Staff Paper

AN ANALYSIS OF SITUATION, STRUCTURE, CONDUCT AND PERFORMANCE IN AIR EMISSION AND WATERSHED EFFLUENT MARKETS

Patricia E. Norris, Associate Professor; Elaine M. Brown, Senior Manager; and Sandra S. Batie, Elton R. Smith Endowed Professor

Staff Paper 2002-06 **March 2002**

Department of Agricultural Economics
MICHIGAN STATE UNIVERSITY
East Lansing, Michigan 48824

An Analysis of Situation, Structure, Conduct and Performance in Air Emission and Watershed Effluent Markets: Lessons for Trading Program Design to Protect Great Lakes Water Quality

Patricia E. Norris, Elaine M. Brown, and Sandra S. Batie
norrisp@msu.edu, browne@msu.edu, and batie@msu.edu

Executive Summary

After much debate and many legislative proposals, the Clean Air Act was amended in 1990 to allow more flexibility in meeting emissions standards for SO_2. Specifically, an SO_2 emissions allowance trading program was implemented. Firms can meet emission standards by any pollution control method, including buying emission allowances from other firms. Analysts have concluded that, with the changes in the Clean Air Act, SO_2 emissions have been reduced by 50 percent and at an estimated $7 billion less than the anticipated cost of the regulatory command-and-control system.

Not surprisingly, policy analysts have explored the opportunities for implementing similar market-based systems for water pollution control. Because much of the on-going impairment of surface water has been attributed to nonpoint sources of pollution, trading programs which incorporate both point and nonpoint discharges are of particular interest. However, despite as many as six efforts across the nation to implement point-nonpoint effluent credit trading programs to reduce nutrient discharges to water, there have been few trades to date.

This research was undertaken to answer the following question: Do current barriers to effluent credit trading programs arise because of fundamental differences between air and water media or because of differences between institutions affecting air and water use, such as the Clean Air Act and the Clean Water Act?

Economic theory offers the situation, structure, conduct, and performance (SSCP) framework, developed by industrial organization economists and extended by institutional and environmental economists, within which to address this research question. In the language of the SSCP framework, the research question can be reframed as: are there fundamental differences in the situation and structure of emission allowance markets and effluent credit markets which result in conduct and performance differences?

A comparative analysis of situation and structure suggests that barriers to effective nutrient discharge credit markets are not a result of fundamental differences in the air and water media or the materials being discharged into air and water. Rather, the barriers exist because of structural differences – differences in institutional structure, program design and program implementation. Many of the structural barriers result from the Clean Water Act and its implementation. More flexibility in water pollution prevention would effectively remove many of these barriers.

This research was supported, in part, by a grant from the Office of the Great Lakes, Michigan Great Lakes Protection Fund and by the Elton R. Smith Endowment in Food and Agricultural Policy, Department of Agricultural Economics, Michigan State University.

35 pages

An Analysis of Situation, Structure, Conduct and Performance in Air Emission and Watershed Effluent Markets

Final report submitted to Michigan Department of Environmental Quality,
Great Lakes Protection Fund
Grant # 99-039

Patricia E. Norris
Associate Professor
Departments of Agricultural Economics and Resource Development
Michigan State University

Elaine M. Brown
Senior Manager, MAXIMUS
formerly Project Coordinator
Institute of Water Research
Michigan State University

Sandra S. Batie
Elton R. Smith Endowed Professor
Department of Agricultural Economics
Michigan State University

March 6, 2002

An Analysis of Situation, Structure, Conduct and Performance in Air Emission and Watershed Effluent Markets: Lessons for Trading Program Design to Protect Great Lakes Water Quality

Executive Summary

After much debate and many legislative proposals, the Clean Air Act was amended in 1990 to allow more flexibility in meeting emissions standards for SO_2. Specifically, an SO_2 emissions allowance trading program was implemented. Firms can meet emission standards by any pollution control method, including buying emission allowances from other firms. Analysts have concluded that, with the changes in the Clean Air Act, SO_2 emissions have been reduced by 50 percent and at an estimated $7 billion less than the anticipated cost of the regulatory command-and-control system.

Not surprisingly, policy analysts have explored the opportunities for implementing similar market-based systems for water pollution control. Because much of the on-going impairment of surface water has been attributed to nonpoint sources of pollution, trading programs which incorporate both point and nonpoint discharges are of particular interest. However, despite as many as six efforts across the nation to implement point-nonpoint effluent credit trading programs to reduce nutrient discharges to water, there have been few trades to date.

This research was undertaken to answer the following question: Do current barriers to effluent credit trading programs arise because of fundamental differences between air and water media or because of differences between institutions affecting air and water use, such as the Clean Air Act and the Clean Water Act?

Economic theory offers the situation, structure, conduct, and performance (SSCP) framework, developed by industrial organization economists and extended by institutional and environmental economists, within which to address this research question. In the language of the SSCP framework, the research question can be reframed as: are there fundamental differences in the situation and structure of emission allowance markets and effluent credit markets which result in conduct and performance differences?

A comparative analysis of situation and structure suggests that barriers to effective nutrient discharge credit markets are not a result of fundamental differences in the air and water media or the materials being discharged into air and water. Rather, the barriers exist because of structural differences – differences in institutional structure, program design and program implementation. Many of the structural barriers result from the Clean Water Act and its implementation. More flexibility in water pollution prevention would effectively remove many of these barriers.

This research was supported, in part, by a grant from the Office of the Great Lakes, Michigan Great Lakes Protection Fund and by the Elton R. Smith Endowment in Food and Agricultural Policy, Department of Agricultural Economics, Michigan State University.

