To do this, it can shut down an old plant and transfer the allowances to the new one, reduce emissions from other plants, or buy discharge allowances from other utilities (Arrandale 1989).

To prime the discharge allowance market and to avoid limiting economic growth, EPA will auction off 2.8% of the total sulfur discharge allowances available in each year. As a result, any utility or independent power producer building a new plant will be assured of at least a limited supply of allowances being available for purchase in any given year. Estimated savings from the 1990 Clean Air Act's emissions trading program range from 30-50% of the cost of a traditional uniform standards approach (Moore 1992).

Some analysts have noted that the highly regulated nature of the electric utility industry may prevent realization of the expected cost reductions from the sulfur emissions trading program (Krupnick 1990). Nevertheless, there are reasons to be optimistic that significant trading and cost savings will occur. The 1990 Clean Air Act includes several provisions that provide the essential framework for an efficient emissions allowance market, including the following;

1. Endowing dischargers with well defined, tradeable emission allowances.
2. Setting aside some unallocated allowances for purchase by new dischargers.
3. Providing clear rights to freely trade and bank discharge allowances.

Another reason for optimism about the emissions trading provisions of the Clean Air Act is the Chicago Board of Trade's plans to actively trade the sulfur dioxide emissions allowances created under the Act (New York Times 7/17/91). The Board of Trade could serve as an effective broker and pricing agent for trades of emissions allowances thereby greatly increasing the efficiency of the market.

Even if an active market for emissions allowances does not develop, the result will be the same aggregate level of emissions reduction at the same cost as would have been achieved with nontransferable allocations of the permissible levels of sulfur and nitrous oxide emissions (Krupnick 1990). However, because the national emissions trading program authorized by the 1990 Clean Air Act does not recognize that emissions reductions in some regions may have greater environmental and monetary benefits than reductions in other regions, it is possible that emissions reductions will not occur where they are needed most. Requiring midwest utilities to purchase emission reduction credits at a ratio of greater than 1:1 would help to ensure sufficient reductions of emissions leading to acid rain in the northeast. Of course adding such a provision to the 1990 Clean Air Act might have created the same kind of regional political battles that blocked passage of previous legislation aimed at controlling acid rain.

Although the provisions to control acid rain have received the most attention, the 1990 Clean Air Act greatly expands the authority for EPA and the states to utilize economic incentives to control a variety of air pollutants. For example, the Act authorizes State Implementation Plans to include economic incentives such as fees and auctioned discharge permits. If polluted areas fail to comply with air quality standards, emissions fees and penalties can be employed to motivate compliance. In particular, if certain heavily polluted areas fail to comply with EPA deadlines, polluting facilities must pay a special fee of \$5,000 per ton for all emissions above 80% of the permitted amount until compliance is reached. This provides a powerful incentive for all sources of air pollution to cooperate in developing an effective pollution control program. In addition, states are required to establish a system of permit fees to recover the direct and indirect costs of administering the air pollution control programs required under the Act.<sup>7</sup>

### 2.2.2 Phosphorus Control in the Dillon Reservoir, Colorado

The Dillon Reservoir, one of Denver's primary sources of drinking water, is located in Summit County in the heart of Colorado's ski region. From 1970 to 1980, Summit County was the fastest growing county in the nation. As a result of this growth and the related increase in seasonal recreational activities, phosphorus levels in Lake Dillon had increased substantially, causing regular summer algae blooms. Continued increases in point and nonpoint source discharges were threatening the water quality of the reservoir and the recreation based economy of the region.

A 1982 EPA Clean Lakes study indicated that the reservoir was already mesotrophic and that phosphorus was the limiting nutrient. Less than half of the human induced phosphorus inputs were due to point sources. The balance was attributable to runoff from roadways, parking lots, golf courses, and other nonagricultural sources. Based upon projections of continued population growth and recreational development, it was determined that even if point source discharges were reduced to zero, continued increases in nonpoint source inputs would cause the lake to become eutrophic (EPA 1984, 1992).

After completion of the Clean Lakes Study, the Colorado Water Quality Control Commission, requested that local industries and governmental entities develop a pollution control program for the Dillon Reservoir. Under the auspices of the Northwest Colorado Council of Governments, a Summit County Phosphorus Policy Committee was convened which consisted of representatives of the State of Colorado, the Denver Water Board, Summit County, surrounding municipalities, local sanitation districts, and industries. The goal established by the Policy Committee was to maintain basinwide phosphorus loadings at their 1982 level. However, as a result of continued population and economic growth, point sources were expected to exceed their 1982 allocation level by 1990, even with advanced phosphorus controls. In addition, point source control measures were not anticipated to be sufficient to prevent the reservoir from becoming eutrophic. Consequently, the Colorado's Water Quality Control Commission recommended that local governments consider placing a moratorium on new development.

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<sup>7</sup> Clean Air Act, sections 101(a)(2), 182(g), 185(a) and 502(b)(3), as amended by the Clean Air Act Amendments of 1990, Pub. L. No. 101-549, 104 Stat. 2399.

In order to permit development in the basin to continue, the Summit County Phosphorus Policy Committee devised a phosphorus discharge trading program. Under the program, phosphorus allocations equivalent to 1982 loadings were incorporated into discharge permits for both point and nonpoint sources. Point source dischargers could exceed their 1982 phosphorus discharge levels by removing two pounds of phosphorus from other sources for every one pound increase in their own phosphorus loading. Due to the integration of the local trading program with the state/federal permit system, enforcement actions could be taken against a point source permit holder for failing to comply with its obligations to operate, maintain, or monitor nonpoint source controls for which it had received discharge credits. The Summit County program also required new developments to install phosphorus control measures and to contribute to a Nonpoint Source Facilities Investment Fund. The fund is utilized to pay for phosphorus control measures at nonpoint sources that existed prior to 1984.

In order to monitor the trading program, regularly update the phosphorus control program, and provide long term water quality monitoring, local governments and sanitation districts in Summit County entered into an intergovernmental agreement creating the Summit Water Quality Committee (SWQC). Colorado law expressly authorizes intergovernmental agreements for the provision of services or performance of public functions for which any or all of the parties have individual authority. Under the terms of the agreement, the SWQC develops implementation plans for water quality programs related to Dillon and Green Reservoirs, conducts water quality monitoring, develops nonpoint source control standards, funds demonstration projects, and provides for a regionally coordinated approach to phosphorus control. (See Appendix B for the full text of the agreement.) The Phosphorus Policy Committee's final report indicates that the formation of the SWQC was a compromise between creation of a regional planning and regulatory agency with state delegated enforcement powers and the continuation of uncoordinated local decisionmaking.

In the eight years since the formulation of the original phosphorus control program for the Dillon Reservoir, economic and population growth have not proceeded as rapidly as originally anticipated and point sources have been able to achieve additional reductions in phosphorus discharges through relatively inexpensive operational changes. Although one point/nonpoint source trade has been completed and two others are under review, there has been a reduced need for point sources to obtain credits through reduction of nonpoint source phosphorus loads.<sup>8</sup>

An understanding of the economic benefits that can be achieved through trading discharge allocations as well as the coordinated, participatory planning approach that has developed in the Dillon watershed, provides a framework to develop cost-effective modifications of the discharge trading system to adjust to changing circumstances. Although slower growth and more effective point source controls have bought some time for Summit County, continued growth is expected to soon cause violations of the phosphorus water quality standard established for the Dillon Reservoir. As a result, the SWQC has begun to shift the focus of the program to promote trades between nonpoint sources. One approach under consideration is the allocation of phosphorus loads on a per acre basis. New developments that exceed their allocation could pay an appropriate amount into a nonpoint source control fund, install additional controls on site, obtain phosphorus credits from another site, or employ some combination of these approaches.<sup>9</sup>

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<sup>8</sup> Personal communication with Lane Wyatt, Water Quality Manager, Northwest Colorado Council of Governments, 7/30/92.

<sup>9</sup> Personal communication with Lane Wyatt, 7/30/92.

### 2.2.3 Nutrient Reductions in the Tar-Pamlico River Basin, North Carolina

The Tar-Pamlico watershed encompasses a 5,400 square mile area that includes all or portions of seventeen counties within the State of North Carolina. The river system empties into the Pamlico Estuary which supports a valuable fishery that is vulnerable to algal blooms and low dissolved oxygen. Nitrogen has been determined to be the limiting nutrient in the estuary, but phosphorus also contributes to localized water quality problems in the watershed. Nutrient loadings are primarily contributed by publicly owned treatment works (POTW's), industrial and mining facilities, and agricultural nonpoint sources.

Based upon findings that sediment and nutrient loads were threatening the estuary fishery, North Carolina's Department of Environmental Management (DEM) proposed nutrient discharge limits in 1989 on point source dischargers in the Tar-Pamlico watershed. The proposed discharge concentration limits were 2mg/l for phosphorus year round, 4 mg/l for nitrogen in summer and 8 mg/l for nitrogen in winter. One estimate indicated that point source dischargers would be required to spend between \$50 and \$100 million to upgrade their facilities to meet the effluent concentration limits (Apogee 1992, B-3).

In response to the DEM's proposed effluent concentration limits, a coalition of publicly owned treatment facilities (the Basin Association), one industrial facility, and several environmental groups worked cooperatively to develop an alternative strategy that included an innovative trading program for nutrient discharges in the Tar-Pamlico River Basin. The proposed strategy was ultimately adopted by North Carolina's Environmental Management Commission in 1989 and was recently updated in 1992.

During Phase I of the strategy, parties to the agreement, which include the Basin Association, the DEM, the North Carolina Environmental Defense Fund, and the Tar-Pamlico River Foundation, must;

- develop an estuarine computer model for the basin,
- evaluate minor capital and operational improvements for nutrient reductions at the wastewater treatment plants,
- perform effluent monitoring at the plants,
- and implement a program of nonpoint source nutrient discharge reductions in lieu of more stringent limits on point source discharges.

These activities are being paid for almost entirely from funds provided by the Basin Association.

Phase II of the strategy which is scheduled to begin in 1995, will include a basinwide permitting process that will be guided by the results of the estuarine computer model. It is anticipated that an expanded trading program including point and nonpoint sources will also become an integral part of Phase II of the program.<sup>10</sup> (See Appendix B for a full text of the Tar-Pamlico Nutrient Sensitive Waters Implementation Strategy.)

Although Phase I of the implementation strategy explicitly promotes point/nonpoint source trades of nutrient loadings, trades between point source dischargers are also implicitly permitted by the structure of the program. The Basin Association, which includes twelve publicly owned treatment works (POTW's), is treated by DEM as one discharger for purposes of nutrient discharge limits. The Basin Association is free to suballocate its overall permitted nutrient loadings among its members in any manner it sees fit. This provides the additional

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<sup>10</sup> Personal communication with Trevor Clements, North Carolina Department of Environmental Management, 8/14/92.

opportunity for trading of point source suballocations between the Basin Association's members in order to achieve its overall nutrient allocations at least cost.

A declining schedule of total load allowances is outlined for the Association in each year of Phase I with a total reduction of 200,000 kg/yr by 1994. In 1991, the Association was able to implement operational improvements at its member facilities and achieve its nutrient reduction targets without the need for offsetting reductions from nonpoint sources. However, the program requires minimum annual payments by the Basin Association to a nonpoint source reduction fund known as the Agricultural Cost Share Program (ACSP). The minimum payments required during Phase I total \$500,000.

If the Basin Association's total nutrient loadings exceed its total permitted load in any remaining year of Phase I, it must contribute to the ACSP fund at a rate of \$56 per kilogram of excess nutrients per year. The contribution rate was based on results of nonpoint source control experiments in North Carolina's Chowan River basin. The required per kilogram contribution is estimated to be sufficient to pay for best management practices (BMP's) that will reduce three kilograms of nutrient discharge from cropland or two kilograms from animal operations (EPA 1992, B-9). The BMP's are assumed to have a useful life of ten years and the Association will receive credit in future years for previous payments to the ACSP. In any year the Basin Association will be required to pay the lesser of its excess loading payment or the minimum payment. The excess loading payment is calculated as follows;

$$[\text{Actual Loading (kg/yr)} - \text{Allowable Loading (kg/yr)}] \times [\text{\$56 (kg/yr)}] - [\text{Prior Payments}]$$

Existing treatment facilities that are not members of the Association and that have design flows of greater than 500,000 gallons per day may also contribute to the ACSP in lieu of meeting the effluent concentration limits originally proposed by DEM. However, nonmember facilities must contribute to the fund at a rate of \$62 per kilogram per year. No new members will be admitted to the Basin Association during Phase I of the program since the Basin Association's permitted loadings were based on the original list of member facilities. Membership will likely be opened to new facilities as part of Phase II of the program.

Implementation of nonpoint source controls is the responsibility of the Division of Soil and Water Conservation (DSWC) which like the DEM is part of North Carolina's Department of Environment, Health and Natural Resources. The DSWC in cooperation with local Soil and Water Conservation Districts will administer the contributions made to the ACSP fund under the Tar-Pamlico nutrient reduction program. Under the guidelines of the ACSP fund, farmers receive 75% of the statewide average cost for implementation of a particular BMP. The local Soil and Water Conservation districts must annually inspect BMP's on at least 5% of the farms that received ACSP funds (Apogee 1992, B-16).

One important aspect of the Tar-Pamlico program is the division of responsibilities between the DEM and the DSWC. The DEM maintains responsibility for permitting point source dischargers, tracking nutrient reduction progress, monitoring water quality, and, where necessary, requiring additional point source treatment controls to address localized water quality problems. Although the DEM can recommend to the DSWC areas in which nonpoint source control expenditures should be targeted, it does not have explicit authority to specify expenditures in certain areas.



The EPA report (Apogee 1992) which describes the Tar-Pamlico nutrient control strategy makes three recommendations to strengthen the point/nonpoint source trading program.

1. DEM should develop a prioritized list of nonpoint source reduction sites in the Tar-Pamlico basin which the DSWC would be obligated to fund with contributions made from the trading program.
2. DEM and DSWC should develop incentives for point source dischargers, the Soil and Water Conservation districts and local farmers to target funding of BMP's to priority sites
3. DEM and DSWC should require annual inspections of all BMP's implemented with funds from the Tar-Pamlico program.

If Basin Association members believe that they will be subject to additional regulatory requirements due to failure of nonpoint source control measures, they may decide to invest in nutrient control equipment at their own facilities, even if this is initially more expensive than making payments to the ACSP fund. By providing Association members with additional assurance that their payments to the ACSP will be effectively utilized, the proposed modifications to the program would help ensure that the overall nutrient reduction targets are achieved at least cost. Although there is a general recognition of the risks involved, all parties to the agreement appear willing to try to utilize the trading program to achieve a more cost-effective solution to the water quality problems of the Pamlico Estuary and river system.

#### 2.2.4 Biological Oxygen Demand in the Fox River, Wisconsin

During the 1970's, effluent from paper mills and municipal wastewater treatment facilities had repeatedly caused low levels of dissolved oxygen in certain sections of the Fox River in Wisconsin. In response to these water quality problems, the state of Wisconsin's Department of Natural Resources (DNR) allocated allowable biological oxygen demand (BOD) among the point sources of pollution discharge to the river. To comply with these reduced BOD allocations, it was necessary for most facilities to implement more stringent pollution controls than the minimum technology standards required under the Clean Water Act (Hahn 1989; Apogee 1992).

Although the State of Wisconsin has also operated a program of transferable discharge permits for the Fox River since 1981, the trading of BOD allowances was never envisioned as a key element of the Fox River pollution control program. After several academic studies indicated the potential for significant cost savings, the option of trading BOD allowances was developed with the strong support of one member of Wisconsin's Natural Resource Commission. However, the trading program was never strongly supported by the professional staff within the DNR and had no constituency within Wisconsin's paper industry.<sup>11</sup> This lack of support by regulators and regulated industries provides at least a partial explanation for the numerous regulatory restrictions that were ultimately placed on the Fox River program of transferable allowances.

In the Fox River program, trading of BOD allowances among points sources is only permitted if the facility buying the rights is new, is expanding its operations or cannot meet its

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<sup>11</sup> Personal communication with Gerald Novotny, Waste Management Division, Wisconsin Department of Natural Resources, 8/17/92. See also Hahn (1989) pp. 391-393.

discharge allocation even with the use of advanced pollution control technology. Trades in which the primary objective is cost savings are not permitted. Trades are effective only for the term of the seller's discharge permit which is a maximum of five years. There is no guarantee that the BOD allocation that was sold in the trade will be reapproved as part of either the buyer's or seller's subsequent discharge permit. Since the useful life of most pollution control equipment is longer than five years, the five year limitation on the guaranteed term of the trade makes it quite risky for facilities to buy or sell discharge allowances.

Other difficulties with the Fox River trading program include the necessity of individual review of all proposed transactions by the DNR. Reviews are reported to take a minimum of six months (Apogee 1992, 22). There is also no possibility of banking unused discharge allowances or acting as a broker by buying and selling allowances. In addition, although discharge allowances are specified in terms of BOD, there is also concern over discharge of toxics. A trade which might not increase BOD, but which might result in an increase in toxic pollutants would be unlikely to be approved.

The guidelines for the Fox River pollution control program essentially require all facilities to install expensive pollution control equipment. Cost saving transfers of allowances are prohibited. Moreover, potential sellers of BOD allowances are at risk of losing the transferred portion of their allocation after their current permit expires, and buyers of allowances have no guarantee that they will be able to repurchase the allowances after the expiration of the seller's current permit. Given the number of restrictions that have been placed on trading in the Fox River program it is no surprise that only one trade has occurred. Even that trade was little more than an administrative reallocation involving the transfer of BOD allowances from a paper mill that had closed its treatment facility, to a municipal treatment plant that had agreed to accept the mill's wastewater.

### 2.2.5 Maine's Watershed Planning Program

The State of Maine has developed a methodology for the allocation and limited trading of nonpoint source nutrient loads in lake watersheds. Guidelines for what is essentially a voluntary local program are outlined in a series of handbooks published by the Maine Department of Environmental Protection. The phosphorus allocation process and a detailed methodology for calculating phosphorus loadings from new developments is described in *Phosphorus Control in Lake Watersheds: A Technical Guide to Evaluating New Development*, September, 1992. (See Appendix B for the full text.) This handbook also includes design criteria and estimated efficiencies for various phosphorus control measures as well as a detailed methodology for calculating phosphorus reduction credits.

The standard guidelines presented in the workbook are based on the assumption that existing lake water quality is high enough to permit additional phosphorus loadings within the watershed. An acceptable level of increased phosphorus is calculated on the basis of the lake's hydrological characteristics and the water quality objectives of the affected communities. The acceptable increase in phosphorus loadings is then allocated on a simple per acre basis to undeveloped land throughout the watershed. The phosphorus export for any proposed new development can be estimated using the handbook's methodology and compared with the acceptable allocation for the proposed development area. The loading calculations assume the inclusion of certain mandatory phosphorus control measures. If estimated phosphorus export

levels exceeds the acceptable allocation for that land area, additional phosphorus control measures must be designed into the proposed development. The proposed development may also generate phosphorus reduction credits by constructing facilities to reduce phosphorus discharges from adjacent roads and developed parcels.

Although the voluntary statewide guidelines only discuss the calculation of phosphorus credits for treatment of stormwater from adjacent roads or parcels that drains onto the proposed development, some communities in the state have applied the basic methodology to calculate credits for off-site control measures paid for by new developments.<sup>12</sup> In addition, the latest edition of the handbook alludes to how the basic methodology can be adapted to watersheds of lakes where phosphorus concentrations are already higher than the maximum desired level.

One potential modification of the basic methodology, is to require new developments to obtain phosphorus reduction credits by financing the installation of phosphorus control measures on existing sources. If phosphorus concentrations in the lake must be reduced, more than one pound of phosphorus may need to be reduced from existing sources for every pound added from new sources. Another methodology is to allocate the required level of nonpoint source phosphorus reductions on a per acre basis for both developed and undeveloped land and then permit trading of phosphorus reduction credits between landowners in order to achieve the desired reductions most cost-effectively. This latter approach requires both new and existing sources to share the financial burden of reducing phosphorus discharges.

#### 2.2.6 Sewer Access Rights - Escondido, California

In the early 1980's the City of Escondido, California was confronted with a combination of rapid growth, enforcement orders from the state to improve its sewage treatment plant, and a lawsuit from neighboring San Diego for nonperformance on a sewer services contract. The City responded to these difficulties by selling sewer access rights as a means of financing the expansion of the City's sewage treatment plant. Within three months, the sale of sewer access rights had raised more than \$16 million, sufficient funds to pay for the necessary expansion to the treatment plant and provide a reserve fund for future rehabilitation (EPA 1989, 64).

Due to conflicts over growth policies in Escondido, voters had prevented the City from using traditional bond financing or user fees to pay for the treatment plant expansion. Faced with legal action from both the state and San Diego to upgrade its treatment facilities, Escondido developed a plan to sell access rights to future sewer capacity. Rights could be purchased by any property owner, renter or lessee in the incorporated area of the city or in the general plan area outside the city. Because the City of Escondido provides sewage treatment for northern San Diego as part of an intergovernmental agreement, San Diego contributed \$4 million for its share of the planned capacity. Another \$12 million in access rights were purchased by local developers and residents.

The access rights were sold in units of 270 gallons per day, which is the estimated capacity required for an average single family residence. Buyers of rights during the three month sale were exempted from future connection fees. In addition, the price of the access rights was planned to increase according to a schedule developed by the city. Buyers of access rights were assured of access to sewer capacity, but approval of building permits or land use

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<sup>12</sup> Personal communication with Joyce Noel, August 7, 1992.

plans was not guaranteed. The access rights could only be resold to the city, according to the price schedule established by the city which guaranteed a profit to early purchasers. A city ordinance or state law authorizing the program was not necessary since each purchaser of rights entered into a separate contract with the city.

After the initial three month sale, sewer access rights could only be purchased if the city had excess treatment capacity or if previously purchased access rights had been tendered to the city for resale. By early 1989, approximately 20% of the access rights had been resold to the city and the city had raised an additional \$3 million through subsequent sales. (EPA 1989, 67)

In order to ensure that one or more developers could not gain monopoly powers through large purchases of access rights, the city reserved the option to deny any purchase. In addition, by requiring resale through the city, Escondido could ensure that undue concentration of access rights was not occurring through secondary market transactions. The city further limited its risks by reserving the right to refund the proceeds if the sale was not successful.

Escondido's sewer access rights program was a highly original response to a public finance problem. The program was successful in part because of the strong demand for new development in Southern California at that time. However, Escondido's sewer access rights are essentially a form of transferable discharge permit. With certain restrictions the rights can be bought and sold and guarantee the holder the ability to discharge wastewater into the city's sewer system. The basic structure of the program could easily be adapted into a system of discharge rights for phosphorus or other pollutants or modified to allow for transfer of more general development rights.

### **3.0 Application of Economic Instruments for Environmental Protection: Lessons from Theory and Practice**

#### **3.1 Discharge Fees**

As discussed in Section I of this volume, discharge fees are a theoretically appealing tool for environmental regulation. A pollution control program based solely on discharge fees reflects an assumption that the right to clean air or clean water is vested with the general public. Polluters are not only provided with a financial incentive to reduce their pollution until their control costs equal the discharge fee but they must also compensate society through payment of fees for their remaining level of pollution. If the discharge fees can be established at the proper level, the result will be an economically efficient level of pollution control. Although the ideal discharge fee system may appear attractive from the perspective of environmental ethics or economic theory, it is very difficult to implement in practice. The difficulties of accurately estimating the true costs and benefits of pollution control make it quite difficult to determine the optimal level of the discharge fee. Consequently, some analysts argue for a second best objective of simply setting the fee to achieve an acceptable, although not necessarily optimal, level of pollution control. But even this second best objective may require some trial and error if sufficiently detailed information is not available regarding the marginal costs of pollution control.

Until relatively recently, clean air, water, and other environmental resources have not generally been in limited supply, at least not in the United States and Canada. There was no need to put a price on their use. To suddenly impose a substantial fee for discharges of pollution may not be viewed as the most equitable means of improving environmental quality. In any case, industries, local governments, and other parties that would have to pay the fee are likely to be at least as well organized and politically influential than those who stand to benefit from reduced levels of pollution. Even if regulators knew what the economically ideal level of the fee should be, they would likely have difficulty imposing it.

The technical and political difficulties of designing and implementing an optimal system of discharge fees have caused most governments to employ them primarily as a means of recovering the costs of pollution control programs that rely on other regulatory mechanisms such as technology standards or discharge permits. The case studies presented in Section 2 illustrate this point. Nevertheless, the German, French, and Dutch systems of wastewater discharge fees, and even the U.S. experience with sewer surcharges, all provide significant incentives for pollution control beyond the requirements imposed by regulatory standards (Opschoor and Vos 1989; Kaczmarek 1990; Bressers 1988; Hudson et. al. 1981).

The French, German and Dutch discharge fee systems appear to be based on an understanding that it would be unfair, and perhaps politically impossible, to suddenly impose the fees at a level necessary to provide strong pollution control incentives. In each case, the original legislation and/or administrative decrees authorizing the fee systems established schedules for gradually increasing the level of the fees over a period of ten to twenty years. In Germany, a period of several years was set after the fees were announced and before they were imposed, with the intent of giving dischargers time to install pollution control equipment. This post announcement/pre-implementation period had the benefit of providing an incentive without immediately imposing a cost. There is some evidence that the tactic worked. At least 10% of

affected firms installed control equipment during the time period between announcement and implementation of the fees (Opschoor and Vos 1989, 40).

There seems to be a willingness on the part of public and private dischargers to pay for the costs of controlling pollution. However, such support is tenuous at best for payment of fees related to the damages imposed by pollution or for fee systems designed to provide pollution control incentives but which are utilized to fund general government expenditures. (Hudson et. al. 1981, 46-7; Brown and Johnson 1984). In recognition of this political reality, many discharge fee systems utilize the revenues to support pollution control activities undertaken by the regulatory agency and/or to subsidize pollution control investments made by organizations paying the fees.

In addition to balancing economic incentives and political acceptance, designers of discharge fee systems must also consider the related issue of administrative feasibility. To have some incentive effect, fees must be established in relation to actual discharges.<sup>13</sup> Pollutants and dischargers included in the fee system should therefore be able to be easily and reliably monitored. The methodology utilized to calculate the fee should also be kept as simple as possible; to minimize monitoring, billing, and other administrative costs; to promote public acceptance; and to ensure that the incentives for pollution reduction are clearly understood.

The essential characteristics of a politically and administratively feasible effluent discharge system are summarized quite well by Brown and Johnson (1984) in their study of the German discharge fee system. These characteristics include the following.

1. Fees cover a small number of pollutants.
2. Fees are used in conjunction with discharge permits or other regulatory standards.
3. Charges begin at a low level and escalate over a pre-defined transition period.
4. Charges are set with the involvement of all interested parties.
5. Measurement and pricing systems are straightforward.
6. Revenues are made available to subsidize investments in abatement technologies.
7. A hardship clause provides for temporary exemptions under exceptional circumstances.
8. The implementation process is clearly defined.

### 3.1.1 Other Applications of Discharge Fees and Related Economic Incentives

There are numerous other forms of financial incentives for environmental protection that share many characteristics with discharge fee systems. These include deposit-refund mechanisms, cross compliance requirements for agricultural programs, and subsidization of environmentally sound technologies or operational practices. In addition, fees intended to protect water resources have been applied not only to wastewater discharges but also on pesticides and fertilizers (including manure) in several European countries and a few states in the U.S (Opschoor and Vos 1989, 45; Stavins 1988, 54-5).

It is appropriate to think of deposit-refund programs as refundable discharge fees. If the discharge does not occur, the fee is refunded. Although deposit-refund systems are most

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<sup>13</sup> For small dischargers standard discharge quantities can be established with allowance for adjustment if the discharger demonstrates that their effluent volume or concentrations have been lower than the assumed quantities.

familiar for beverage containers, they have also been employed for motor oils, certain types of containerizable hazardous wastes, and pesticide containers. What amounts to a deposit-refund system can also be employed to provide incentives for environmental protection during resource extraction and construction activities. For example, certain guidelines might be established for environmentally sound housing construction or timber harvesting activities. A refundable deposit or performance bond would then be required of the contractor. The deposit would be refunded if the required environmental management practices are followed throughout the project. Whereas a typical deposit-refund system places responsibility for obtaining the refund on the purchaser, a performance bond system places some of the burden for monitoring and inspection on the regulatory agency. However, a properly managed performance bond system may be preferable to simple regulations because it provides a direct financial incentive for compliance.

Although federal funding for the installation of mandatory pollution control equipment at municipal and industrial facilities has been greatly reduced, control of nonpoint sources of water pollution still largely depends on voluntary participation in publicly subsidized programs. Providing farm owners with full or partial funding for implementation of best management practices (BMP's) to control erosion or reduce runoff of nutrients is a kind of reverse discharge fee. Consequently, the optimal level of payments to farmers for utilization of various BMP's can be determined in much the same way as the establishment of an optimal system of discharge fees. Payments should be set at a level that will elicit participation resulting in the maximum net benefits to society. This will only be possible if the subsidies for adoption of BMP's vary according to the environmental benefits that will result from their adoption at different sites. Farms located far from important waterways and/or have little export of pollutants, should receive lower levels of funding for adoption of BMP's. Conversely, farms that have a greater potential to add significantly to the pollution of important water bodies should receive higher levels of funding.

In addition to direct subsidies for the use of BMP's, many agricultural programs have incorporated what are known as cross compliance requirements as a means of promoting environmental protection. The basic concept behind cross compliance requirements is to take advantage of the financial incentives already provided by other agricultural programs. If a farmer wishes to be eligible for price supports, crop insurance, or some other farm income program, he or she must also comply with some combination of requirements for erosion control, fertilizer and pesticide management, or diversion of cropland for wildlife habitat. If farm income support programs are already in operation, the addition of environmental cross compliance requirements can be a very cost-effective way of improving environmental quality. There are however some tradeoffs to be considered in the design of cross compliance requirements.

One type of cross compliance design that minimizes monitoring costs is to require all farmers to employ specific practices in order to be eligible for income support programs. This might be called the technology standards approach to cross compliance. The farmer will presumably participate if the costs of the environmental requirements are less than the other benefits which the farmer receives from the program. But this could lead to inefficient investments in agricultural pollution control. The appropriate comparison for an economically efficient cross compliance program is between the farmer's costs of complying with the environmental requirements and the resulting environmental benefits to society. Presumably this comparison could be performed by the appropriate governmental agency and only those measures which have net benefits would be included in the cross compliance requirements.

Unfortunately, the costs and benefits of certain BMP's, or conservation reserve requirements, vary considerably across farms in the same region and across regions of the country. These variations make it very difficult for public officials to develop or apply a standard set of measures that will always yield net benefits.

Another approach to cross compliance policy would be to require farms to meet or exceed certain limits on soil erosion and/or nutrient runoff in order to be eligible for income support programs. The farmer would be free to achieve these conservation limits in the most cost effective manner possible. If the costs of environmental compliance exceeded the income benefits of the program, the farmer would always have the option not to participate. This discharge limit approach to cross compliance has the advantage of providing incentives only to farms that currently exceed certain erosion or nutrient export limits. Unfortunately, monitoring erosion or nutrient transport rates from individual farms can impose significant extra costs on the regulatory agency. It also does not guarantee that the environmental benefits of reducing nutrient transport or soil erosion exceed the costs of doing so.

An efficient cross compliance program, or for that matter any program focusing on agricultural nonpoint source controls would seek to target the incentives to farms that have relatively high rates of nutrient or pesticide export and which are located near sensitive waterways that are used for recreational or water supply purposes. If monitoring difficulties prohibit the use of nutrient or pesticide export limits, then a set of BMP's focusing on inputs and control measures should be adopted. However, the system of subsidies and incentives for implementation of the BMP's should be flexible enough to take into account physical, ecological, and operational differences between farms. The Tar-Pamlico nutrient control program described in Section 2 is attempting to develop a system for targeting nonpoint source nutrient control expenditures.<sup>14</sup> In addition EPA has suggested that the Tar-Pamlico program incorporate incentives to promote implementation of BMP's at priority locations. Properly designed cross compliance requirements, in combination with targeted subsidization of BMP's, could be utilized to provide a reasonably efficient combination of incentives.

### **3.2 Transferable Discharge Permits**

The empirical literature indicates that successful use of economic instruments for environmental protection is often the result of a series of modest improvements in existing regulatory programs. From this perspective, the right to transfer discharge permits is an evolutionary refinement of the nontransferable permit systems previously developed under the Clean Air and Clean Water Acts. There are several likely reasons why the concept of granting the right to transfer discharge allocations developed first for air pollution control. First the original Clean Air Act established a system of air control regions which required regulators to think in terms of the total air pollutants being emitted within a well defined geographic area. In addition, the Clean Air Act is not based on the imposition of explicit technology standards. Finally, the Clean Air Act's requirement to prevent significant deterioration in pristine regions and the difficulty many polluted regions faced and still face in complying with the ambient standards established under the Act, forced regulators to develop a method to allow continued

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<sup>14</sup> Personal communication with Trevor Clements, North Carolina Department of Environmental Management, 8/14/92



economic growth without further degradation of air quality. This led to the EPA's offset policy and the first experiments with transferable emission reduction credits.

Although watershed boundaries provide a more natural framework for water pollution control programs than political borders, there have until recently been few federal pollution control programs that required an integrated watershed focus. Instead, federal and state regulators have devoted their energies to ensuring compliance with the technology standards required of municipal and industrial point sources of water pollution. As many regions of the country have reached compliance with these standards, there is a growing recognition that integrated regulatory strategies encompassing all sources of pollution within a watershed will be needed to achieve water quality objectives. As part of this growing focus on integrated watershed planning, the EPA and many states have begun to experiment with programs that allocate acceptable pollution loads to all dischargers, and in some cases allow trading of these allocations between point and nonpoint sources.<sup>15</sup>

### 3.2.1 An Illustrative Example

Section 1.2.2 of this report presented a simple numerical example of the potential benefits of allowing transfers of discharge permits between two facilities. Prior to discussing the application of transferable discharge permits to the Lake Champlain Basin, it may be beneficial to present a slightly more realistic example involving a hypothetical watershed with several point and nonpoint sources of phosphorus discharge. In this fictitious watershed there are two types of publicly owned treatment plants (POTW's), one industrial facility, and two distinct types of agricultural land uses, as well as nonpoint source discharges from urban and suburban areas. The quantities of phosphorus discharged from each of these sources, and the marginal pollution control costs of each source, are summarized in Table 4.