An Analysis of Situation, Structure, Conduct and Performance in Air Emission and Watershed Effluent Markets: Lessons for Trading Program Design to Protect Great Lakes Water Quality

Table of Contents

List of Tables

An Analysis of Situation, Structure, Conduct and Performance in Air Emission and Watershed Effluent Markets: Lessons for Trading Program Design to Protect Great Lakes Water Quality

Patricia E. Norris, Elaine M. Brown and Sandra S. Batie

Introduction

The regulatory command-and-control approach of the original federal Clean Air Act produced environmental benefits but at a higher cost than might have been necessary under a more flexible policy framework. After much debate and many legislative proposals, the Clean Air Act was amended in 1990 to allow more flexibility in meeting emissions standards for SO_2. Specifically, an SO_2 emissions allowance trading program was implemented. Firms can meet emission standards by any pollution control method, including buying emission allowances from other firms. The history of this new market-based program of allowance trading is short. Nevertheless, analysts have concluded that, with the changes in the Clean Air Act, SO_2 emissions have been reduced by 50 percent and at an estimated $7 billion less than the anticipated cost of the regulatory command-and-control system (Burtraw).

Not surprisingly, given the performance observed in the market for SO_2 emissions allowances, policy analysts have explored the opportunities for implementing similar market-based systems for water pollution control. Because much of the on-going impairment of surface water has been attributed to nonpoint sources of pollution, trading programs which incorporate both point and nonpoint discharges are of particular interest. However, despite as many as six efforts across the nation to implement point-nonpoint effluent credit trading programs to reduce nutrient discharges to water, there have been few trades to date.

Several researchers have evaluated the recurring failure of effluent credit markets in water quality policy, and some have developed criteria that a successful market would need to satisfy (for example, see Letson; Hoag and Hughes-Popp; Apogee Research, Inc. 1992). Hoag and Hughes-Popp concluded that, for a market in effluent credits to function, the following conditions should be satisfied:

1. Low transaction costs to increase potential for trading
2. Sufficient number of point and nonpoint sources (not too many and not too few) to keep transaction costs low

3. Marginal abatement costs that differ between traders
4. Reasonable enforcement costs
5. Reasonable trading ratio to keep costs of trading low
6. Loadings must exceed regulation limits.

To develop this list, Hoag and Hughes-Popp reviewed a rich collection of literature on economic theory of permit trading and case studies where trading has been proposed for water pollution reduction. However, a clear void in their work and in that of others is an explicit comparison of successful air emission allowance trading programs to pilot watershed effluent trading programs. To date, there has not been an attempt to use the SO_2 emissions allowance market as a laboratory from which to evaluate the potential for trading to reduce discharges to water. Specifically, the following research question has not been addressed: Do current barriers to effluent credit trading programs arise because of fundamental differences between air and water media or because of differences between institutions affecting air and water use, such as the federal Clean Air Act and Clean Water Act? Air and water quality programs, administered by states with delegated authority, derive from these federal laws. This research was conducted to answer this question and offer insights into how a state might develop a successful point-nonpoint watershed effluent credit trading program.

Research Methods

Economic theory offers the situation, structure, conduct, and performance (SSCP) framework, developed by industrial organization economists and extended by institutional and environmental economists (Marion and Mueller; Schmid; Ostrom; Thomson), within which to address this research question. In the language of the SSCP framework, the research question can be reframed as: are there fundamental differences in the situation and structure of emission allowance markets and effluent credit markets which result in conduct and performance differences? More importantly for policy design, can lessons be learned from the evaluation of situation, structure and conduct in the emission allowance market and applied to design of a functioning market for effluent credits with the desired performance?

Since the research question requires us to analyze the situation, structure, conduct and performance of two different markets – a market for air emission allowances and a market for watershed effluent credits – the comparative analytics of synectics can be used to test for similarities between the two markets. In this application, the synectic process forces us to abandon the standard process of simply comparing the functioning (or lack thereof) of two market systems and to focus, instead, on the situations and structures that define the markets. The extent of similarities and differences in situation and structure can be expected to illuminate the potential for similar market conduct, with the potential to offer similar market performance – a reduction in pollutant discharges at a reduced control cost.

Situation, Structure, Conduct and Performance

The situation, structure, conduct and performance (SSCP) analytical framework enables an explicit look at why and how markets function (Marion and Mueller; Schmid; Ostrom; Thomson; Thompson, Matthews and van Ravenswaay). In the analysis of a functioning market, situation refers to the characteristics of the goods and services being traded that create interdependencies between traders. For example, the extent to which use of a resource by one individual is affected by or precludes use by others, the transaction costs associated with use of the resource, or the information costs associated with use of the resource are situations which arise because of the physical nature of the resource. Situation also refers to the characteristics of those doing the trading, for example the number or size of potential traders and their preferences or objectives (Schmid; Thompson, Matthews and van Ravenswaay).

Structure refers to the institutions that empower different interests within a market system **and** between markets and alternative regulatory systems. The institutional economics literature offers an array of definitions of *institutions*. Generally, institutions are the sets of rights and obligations affecting people in their economic lives (Matthews). More specifically, references to institutions include

> "...those legal, political and administrative structures and processes through which decisions are made with respect to public policy. These structures and processes consist of laws and regulations that govern the distribution of benefits and costs and set the ground rules for conflict resolution (Ingram et al.)."

Schmid describes structure as that which determines who has the opportunity to participate in resource-use decisions and how that opportunity is enabled and constrained. The institutional structure within which a market functions selects whose preferences or expectations will count. Structure is chosen, while situation is inherent.

Conduct is how buyers and sellers behave in a market. That behavior reflects the opportunity sets arising from the institutional structure chosen. The way in which participants in a market conduct themselves, in turn, determines the performance of the market (Thompson, Matthews and van Ravenswaay.). In general, the performance indicator used reflects the interests of various stakeholders, which may include reductions in discharges, costs of pollution control, or how the costs are distributed.

This framework provides an opportunity to evaluate and project the experience of existing markets for air emission reduction credits. In this case, *situation* refers to the physical environment within which the trading program is designed, including the characteristics of the air resource, the dynamics of air flows, and the characteristics of the emissions themselves. It also refers to the characteristics of those who are discharging to the air. *Structure* refers to opportunities and constraints introduced by the Clean Air Act and other institutions affecting the context within which pollution control and/or SO_2 trading occurs. The pollution control decisions made by SO_2 emitters and the decision to participate in an SO_2 trading program are the conduct of interest here. Research has shown that changes in the structure of the Clean Air Act resulted in changes in pollution control technologies so that SO_2 credits have not been traded as widely as had been anticipated. However, trades have occurred. It is this *conduct* – the modifications to control technologies and the trading – that, ultimately, changed the *performance* of clean air policies. In the case of air quality policy, we are interested in the extent to which pollution reduction goals are achieved and the extent to which the costs of achieving those goals are reduced.