Assume that after several years of study, public officials have determined that phosphorus discharges must be reduced by fifty percent in order to protect the recreation based economy of this imaginary watershed. One seemingly equitable means of achieving this objective would be to simply require all sources of phosphorus pollution to reduce their discharges by fifty percent. Given the baseline discharges and marginal pollution control costs assumed in this example, a uniform fifty percent reduction in phosphorus discharges would require a total expenditure of \$9.7 million, as shown in Table 5. However, a quick review of Table 5 indicates that a uniform control requirement of fifty percent would result in a highly skewed distribution of pollution control costs. The high total cost and uneven distribution of costs could be expected to motivate public officials to explore other options.

Assuming that accurate information on marginal control costs of all dischargers is available, a least cost command and control strategy could easily be developed. Dischargers with the lowest marginal control costs would be required to reduce their discharges by higher percentages than those with relatively high marginal phosphorus control costs. As summarized in Table 5, this approach would reduce total phosphorus control expenditures required in this

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<sup>15</sup> In April, 1992 the EPA sponsored a national conference on point/nonpoint source trading programs. the conference was attended by regulatory staff from nine states and one Canadian province as well as numerous representatives from industrial associations, environmental groups, and federal agencies.

fictitious watershed by more than one third, to \$5.2 million. Unfortunately, this alternative would still result in a very uneven distribution of pollution control costs.

Table 4 Phosphorus Discharges and Marginal Control Costs for a Hypothetical Watershed

Discharger	Baseline Discharge (lbs. of P/yr.)	Marginal Cost (\$/lb.) of Reducing Phosphorus From				
		0-10%	10-25%	25-50%	50-75%	75-90%
POTW 1	165,000	1	2	5	20	60
POTW 2	75,000	15	30	50	80	150
Agric. 1	250,000	2	4	8	15	50
Agric. 2	105,000	5	12	25	50	110
Urban NPS	150,000	10	30	75	150	350
Suburban NPS	155,000	15	20	40	100	200
Industry	100,000	5	8	15	25	100
Total	1,000,000					

Table 5 Pollution Control Costs of Two Nontransferable Discharge Allocations for a Hypothetical Watershed

Discharger	Baseline Discharge (lbs. of P/yr.)	Uniform Reduction		Least Cost Alternative	
		Required Reduction	Pollution Control Cost	Required Reduction	Pollution Control Cost
POTW 1	165,000	50%	\$272,250	75%	\$1,097,250
POTW 2	75,000	50%	\$1,387,500	10%	\$112,500
Agric. 1	250,000	50%	\$700,000	75%	\$1,637,500
Agric. 2	105,000	50%	\$897,750	50%	\$897,750
Urban NPS	150,000	50%	\$3,637,500	10%	\$150,000
Suburban NPS	155,000	50%	\$2,247,500	25%	\$697,500
Industry	100,000	50%	\$545,000	75%	\$1,170,000
Total	1,000,000	50%	\$9,687,500	50%	\$5,762,500

In order to minimize the total cost of phosphorus control and ensure an equitable distribution of those costs, public officials in our hypothetical watershed should consider implementing a system of transferable discharge permits. Utilizing the same information on marginal control costs that was used to develop the least cost command and control strategy, the effects of various initial allocations of transferable discharge permits could easily be determined.

Table 6 presents one initial allocation of transferable discharge permits. This alternative would still achieve the targeted fifty percent reduction in phosphorus discharges at least cost, but would have a much more equitable distribution of phosphorus control costs, as compared with the results of the least cost command and control strategy summarized in Table 5.

Table 6 An Initial Allocation of Transferable Discharge Permits and the Resulting Distribution of Pollution Control Costs for a Hypothetical Watershed

Facility	Baseline Discharge (lbs. of P/yr.)	Initial Allocation	Direct Pollution Control Costs	Costs (Revenues) from Purchase (Sale) of TDP's <sup>1</sup>	Total Net Pollution Control Costs
POTW 1	165,000	48,500	\$1,097,250	\$(199,375)	\$897,875
POTW 2	75,000	52,000	\$112,500	\$426,250	\$538,750
Agric. 1	250,000	87,000	\$1,637,500	\$(673,750)	\$963,750
Agric. 2	105,000	60,000	\$897,750	\$(206,250)	\$691,500
Urban NPS	150,000	105,000	\$150,000	\$825,000	\$975,000
Suburban NPS	155,000	107,500	\$697,500	\$240,625	\$938,125
Industry	100,000	40,000	\$1,170,000	\$(412,500)	\$757,500
Total	1,000,000	500,000	\$5,762,500	\$0	\$5,762,500

<sup>1</sup> Transferable discharge permits are assumed to be bought and sold at a price of \$27.5/lb. which is the average of the marginal costs of buyers and sellers as outlined in Table 4.

### 3.2.2 Trading Rules, Market Administration, Monitoring and Enforcement

The preceding example as well as most of the case studies presented in this report have defined a single airshed or watershed within which transfers of discharge allocations can occur. However, in the case of a large, ecologically diverse region, it may be preferable to define several subregions in order to minimize localized violations of environmental quality standards. Some steps in this direction seem to be underway as part of Phase II planning for the Tar-Pamlico nutrient control program. For control of phosphorus discharges in the Lake Champlain basin it may be necessary to define at least five regions corresponding to the five ecological zones of the lake. Discharge limits and guidelines for transfers of permitted allocations within and between these regions would have to be based on the unique hydrological, ecological and economic characteristics of each zone.<sup>16</sup>

Some of the issues that hindered early efforts to create transferable emission reduction credits under the Clean Air Act and that have effectively prevented trading of discharge allocations in the case of the Fox River, were the lack of clearly defined discharge rights, including the transferability of discharge allocations. In the case of the Clean Air Act, there was uncertainty over what pollution sources were eligible to engage in trades of pollution reduction

<sup>16</sup> See Teitenberg 1980, for an excellent discussion of the critical issues involved in the design and operation of a TDP system with multiple trading zones.

credits and the permissible or baseline emissions for those sources. In the Fox River case, limitations and uncertainty over the transferability of discharge allocations severely limited the incentives to buy or sell them. In addition, both the Fox River program and early efforts to promote banking of air pollution emission credits suffered from concerns about whether discharge rights that had been sold or banked would be reauthorized after expiration of the existing permit. For an efficient market to develop for any commodity, service, or activity, the characteristics and ownership rights of the item being bought and sold must be reasonably stable and well defined. The market for transfers of permitted discharge allocations is no exception.

Even if discharge rights and opportunities for transfer of those rights are clearly defined, holders of discharge permits may still be reluctant to offer them for sale if there is some concern over the ability to purchase additional discharge permits in the future. One way to allay these concerns, that has been incorporated into the 1990 Clean Air Act, is for the regulatory agency to reserve some portion of the acceptable level of pollution discharges for allocation or sale in future years. This guarantees that a minimum amount of discharge rights will be available to new and expanding facilities. The knowledge that some discharge permits will be on the market in the future, will hopefully make dischargers with low marginal costs of pollution control more willing to reduce their pollution by more than is required in order to sell the resulting excess discharge allocation.

There is a substantial body of theoretical literature that explores the potential for one or more dischargers to strategically manipulate the market for transferable discharge permits.<sup>17</sup> The primary concern of these theoretical analyses is that if only a small number of dischargers have the ability to reduce their pollution sufficiently to offer discharge allocations for sale, then one, or a few of these firms acting in collusion, could withhold permits in order to benefit from an increase in the market price. Depending on the initial allocation of the permits, the net effect of this market manipulation would be some increase in the overall costs of the program and/or a different allocation in the distribution of those costs, relative to the results from a perfectly competitive market. Similar problems can arise if one or a few firms are able to buy most of the available discharge allocations available on the market and then strategically manipulate their resale value.

Although economists have developed several models with which to analyze the outcomes of markets dominated by one or a few firms, there are no deterministic formulas with which to assess the potential for market manipulation. One classic analysis of market structure and competition found that when there are approximately fifteen equal size firms in a market, collusion and strategic manipulation become extremely difficult.<sup>18</sup> In addition, a mathematical simulation of a market for permits for the discharge of oxygen demanding pollutants along a particular stretch of the Mohawk River in New York, indicated that even though one city (Utica) accounted for approximately 45% of total discharges, it would be unable to significantly manipulate the market price even with perfect information about the pollution control costs of other dischargers (DeLucia 1974, 69).

In the Champlain Basin, there are over seventy point sources of water pollution and there are numerous nonpoint sources of phosphorus, biological oxygen demand, and pathogens. However, as indicated above, there would need to be several distinct trading zones within the

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<sup>17</sup> See for example, DeLucia (1974); Eheart and Brill and Lyon (1983); Hahn (1983); Missiolek 1989.

<sup>18</sup> F.M. Scherer, *Industrial Market Structure and Economic Performance*, 1979 pp. 168-191.

basin in order to protect local water quality conditions. In analyzing the potential application of transferable discharge permits it would be important to examine the number and size of dischargers within each of the potential trading zones as well as the potential for trades between zones. The two dischargers that might be large enough to manipulate the market would be the City of Burlington and the International Paper plant. However, the inclusion of nonpoint sources in the trading program, an appropriate allocation of the initial discharge permits, and careful monitoring of the market would greatly reduce the potential for manipulation. The basic pricing systems enforced or promoted by the regulatory agencies of New York, Vermont and Quebec would also have significant effects on the efficiency of the market for discharge permits. There is a growing body of evidence that double sealed or double continuous auction methods are significantly more efficient than a system that employs posted prices or individual negotiation of contracts.<sup>19</sup>

For any environmental regulatory program to be successful, the regulatory agency must have the ability to monitor and, when necessary, enforce compliance. Regulatory programs that are based on discharge concentration limits or maximum discharge allocations normally require some method of periodically sampling the discharges of regulated entities. For small dischargers it may be appropriate to simply estimate the level of pollution based upon the level of production and the technologies employed by the operation. If the right to transfer some portion of the discharge allocation is included in the pollution control program, then the regulatory agency has the added requirement of maintaining records of all transfers in order to know what level of discharge is permitted at each source. The simplest way to ensure that discharge permit records are kept accurate is to require regulatory review of all proposed transfers.<sup>20</sup> This may be simplest for the regulatory agency, but unless the criteria which will be used in the review process are clearly defined, and the regulatory review can be completed expeditiously, regulated entities may find it is too risky to invest the time and money necessary to negotiate transfers of discharge allocations.

The ability to enforce compliance is a critical aspect of any regulatory program. If the legal or financial penalties for non-compliance are too lenient or if regulators are hesitant to impose these penalties, then at least some regulated entities are likely to chronically exceed their permitted discharge levels. Obviously this will result in excess pollution and a higher level of environmental damages. However, in a regulatory program employing transferable discharge permits, the ability to exceed permitted discharge levels with relative impunity will also reduce the market value of discharge permits. Why should a discharger pay for the right to exceed its discharge allocation if regulators fail to impose penalties for non-compliance? Conversely, there is no incentive for dischargers to reduce their pollution below required levels if the market value of these pollution reduction credits has been eroded due to lax enforcement. In order to encourage cost saving transfers of discharge permits, the regulatory agency must be perceived as having the ability and willingness to impose significant penalties for noncompliance.

One method for streamlining the approval of proposed transfers of discharge allocations and minimizing enforcement problems is to incorporate aspects of a discharge fee into the program. This approach is being utilized in the Tar-Pamlico program described in Section 2

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<sup>19</sup> See V.L. Smith and A.L. Williams, Experimental Market Economics, *Scientific American*, v. 267 no. 6, December, 1992, 116-121.

<sup>20</sup> There are markets for the transfer of rights to other natural resources, such as land, that require only registration, rather than approval, of the transaction with the appropriate governmental agency.

above. If the Basin Association exceeds its annual nutrient allocation, it simply pays an amount to a nonpoint source control fund that is based on a multiple of the per unit costs of nonpoint source nutrient control and the difference between the Association's actual and permitted nutrient discharge. It then becomes the responsibility of North Carolina's regulatory agencies to use the funds to ensure implementation of offsetting nonpoint source control measures. The fee based approach to pollution trading, which is also being considered for the Dillon Reservoir<sup>21</sup>, eliminates the transaction costs and uncertainty faced by regulated entities seeking to enter into transfers of discharge allocations.

There are many methods, only some of which are outlined above, by which regulators can promote a smoothly operating market for the transfer of discharge permits. However, the most important single requirement for a successful discharge trading program is widespread support from all affected parties. Most of the problems that plagued early emissions trading programs under the Clean Air Act and that have hindered the Fox River trading program are traceable to tepid support from some combination of regulators, industry, and environmentalists (Roberts 1988). Conversely, the relative success of the Tar-Pamlico and Dillon Reservoir programs are due in large measure to the participatory manner in which they were developed. In these latter two cases, coalitions of industry, local government, and environmental groups were formed in response to regulatory proposals that included stringent uniform control measures. Working cooperatively, these coalitions were able to formulate and gain approval for alternative regulatory programs that included more flexible measures such as pollution reduction credits. Because the programs were designed to meet the overall pollution control requirements established by regulators and were jointly developed by environmental groups and the regulated community, they received strong support from the public and the regulatory agencies. Moreover, the participatory, integrated planning processes that were developed for the Tar-Pamlico and Dillon watersheds have provided the basis for continued adjustment of the programs in light of new information and changing circumstances.

From the theoretical literature and case studies reviewed for this report it is possible to compile a list of critical although not necessarily sufficient conditions for the development of a successful program involving the transfer of permitted pollution discharges from one source to another. Many of the conditions which are outlined below are not unique to transferable permit systems but rather are common to any effective environmental regulatory program.

1. Ability to determine the maximum level of pollutant discharge in the control region that is consistent with the achievement of environmental quality standards.
2. Publicly supported methodology for allocating the total acceptable discharge to individual sources of pollution.
3. Clear definition of the pollution discharge rights conferred by the initial allocation.
4. Clear guidelines governing permissible trades of permitted discharge allocations.
5. Initial differences in the marginal pollution control costs of different sources of pollution in the control region.
6. Well defined, efficient procedures for review of proposed transactions.
7. Ability for the regulatory agency to maintain records of all transfers of permitted discharge allocations.

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<sup>21</sup> Personal communication with Lane Wyatt, Water Quality Manager, Northwest Colorado Council of Governments, 7/30/92

8. Ability for the regulatory agency to satisfactorily monitor pollution discharges from all sources or establish baseline emissions and determine effectiveness of pollution control measures.
9. General support for the program from the regulatory and regulated communities as well as environmental groups and other key constituencies.

### 3.2.1 Other Applications of Transferable Permits

There are numerous other environmental protection programs that employ some variation of transferable rights or permits. Some of the first and most ingenious uses of these market mechanisms have been employed in the field of land use planning. These programs are usually based on some form of transferable development rights which are defined in local zoning ordinances and in state or federal laws that impose development restrictions for historic or environmental reasons. They are widely used to protect farmlands and historic districts as well as wildlife habitats, aquifer recharge areas, wetlands, and other ecologically valuable lands. For example, if a privately owned wetland is threatened by development, it may be possible for regulatory agencies and nonprofit groups to negotiate a transfer of some or all of the development rights that pertain to the wetlands area and surrounding parcels to another location. Obviously, this kind of program can only be successful if there are binding limits on development in certain locations, and the community is willing to override these limits in order to preserve other environmentally or culturally valuable sites.

It should be noted that the allocation of phosphorus export limits to undeveloped land, as in the Maine case study, can itself create binding limitations on development in certain areas. In some cases, transfer of development rights pertaining to a threatened and ecologically valuable site could justify approval of a development project at another location.

Other examples of transferable property rights that may have applications to Lake Champlain are for the management of recreational boating and shoreline development. If it were determined that beyond a certain number of boat slips, recreational quality would be severely degraded, a system of transferable boat slip rights would be preferable to a nontransferable allocation. A developer seeking approval for a new marina that exceeded the boat slip allocation for that community would have to purchase unused boat slip rights that had been allocated to other communities. Similarly, if it were generally acknowledged that even the restricted development of all shoreline parcels would seriously degrade the aesthetic enjoyment of property owners and visitors to the lake, a system of transferable development rights could permit somewhat denser development in certain areas while preserving others in a relatively pristine state.

#### **4.0 Potential Applications of Economic Instruments for Environmental Protection in the Lake Champlain Basin**

This volume has attempted to outline the theoretical benefits, empirical successes and problems associated with the use of economic instruments for environmental protection. A complete assessment of the applicability of these instruments to the Lake Champlain Basin would require a detailed analysis of the costs of pollution control from all sources and of the existing legal and regulatory framework operative in New York, Vermont, and Quebec. However, it is clear that many of the basic requirements for the effective use of economic incentives and market mechanisms exist in the Champlain Basin. In particular, the Basin contains over seventy point sources of water pollution as well as thousands of nonpoint sources with dramatically different marginal costs of pollution control.<sup>22</sup> In addition, the Lake Champlain Special Designation Act has imposed an integrated, basin-wide perspective on federal, state, and local environmental planning in the region. These factors alone indicate that there is the potential to realize significant cost savings and a more equitable distribution of costs by incorporating economic instruments into the pollution control program being developed for the Basin.<sup>23</sup>

The success of any regulatory program is closely linked to the manner in which that program is developed and implemented. As indicated by the case studies in Section 2, this is particularly true for programs that incorporate the use of discharge fees and transferable permits. Given, the potential benefits from the use of economic instruments for pollution control and the importance of participatory planning in developing such programs, this final section includes only one recommendation, followed by a number of observations and suggestions for further investigation.

**It is recommended that the Lake Champlain Management Conference convene a special working group consisting of representatives from major industries, local trade associations, municipalities, water supply and wastewater treatment districts, recreational users groups, state and federal regulatory officials, and environmental organizations in order to further investigate and propose potential uses of economic instruments as part of the pollution control program being developed for the basin.**

The activities of this working group would need to be coordinated with those of the Plan Formulation Team, the Technical Advisory Committee, and the Citizens Advisory Committees. Whatever organizational arrangements are ultimately developed it is critically important that all affected and interested constituencies are represented. The case studies indicate that this kind of representative working group might be most effectively convened after the overall levels of pollution control that are required to maintain or improve the lake's water quality are

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<sup>22</sup> The Vermont Agency of Natural Resources 1990 Phosphorus Reduction Plan indicates that marginal costs of phosphorus removal from municipal treatment plants in the region vary from \$3 to \$655 per pound. Studies of nonpoint source controls indicate the costs of best management practices for nutrient control can vary from no net cost for conservation tillage to several hundred dollars per pound for urban best management practices and septic tank renovations (Sessions and Filmore 1989).

<sup>23</sup> A recent EPA report listed Lake Champlain watersheds as having the necessary conditions for application of point/nonpoint source nutrient trading programs (Apogee 1992).



determined. In this way, the working group may come to view its task as an opportunity to develop equitable, cost-effective and flexible mechanisms for achieving what will hopefully be a commonly shared set of water quality objectives for the region. However, as described in Volume IV of this report, the development of a pollution control program for the basin should ideally involve a coordinated review of the aggregate costs and benefits, as well as the distributions of costs and benefits, associated with achieving various combinations of water quality standards and pollution control strategies. The working group recommended above could play an important role in that policy development process.

#### **4.1 Initial Allocation of Discharge Permits**

The first step in developing a program of transferable discharge permits, or any effective pollution control strategy, is to allocate the acceptable level of pollution discharges to the various sources of pollution in the region. This allocation will need to consider not only the basin as a whole but also the assimilative capacity of the lake's five major ecological zones. Whether or not these allocations are designed to be transferable, they will still have significant consequences for the distribution of the costs of the pollution control program.

As illustrated in the examples provided in Sections 1.2.2 and 3.2.1, a transferable permit program has the advantage of providing the flexibility necessary to achieving an equitable distribution of costs without increasing the total costs of the program. Given this flexibility, the allocation of point source phosphorus discharges to point sources might take account of a number of factors including the population served by municipal treatment plants, average daily flows at the plant, prior levels of phosphorus discharge, estimated phosphorus control costs, and the economic status of the industry or community.<sup>24</sup> Staggering the terms of the discharge permits and reserving a portion of the acceptable level of discharge for allocation in future years would provide some flexibility to accommodate economic growth and adjust to technological change or new information on ecological or economic conditions.

As part of a pollution control program that incorporates transferable discharge permits or pollution reduction credits, the regulatory agency could address nonpoint sources of pollution in several different ways. For example the program could;

1. Explicitly allocate a portion of permitted phosphorus discharges to nonpoint sources and then permit transfers of these allocations with point sources and other nonpoint sources. (The allocation could be on a simple per acre basis, as in Maine's lake management program, or the allocation might be adjusted to account for current land uses.).
2. Allow point sources and new development projects to earn phosphorus reduction credits by financing nonpoint source controls, but without requiring existing nonpoint sources to meet specific discharge allocations.

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<sup>24</sup> This assumes that discharge permits are initially distributed free of charge. Although there is a substantial theoretical literature on methods of auctioning discharge permits no actual program has yet done so, at least not for the initial allocation. The 1990 Clean Air Act authorizes EPA to auction a small percentage of emission allocations in future years.

## 4.2 Trading Rules and Guidelines

The beauty and recreational opportunities of the Lake Champlain region are likely to continue to attract new businesses, residents, and vacationers. The use of transferable discharge permits or pollution reduction credits is an ideal way to accommodate continued growth without jeopardizing environmental quality. As municipalities apply for permits to expand their treatment plants or new developments apply for building permits, they would be required to offset any additional phosphorus loads they create by financing equal or greater reductions at other point or nonpoint sources. The financing of offsetting phosphorus reductions could be performed through direct agreement with existing sources of pollution, indirectly through contributions to a basin-wide phosphorus control fund, or by purchasing "banked" phosphorus reductions from existing point sources. Some phosphorus discharge allocations could also be reserved by the regulatory agency for allocation to new facilities. Limiting the term of discharge permits to three to five years can also provide the regulatory agency with the opportunity to adjust allocations in response to economic growth. However, if permits must be renewed every few years it is important that the program still provide sufficient incentives for transfers of discharge permits that result from capital investments in pollution control equipment.

In addition to financing pollution control measures at point and nonpoint sources, it may be appropriate for dischargers to earn phosphorus reduction credits through investments in certain natural methods of phosphorus attenuation and extraction such as the construction of artificial wetlands, restoration of filled wetlands, or harvesting of lake plants. Analysis of nutrient cycling in wetlands and nutrient uptake by shoreline plants would provide the necessary information to evaluate these alternatives.

Many pollution control programs involving transferable discharge permits require new sources of pollution and dischargers seeking to exceed their permitted allocation to offset existing sources on a greater than one to one basis. A trading ratio of greater than one to one may be required due to uncertainty over the effectiveness of pollution control measures as well as to ensure continued improvement in environmental quality. For transactions involving the transfer of pollution reduction credits from a nonpoint source to a point source, a ratio of two or three to one may be desirable in order to account for variability in the effectiveness of nonpoint source control measures. However, if certain structural nonpoint source controls have well determined efficiencies, they may be treated like point source controls with respect to trading ratios. In order to evaluate various trading ratios, the Management Conference's ongoing project to estimate the total loadings and control costs of the major sources of nonpoint source pollution should consider both the marginal costs and the variability in the effectiveness of various control measures. Some carefully selected and managed demonstration projects may also be necessary to verify costs and effectiveness under local conditions.

Guidelines for a nutrient discharge trading program in the Lake Champlain watershed will also need to account for the different conditions existing within the lake's five major ecological zones. For example, the required ratio for trades between dischargers in the watershed of the Main Lake and dischargers in the watershed of the Inland Sea would need to take account of the rates of nutrient transfer between the two bodies of water. In addition, the trading or offset ratios between pollution sources that are located close to the lake or tributary streams and those located far up the watershed might take account of the effects of nutrient attenuation and deposition. The Management Conference's ongoing and planned projects for

hydraulic modeling and nutrient transport should provide critical information for the evaluation of these conditions.

An important consideration with respect to the foregoing discussion of trading ratios and guidelines, is the tradeoff between accurately accounting for all circumstances and the costs of administering the program. The greater the number of special cases and unique trading ratios, the more expensive it will be to administer the program. A potential solution to this dilemma is to require or allow dischargers seeking pollution reduction credits to make payments into a basin-wide pollution control fund. The payments might vary depending on the location of the discharger purchasing the pollution reduction credits, or, the payment rate may simply be established based upon the average conditions and marginal pollution control costs for the basin as a whole. Whatever rates are established, it then becomes the responsibility of the regulatory agencies to use these funds most effectively and to adjust the contribution rates when necessary.

Another option is for promoting an efficient market is for the appropriate regulatory agencies to administer annual, semiannual or even quarterly auctions of discharge permits. Buyers and sellers would be required to submit sealed bids which would then be reviewed and ultimately approved by the appropriate regulatory agency. After the auction is complete all approved transactions would be consummated at one market clearing price. This price and the volume of transactions would then become public information in much the same way that stock and bond prices are published daily. The use of double sealed auction processes can help minimize price manipulation, while providing all parties with important information about the market value of transferable discharge permits.

#### **4.3 Administration, Monitoring, and Enforcement**

There are many institutional forms through which a transferable discharge permit program could be administered. It is possible that such a program could be conducted by the regulatory agencies of the states of New York and Vermont and the province of Quebec, perhaps through a modification of the legal and administrative framework of the existing Lake Champlain Compact. However, as previously indicated in Section 3, active trading of discharge allocations is not likely to occur and contributions to any basin-wide pollution control fund are likely to be inadequate, unless there is prompt review of proposed trades, as well as efficient monitoring and enforcement efforts. Most pollution control programs that focus on a particular watershed or airshed have established a regional body to ensure coordinated planning, administration and local participation, and in some cases, to assist with monitoring and enforcement. Such regional agencies include the Chesapeake Bay Commission, the Delaware River Basin Commission, The Puget Sound Authority and the Lake Tahoe Regional Planning Agency. The powers and responsibilities of these regional bodies are in large measure a reflection of the particular political and institutional conditions under which they were developed.

Residents of the Lake Champlain basin could perceive the creation of a regional environmental planning and administrative agency as either an opportunity to increase local control over pollution control programs or simply as another layer of bureaucracy. If the impetus for such a regional planning and environmental agency came from local officials, and community leaders, and the membership of its managing board were designed to be fully representative of the diverse interests within the basin, it might receive widespread support and

be capable of coordinating local, state, and provincial regulatory programs. Whatever institutional arrangements for program planning and administration are ultimately agreed upon, it is essential for the success of the program that there be fully representative local involvement in the decisionmaking process.

#### **4.4 Discharge Fees**

Although discharge fees can be an efficient mechanism for reducing water pollution, the added financial burden they place on dischargers makes it politically difficult to use them as the sole method of pollution control. As outlined in Section 2, guidelines for implementation of an acceptable discharge fee system include;

1. The involvement of all affected parties in designing the fee structure.
2. Initiating the fee at a low level and increasing it gradually, if necessary.
3. Using the revenues to defray the costs of administering the pollution control program and to provide financial assistance for implementation of pollution control measures.

In the Lake Champlain Basin a system of discharge fees covering phosphorus, and perhaps other pollutants such as biological oxygen demand or certain toxics, could be implemented in conjunction with a system of transferable discharge permits. Even at relatively low levels, the fees would still provide incentives for dischargers to maintain efficient operations or utilize best management practices. If the revenues could be utilized only for administration of pollution control efforts within the Basin and to provide subsidies to dischargers for the implementation of pollution control measures, a system of discharge fees might receive more widespread support. Final recommendations on whether and how to utilize discharge fees as part of the pollution control program for the Basin, should be developed by the working group proposed above.

#### **4.5 Other Applications of Economic Instruments**

Section 3 included a brief review of other uses of economic incentives and market mechanisms that might be applicable for environmental protection in the Lake Champlain basin. Each of the other potential applications listed below has its own set of administrative requirements and design considerations that should receive further investigation as part of the development of a comprehensive pollution control strategy.

1. Environmental cross compliance requirements for agricultural programs.
2. Targeted, graduated incentives for agricultural nonpoint source control programs based on the expected benefits of these controls for various combinations of environmental conditions (e.g. soil, slope, distance to stream) and types of farm operations.
3. Performance bonds for use of best management practices during construction and forestry activities.
4. Transferable allocations of boat slips.
5. Transferable development rights for protection of wetlands, critical habitat, scenic areas and farmland or open space.

#### 4.6 Suggestions for Further Research

The Lake Champlain Management Conference, its various committees and subcommittees, and other interested parties have expressed a clear interest in protecting the unique environmental characteristics of the lake and its surrounding watershed. Given limited public and private resources, the importance of achieving that objective in the most cost-effective manner has repeatedly been stressed. The inclusion of an appropriate set of financial incentives and market mechanisms as part of a larger pollution control and environmental restoration strategy has the potential to not only reduce the costs, but also to increase the effectiveness of the overall program. In order to accurately assess the potential cost savings and develop a legally and administratively feasible set of economic instruments that will meet with public approval, several suggestions for further research are outlined below.

- ♦ Develop a mathematical programming model to estimate the potential cost savings attainable from the use of economic instruments as compared with various command and control regulatory approaches. Data requirements include the volume, pollutant concentrations, pollutant removal efficiencies, and marginal costs of increasingly stringent pollution control measures for all major point and nonpoint sources of pollution.
- ♦ Develop proposed guidelines and ratios for transfers of permitted discharge allocations between point and nonpoint sources and between ecological zones of the lake. Data requirements include rates of hydrological mixing between zones of the lake, phosphorus attenuation in streams and soils, as well as the cost, effectiveness and reliability of point and nonpoint source control measures.
- ♦ Evaluate alternative discharge fee systems for operation in conjunction with discharge permits. Design considerations include the sources of pollution to be covered by proposed fees, volume and pollutant concentrations, population served and/or financial characteristics of the relevant sources of pollution, effective incentive mechanisms in lieu of high charge levels, billing and administrative needs and specific guidelines for use of the fee revenues.
- ♦ Review existing pollution control efforts in the agricultural, construction and forestry sectors and design appropriate uses of economic incentives. Policy instruments that should be considered include cross compliance requirements, targeted and graduated subsidies for implementation of best management practices and performance bonds for construction and forestry activities.
- ♦ Evaluate alternative institutional arrangements for planning, coordination, and administration of point and nonpoint source pollution control programs for the basin that include transferable discharge permits and discharge fees. This task should include an analysis of existing legal authorization for, or restrictions on, the use of economic instruments in New York, Vermont and Quebec.

The research tasks outlined above should be conducted in consultation with the recommended working group on the use economic instruments. In all cases a range of options should be presented to the group for discussion, further research and amendment. Eventually, the working group would present a final set of recommendations to the Plan Formulation Team and the Management Conference, regarding the incorporation of economic instruments into the Lake Champlain pollution control and restoration program.

## Appendix A

### Annotated Bibliography

The following is a selected bibliography and brief description of seventy of the most relevant references found in the literature review. Emphasis was placed on locating case studies and other empirical investigations, as well policy analyses accessible to readers with no formal training in economics. More technical or theoretical materials are noted in the descriptions following each reference. The locations where each item was found in the research for this project are noted in parentheses at the end of each reference.

Ackerman, B.A. and Stewart, R.B., 1988, Reforming Environmental Law: The Democratic Case for Environmental Incentives, *Columbia Journal of Environmental Law*, 13:171-199, (Cornell-Law)

This article summarizes the economic shortcomings of traditional environmental regulation, discusses the implementation and administrative requirements of economic incentive systems and argues that an environmental regulatory system based on economic incentives will promote improved public discourse on the basic choices involved in environmental regulation.

Based upon a review of more than twenty other studies, the authors outline the following problems with technology based standards. 1) Billions of dollars are wasted annually by ignoring inter-firm variations in control costs. 2) Disproportionate burdens are imposed on new plants, processes and developments. 3) No incentives are provided for development of new pollution control technologies and processes. 4) Excessive information requirements are imposed on regulators which often leads to costly and time consuming litigation. 5) Intelligent priority setting is prevented.

The benefits of economic incentives outlined by the authors include a reduction in regulatory information requirements, a source of revenue for environmental programs, stronger incentives for monitoring and enforcement and reduced incentives for litigation. The authors also argue that the implementation and administrative requirements of economic incentive systems are less onerous than traditional command and control approaches. In the case of a system of transferable discharge permits, operating an efficient auction system for the permits would probably be the most difficult task. However, the federally operated system of auctioning offshore oil and gas leases is an example of a technically efficient governmentally managed auction process.

The authors make the interesting claim that economic incentives will focus the environmental policy debate on the critical question of the economically and environmentally appropriate amount of a particular pollutant that should be permitted to be discharged. They argue that traditional regulatory approaches obscure this question with endless arguments over the best available control technology and the lowest achievable emission rate.

Anderson, T.L. and Lead, D.R., 1991, *Free Market Environmentalism*, Pacific Inst. for Pub. Policy, (Cornell-Uris, UVM)

This book addresses a wide range of environmental issues and generally argues for the creation of property rights for environmental assets as the most effective means of controlling pollution. In chapter 10 several studies of alternative water pollution control strategies for the Delaware, Hudson and Fox Rivers are cited as evidence of the potential cost savings of incentive-based approaches. The authors argue that the information on the costs of water pollution that is necessary for an efficient system of effluent fees is often not available. They therefore favor a system of marketable discharge permits (MDP's). The authors view MDP's as a first step toward the creation of property rights for water resources.

The efforts of the Anglers Cooperative Association in England to protect public fishing rights from excessive pollution is cited as another step in the evolution of property rights for water resources. The authors suggest that water pollution in the U.S. could be reduced if a system of fishing rights were established. Liability rules would evolve so that owners of fishing rights could bring suit against an upstream polluter whose effluent damaged their fishery resource. The authors recognize however, that this type of property rights approach is likely to fail if the sources of water pollution are numerous and diverse.

Apogee Research, 1992, Incentive Analysis for Clean Water Act Authorization: Point Source/Nonpoint Source Trading, pp 104, Prepared for U.S. EPA Offices of Water and Policy, Planning and Evaluation, (EPA)

This report primarily examines point source/nonpoint source effluent trading as one option to achieve nutrient water quality objectives at least cost. The report explains how pollution trading programs operate, defines some necessary conditions for successful effluent trading programs and outlines several potential trading scenarios. Four point source/nonpoint source trading programs and one point source/point source trading program are reviewed as case studies. The national applicability of point source/nonpoint source trading programs is considered on the basis of information contained in EPA's Water Body System database. Finally, the report discusses the current legal basis for effluent trading programs under the Clean Water Act and recommends several means by which the Act could be amended during its reauthorization in order to provide more explicit sanctions and incentives for trading programs.

The report provides a useful checklist of conditions that are necessary for the implementation of a successful effluent trading program. In addition one of the appendices of the report lists watershed in which point source/nonpoint source nutrient trading programs currently appear applicable. Most of the subwatersheds of the Lake Champlain basin appear on this list.