Applying the SSCP framework to water quality policy and attempts to establish effluent credit markets, we can describe the situation and structure similarly to the description for air above. For water quality policy, *situation* refers to the characteristics of the water resource, the dynamics of hydrology, and the characteristics of the effluents discharged. It also refers to those who are discharging effluents – where they are located, how they are operating, and how those operations affect water quality. *Structure* refers to institutions such as regulations imposed under the Clean Water Act, the system of property rights in water that has come to be recognized under this law, as well as common, commercial, and contract law, and the interaction between federal and state water quality programs.

Together with the World Resources Institute and Michigan State University, Michigan Department of Environmental Quality examined the economic feasibility of effluent credit trading in the Saginaw Bay watershed. The 1997 study determined that environmental and economic benefits could be gained from trades of nutrient credits between point and nonpoint sources.[1] The study also concluded that the economic feasibility of nutrient reduction credit trading is watershed dependent – factors critical to success, such as geophysical features, meteorological conditions, land use patterns, distribution of discharges between point and nonpoint sources, and economic growth, vary widely between watersheds (Batchelor). Similar studies in other midwestern states provided similar findings (Faeth).

It is the *conduct* of potential market participants and *performance* of the effluent credit markets themselves that have confounded policy makers and researchers to date. In pilot effluent credit trading programs, point and nonpoint source dischargers have not traded effluent credits. There is evidence that, as with air emission sources, some water programs have caused point source dischargers to adopt new technologies, but there is little evidence that any control cost reductions have been enabled by flexibility in technology choice. In short, pilot effluent credit markets have not performed in the way that program designers have hoped – to achieve greater pollution control at lower total cost.

Synectics

Synectics is a research method based on combining the problem-stating and problem-solving processes, whereby the process of comparison is used to force expression of a problem in a new way (Gordon). The synectics approach is designed to promote the recognition of analogous problems and refers broadly to the investigation of similarities. Dunn pointed out that "people frequently fail to recognize that what appears to be a new problem is really an old one in

---

[1] Critics of effluent credit markets cite too much uncertainty related to extreme storm events and nonpoint controls as a reason why point-nonpoint trading will not protect water quality sufficiently. However, experiences with combined sewer overflows and other POTW failures indicate that point source controls are not without their weather-related uncertainties (Stephenson, Norris and Shabman).

disguise, and that old problems may contain potential solutions for problems that appear to be new." The synectic approach applied for this research is the direct analogy mechanism described by Gordon as "the actual comparison of parallel facts, knowledge or technology." Dunn, in turn, described direct analogy as a process whereby the analyst "searches for similar relationships among two or more problem situations."

Situation – The Air and Water Media

Within the SSCP framework, situation is the physical characterization of the resource and the biogeochemical processes that occur within that media. More specifically, the biophysical characteristics of air and water as waste assimilating media (the sulfur dioxide assimilative capacity of air and the nitrogen and phosphorus assimilative capacity of water) describe the situation within which a discharge credit market functions.

The air resource is comprised of a mixture of gases that make up the atmosphere. Air quality and pollutant dispersion are determined by the physical characteristics of large air mass movement, weather and climate conditions, and local air movement. The water resource is characterized by the hydrologic cycle and its role in the geochemical cycles of materials such as sulfates and nitrates. Water quality and assimilative capacity are influenced by water movement and temperature.

The term *airshed* is sometimes used when describing air management programs. However, airshed is not an accurate description since air does not flow in a single direction like water. A watershed is an area of land in which all the precipitation that fall on the land flows to a common outlet from which it enters a stream, lake, river, wetland or the ocean (Black, 1996). Unlike an airshed, the physical boundaries of a watershed can be delineated.

The physical characteristics of air and water (as well as the biogeochemical characteristics of materials discharged) determine the behavior of materials discharged to these media. Table 1 summarizes the behavior of sulfur dioxides in air and nitrogen and phosphorus in water. (See Brown for a detailed discussion of the biophysical characteristics of air and water and the sulfur, nitrogen and phosphorus cycles.) The primary difference between the chemicals' behavior in air and water relate to the physical characteristics of the resources. Materials discharged to the air will disperse over a wide area, while materials discharged to water will flow downstream. Also, technological developments have made monitoring of ambient air quality simpler and less costly than monitoring ambient water quality. For both resources, monitoring of discharges is relatively easy for stationary or point sources. However, mobile sources of discharges to air and nonpoint sources of discharge to water are more difficult to monitor.

Structure – Institutions in Air and Water Use

Air and water use are governed by a set of property rights, some explicit and some implicit, that have evolved as pressures on the resources have changed and public interest in the quality of the resources has grown. Federal laws describe how some users of the resources must limit discharges to both air and water. These rights and regulations establish structure, as defined within the SSCP framework.

Air

Limits on discharges to air were first implemented by state and local laws and ordinances, in recognition of the health impacts of polluted air (Kupchella and Hyland; Boubel et al.). Specifically, non-domestic sources of discharges were required to limit discharges. This approach was captured in federal legislation in 1970, when the Clean Air Act required certain industries to obtain licenses to discharge pollutants into the air. (The first federal air pollution statute was enacted in 1955 – it provided support for research, training and technical assistance and was administered by the Public Health Service.) The Clean Air Act, then, established the rights of these industrial sources to discharge, within limits.

Other pollutant sources are not subject to discharge limits. These smaller sources (individuals, vehicle drivers, and industries such as gravel pits, lawn care companies and agriculture) are free to emit pollutants into the air without a license. This lack of regulation occurs, in part, because the administrative, transaction and enforcement costs to permit these sources are prohibitive (Dales; Stavins 1995)

The 1970 Clean Air Act Amendments created procedures for the U.S. Environmental Protection Agency (USEPA) to set national standards for air quality, required automobile manufacturers to reduce automobile emissions, required use of best available control technology

(BACT) for new sources, regulated air toxics, and expanded federal enforcement authority. The 1977 Clean Air Act Amendments substantially expanded the statute and added the Prevention of Significant Deterioration program to protect high quality air that exceeds national standards (McCarthy et al.). The purpose of the Clean Air Act is to 1) protect and enhance the quality of air to promote public health and welfare; 2) continue and enhance a national research and development program to obtain prevention and control of pollution; 3) provide technical and financial assistance to State and local governments as they develop and implement pollution prevention and control programs; and 4) encourage the development of regional pollution prevention and control programs (42 USC 7401).