Arrandale, T., Sept. 1989, Free Market Environmental Protection, *Editorial Research Reports*, 2:490-503, Congressional Research Service, (Cornell-Uris)

This article provide a non-technical survey of proposals by the Bush administration, economists and some environmental groups to utilize market-based approaches to promote environmental protection. The mechanisms discussed include, imposing fees or taxes on pollution discharges, issuing marketable discharge permits, requiring deposits on hazardous materials and eliminating subsidies for environmentally harmful activities. Arrandale summarizes the arguments for using economic incentives with a quote from Richard B. Stewart of the Harvard Law School Our current environmental regulatory system was an

understandable response to a perceived need for immediate controls to prevent a pollution crisis. But the system has grown to the point where ... it strangles investment and innovation ... encourages costly litigation and delay ... (and) unduly limits private initiative and choice. The centralized command system is simply unacceptable as a long term environmental protection strategy for a large and diverse nation committed to the market and decentralized ordering.

Arrandale's article cites several studies indicating that significant savings have been realized through the partial emissions trading authorized by the Clean Air Act. Also mentioned is a recent program by the Los Angeles Metropolitan Water District to obtain additional supplies of water by financing \$155 million in water conservation investments made by a nearby irrigation district.

The author also reviews some of the arguments often offered in opposition to market-based approaches to pollution control. Some environmentalists contend discharge permits or fees are an inappropriate license to pollute. Others argue that market-based approaches will be too difficult to administer.

Atkinson, S. and Teitenberg, T., 1991, Market Failure in Incentive-Based Regulation: The Case of Emissions Trading, *Journal of Environmental Economics and Management*, 21:17-31, Harvard-KSG and Cornell-Olin)

This article presents a mathematical model intended to examine why the EPA's emissions trading program for air pollutants has realized only a portion of the theoretically achievable cost savings. The authors demonstrate that the cost savings available from emissions trading are limited by several factors including the requirement that all trades must maintain or improve local air quality, that trades must be negotiated bilaterally and in sequence between trading partners rather than through a multilateral market and that traders do not have full information on which trades would provide the greatest economic benefits. Transaction costs such as brokers fees or the costs of air quality modeling tend to further limit the achievable cost savings of emissions trading programs.

The analysis presented in the article indicates that given the relatively restrictive EPA and state guidelines for the emissions trading process, the degree of cost savings that have been achieved are not unexpectedly low. Cost savings can be expected to be greatest for pollution rights markets involving uniformly mixed pollutants and/or markets which permit banking of emissions reduction credits. Under these circumstances it is more likely that firms and brokers will be able to structure the most cost-effective trades.

Blaser, W.L. et. al., 1989, Economic Analysis of Proposed Amendments to Water Pollution Regulations: Phosphorus Discharges R87-6, NTIS PB89-152698, (Cornell-Eng.)

This report examines the environmental costs and financial benefits of reducing Illinois' stringent phosphorus (P) control requirements for publicly owned treatment plants in six lake basins. For five of the six basins, the report concludes that non-point sources of P constitute most of the total P load and the financial benefits (avoided costs) of relaxing point source P control requirements outweigh any minor environmental damages. The report contains estimates of capital and operating costs for several P control options for a range of treatment plant sizes. It also attempts to estimate the effect of changes in water quality on recreational benefits.



Bockniarz, Zbigniew, 1990, Economic Incentives to Protect Water Quality in Market and Planned Economies, *Natural Resources Forum*, (Cornell-Mann)

This article provides a non-technical introduction to, and brief survey of, the use of economic incentives in water pollution control. It includes definitions of legal and economic instruments and a summary of the potential benefits of the use of economic instruments. In addition, there are brief reviews of incentive-based water pollution control strategies that have been adopted in France, the Netherlands, Germany and Eastern Europe. The author also theorizes that environmental protection efforts follow a progression from the use of legal instruments to the incorporation of economic incentives and finally to the integration of environmental policy with socio-economic development strategies.

Bressers, H.T.A., 1988, Effluent Charges Can Work: The Case of Dutch Water Quality Policy, In *Environmental Policy in a Market Economy*, Dietz, F.J. and Heijman, J.M. eds., 5-40, Selected papers from the conference 'Environmental Policy in a Market Economy', (Cornell-Mann)

This article includes a brief survey of Dutch water quality policy and a statistical analysis of the relative contribution of direct regulation and effluent fees in the improvement of water quality in the Netherlands. Although effluent charges were first imposed primarily as a means of financing pollution control efforts, Bressers demonstrates that they have had a strong incentive effect. Based upon his statistical analysis, Bressers concludes that the majority of the reductions in industrial water pollution in the Netherlands has been the result of the effluent fees rather than the imposition of direct regulatory standards.

Bressers, H.T.A., 1983, The Role of Effluent Charges in Dutch Water Quality Policy, In *International Comparisons in Implementing Pollution Laws*, P.B. Downing and K. Hanf eds. (Cornell-Law, UVM)

This paper begins with a brief survey of Dutch water quality policy including a discussion of the use of effluent charges as an instrument of environmental protection. The remainder of the paper is devoted to a statistical analysis of the effectiveness of Dutch effluent charges in reducing industrial discharges of organic pollutants. Bressers utilizes a multiple regression analysis to investigate the relationship between the burden of effluent charges (total charges/total sales) on different types of industries and the percentage reduction in the discharge of water pollution by these industries. The costs of pollution abatement and changes in production levels by industry are also included as variables in the analysis. In general, the model indicates that differences in the burden of the effluent charges account for more than 75% of the differences in water pollution levels amongst 12 industrial sectors.

Brown, G.M. Jr. and Johnson, R.W., 1984, Pollution Control by Effluent Charges: It Works in the Federal Republic of Germany Why not in U.S., *Natural Resources Journal*, 24, (Cornell-Mann)

Based upon their review of the German experience with effluent charges, the authors provide the following list of characteristics of a politically and administratively feasible effluent discharge fee system. 1) It covers a small number of pollutants. 2) It is used in conjunction with a permit/uniform standards approach. 3) Charges begin at a low level and

escalate over a pre-defined transition period.. 4) Charges are set with the involvement of all interested parties. 5) Measurement and pricing systems are straightforward. 6) Revenues are made available to subsidize abatement technologies. 7) A hardship clause provide for temporary exemptions under exceptional circumstances. 8) The implementation process is clearly defined.

Political support for market-based approaches to environmental management emerged in Germany in the early 1970's. During this period initial legislative proposals for water pollution control envisioned a system of effluent charges based on the estimated damage caused by pollution discharges. However, pressure from some Lander (states) and industries yielded a more moderate charge system that operates in tandem with a traditional approach based on technology standards. Still, the resulting system imposes a set of discharge fees explicitly based on the assumption that pollution dischargers cause damages to other users of the water body. Dischargers that meet the minimum effluent standards receive a 50% discount on the discharge fees and are not subject to legal action by the government.

Although the level of effluent charges imposed under the German system is perceived to be too low to achieve water quality objectives in the absence of minimum effluent standards, a German government study estimated that the combined effluent charge-technology standards approach is approximately 1/3 less expensive than a system based solely on uniform standards.

Burtraw, D., Summer 1991, Compensating Losers When Cost-Effective Environmental Policies are Adopted, *Resources*, n. 104:1-5, Resources for the Future, (Cornell-Olin)

This article argues that cost-effective incentive-based approaches to environmental problems promise significant cost savings relative to traditional regulatory approaches. But because policy changes can adversely affect some members of society, the provision of compensation may be needed to ensure political support and satisfy equity concerns. The degree of compensation is related to the baseline against which the new environmental policy is compared. Comparison against a no regulation situation would identify all polluters as being damaged. However, comparison with a no pollution state or with a less efficient, uniform standards approach to regulation might indicate that no compensation is required. Whether the policy is expected or unexpected and whether the adversely affected parties are advantaged or disadvantaged groups also can affect the public perception of just compensation.

This article advocates the use of linked compensation programs where the form of compensation is linked to the type of harm. For instance if the new policy required farmers to reduce the runoff of nutrients and topsoil from their land, the form of compensation might include technical assistance on what practices were most effective. The article suggests that this kind of linked compensation should often be an explicit component of incentive-based environmental programs.

Corcoran, E., Nov. 1989, Polluting Rights: How to Build a Market for an Unwanted Commodity, *Scientific American*, v.263 no.11 76-78, (Harvard-KSG and Cornell-Mann)

This brief article provides a concise description of the sulfur dioxide emission trading program authorized by the 1990 Clean Air Act. The essential objectives, structure and deadlines of the program are outlined together with a discussion of monitoring technologies and administrative considerations. The potential for localized pollution problems and the

difficulties the program may encounter from state public utility commissions are also discussed.

Cumberland, J.H., 1991, Improved Policy Instruments for the Management of Enclosed Coastal Seas and Estuaries, *Marine Pollution Bulletin*, 23:773-777, Maryland Univ., Solomons Ctr. for Environmental and Estuarine Studies, (Cornell-Mann, UVM)

While acknowledging the beneficial critique of environmental policy that has been provided by economists, this paper proposes an expanded set of criteria for environmental policy analysis and management. In the framework presented by the author, economic efficiency, distributional equity, scientific validity and public acceptability are the joint criteria on which environmental policies should be evaluated. This framework is then loosely employed in the analysis of several resource management issues affecting the Chesapeake Bay.

For water quality protection the author believes that a system of freely distributed marketable discharge permits is more feasible politically than a regulatory approach that relies heavily on discharge fees. The author also recommends some curtailment of open access to the Chesapeake fishery through the granting of leases and transferable quotas to fishermen. Waterfront and wetland land use controls and real estate markets are perceived to be inadequate to protect ecologically sensitive and recreationally valuable areas. The author recommends establishing a fund for acquiring key land parcels with revenues generated from a land transfer tax. Also recommended are marginal cost pricing and impact fees for public services provided to new developments as well as zoning changes and economic incentive programs that shift the focus of industrial and commercial development to inland areas.

DeLucia, R.J. et. al., 1974, *An Evaluation of Marketable Effluent Permit Systems*, pp 165, Prepared for U.S. EPA Office of Research and Development by Meta Systems Inc., EPA-600/5-74-030, (Cornell-Eng.)

This report is a study of the practical problems and prospects of using marketable effluent permits as a means of water pollution control. The study details the requirements of MEP systems, discusses their theoretical advantages and examines them in the context of industrial organization theory. The study also includes results from a simulation model using data from the Mohawk River to determine the effects of alternative guidelines for MEP systems. The report concludes that marketable permits are a promising water pollution control option.

Dorfman, R. and Dorfman, N.S., eds., 1977, *The Economics of the Environment*, pp 489, (Cornell-Uris)

This book is a collection of some of the best articles on environmental economics during the period 1960-1975. Although most of the articles are written by economists, they are quite accessible to the non-technical reader. The articles are grouped into several categories including economic analysis, policies for environmental protection, the long run dynamics of resource use and the measurement of costs, benefits and social welfare. Overall the collection provides an excellent introduction to the use of economic analysis and economic incentives in environmental policy as well as the importance of considering environmental factors in determining economic policy.

DPRA Associates, 1986 (revised 1989), *An Evaluation of the Cost Effectiveness of Agricultural BMP's and POTW's in Controlling Phosphorus Pollution in the Great Lakes*, pp 76, Prepared for the Environmental Protection Agency, Office of Policy, Planning and Evaluation, (EPA)

This report compares the cost per pound of phosphorus removed by various conservation tillage practices with chemical removal of phosphorus at publicly owned treatment plants in the Great Lakes basin. Information on conservation tillage was derived from a case study of the Honey Creek watershed in Ohio. Point source phosphorus treatment costs were estimated from 11 POTW's that had been upgraded for phosphorus removal. Cost estimates for four conservation tillage practices were inclusive of pesticide controls sufficient to meet water quality criteria. In addition, the report provides an innovative methodology for estimating the costs of nonpoint source controls in relation to increasing levels of reliability for achieving the phosphorus removal targets.

The report concludes that the first 25% of phosphorus reduction in the Honey Creek watershed can on average be most cost effectively achieved through the use of nonpoint source controls. Additional levels of phosphorus reduction would be most cost effectively achieved through chemical treatment at the larger treatment plants.

Dudeck, D.J. and Palmisano, J., 1988, Emission Trading: Why is this Thoroughbred Hobbled?, *Columbia Journal of Environmental Law*, 13:218-256, (Cornell-Law)

This article outlines the theory of emissions trading, discusses the potential benefits of using market-mechanisms for pollution control, describes the practice of emissions trading that has developed under the Clean Air Act and proposes some improvements to the air emissions trading system. In addition, the article proposes an extension of the emissions trading system for use in controlling ozone depleting chemicals and greenhouse gases.

After a detailed description of EPA's emissions trading program, the authors examine the results and conclude that it has not resulted in any degradations in air quality, while the total cost savings of the program through 1985 are in excess of \$500 million. Some concerns of environmentalists and regulators regarding emissions trading are discussed and recommendations are made for preventing paper trades of non-existent emissions reductions.

The article concludes with a discussion of various proposals to utilize emissions trading to control other air pollutants of national and international concern. The authors believe that a system of transferable emissions rights could usefully be applied to control ground level ozone as well as stratospheric ozone depleting chemicals such as chloroflourocarbons (CFC's) and emissions of greenhouse gases.

Eheart, J.W. and Brill, E.W. Jr., 1983, Transferable Discharge Permits for the Control of BOD: An Overview, In *Buying a Better Environment: Cost Effective Regulation through Permit Trading*, 163-195, Proceedings of a National Conference on Regulatory Reform, Transferable Permits and Environmental Quality, (Cornell-Mann)

This article provides a comprehensive discussion of the design and implementation of transferable discharge permit (TDP) systems for water quality protection. The general advantages of TDP systems relative to traditional regulatory approaches are outlined and specific design criteria for TDP systems are presented. These include clearly defined water quality goals, definition of permit rights, procedures for initial distribution and subsequent

exchanges, permit duration, quantity of permits allocated, geographic or other restrictions on permit transfers and monitoring and enforcement considerations.

The theoretical discussion of alternative TDP systems is supported and clarified by computer simulations of the outcomes of these systems relative to traditional regulatory approach for four river systems (Willamette, Delaware, Mohawk and Upper Hudson). The simulations were based upon actual hydrologic data and pollution discharges to these rivers. In general the TDP systems are estimated to reduce the cost of achieving dissolved oxygen standards by 25% to 35% relative to a uniform treatment standards.

If the watershed is large and heavily utilized, unrestricted trading of discharge permits could lead to water quality violations at certain locations. Much of the article is devoted to examining the following mechanisms for structuring TDP systems to prevent localized water quality violations. The following options are assessed in the article; 1) Revaluing the permit (based upon hydrologic criteria) when it is traded to a different geographic location. 2) Reducing the quantity of permits to ensure standards are met at all locations under all circumstances. 3) Separating the watershed into distinct zones and limiting transfers between zones, limiting permit quantities by zone or revaluing permits when traded between zones.

The computer simulations indicate that different combinations of the above methods will result in different tradeoffs between cost-effectiveness, equity and administrative complexity. Moreover the specific effects of each method are dependant on the physical characteristics of the water body and the size, location and control costs of the dischargers to the water body.

The article also provides an informative discussion of several methods for the initial distribution of discharge permits including free distribution based upon a uniform treatment standard, single price auctions and incentive compatible auctions.

Environmental Protection Agency, 1991, *Economic Incentives: Options for Environmental Protection*, Report of EPA Economic Incentives Task Force, (Harvard-KSG)

This report is the product of an internal EPA task force consisting of staff from every program area within the agency. Economic instruments which were considered by the task force included marketable permits, monetary incentives, deposit-refund systems, information disclosure and environmentally oriented federal procurement policies.

For water resources, the report discusses changes in water pricing mechanisms, deposit-refund systems for pesticide containers and reduction of federal subsidies for coastal development. Market based approaches for managing municipal waste, greenhouse gas emissions and various toxic wastes are also considered in the report. The description and analysis of each policy option is rather general, with very little quantitative analysis and usually ambiguous conclusions. There are also only a few references to, and no analysis of, actual examples of economic incentives used in environmental policy.

Environmental Protection Agency, 1989 *Public-Private Partnership Case Studies: Profiles of Success in Providing Environmental Services*, EPA Administration and Resource Management, September, 1989, PM-225

This report provides short descriptions of innovative programs for financing municipal environmental facilities or delivering environmentally related municipal services.

Ervin, D.E. and Heffernan, W.D. and Green, G.P., Aug. 1984, Cross Compliance for Erosion Control: Anticipating Efficiency and Distributive Impacts, *American Journal of Agricultural Economics*, 66:273-78, (Cornell-Mann, UVM)

This article summarizes an economic analysis of recommended programs to subsidize erosion control practices by increasing commodity support payments to farms that meet certain conservation targets. The analysis indicates that under such a cross-compliance program, most payments will go to flatland farms that would nearly meet the conservation standards without the subsidies. The authors suggest the program could be improved by providing a sliding scale of subsidies relative to the marginal environmental benefits of erosion control practices on different soil types and farm locations.

Foster, D., 1983, Planning for the Development of Economic Incentives Under Institutional Constraints, *In Buying a Better Environment: Cost Effective Regulation Through Permit Trading*, Joeres, E.F. and David, M.H. eds., Proceedings of a National Conference on Regulatory Reform, Transferable Permits and Environmental Quality, (Cornell-Mann)

This paper attempts to explain why economic incentives for pollution control are only slowly being adopted and suggests that the most successful means of implementing market-based approaches is through a process of guided incrementalism. The author outlines various impediments to market-based pollution control systems including, existing regulatory processes and procedures, the professional training and orientation of most environmental regulators (i.e. engineers, lawyers and physical scientists with very few economists) and existing environmental laws that impose technology based emission standards on all sources.