The Clean Air Act, as amended in 1990, requires USEPA to set National Ambient Air Quality Standards for pollutants that are found across the country (42 USC 7409). These standards are set for six air pollutants: sulfur dioxide (SO_2), particulate matter, nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), and lead. These are called criteria pollutants and emissions limits are set for each. Primary standards are established to protect public health, while secondary standards protect welfare (e.g. environmental and property damage) (U.S. EPA). In addition, the 1990 amendments included, as a goal, the reduction of acid deposition – specifically, the reduction of SO_2 emissions to 10 million tons below 1980 levels by 2010 (42 USC 7651). The reductions in SO_2 may be met through an emission allocation transfer system (i.e. an allowance trading program).

SO_2 Allowance Trading

The SO_2 allowance trading program authorized by Title IV of the Clean Air Act is unique, detailed and complex. It involves complex calculations to determine the allocation of allowances for each affected unit[2] listed for Phase I and Phase II of the program. Since 70 percent of the total SO_2 emissions in the United States come from electric utility emissions, the allowance trading program targets those emitters. Phase I (January 1, 1995 - December 31, 1999) is targeted at the largest fossil-fuel burning units (electricity generating power plants that have more than 100 megawatts of capacity and are emitting SO_2 at a rate higher than 2.5 pounds

---

[2] Affected units are dischargers subject to emission reduction requirements.

per million BTUs of energy output). Phase I requires 263 burning units to reduce emissions to 2.5 pounds per million BTUs. Phase II (begun January 1, 2000) will affect more than 2000 units and require all units to reduce SO_2 emissions to 1.2 pounds per million BTUs. Because affected units affected by Phase II could opt-in to Phase I, 445 affected units were given allowances in the program in 1995 (McLean; Kerr).

The structure for the SO_2 allowance trading program is also established in Title IV of the Clean Air Act. Each operator of an affected unit is given a permit that allows emissions up to the allowance calculated and allocated by USEPA. (In 2000, USEPA allocated a maximum of 8.90 million allowances annually.) Each affected unit must be permitted under Section 408 in Title IV of the Clean Air Act and, through that five-year permit, obtain allowances to cover actual emissions for each year. The affected units are subject to the requirements of other titles of the 1990 Clean Air Act including demonstrating that each unit can meet primary or health-based national ambient air quality standards (NAAQS), new source performance standards, and Prevention of Significant Deterioration provisions (McLean). Annual emissions in excess of allowances will result in a fine of $2000 per ton of SO_2 emissions over the permitted level and deduction of that number of allowances for the next year. This fine does not limit the ability of USEPA or a state or local permitting and regulatory authority to levy other fines authorized in Title I of the Clean Air Act.

In addition to the allocated allowances, an operator of an affected unit may obtain SO_2 allowances through three other sources. USEPA withholds 2.8 percent of the allowances from the allocation process. Some are sold at $1500 per allowance in direct sales, and others are sold at an annual auction on the Chicago Board of Trade. Title IV of the Clean Air Act also provides for issuing bonus allowances for conservation and renewable energy efforts, using flue gas desulfurization systems (e.g., scrubbers), and for early reduction credits (McLean). Finally, operators of affected units (or anyone else) may buy and sell allowances from other allowance holders. If an operator knows that actual unit emissions will be less than the allowances held, than excess allowances may be sold, traded, or banked for future use.

Since there is a cap on total emissions from all affected units that must reduce emissions to meet the cap, there is a value and a market for allowances. Any person may buy an allowance that an affected unit may choose to sell. In addition, as new affected units come on line after

January 1, 2000, they need SO_2 allowances to operate. These new affected units are not allocated allowances like existing units. Rather, under Title IV of the Clean Air Act, they must obtain allowances from any entity that holds them.

Although USEPA administers the Clean Air Act, the primary implementation and regulation of permitted sources is carried out by state and local governments. The federal government sets the standards and provides technical assistance and funding to state and local government programs. Each state, as part of its state implementation plan (SIP) must also submit a plan describing how the state will implement the SO_2 allowance trading program.

Water

The federal government has the authority to enact legislation to regulate water based on the *commerce clause* (Article 1, section 8, clause 3) of the United States Constitution, which authorizes the federal government to regulate activities that affect interstate commerce (Braddock). The first legislation to protect water use, the Rivers and Harbors Act, was passed in 1899 and focused on preserving navigation. Only in the past 50 years has Congress enacted water quality protection legislation.

The initial response of the federal government to water quality problems was to enact legislation to facilitate state activities to protect water quality. In 1948, the Water Pollution Control Act gave state and local governments technical assistance funds to promote activities to protect water quality. At that time, water pollution was viewed as a state and local government problem so there were no federal goals and objectives, or even limits or guidelines. The Water Quality Act of 1965 made states responsible for setting water quality standards for interstate navigable waters (Copeland 1999a).

The federal approach to water quality protection was changed with passage of the Clean Water Act of 1972. Approaches of previous laws were abandoned; the new law established a federal program for protecting and restoring water quality. The law established goals of achieving fishable and swimmable water quality by 1983 and eliminating discharges to the nation's waters by 1985. The 1972 statute made it illegal to discharge a pollutant without a permit, strengthened the water quality standards system, encouraged the use of best available pollution control technology (BAT) that is economically achievable, and provided billions of dollars for construction of sewage treatment plants (Copeland 1999b). It also defined nonpoint sources of water pollution and directed states to identify nonpoint problems and develop plans for reducing nonpoint discharges.