To overcome these impediments to change and successfully implement alternative pollution control strategies Foster recommends the following actions: 1) Identify major goals and constraints. 2) Identify beneficiaries and build a constituency for change. 3) Find opportunities for change that have minimal impact on major stakeholders. 4) Introduce change in a gradual self-sustaining manner. 5) Be ready to capitalize on change induced by external forces. 6) Focus more on implementation issues than on theory. 7) Be patient.

Freeman, A.M. III, 1991, Water Pollution Policy, *In Public Policies for Environmental Protection*, Portnoy, P.R. ed., 97-151, (Cornell-Uris)

This chapter traces the historical development of water pollution policy from the Refuse Act of 1899 through the Clean Water Act (CWA) of 1972 and subsequent amendments. It also includes a thorough analysis of the accomplishments of the CWA and the resulting benefits and costs. On the accomplishments side there has generally been an improvement in water quality across the country with substantial improvements in some areas. However, there also are significant areas of the country where water quality has declined since 1972. The author indicates the lack of dramatic improvement in water quality may in part be due to slow implementation of many features of the CWA. In terms of costs and benefits, Freeman finds that by almost any measure the costs of controlling water pollution have been greater than the benefits. To improve the benefit/cost ratio Freeman recommends greater flexibility in setting standards and greater use of economic incentives

Gaines, S.E. and Westin, R.A. et. al., 1991, *Taxation for Environmental Protection*, pp 243, (Cornell-Law)

This book provides a detailed review of the use of taxation and fees at the national level for environmental protection in France, Germany, Sweden, Britain and the U.S. The book focuses primarily on the historical development and legal structure of the use of environmental taxes in each of these countries. In addition, the authors occasionally draw conclusions about the effectiveness and economic efficiency of the various tax and fee systems described in the book. The systems of effluent charges in effect in France and Germany are well documented as are the provisions of the U.S. 1990 Clean Air Act that relate to the use of economic incentives. Also included is an opening chapter on the general theory of using economic incentives in environmental policy. .

Grenell, P., 1991, Non-Regulatory Approaches to Management of Coastal Resources and Development in San Francisco Bay, *Marine Pollution Bulletin*, 23:503-507, (Cornell-Mann, UVM)

This article describes the role of the California State Coastal Conservancy in management of the coastal resources of San Francisco Bay and tributary rivers. The Conservancy is a state agency created in 1976 with no regulatory powers but a broad mandate to protect, restore and enhance California's coastal resources. In the Bay area, the Conservancy operates as a coordinator, broker, problem solver and implementation agency on issues that do not fit easily into the jurisdictions of existing regulatory agencies.

The article describes several examples of successful projects managed by the Conservancy including purchase of critical wetlands, resolution of multiple use conflicts and implementation of demonstration projects for the use of wetlands to provide tertiary treatment of wastewater. The Conservancy's success seems to stem from its ability to plan, design and fund projects and to coordinate involvement from diverse groups on issues that cut across political jurisdictions or narrowly defined regulatory mandates.

Hahn, R.W., 1983, Designing Markets in Transferable Property Rights: A Practitioners Guide, In *Buying a Better Environment: Cost Effective Regulation Through Permit Trading*, Joeres, E.F. and David, M.H. eds., Proceedings of a National Conference on Reg. Reform, transferable Permits and Environmental Quality, (Cornell-Mann)

This paper outlines a framework for the design and testing of market mechanisms of pollution control. Three basic objectives are recommended for the initial design of a discharge trading market; 1) Establish a price signal so that buyers and sellers are readily aware of the market price. 2) Subject to other constraints, structure the market so that all cost-effective trades are permitted to occur. 3) Allow for equity considerations .

The author analyzes a specific institution, the zero revenue auction, for trading discharge rights. Under this system market participants (pollution dischargers) receive an initial allocation, presumably based upon equity considerations. Each discharger must then offer their complete permit allocation for sale and a set of bids must be expressed by each participant for the repurchase of discharge permits. The bids of all participants are aggregated to determine the equilibrium price and the discharge rights are reallocated based upon the individual bids and the equilibrium price. Participants that end up purchasing fewer discharge rights than their initial (free) allocation, receive payments from participants whose bids result in the purchase of additional discharge permits.

The utilization of a zero revenue auction is presented as an alternative to simply allocating the permits and letting dischargers trade them if and how they see fit. Experiments utilizing student volunteers as market participants indicate that the zero revenue auction discourages hoarding of discharge rights and through repetitive auctions leads to an efficient market allocation.

Hahn, R.W. and Gordon, L.H., 1987, The Market for Bads: EPA's Experience with Emissions Trading, *Regulation*, nos. 3/4, (Cornell-Law)

This article reviews the achievements and deficiencies of EPA's air pollution emissions trading program during the period 1973-85. The authors found that over 9000 trades of emissions credits had occurred during this period resulting in approximately \$4.4 billion in savings. However, most of these trades occurred between plants of the same firm or between smokestacks of the same plant.

The scarcity of inter-firm trades of emission credits is attributed to uncertainty over the property rights inherent in the tradeable emission credits. This uncertainty arises in part from the difficulty of determining baseline emissions. In addition, numerous changes in and repeated controversy over the regulations governing the trading process provided firms with the impression that if they banked credits by reducing pollution more than was legally required, they would not be permitted to sell all of these credits in the future.

To strengthen the emissions trading market, the authors recommend that the EPA and the states make a greater effort to determine baseline emissions and develop clear guidelines regarding permissible trades, including the unrestricted use of emissions credit banks.

Hahn, R.W. and Stavins, R.N., 1991, Economic Incentives for Environmental Protection: Integrating Theory and Practice, CSIA Discussion Paper, 91-15, Center for Science and International Affairs, Kennedy School of Government, Harvard Univ., (Harvard-KSG)

This paper seeks to define critical areas of research that will help identify and facilitate appropriate uses of economic incentives for environmental protection. The authors seek to broaden the type of policy instruments as well as the objectives and constraints that are normally considered in analyses by environmental economists. In addition, they hope to expand the criteria on which alternative environmental regulatory options are evaluated.

In general, economists tend to focus primarily on pollution fees or taxes and marketable discharge permits (MDP). The authors note that the institutional and political context of individual environmental problems can dramatically affect the choice of preferred policy instruments. They suggest that economic analysis should be expanded to include not only fees and marketable permits but also deposit refund systems, indirect instruments and combinations of market-based approaches and regulatory standards.

In designing and evaluating market-based environmental policies the authors argue that the existing regulatory framework must be explicitly considered. In addition, the implications of potentially significant transaction costs must be evaluated in designing MDP systems. Other issues that should be evaluated in environmental policy design include monitoring and enforcement requirements and capabilities, uncertainty regarding costs and benefits and dynamic incentives for technological improvement.



Hahn, R.W. and Stavins, R.N., 1990, Incentive Based Environmental Regulation: A New Era from an Old Idea?, CSIA Discussion Paper, E-90-13, Center for Science and International Affairs, Kennedy School of Government, Harvard University, (Harvard-KSG)

This report reviews the main types of regulatory instruments (including command and control mechanisms and incentive-based approaches), briefly summarizes U.S. experience with incentive-based environmental policies and then discusses why incentive-based approaches are now being embraced at the federal and state levels. Much of the information is an abbreviated version of Agenda 88 (see Stavins 1988). However the report does provide a useful review of the factors that tend to promote the use of economic instruments in environmental protection.

The authors contend that the use of economic instruments will tend to increase with increases in 1) the political demand for environmental quality, 2) the incremental cost of improving environmental quality, 3) the potential of economic incentives to improve environmental quality at lower cost, 4) the absence of concentrated losers, 5) understanding of how economic instruments work, 6) confidence in the actual application of economic instruments and 8) influence of regulators, activists and academics familiar with the use of economic instruments for environmental protection.

Harrison, P. and Sewell, W.R.D., 1980, Pollution Control by Agreement the French System of Contracts, *Natural Resources Journal*, 20:765-786, (Cornell-Mann)

This article reviews the historic development of water pollution control strategies in France, focusing on the system of effluent charges employed by the Agences Financieres de Bassin. These organizations impose effluent discharge fees on all municipal and industrial pollution sources within a river basin. The charges are based on the characteristics of the pollutant (e.g. suspended solids, BOD, COD, etc.) and on the volume of pollutant discharged. The charges vary within a particular river basin depending on location. Dischargers located within a highly polluted or ecologically sensitive zone are charged a higher rate. The charges are reduced if certain water pollution control equipment is installed, with the reduction depending on the efficiency of the pollution control equipment or process. A portion of the revenues raised from the discharge fees are used to provide grants and subsidized loans for the installation of water pollution control equipment at municipal treatment plants or factories within the basin.

Since the discharge fee system was adopted, the level of charges imposed has risen steadily as was initially intended. The effluent charges are supplemented by a system of voluntary contracts between firms and the government for more rapid implementation of pollution control measures. Although it is unclear whether these voluntary contracts are the result of the financial considerations, exemption from the discharge fees during installation of control equipment appears to be a central facet of the agreements.

Hester, G.L. and Hahn, R.W., 1989, Marketable Permits: Lessons from Theory and Practice, *Ecology Law Quarterly*, 16:361-406, (Cornell-law, UVM)

This article provides an excellent summary of the experience of federal, state and local governments with tradeable discharge/emissions permit (TDP) systems through 1989. The core of the article is a comparative analysis of TDP systems for air pollution emissions, lead content in gasoline, biological oxygen demand in the Fox River in Wisconsin and

phosphorus discharges into the Dillon Reservoir in Colorado. The analysis of these programs is then summarized in the form of a basic theory of the political economy of TDP systems.

The success of TDP systems will be influenced by various institutional, legal and political factors in addition to the standard economic requirements of potential costs savings from trades and a sufficient number of market participants. The existing legal and regulatory framework, the quality and cost of monitoring technologies and the degree of agreement between parties regarding the legal characteristics of discharge rights all have an important bearing on the success of TDP programs. In addition, the degree to which trades are limited or burdened by regulatory requirements has a significant effect on the success of a TDP program. The authors conclude that the temporary trading program for lead content in gasoline and the phosphorus discharge trading program affecting the Dillon reservoir were or are likely to be the most effective because there were relatively few restrictions on trades, administrative requirements were not excessive and there was general agreement from all parties regarding the benefits of the trading program.

Howe, C.W. and Lee, D.W., 1983, Priority Pollution Rights: An Adaptation of Western Law to Pollution Control Problems, *In Buying a Better Environment: Cost Effective Regulation Through Permit Trading*, Joeres, E.F. and David, M.H. eds., Proceedings of a National Conference on Regulatory Reform, transferable Permits and Environmental Quality, (Cornell-Mann)

This paper extends the theoretical models of marketable discharge permits to include a mechanism for dealing with temporal variability in environmental conditions such as air inversions or low stream flows. The suggested approach is a system of pollution rights or discharge permits that are differentiated in terms of priority. The most senior permits would be the last to be temporarily revoked in the event of weather conditions that reduced the assimilative capacity of the environment. Since the permits would be marketable, over time the higher priority permits would be expected to command higher prices. The system would be economically efficient since parties that had the greatest need for uninterrupted rights to a certain level of pollution discharge would acquire the high priority permits through mutually beneficial market exchanges. The pollution control authority would be responsible for monitoring environmental conditions and notifying discharge permit holders when conditions required temporary suspension of their discharge rights.

Hudson, JF. and Lake, E.L. and Grossman, D.S., 1981, *Pollution-Pricing*, pp 213, (Cornell-Eng.)

This book summarizes the results of a study of industrial effluent charges in five metropolitan sewer systems and the response to these charges by over 100 industrial facilities. The five cities included in the study were Atlanta, Chicago, Dallas, Salem, Oregon and South San Francisco. The systems of industrial sewer charges for each of the communities were based on the amount and type of pollutants discharged by each industrial facility. Although these charges were invariably a small fraction of any firm's total costs, they nevertheless provided firms with incentives to reduce the volume or strength of their effluent. Through surveys and interviews with plant managers, financial officials and engineers the authors completed an exhaustive analysis of the types of response taken by each firm. Virtually all firms took some action to reduce the amount of their effluent charge. Many of the firms made significant adjustments in their processes and/or technologies.

Industrial Economics, Inc., 1987, *Point/Nonpoint Trading to Reduce Phosphorus Loads to Chesapeake Bay: The Wicomico Case Study*, pp 81, Prepared for U.S. EPA Office of Policy, Planning and Evaluation, (EPA)

This report examines the cost savings that could be achieved through a point/nonpoint source phosphorus discharge trading program in the Wicomico watershed of Chesapeake Bay. The methodology used in the report was to first estimate the costs of three levels of phosphorus reduction that could be achieved by the watershed's only sewage treatment plant and then to compare these costs with the least-cost combination of point and nonpoint source controls. At all levels of reduction in phosphorus loadings that were evaluated in the study, a trading system that provided incentives for the use of both point and nonpoint source control measures would be more than 50% less costly than a control strategy that relied solely on point source reductions.

Industrial Economics, Inc., 1984, *Case Studies on the Trading of Pollution Loads, Dillon Reservoir, Final Report 3-2*, Prepared for U.S. EPA Office of Policy Analysis, (EPA)

This case study examines the potential economic benefits of point/nonpoint source trading of discharge allocations in reducing the discharge of phosphorus to the Dillon reservoir in northwestern Colorado. The study compares the cost-effectiveness of improved phosphorus treatment at the four wastewater treatment plants in the watershed with the cost-effectiveness of available (urban) nonpoint source controls. This analysis is utilized to develop a point source/nonpoint source trading strategy that can reduce the cost of maintaining phosphorus loadings within 1984 allocations.

The study estimated point source phosphorus control costs for three different technologies. The actual cost-effectiveness of a nonpoint source demonstration project were adjusted based upon the diminishing returns expected from an expanded nonpoint source control program. The estimated cost savings of a trading program were developed from these cost estimates.

Since completion of this study, actual experience of the four wastewater treatment plants in the Dillon Reservoir has shown that the estimates of point source phosphorus control costs were too high. This has reduced the incentives for point source/nonpoint source trades and led to a greater emphasis on trading of phosphorus discharge rights between nonpoint sources.

Jaffe, A.B. and Stavins, R.N., 1991, *Evaluating the Relative Effectiveness of Economic Incentives and Direct Regulation*, CSIA Discussion Paper, 91-1, Center for Science and International Affairs, Kennedy School of Government, Harvard University, (Harvard-KSG)

This paper outlines a framework for analyzing the effect of various policy options on the diffusion of environmentally desirable technology. The model is designed to allow statistical analysis of the relative effectiveness of economic incentives and direct regulations in fostering adoption of energy conserving technologies by building owners. However, the analytic approach that is developed in the paper could be applied to the evaluation of policies related to a broad set of environmentally beneficial technologies or practices such as the adoption of innovative pollution control measures.

Jaksh, J. and Niedzialkowski, D., October, 1985, Speeding Water Clean-up While Saving Money, *EPA Journal*, 11:24-25, EPA, (Cornell-Mann)

This brief article summarizes the phosphorus control strategy that was originally adopted for the Dillon Reservoir in Colorado. The program was the first point - nonpoint source tradeable discharge rights system in the U.S. It was developed by local municipalities, environmental groups and industry and approved by the state of Colorado and the EPA in 1984. The trading system requires that any point source phosphorus discharges above 1982 levels must be offset by reductions in (nonagricultural) nonpoint source phosphorus discharges on a 2 to 1 ratio. A county-wide Water Quality Committee was established to monitor the trading program and provide long term water quality management.

The article outlines the chronology of development of the phosphorus control strategy for the Dillon Reservoir and summarizes the major features of the program. The authors cite several factors that led to the successful development of a pollution reduction trading program for the reservoir. 1) Sufficient water quality data existed to evaluate point and non-point source control strategies. 2) All interested parties had continuing input. 3) Effective, relatively low cost nonpoint source control options were available.

Just, R.E. and Antle, J.M., 1990, Interaction Between Agricultural and Environmental Policies, *American Economic Review*, 80:197-202, (Harvard-KSG)

This article presents a moderately technical methodology that can be utilized to evaluate the interactions between agricultural and environmental policies. The analytical approach combines ecological and economic variables to model land management practices by farmers and the resulting effects on farm income and environmental resources. The model can be utilized to examine the environmental effects of various combinations of agricultural policies such as price supports, conservation reserve payments and input restrictions. The authors conclude that existing agricultural policies and programs can be structured to provide effective incentives for environmentally sound decisions concerning land use and crop inputs.

Data requirements of the model include physical attributes of agricultural land, acreage in production, potential production with different soil types and input decisions, and input and production prices. Even without detailed data of this type, the model can be utilized to evaluate the probable effects of various agricultural programs and environmental regulations on agricultural nonpoint source pollution or cropland diversion for conservation.

Kasmanian, R. et. al., 1986, Beyond Categorical Limits: The Case for Pollution Reduction Through Trading, pp. 35, Paper presented at 59th Annual Water Pollution Control Federation Conference, Los Angeles, 10/6/86, EPA Office of Policy, Planning and Evaluation, (EPA)

This paper presents the concept of pollution reduction trading and reviews its application in several case studies. The case studies include the Dillon and Cherry Creek Reservoirs in Colorado, the Upper Wicomico watershed in Maryland and the Honey Creek watershed in Ohio. The Colorado case studies examine the development and implementation of existing trading programs for point and nonpoint phosphorus discharges. The Maryland and Ohio case studies summarize the potential cost savings that could be achieved if point/nonpoint source trading programs were utilized to control phosphorus discharges. Based upon their

analysis of these case studies the authors outline several conditions that are essential for a successful phosphorus discharge trading program.