The Clean Water Act is a technology-based statute that requires regulated sources to use prescriptive technologies to control discharges. The concept of best practicable control technology (BPT) is used primarily for controlling conventional pollutants such as suspended solids, biochemical oxygen-demanding materials (e.g. phosphorus, nitrogen and organic matter), fecal coliform and bacteria, and pH. Conventional pollutants are those that are naturally occurring in the environment and that deplete the dissolved oxygen supply in the water. In the case of industrial sources after 1989, the Act requires greater than BPT pollution abatement. This higher technology standard is termed best available technology (BAT) that is economically achievable. The BAT control level focuses on toxic substances (Copeland 1999b). Publicly-owned treatment works (POTWs) are required to meet similarly high standards by installing secondary treatment systems that break down organic pollutants and remove 80 to 90 percent of the oxygen demand and suspended solids before discharge to the environment (Moore and Moore).

A higher level of pollution control is required as technology improves to reduce discharges into the water of the nation (Copeland 1999b). For example some POTWs now have tertiary treatment systems that chemically treat the effluent, reducing the oxygen demand of the effluent by removing inorganic materials such as phosphorus and nitrogen, before it is discharged. This higher standard may be required for a POTW to expand in a watershed where degraded waters are not currently meeting designated uses or to produce high quality waters for use as a public water supply downstream (Moore and Moore). While secondary treatment removes up to 50 percent of total nitrogen and 30 percent of total phosphorous, tertiary treatment can remove 90 to 95 percent of the phosphorus through precipitation techniques and up to 86 percent of the nitrogen through a denitrification process (Manahan).

The permitting of discharges into the waters of the nation is implemented through the National Pollutant Discharge Elimination System (NPDES). Nationwide, some 65,000 industrial and municipal (i.e. publicly-owned treatment works) dischargers must obtain permits. Nonpoint sources are not subject to the NPDES permitting requirements. NPDES permits include the control technology to apply to each pollutant, the effluent limitation[3] a source must meet and the deadline for compliance. With approval from USEPA, states may administer the NPDES program under state law. As of January 1999, 43 states have been delegated authority to administer the NPDES permit program. USEPA issues permits for the remaining seven states.

Regulatory Requirements for Nitrogen and Phosphorus Discharges

USEPA considers nitrogen and phosphorus to be pollutants that may need to be regulated to protect water quality (U.S. EPA 1998a). These plant nutrients are the focus of proposed new water quality criteria that would be used for determining if water bodies meet designated uses and for Total Maximum Daily Load Determinations (U.S. EPA 1998b). Nitrate nitrogen has an ambient standard of 10 mg/l to protect drinking water supplies. There is no ambient standard for inorganic phosphorus to protect water quality. Some states have established discharge standards for N and P. For example, in Michigan the total P standard is 1 mg/l maximum monthly average for the effluent discharge.[4] For nitrogen, the discharge limit for nitrates is addressed through an un-ionized ammonia criterion of 320 μg/l for cold water and 420 μg/l for warm water resources (Heaton). Generally, nonpoint sources of nitrogen and phosphorus are not subject to these limits.

Nitrogen and Phosphorus Discharge Credit Trading

There is no federal statutory authority to implement nitrogen or phosphorus discharge credit trading programs. USEPA has approved trading principles for specific water pollution problems on a limited basis (Jarvie and Solomon 1998). In 1996, USEPA issued the *Effluent Trading in Watersheds Policy Statement* (U.S. EPA 1996b) and the *Draft Framework for Watershed-based Trading* (U.S. EPA 1996a). The policy statement supports trading ***within the regulatory context*** of the Clean Water Act. In lieu of federal regulations for nutrient discharge

[3] Effluent limitations are restrictions established by USEPA on the quantities, rates and concentrations of chemical, physical, biological or other constituents discharged from a point source.

[4] MDEQ administrative rule 323.1060.

trading, the USEPA framework has identified eight principles for effluent or nutrient trading (U.S. EPA 1996a). They are:

1. Trading participants must meet the minimum applicable Clean Water Act (CWA) technology-based standards.
2. Trades must be consistent with water quality standards throughout the watershed as well as meet the requirements of the CWA, other federal and state laws, and local ordinances.
3. Trades are developed within a TMDL or other equivalent analytical and management framework.
4. Trades must occur within the current regulatory and enforcement mechanisms.
5. Trading boundaries generally coincide with watershed or water body segment boundaries, and trading areas are a manageable size.
6. Trading will generally add to existing ambient monitoring.
7. Careful consideration is given to types of pollutants traded.
8. Stakeholder involvement and public participation are key components of trading.

Several states are in the process of developing, or have developed, rules to establish state nutrient discharge trading programs. Since these programs complement existing point source regulatory programs, they may use existing compliance requirements and enforcement actions (Jarvie and Solomon).

Comparing Structural Components

The environmental economics literature has, over time, developed a list of institutional, design and implementation components – structural components – that are essential for a successful market incentive-based trading program. The institutional components include:

- clearly defined property rights (including the rights, liability and responsibilities of the participating parties) (Schmid; Dales)
- an institutional framework that supports implementation of the program (Stavins 1995; Stavins 1997; Apogee Research, Inc. 1992)

- clear choice of an open or closed trading system (closed trading programs operate with a cap on total emissions while open programs do not) (Faeth)
- program goals (Solomon)
- internal flexibility (ability to make internal operations changes) and external flexibility (ability to select from among alternatives for reaching the performance goal) for participants (Tietenberg 1990; Stephenson, Shabman and Geyer), and
- opportunities to respond to financial incentives[5] for pollution prevention (Stephenson, Shabman and Geyer).