The authors conclude that trading programs offer several benefits relative to traditional approaches for achieving water quality objectives. These benefits include greater cost-effectiveness, institutionalization of nonpoint source controls through existing regulatory mechanisms and providing the means to accommodate economic growth while improving water quality.

Kneese, A.V. and Bower, B.T., 1968, *Managing Water Quality: Economics, Technology and Institutions*, pp 317, (Cornell-mann)

This book provides a comprehensive introduction to the principles of environmental economics as applied to water quality management. The book addresses both the issue of determining the optimal level of water quality and how a given water quality standard can be achieved most cost effectively. Case studies comparing alternative water pollution control strategies are presented for the Potomac and Delaware River basins. The last section of the book reviews various institutional and organizational approaches to water quality management.

The first section which reviews the costs and benefits of water pollution control is theoretically sound but the data needs updating. In the 24 years since the book's publication, significant additional research has been performed on the public health, recreational, aesthetic and ecological effects of water pollution. The discussion of alternative market based approaches to water pollution control in section 2 of the book is moderately technical with a distinct emphasis on effluent charges. Use of transferable discharge permits is not discussed. The case studies presented in section 3 provide evidence for the cost effectiveness of effluent charges relative to uniform technology based standards. For the lower Delaware River, a system of spatially differentiated effluent charges was estimated to reduce the costs of meeting various dissolved oxygen standards by approximately 50%.

Section 4 provides descriptions and analysis of water quality management systems employed in France, England, Germany and the U.S. But again, legislative, institutional and environmental developments since 1968 require an updated review of water quality control arrangements in these countries. The last chapter provides a useful review of the appropriate roles of federal, state and local government as well as regional water resource authorities in dealing with interstate water quality problems.

Kosland, C.D., Aug. 1986, Empirical Properties of Economic Incentives and Command and Control Regulation for Air Pollution Control, *Land Economics*, 62:250-68, (Cornell-Mann, UVM)

This study uses a spatially differentiated, stochastic model to examine the efficiency of alternative air pollution control strategies in the Four Corners region of the southwest (CO, UT, NM, AR). The study predicted that the most efficient command and control approach would be twice as costly as the least cost strategy. Given imperfect knowledge of marginal pollution control costs and benefits, transferable discharge permits were found to be more efficient than a strategy based on emissions fees.

Spatially differentiated and spatially uniform pollution control strategies were also modeled. If the marginal damage from pollution is constant, the study found that there is little loss of efficiency with spatially uniform controls. But if the marginal damage from

pollution is increasing then a spatially uniform control strategy is shown to be substantially less efficient than a system which divides the airshed into distinct subregions

Krieger, F. and Pla, M., March, 1990, A Market Approach to Cleaning Up San Francisco Bay, *Water Environment and Technology*, 21-23, (Harvard)

This brief article describes a plan by California's State Water Resources Control Board (SWRCB) to implement a pollution offset policy for San Francisco Bay. The plan would require a discharger seeking an increase in pollutant loadings to obtain a similar reduction from other sources. This policy is expected to lead to growing communities that have installed secondary wastewater treatment plants seeking pollution offsets from industrial pre-treatment programs and from nonpoint sources. The authors also suggest that a system of marketable discharge permits might eventually be traded amongst the nine publicly owned treatment plants that discharge to the southern portion of San Francisco Bay.

Krupnick, A.J. and Bohi, D.R. and Burtraw, D., Summer 1990, Emissions Trading in the Electric Utility Industry, *Resources*, n. 100, Resources for the Future, (Cornell-Olin)

Emissions trading as a means of controlling sulfur dioxide emissions is a key component of the recently adopted Clean Air Act. Although the highly regulated nature of the electric utility industry may prevent realization of the expected cost reductions from the sulfur emissions trading program, the authors are optimistic since the Clean Air Act includes provisions that provide the essential framework of a well functioning emissions permit system. Important features of the Act include; 1) endowing dischargers with well defined tradeable emission allowances, 2) setting aside some unallocated allowances for purchase by new dischargers and 3) providing clear rights to freely trade and bank discharge allowances. The authors note that there is very little risk in attempting to establish an emissions trading program. Even if an active market for emissions reduction credits does not develop, utilities must still to reduce their emissions to the same level that would be required by a more traditional regulatory approach.

Logan, T.J. and Forster D.L., Nov. 1982, *Alternative Management Options for the Control of Diffuse Phosphorous Loads to Lake Erie*, National Technical Information Service, ADA 122 223 Ohio State Univ., (Cornell-Eng.)

This report first examines the increase in levels of available phosphorus (P) in the agricultural soils of a Lake Erie watershed due to fertilizer use. It then compares the economic costs and reductions in P loadings to streams that could be achieved through a wide range of management practices and structural measures including no-till cropping, cover crops, contour and strip cropping, runoff control structures, terraces, vegetative filters and manure management. The estimates of costs and phosphorus discharge reductions used in the report were derived from published literature and SCS data. Specific methodological assumptions are explicitly outlined in the report.

Reduction of excessive fertilizer use was the most cost effective control measure but yielded only minor reductions in total P loadings to streams. Conservation tillage and manure storage and management practices yielded the greatest benefits in terms of reduced P loadings. The report provides detailed tables with costs and P discharge reductions per acre for each of the control measures evaluated.

Luken, R.A., 1990, *Efficiency in Environmental Regulation*, pp 361, (Cornell-Mann)

This book compares the regulatory approaches of the Clean Air Act with those of the Clean Water Act in the context of their application to the pulp and paper industry. The study includes analysis of historical data as well as projections of future levels of pollution, pollution control costs and benefits in this industry. The author concludes that the regulatory structure of the Clean Air Act provided regulators with greater flexibility than the technology standards embedded in the Clean water Act. As a result, the benefits of controlling air pollution in the pulp and paper industry are estimated to have exceeded the costs, while the opposite appears to be the case for water pollution control in this industry.

Maloney, M.T. and Yandle, B., 1983, Building Markets for Tradeable Pollution Rights, In, *Water Rights: Scarce Resource Allocation, Bureaucracy and the Environment*, T.L. Anderson ed., Pacific Institute for Public Policy, (Cornell-Olin)

The purpose of this article is to explain the historical development of water quality control strategies in the U.S. with particular attention to the development of tradeable discharge rights. The author first raises the question of why some natural resources, such as land, have well structured property rights and smoothly functioning markets in which those rights are exchanged. He then identifies three stages of property rights for natural resources 1) open access without scarcity 2) Common or public property 3) private property.

In the context of water quality, decreases in assimilative capacity of a water body due to pollution discharges will increase the value of that assimilative capacity. As this occurs the water resource will gradually be transformed into common/public property with prescribed uses such as permits for pollution discharge by a specific user in specified amounts at a particular location. As resource users and managers continue to cope with scarcity, measurement and monitoring capacity will develop to allow transferability of the discharge permits. Continued or increased resource scarcity will increase the value of transferable property rights.

Malueg, D.A., 1989, Emission Credit Trading and the Incentive to Adopt New Technology, *Journal of Environmental Economics and Management*, 16:52-57, (Harvard-KSG and Cornell-Olin, UVM)

This paper examines the claim that emissions trading programs increase firms incentives to adopt new pollution control technology. The author demonstrates that relative to a uniform emissions standard, an individual firm may have less incentive to adopt new pollution control technology if it would be a net producer of emissions credits both before and after adoption of the new technology. This is a relatively rare case since it assumes that the firm would be exceeding its pollution control requirements even if it had no incentive to do so. In addition, the paper does not consider the relative incentives of the industry as a whole to adopt new pollution control technologies under different regulatory approaches. The degree of adoption of new technology by all firms in the industry would appear to be at least as great under an emissions trading program.

Martin, D. and Joeres, E. and Eheart, J.W., 1980, Distribution Methods for Transferable Discharge Permits, *Water Resources Research*, 16:833-43, (Cornell-Mann)

Utilizing actual data for 53 municipal treatment plants, this article simulates a marketable discharge permit (MDP) system for controlling phosphorus discharges to Lake Michigan

from the state of Wisconsin. The simulation analyzes alternative methods for initial distribution of the discharge permits and compares the outcomes against the static least cost solution for removing a given level of phosphorus.

The distribution methods analyzed in the study consist of a single price auction and various free distribution approaches based on hydraulic load, pollutant load and population served. Subsequent to the initial distribution, the model assumes that trading of the permits occurs at quarterly auctions coordinated by the pollution control agency.

Assuming treatment plant operators are aware of the costs of phosphorus control at their facilities and submit discharge permit bids with the objective of minimizing costs, the model indicates that a MDP system will be virtually identical to the least cost control strategy. The market clearing price for the phosphorus discharge permits at an aggregate phosphorus removal of 85% was \$2 per pound in 1980 dollars. The same market price is ultimately reached whether the permits are initially sold at an auction or originally allocated to dischargers at no cost.

With free initial distribution the market clearing price arises from voluntary transactions between treatment plant operators. The simulation indicates that these transactions will result in the purchase of phosphorus discharge rights by small treatment plants with high per unit costs of phosphorus removal and the sale of discharge rights by large plants that are able to realize economies of scale in phosphorus removal. Even with these discharge right purchases by small treatment plants their costs under the system are lower than they would be under a uniform regulatory standard.

McGartland, A., 1988, A Comparison of Two Marketable Discharge Permit Systems, *Journal of Environmental Economics and Management*, 15:33-44, (Cornell-Mann and Harvard-KSG, UVM)

This article compares the outcomes of two marketable discharge permit (MDP) systems under conditions of perfect and imperfect competition. The two systems are an ambient permit system (APS) that defines allowable emissions in terms of pollutant concentrations at a set of monitoring points and a pollution offset system (POS) that defines a set of discharge or emission licenses which confer the right to emit pollutants at a certain specified rate. The author summarizes the technical literature comparing the two systems to indicate that they are identical under conditions of perfect competition.

Under conditions of imperfect competition in the market for discharge permits, the POS option has the advantage of much lower transaction costs between buyers and sellers. However, this conclusion holds only if the pollution control agency has the ability to play an active role in defining the effects of discharge permit transactions at the critical monitoring points.

McSweeney, W.T. and Kramer, R.A., May 1986, The Integration of Farm Programs for Achieving Soil Conservation and Nonpoint Pollution Control, *Land Economics*, 62:159-173, (Cornell-Mann, UVM)

This article summarizes the results of a mathematical programming model used to simulate the effectiveness of alternative incentives for adopting soil conservation and non-point source pollution control strategies. The first option limited access to commodity support and crop insurance programs to farms that did not exceed minimum standards for total soil loss rates. The second option required adoption of certain soil conservation and



non-point source control practices in order to be eligible for the agricultural support programs. Both options were compared against a baseline of open access to the agricultural support programs. Requiring certain best management practices in order to be eligible for the farm support programs yielded the largest reductions in nitrogen and phosphorus losses from farms in the model. However, the cost-effectiveness of the two approaches was not compared.

Moore, T.H., March 8, 1991, Acid Rain: New Approach to An Old Problem, *Editorial Research Reports*, 130-143, Congressional Research Service, (Cornell-Uris)

This article provides a succinct, non-technical summary of the sulfur and nitrogen oxide emission trading provisions of the 1990 Clean Air Act. The Act divides sulfur dioxide emission controls into two phases. Phase I, beginning in 1995, will control emissions of large power plants that emit more than 2.5 pounds of sulfur dioxide for every million BTU's of energy produced. Phase II will cover smaller plants that emit more than 1.2 pounds of sulfur dioxide per million BTU's. To reduce plant emissions to the required levels a plant's owners can make any number of process or technological changes or they can buy excess sulfur discharge allowances from another utility. If a utility wants to build a new plant after 1999 it will first need to accumulate enough discharge allowances to run it. To do this it can shut down an old plant and transfer the allowances to the new one, reduce emissions from other plants or buy discharge allowances from other utilities.

To prime the allowance market and to avoid limiting economic growth, EPA will auction off 2.8% of the total sulfur discharge allowances available in each year. As a result, any utility or independent power producer building a new plant will be assured of at least a limited supply of allowances being available for purchase in any given year. Estimated savings from the 1990 Clean Air Act's emissions trading program range from 30-50% of the cost of a traditional uniform standards approach.

Nickum, J.E. and Easter, K.W., Aug. 1990, Institutional Arrangements for Managing Water Conflicts in Lake Basins, *Natural Resources Forum*, 210-221, (Cornell-Mann)

This article discusses conflicts over lake water quality and quantity from the perspective of market and non-market failure. Market failures would include poorly defined property rights, financial incentives that do not reflect full social costs and high transaction costs. Non-market failures focus on problems in the formation, implementation and enforcement of appropriate governmental regulations. The authors acknowledge that recognition of the problems inherent in traditional government regulation has led to greater consideration of market-based approaches such as tradeable permits or negotiated contracts. However, they suggest that market and non-market approaches to regulation would benefit by greater collective action by water users. To promote effective collective action the authors make the following recommendations. 1) Develop institutional arrangements that provide for assurance, reciprocity and fairness. 2) Establish water user organizations. 3) develop incentives for local participation. 4) Promote local leadership and accountability.

Noll, R.G. and Hahn, R., 1988, Designing a Market for Tradeable Emissions Permits, *In Reform of Environmental Regulation*, Magat, W.A. ed., (Cornell-Law)

This article presents a methodology for evaluating the feasibility of marketable discharge permit (MDP) systems. The proposed methodology is demonstrated in the context of designing a MDP system for particulate sulfate emissions in the Los Angeles region.

The authors define the major design objectives for the MDP system to be equity in the initial distribution of permits and sufficient early transactions to produce reasonably efficient prices for permits. Several methods for initial allocation of permits are discussed including 1) free distribution based on emissions levels prior to recent control measures, 2) free distribution based on emissions allowed under current standards, 3) free distribution based on the estimated least cost strategy and 4) an auction process that redistributes the revenues to the auction participants. The strengths and weaknesses of each of these approaches is examined in relation to the L.A. case study.

The article also includes a review of the information requirements of a MDP system which include, 1) estimates of the approximate costs of regulation to both government and industry, 2) assessment of monitoring and enforcement capabilities, 3) knowledge of pollution sources, 4) understanding of the relationship between emissions levels and environmental quality. The authors observe that these information requirements are essentially the same as those needed for any well designed system of environmental regulation.

Northwest Colorado Council of Governments, 1984, *Point Source-Nonpoint Source Trading in the Lake Dillon Watershed*, pp 11, (NCCG)

This report provides a fairly detailed description of the process and rationale behind development of the phosphorus discharge trading program that was adopted in Summit County Colorado. It describes the institutional setting, the major issues and the concerns of affected organizations and constituents. In addition, it provides a detailed presentation of the capital and operating costs of two urban/suburban nonpoint source phosphorus control demonstration projects. The per unit control costs of these measures is estimated to be \$67/lb. of phosphorus removed for the nonpoint source controls as compared to \$860/lb. for the least expensive point source removal option (activated aluminum).

The phosphorus control program for the Dillon reservoir was developed by local governments and adopted by the Colorado Water Quality Control Commission. The plan included an effluent trading system that provides point sources with credit for reducing non-point source discharges that existed prior to 1984. The objective of the trading program was to maintain water quality in the reservoir while permitting increases in point source flows that were expected to occur from continued development.

Nowak, P.J. and Korsching, P.F., 1983, Social and Institutional Factors Affecting the Adoption and Maintenance of Best Management Practices, In: *Agricultural Management and Water Quality*, Schjaller, F.W. and Bailey, G.W. eds., (Cornell-Mann)

This paper argues that the lack of widespread adoption of best management practices (BMP's) to control agricultural nonpoint source pollution is due to a lack of understanding of the social and institutional factors that affect farming practices. A survey of Iowa farmers is described which provided the following most frequently cited reasons for not adopting

BMP's. 1) Water pollution is not a serious problem. 2) BMP's are not effective. 3) BMP's are a nuisance to employ.

The core of the article is a statistical analysis of the factors affecting BMP adoption in three watersheds in Iowa. Although the authors provide numerous theoretical reasons why education programs, economic incentives and legal mandates often fail to promote widespread adoption of BMP's, the results of their statistical analysis appear to indicate that a combination of educational programs and strong economic incentives were sufficient to overcome various social and institutional impediments to BMP adoption.

Oates, W.E. and Portney, P.R. and McGartland, A.M., 1989, The Net Benefits of Incentive-Based Regulation: A Case Study of Environmental Standard Setting, *American Economic Review*, 79:1233-1242, (Harvard-KSG)

This article attempts to compare the benefits of reduced pollution control costs that can be achieved through the use of economic incentives with the benefits of localized environmental conditions that exceed the regulatory standard. The authors observe that the use of certain types of discharge fee and transferable discharge permit (TDP) systems can result in ambient environmental quality that is spatially more uniform across a watershed or airshed than command and control regulatory approaches. If the regulatory framework is structured to achieve the environmental standard at all locations at least overall cost, then the net benefits relative to a less cost-effective approach must be reduced by the foregone benefits of higher environmental quality at certain locations in the region.

The authors utilize estimated marginal cost and benefit data for control of total suspended solids in the Baltimore airshed to illustrate their thesis. Without any adjustment for localized over-achievement of the air quality standard, the least cost control policy had net benefits of \$45 million relative to \$18.5 million for a command and control regulatory approach. However, after adjustment for localized over-achievement the difference in net benefits is reduced to \$6 million.

OECD, 1991, *Environmental Policy: How to Apply Economic Instruments*, pp 130, Organization for Economic Cooperation and Development, (Cornell-Mann)

This book is intended as a practitioners manual for evaluating and designing economic instruments for environmental protection. Topics covered include guidelines and criteria for application of economic instruments to water, air, noise and waste management. There is also a discussion of how to utilize economic instruments in various sectors of the economy including energy, agriculture, transportation and manufacturing. The presentation is non-technical and policy oriented.

Due to the broad scope of pollutants, instruments and sectors covered in the book provides only the most general criteria and guidelines on which to design effective incentive-based pollution control programs are presented. Criteria for evaluation of economic incentive programs include environmental effectiveness, economic efficiency, equity, administrative feasibility and cost and public acceptability. To increase the chances of public acceptance, the book recommends the provision of adequate information on the program, involvement of all affected parties and gradual implementation.

In relation to water pollution control, the use of effluent charges and marketable permit systems is recommended. The potential problem of pollution hot spots arising with a marketable permit system is recognized, although the same problem can arise when utilizing

a system of effluent charges or uniform emission standards.. This problem can be minimized by separating the control region into separate geographic zones with different charges and trading criteria for the separate zones.

In the agricultural sector, the book recommends the elimination of environmentally damaging subsidies and the adoption of a system of charges on fertilizer and pesticide use combined with subsidies for environmentally sound farming practices.

Opaluch, J.J. and Kashmanian, R.M., 1985, Assessing the Viability of Marketable Permit Systems: An Application in Hazardous Waste Management, *Land Economics*, 61:263-271, (Cornell-Mann, UVM)

This article analyzes various potential marketable discharge permit (MDP) systems involving industrial electroplaters in Rhode Island that discharge heavy metals to a municipal sewer system. An environmentally acceptable level of heavy metal discharge permits would be allocated to the jewelry/electroplating firms who would then be free to utilize various pre-treatment options for their wastes and/or purchase additional discharge permits in order to continue to discharge these wastes to the sewer system. Actual discharge information for the industry and cost data for four pre-treatment technologies are analyzed through the use of a step-wise linear programming model to determine the potential cost savings of the MDP system. The model indicates that the potential savings to the electroplating industry approach 50% of their existing treatment costs.

The second part of the article considers the distributional impacts on the electroplating industry of two MDP systems. Under one option, the discharge permits are auctioned to the firms in the industry. This results in small and medium size firms still realizing cost savings relative to a uniform regulatory standard. Large firms with economies of scale in pre-treatment would experience an increase in pollution control costs when the costs of the permits is included. With a system of free initial distribution of the permits, the small and medium size firms would realize even greater cost savings and large firms would experience the same costs as they would under a uniform regulatory standard. The authors conclude that the distribution of costs and benefits of a MDP system will affect the chances of adoption as much as the aggregate net benefits of the proposal.

Oppenheimer, J.A. and Russell, C., 1983, Tempest in a Teapot: The Analysis of Environmental Groups Trading in Markets for Pollution Permits, In *Buying a Better Environment: Cost Effective Regulation Through Permit Trading*, Joeres, E.F. and David, M.H. eds., Proceedings of a National Conference on Regulatory. Reform, transferable Permits and Environmental Quality, (Cornell-Mann)

This paper discusses the potential for and the possible implications of environmental groups becoming active purchasers of pollution discharge rights as a means of reducing the level of pollution. The authors conclude that the participation of environmental groups in markets for discharge rights would have an ambiguous effect on the economic efficiency of these markets. However, they argue that since pollution reductions normally benefit many segments of society, it would be extremely unlikely that any environmental group would find it beneficial to use its limited resources to pay for pollution reduction through the purchase of discharge rights.

Opschoor, J.B. , Vos, H.B., 1989, *Economic Instruments for Environmental Protection*, pp 130, OECD, (Cornell-Mann)

This book is the summary report of a project conducted by the Organization for Economic Cooperation and Development (OECD) to survey and assess the use of economic incentives for environmental protection in Europe and North America. The report covers various forms of pollution or product charges, taxes and subsidies, market creation (transferable discharge permits), performance bonds and non-compliance fees and penalties. Examples of these instruments from various of the OECD countries are examined in terms of environmental effectiveness, economic efficiency, administrative efficiency and concordance with the countries institutional framework for environmental protection.

In the area of water pollution control, the report summarizes the French, German and Dutch systems of discharge fees as well as two American examples of transferable discharge permits. The three European discharge fee systems each impose a set of fees on polluters with the amount of the fee determined by the quantity and biochemical characteristics of the pollution discharge. All of the systems rely on a combination of uniform regulatory standards and discharge fees but the report indicates that the fees have resulted in additional pollution reductions as well as cost savings.

A Dutch system of charging farmers for excessive applications of manure and the Swedish system of taxing fertilizers to discourage excessive use are also discussed in the report. In the Netherlands, a fee of approximately \$0.75 per kg of phosphorus per hectare is charged for all manure applications above 125 kg of phosphorus per hectare. In Sweden, a tax of approximately 5% is imposed on all sales of fertilizers with the funds primarily dedicated to research on agricultural pollution.

Portnoy, P. R., 1991, The Evolution of Federal Regulation, In: *Public Policies for Environmental Protection*, Portnoy, P.R. ed., 7-27, (Cornell-Uris)

This chapter provides a brief historical review of the development of environmental legislation and administration in the U.S. It also summarizes the underlying policy choices involved in environmental protection such as whether to utilize a benefit-cost framework and whether to employ uniform emission standards, technology standards , economic incentives or a hybrid approach. The author observes that advances in environmental toxicology have shown that very few pollutants actually have a threshold level below which exposure does not cause any harm. Given this reality, setting an ambient standard for these pollutants at any level above zero necessarily involves some tradeoff between benefits and costs. The authors review of U.S. environmental legislation reveals a hybrid approach with many contradictions and shortcomings. These issues are addressed in more detail in other chapters of this collection of essays.

Portnoy, P. R., 1991, Air Pollution Policy, In: *Public Policies for Environmental Protection*, Portnoy, P.R. ed., 7-27, (Cornell-Uris)

This chapter reviews the historical development of air pollution control policy in the U.S. and provides a detailed economic analysis of air pollution control since the passage of the Clean Air Act of 1970. The author finds that in many important categories there has been significant improvement in air quality since 1970 and that the benefits of these improvements have generally exceeded the costs of achieving them. This conclusion notwithstanding, Portnoy also indicates that there are several ways in which the Clean Air

Act could be made more cost-effective. The authors recommendations include greater use of economic incentives, greater flexibility for regulators to balance costs and benefits in setting standards and improved monitoring of emissions and ambient air quality.

Roberts, M.J., 1988, Some Problems of Implementing Marketable Pollution Rights Schemes: The Case of the Clean Air Act, In: *Reform of Environmental Regulation*, Magat, W.A. ed., 93-118, (Cornell-Law)

This article examines some of the difficulties encountered in the emissions trading arrangements that have developed under the Clean Air Act of 1970 and its amendments. Although substantial cost savings have been realized as a result of the emissions trading programs of the Clean Air Act, the market for emissions credits has not been as active as many economists had hoped. Consequently significant additional cost savings have gone unrealized. Problems have been encountered in determining the baseline that defines emissions rights, verifying reductions in emissions levels, the disparity between types of emissions involved in trades (e, g. different sizes of particulates or chemical species of a pollutant) and geographic considerations in emissions trading (i.e. preventing hot spots).

Roberts concludes that many of the shortcomings with the air emissions trading system are due to the failure of the government to fully support a system of marketable discharge permits. For Roberts, the keys to making pollution markets work are to reduce transaction costs between buyers and sellers and to clearly define the rights conferred by transferable discharge permits. If the EPA and state regulators had performed more of the modeling and monitoring of emissions necessary to define a permissible trade, a more active market for emissions credits might have developed more rapidly.

Robillard, P.D. and Walter, M.F., 1983, A Framework for Selecting Agricultural Nonpoint Source Controls, In *Agricultural Management and Water Quality*, Schaller, F.W., Bailey, G.W., eds., 330-348, Nat. Conf. on Agric. Practices and Water Quality, Iowa State Univ., (Cornell-Mann)

This paper presents a framework for evaluating alternative nonpoint source (NPS) control methods in situations where very little data is available regarding site specific or regional NPS pollutant loadings. Key elements of the framework are comparison of all NPS control costs with point source control alternatives and estimation of NPS loadings that exceed background levels. The methodology presented includes comparison of NPS loads from different agricultural land uses and management practices, analysis of costs for various control options and comparison of costs with available point source control options. The authors utilize published data on control costs, the Universal Soil Loss Equation and the Cornell Nonpoint Source model and linear programming to demonstrate their methodology for the Harvey Creek watershed in Ohio.

Russell, C.S., 1988, Economic Incentives in the Management of Hazardous Waste, *Columbia Journal of Environmental Law*, ?, (Cornell-Law)

This article reviews the major aspects of the hazardous waste management systems imposed by the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Responsibility, Compensation and Liability Act (CERCLA). The author concludes that hazardous waste management regulations are the epitome of the command and control approach. Firms are told exactly what to do including how to dispose of wastes,

what disposal sites to use and what technologies to employ. This approach provides numerous incentives for illegal disposal.

If the regulatory objective is to discourage disposal in unapproved sites, the author recommends the use of positive incentives such as a deposit refund system. However, if the objective is to simply reduce the use of a particular class of products, such as pesticides, then a tax may be the most appropriate instrument.

The article includes a review of deposit-refund systems and product taxes in Germany, Norway and Sweden. The deposit-refund systems include motor oils, lead batteries and car bodies. The product taxes are targeted primarily at pesticides and fertilizers. In 1981 Sweden imposed a 10% tax on fertilizers with a planned rise in the tax rate to 25%.

Sessions, S. and Fillmore, L., 1989, *Evaluation of Measures to Control Point and Nonpoint Sources of Pollution to Boone Reservoir, TN*, pp 59, Prepared by Sobotka & Co. for U.S. EPA Office of Policy Planning and Evaluation, (EPA)

This report compares the costs per pound of phosphorus, nitrogen and biological oxygen demand removed by various agricultural and urban nonpoint source control methods with several chemical and biological point source control methods. Cost estimates were based on published literature and on results from demonstration projects in the Boone reservoir watershed. The analysis indicates that conservation tillage and dairy farm best management practices were amongst the most cost effective for reduction of phosphorus loadings, followed by chemical point source controls. Urban best management practices and septic tank renovation were amongst the least cost-effective measures for phosphorus reduction.

Stavins, R.N. et. al., 1988, *Project 88: Harnessing Market Forces to Protect Our Environment*, pp 76, Study sponsored by senators Tim Wirth (CO) and John Heinz (PA), (Harvard-KSG)

This report was prepared for Senators Tim Wirth and John Heinz by a group of researchers directed by Robert Stavins of the Kennedy School of Government at Harvard University. The immediate objective of the report was to provide the incoming Bush Administration with a comprehensive set of recommendations for market-based approaches to environmental protection. The report covers national air, water, land use, and waste management issues as well as global problems such as climate change and ozone depletion. At the state, national and international levels the report generally recommends the use of transferable discharge permits as the preferred market approach to environmental protection.

In the area of water quality, the report strongly recommends the use of marketable discharge permits (MDP) as a means of controlling point sources of pollution. The difficulties of implementing MDP systems for non-point sources are discussed, nevertheless, the report suggests that market-based approaches to nonpoint source pollution control could still be implemented in certain situations. The Dillon Reservoir in Colorado is cited as an example.

Other relevant programs discussed in the report include a tax on fertilizer use that has been adopted in Iowa and the Reinvest in Minnesota (RIM) program which provides financial incentives to farmers to divert farmland to other uses in cases where this will result in improvements in water quality or wildlife habitat. The report points to the RIM program as a model and recommends that other agricultural conservation programs such as the national Conservation Reserve Program should be targeted to lands that are both highly susceptible to water caused erosion and are in close proximity to important water bodies.

Greater use of cross-compliance with conservation objectives is also recommended for agricultural income support programs.

The principal recommendation with regard to hazardous waste management is the use of a deposit-refund system for hazardous substances that are sold in standardized containers.

Stevenson, R.W., January 30, 1992, California Proposal Would Let Industry Sell Pollution Rights, *New York Times*, (Harvard, Cornell, UVM)

This article outlines a proposal by the South Coast Air Quality Management District (SCAQD) in California to shift from a command and control regulatory approach to an emissions trading strategy. The proposal would affect the entire southern California region and would apply first to the largest 2700 emitters with smaller companies to be added later. Given the national reputation of the SCAQD amongst environmental regulators, the successful implementation of the SCAQD's regional emissions trading plan could trigger similar programs across the country.

The article also documents concern about various aspects of the plan as expressed by some members of SCAQD's board as well as some environmentalists and labor leaders. One environmental group recommended the emissions trading approach be implemented first for nitrous oxide emissions which are easier to monitor than other pollutants that would be included in the proposed program. Labor leaders expressed concern that the plan might allow companies to close their factories and profit from the sale of the resulting emissions reductions.

Stewart, R.B., 1988, Controlling Environmental Risks through Economic Incentives, *Columbia Journal of Environmental Law*, 13:153-69, (Cornell-Law)

This article identifies three types of economic incentives for environmental protection; pollution charges or discharge fees, transferable permits or discharge rights and deposit-refund systems. Various systems of uniform standards for environmental regulation are also defined including ambient standards and technology based standards. The author argues that the benefits of using economic incentives include cost savings, reduced information requirements on the part of regulators, greater flexibility, easier accommodation of economic growth, improved debate of environmental quality objectives and a source of revenue which can be used to compensate those impacted by pollution and/or promote further pollution reductions.

The article also summarizes and responds to many common objections and obstacles to expanded use of economic incentives. Significant attention is given to the charge that economic incentives allow human health and environmental quality to be traded for dollars. If properly structured, the author argues that economic incentives can be utilized to achieve any given environmental quality standard and to require polluters to pay for the residual damage caused even after that standard is met. This is contrasted with traditional regulatory approaches which necessarily permit a certain level of pollution free of charge. Economic incentives can also be structured to achieve almost any set of equity criteria.

Teitenberg, T.H., 1980, Transferable Discharge Permits and the Control of Stationary Source Air Pollution, *Land Economics*, 56:391-415, (Cornell-Mann, UVM)

This article begins with an historical review of the movement toward tradeable discharge permits in air quality management. It also includes an excellent analysis of the strengths and



weaknesses of alternative designs for tradeable discharge permit (TDP) systems including cost-effectiveness, equity, and monitoring and enforcement. In addition it summarizes the results of various computer simulations of TDP systems in comparison to traditional regulatory approaches.

Teitenberg distinguishes between three types of TDP systems. The first has a single market for an entire regional airshed (or watershed). This is the simplest TDP system to administer but may lead to local pollution hot spots or higher than necessary costs to ensure that the air quality standard is achieved in all locations. In the second design alternative the airshed is divided into smaller zones with permits traded within the zones but not between them. This ensures that the environmental standard is met in all locations but in preventing trades between zones it reduces the cost-effectiveness of the system. In the third TDP system design, the air(water)shed is divided into distinct zones with trading of permits within zones on a one for one basis and trades between zones adjusted by estimates of pollutant transport. This system is more complex to administer but it ensures that the environmental standards are achieved in all zones at least cost.

Alternative methods for initially distributing the discharge permits are also reviewed. The initial allocation method affects the level of costs faced by dischargers and the revenue generated by the pollution control agency. However, the initial allocation will not affect the efficiency of the system since the market will reallocate the permits through voluntary purchases and sales between dischargers. Therefore, the initial allocation provides the pollution control agency with significant influence over the ultimate distribution of the pollution control costs under a TDP system.

Teitenberg's review of four computer models of air and water TDP systems indicates that traditional regulatory approaches such as uniform discharge standards can be from 2 to 10 times more expensive in achieving a given environmental objective. In addition, TDP systems that use separate zones with transport-adjusted trades between zones can reduce costs by 50% relative to TDP systems that have only one undifferentiated market for an entire air or watershed.

Young, C.E. and Shortle J.S., 1989, Benefits and Costs of Agricultural Nonpoint-Source Pollution Controls: The Case of St. Albans Bay, *Journal of Soil and Water Conservation*, 44:64-67, (Cornell-Mann)

This article estimates the expected benefits and actual costs of a phosphorus (P) control program in the St. Albans watershed of Lake Champlain. The program included manure storage measures to control phosphorus runoff from agricultural land uses and upgrading of municipal treatment plants for increased phosphorus removal. Over the fifty year period 1981-2030, the present value of benefits were estimated to exceed costs by \$1.7 million.

An important assumption of the study is that by 1991, water quality in St. Albans Bay would improve to a level equivalent to the adjacent areas of Lake Champlain. Apparently, this degree of improvement has not yet been realized. Nevertheless, the methodologies and data sources utilized in this study to estimate benefits and costs of water quality improvement could provide a useful model for other studies.

Zander, B., Nov/Dec 1991, Nutrient Trading in the Wings, *EPA Journal*, 47-9, (Cornell-Mann)

This brief article outlines the historical development of the phosphorus trading program developed for the Dillon Reservoir in Colorado. It examines the ecological, economic and

political factors that led to the adoption of the first point source/nonpoint source trading program in the country. In addition it discusses the recent developments that have led to a shift in focus for the program towards encouraging trades between nonpoint sources of phosphorus.