Design components include:

- a standard unit of the pollutant to trade (Tietenberg 1990)
- reasonable trading ratios (Hoag and Hughes-Popp)
- opt-in provisions (Environmental Law Institute; McLean), and
- banking (ability to purchase or save credits for future use or sale) (Tietenberg 1998; Stavins 1997)

Finally, implementation components include:

- low initial transaction costs (among trading parties with limited government regulation of the transaction) (Solomon)
- low information costs (ease of finding trading partners and other information necessary to trade) (Stavins 1997), and
- low monitoring and enforcement costs (Hoag and Hughes-Popp)

Table 2 compares the SO_2 allowance trading and nutrient discharge credit trading structures to these key structural components. While there are economic incentives for nutrient discharge credit trading (nonpoint controls can be implemented at lower cost than point source

---

[5] While the regulatory community tends to use the term *incentive* to mean financial incentives such as subsidies, economists use the term to refer to things that cause people to take specific actions. For example, in this context, financial incentive means there is some financial benefit for pollution prevention, either from the ability to seek a lower cost control technique or the ability to purchase discharge credits at a cost lower than control costs. An example of a regulatory incentive would be a penalty associated with violating a discharge performance standard.

controls), there are also disincentives built into the structure. That property rights are not clearly defined for nonpoint sources while they are clearly defined for point sources is problematic. As one example, that a point source who trades nutrient discharge credits with a nonpoint source must modify its NPDES permit and also remains liable for possible nonpoint discharges results in both legal uncertainty and high transaction costs. That USEPA has provided nutrient trading guidelines rather than rules means that nutrient credit trading programs lack some structural components that are key. Further, the lack of compliance flexibility for potential nutrient discharge credit traders limits the incentives for trading. (For a complete description of the material summarized in table 2, see Brown.)

The Regional Clean Air Incentives Market (RECLAIM) in the Los Angeles area is an example of a regional program modeled after the federal SO_2 allowance trading program. RECLAIM addresses NOx and SOx emissions[6] from stationary sources through a market for RECLAIM Trading Credits – emissions credits that are allocated to participating facilities annually (Luong, Tsai and Sarkar). The program was adopted in 1993. Each facility with emission restrictions is issued an annually declining allocation of emission credits. RECLAIM credits may be bought or sold as the facilities deem appropriate. Facilities may also use emissions reduction credits generated by stationary sources not in the program and mobile source emission reduction credits[7] (SCAQMD).

Market structure in the RECLAIM program is compared to structure in four regional nutrient credit trading programs in table 3. The structures of these four water quality programs, developed within the framework provided by USEPA, are described briefly.

- Tar-Pamlico River Basin Nutrient Trading Program, North Carolina

  Initiated in September 1989 in response to excess nutrients in the Tar-Pamlico River system, the Tar-Pamlico River Basin program set a nutrient loading goal. Based on modeling results, points sources who chose to participate in the trading

[6] NOx and SOx are shorthand terms to denote more than one form of the compound, e.g. NO_2 and NO_3.

[7] These credits would be comparable to a nonpoint source credits, if such credits existed in water quality trading programs.

program became members of the Tar-Pamlico Basin Association. The Association as a whole, rather than individual members, was given a nutrient loading limit. Membership in the association afforded members the opportunity to reallocate load among themselves, if necessary, to meet the limit. If the association exceeded the loading limit, it would be required to pay into a fund that would be used to pay for controls of nonpoint sources (Green).

- Dillon Reservoir Program, Colorado

  In 1982, the state of Colorado established an ambient water quality standard for phosphorus in the Dillon Reservoir. Individual discharge limits and the rules for phosphorus discharge credit trading were established in 1984. A 2:1 trading ratio was set; trades had to be approved by the state water quality agency and included in the point source NPDES permits. However, trading opportunities were made contingent upon local governments in Summit County adopting regulations that required best management practices or other methods of pho9sphorus control for all new nonpoint sources (CDPHE, 1997).

- Cherry Creek Program, Colorado

  The Colorado Water Quality Control Commission established a phosphorus standard for the Cherry Creek Reservoir in 1984. The total annual phosphorus load for point and nonpoint sources was set, and allocations were assigned to all point sources dischargers based on the observed nonpoint discharges. Point sources could purchase discharge credits from nonpoint sources only after total nonpoint discharges were reduced by 50 percent. The Cherry Creek Basin Authority must approve all trades, subject to case-by-case trading ratios, and the NPDES permits of the point sources must be amended to reflect the trade (CDPHE, 1998).

- Lower Minnesota River Program, Minnesota.

  The Minnesota Pollution Control Agency established a limit for chemical biological oxygen demand for the last 25 miles of the Minnesota River in 1988. The load was fully allocated among point sources in the reach and upstream loadings. State guidelines for effluent trading specify that trades substitute nonpoint source load reductions for point source load requirements of a discharger who holds an NPDES permit (Senjem).

A complete description of the situation and structure of each of these programs is provided in Brown.

There are important differences in market structure for RECLAIM and the four water quality programs. Although property rights are defined, nonpoint sources of nutrient discharges are not regulated as point sources are. This limits the incentive for nonpoint sources to participate. With the exception of the Tar-Pamlico program, the lack of compliance flexibility and economic incentives for participation limits the effectiveness of the market. In the nutrient credit trading programs, uncertainties associated with nonpoint discharges result in uncertainties about trading ratios; potential traders are required to negotiate trading ratios based on their individual situations. Transaction and information costs are quite high in the water quality programs, especially in terms of potential trades between point and nonpoint sources of discharge.

Conduct – How Buyers and Sellers Respond

Conduct is how buyers and sellers behave in a market. In the context of emissions allowance trading and discharge credit trading, the conduct of interest is whether dischargers have modified their control technologies and/or traded allowances or credits. The information in tables 4a and 4b summarizes the number of transfers or trades of SO_2 allowances that occurred during the 1994-2000 period. The number of trades is smaller than initially was anticipated, largely because the flexibility afforded by the Clean Air Act amendments has enabled dischargers to adopt lower-cost control technologies to meet allowed emission levels.

As of 1999, 370 facilities were participating in the RECLAIM program. These facilities have actively traded RECLAIM credits and have installed emissions reduction technologies (Luong, Tsai and Sarkar). During the 1998 year, 441 RECLAIM credit transactions were recorded; 541 transactions occurred during the 1999 year.

An analysis of market conduct in the four nutrient discharge credit trading programs reveals little market activity (Brown).

- In the Tar-Pamlico program, point sources met the nutrient reduction goals through technological changes and by re-allocating discharge levels among themselves. Because the load limit has never been exceeded, the Association members have not looked to discharge credit trading with nonpoint sources for assistance.
- Point sources in the Dillon Reservoir watershed have met their loading allocations through increased operating efficiency and have not traded discharge credits with nonpoint sources.
- In the Cherry Creek program, point and nonpoint sources must meet discharge limits before credits can be generated. To date, these limits have not been met and no credits have been traded.
- Only in the Minnesota River Program has there been trading of discharge credits. The Rahr Malting Company, a point source that wished to construct its own wastewater treatment plant, implemented nonpoint phosphorus reductions upstream in exchange for its permitted Chemical Biological Oxygen Demand increases. The company has trading agreements with at least four upstream landowners; the offsets generated by these trades are included in the company's NPDES permit, as well as requirements for monitoring the maintenance of the nonpoint source controls.

Performance – Environmental Quality and Program Costs

Numerous studies on the economic benefits and environmental impacts of SO_2 allowance trading have been conducted (Burtraw 1996; Burtraw 1998; Bohi and Burtraw; McLean). A 1996 U.S. Geological Survey report indicated that, between 1994 and 1995, ambient concentrations of SO_2 declined by 17 percent nationally (Lynch, Bowersox and Grimm). Burtraw (1998) reviewed studies of economic benefits and concluded that the allowance trading program reduced pollution control costs by $780 million annually (in 1995 dollars) as compared to the cost of the traditional command-and-control programs. The economic benefits to the utility companies that are required to participate are the result of several factors. With allowance trading, participants have flexibility in determining how they will use allowances to cover their SO_2 emissions. In addition, participants are given flexibility to determine how they will meet their emissions reduction requirements and are able to choose the least-cost option.

Performance in the RECLAIM program can be illustrated by reductions in emissions and the costs of RECLAIM credits traded. Actual emissions were below aggregate allocations of emissions each year from 1994 through 1998. These emissions reductions occurred at a lower cost than was projected for the command-and-control approach (Luong, Tsai and Sarkar).

In the nutrient discharge credit trading programs, initiation of the load reduction requirements and specific program requirements have led point sources to reduce discharges in the Tar-Pamlico and Dillon watersheds. In the Tar-Pamlico watershed, the point source members of the Association met their load reductions through increased operating efficiency and re-allocating the load among themselves. The members have not exceeded their load limit, which would open the opportunity for trading. Estimates suggest that the point sources met their performance goals for reduced discharges at one-seventh of the cost what would have been observed if a more restrictive approach had been pursued (Green).

In the Dillon Reservoir, increasing operating efficiencies allowed point sources to reduce their phosphorus loading by 85 percent between 1981 and 1991. The improved operating efficiency reduced phosphorus loading to the reservoir at lower costs to the point sources than would have been the case with a full upgrade. Because point sources remain below their loading allocation, there has been no incentive to trade with nonpoint sources (Zander).

In the Cherry Creek Basin, the opportunity to trade discharge credits is not available until point and nonpoint sources meet the phosphorus load reductions assigned to them in 1984. Neither point nor nonpoint sources have met those load reductions, and the deadline to do so has been extended several times (CDPHE, 1998; Apogee Research, Inc.).

Only in the Minnesota River program have there been discharge credits traded. The economic and environmental benefits arising from those trades have not been reported (Brown).

Conclusions

There are clear differences in the conduct and performance of existing air emission allowance and nutrient discharge credit markets. Comparing situation and structure, it appears that current difficulties with water quality trading program design do not arise because of fundamental differences between the air and water media (*situation*). Rather, the difficulties arise because of *structure* issues. The lack of flexibility for participants, few economic incentives for participation, and high transaction costs are barriers to effective markets for nutrient discharge credits. In addition, attempts to incorporate point and nonpoint source dischargers into trading programs have been limited because of differences in property rights of point and nonpoint sources. These differences in structure give rise to differences in *conduct*, which, in turn, affect market *performance*. This research suggests that changes in the Clean Water Act are needed to reduce the structural barriers – barriers that have been effectively eliminated in the Clean Air Act. However, it is clear that modifications to the Clean Water Act are not likely in the future. As such, an alternative conclusion from this research is that effective control of nonpoint sources of nutrient discharges may require consideration of alternative innovative policy approaches that can be implemented within the current legal framework.

References

Apogee Research, Inc. *Incentive Analysis for Clean Water Act Reauthorization: Point Source/Nonpoint Source Trading for Nutrient Discharge Reductions*. Report prepared for U.S. Environmental Protection Agency, Office of Water and Office of Policy, Planning and Evaluation, Washington, D.C. 1992.

Apogee Research, Inc. *Nutrient Trading in the Dillon Reservoir*. Report prepared for U.S. Environmental Protection Agency, Office of Water, Washington, D.C. 1991a.

Apogee Research, Inc. *Nutrient Trading in the Tar-Pamlico River Basin*. Report prepared for U.S. Environmental Protection Agency, Office of Water, Washington, D.C. 1991b.

Batchelor, D.J. *Market-Based Program Feasibility Study*. Michigan Department of Environmental Quality, Surface Water Quality Division, Lansing. July 1997.

Black, P.E. *Watershed Hydrology.* Second edition. Ann Arbor Press, Chelsea, MI. 1996.

Bohi, D.R. and D. Burtraw. "SO_2 Allowance Trading: How Experience and Expectations Measure Up. Discussion Paper 97-24. Resources for the Future, Washington, D.C. 1997.

Boubel, R.W., D.L. Fox, D.B. Turner and A.C. Stern. *Fundamentals of Air Pollution*. Third edition. Academic Press, San Diego, CA. 1994.

Braddock, T. *Wetlands: An Introduction to Ecology, the Law and Permitting*. Government Institutes, Rockville, MA. 1995.

Brown, E.M. *Lessons for Trading Program Design to Protect Water Quality: A Synectic Analysis of Air and Water Quality Protection Programs.* M.S. Thesis, Department of Resource Development, Michigan State University, East Lansing. 2000.

Burtraw, D. "Cost Savings, Market Performance, and the Economic Benefits of the U.S. Acid Rain Program." Discussion Paper 98-28-REV. Resources for the Future, Washington, D.C. 1998.

Burtraw, D. "Trading Emissions to Clean the Air: Exchanges Few but Savings Many." *Resources*. (Winter 1996):3-6.

Colorado Department of Public Health and Environment (CDPHE). "Dillon Reservoir Control. 5 CCR 1002-71, last amended 1997.

Colorado Department of Public Health and Environment (CDPHE). "Cherry Creek Reservoir Control. 5 CCR 1002-72, last amended 1998.

Copeland, C. *Clean Water Act: A Summary of the Law*. Congressional Research Service, Report RL30030. 1999a. Visited 4/30/2000 at http://www.cnie.org/nle/h20-32.html.

Copeland, C. *Water Quality: Implementing the Clean Water Act*. Congressional Research Service, Issue Brief to Congress IB89102. 1999b. Visited 4/30/2000 at http://www.cnie.org/nle/h20-15.html.

Dales, J.H. *Pollution, Property and Prices: An Essay in Policy-Making and Economics.* University of Toronto Press, Toronto, Ontario, Canada. 1968.

Dunn, W.N. *Public Policy Analysis*. Prentice Hall, Englewood Cliffs, NJ. 1994.

Faeth, P. *Fertile Ground: Nutrient Trading's Potential to Cost-effectively Improve Water Quality*. World Resources Institute: Washington, D.C. 2000.

Gordon, W.J. *Synectics*. Harper and Rowe: New York. 1961.

Green, M.A. "An Innovative Approach to Nutrient Management." Paper presented at Market Based Trading for Water and Wetlands Conference, Washington D.C. 1996.

Heaton, S. Michigan Department of Environmental Quality, Surface Water Quality Division, Lansing, MI. Personal communication, 5/15/2000.

Hoag, D.L. and J.S. Hughes-Popp. "Theory and Practice of Pollution Credit Trading in Water Quality Management." *Review of Agricultural Economics*. 19(1997):252-262.

Ingram, H.M., D.E. Mann, G.E. Weatherford and H.J. Cortner. "Guidelines for Improved Institutional Analysis in Water Resource Planning." *Water Resources Research*. 20(1984):323-334.

Jarvie, M. and B.D. Solomon. "Point-Nonpoint Effluent Trading in Watersheds: A Review and Critique." *Environmental Impact Assessment Review*. 18(1998):135-157.

Kerr, R.A. "Acid Rain Control: Success on the Cheap." *Science*. 282(1998):1024-1027.

Kupchella, D.E. and M.C. Hyland. *Environmental Science: Living within the System of Nature.* Prentice-Hall, Engelwood Cliffs, NJ. 1993.

Letson, D. "Point/Nonpoint Source Pollution Reduction Trading: An Interpretive Survey." *Natural Resources Journal*. 32(1992):219-232.

Luong, D., S. Tsai, and D. Sarkar. *Annual RECLAIM Audit Report for the 1998 Compliance Year*. South Coast Air Quality Management District, Diamond Bar, CA. 2000.

Lynch, J.A., V.C. Bowersox and J.W. Grimm. *Trends in Precipitation Chemistry in the United State, 1983-1994: An Analysis of the Effects in 1995 of Phase I of the Clean Air Act Amendments of 1990, Title IV*. Open-file Report 96-0346. U.S. Geological Survey, Washington, D.C. 1996. Visited 8/2/1999 at http://water.usgs.gov/public/pubs/acidrain/index.html.

Manahan, S.E. *Environmental Chemistry*. Fifth edition. Lewis Publishers, Chelsea, MI. 1991.

Marion, B.W. and W.F. Mueller. "Industrial Organization, Economic Power and the Food System." In P. L. Farris (ed.), *Future Frontiers in Agricultural Marketing Research*. pp. 16-37. Iowa State University Press, Ames, Iowa. 1983.

Matthews, R.C.O. "The Economics of Institutions and The Sources of Growth." *Economic Journal*. 96(1986):903-918.

McCarthy, J.E., L.B. Parker, L. Schierow and C. Copeland. Summary of Environmental Laws Administered by the EPA: Clean Air Act. Congressional Research Service. 1999. Visited 4/30/2000 at http://www.cnie.org/nle/leg-8/d.html.

McLean, B.J. "Evolution of Marketable Permits: The U.S. Experience with Sulfur Dioxide Allowance Trading." *International Journal of Environment and Pollution*. 8(1997):19-36.

Moore, J.W. and E.A. Moore. *Environmental Chemistry*. Academic Press, New York, NY. 1976.

Ostrom, E. "A Method of Institutional Analysis." In F. Kaufman (ed.), *Guidance, Control and Evaluation in the Public Sector*. Walter de Gruyter, Berlin, Germany. 1986.

Schmid, A.A. *Property, Power, and Public Choice – An Inquiry into Law and Economics*. Praeger, New York, NY. 1987.

Senjem, N. "Case Study: Minnesota – Pollutant Trading at Rahr Malting Company." Presentation at Environmental Regulatory Innovations Symposium, Minneapolis, 1997. Visited 3/19/2000 at http://www.pca.state.mn.us/hot/es-mn-r.html.

Solomon, B.D. "New Directions in Emissions Trading: The Potential Power of New Institutional Economics." *Ecological Economics*. 30(1999):371-387.

South Coast Air Quality Management District (SCAQMD). "RECLAIM Program Three-Year Audit and Progress Report." 1998. Visited 3/23/2000 at http://www.aqmd.gov/hb/980539a.html.

Stavins, R.N. "Transaction Costs and Markets for Pollution Control." *Resources*. (Spring 1995):9-10, 18-20.

Stavins, R.N. "What Can We Learn From the Grand Policy Experiment" Positive and Normative Lessons from SO_2 Allowance Trading." Discussion paper 97-45, Resources for the Future, Washington, D.C. 1997.

Stephenson, K., P.E. Norris and L. Shabman. "Watershed-based Effluent Trading: The Nonpoint Source Challenge." *Contemporary Economic Policy*. 4(1998):412-421.

Stephenson, K., L. Shabman and L. Geyer. "Toward an Effective Watershed-based Effluent Allowance Trading System: Identifying the Statutory and Regulatory Barriers to Implementation." *The Environmental Lawyer*. 5(1999):775-815.

Swift, B., Pendergrass, J., Wilkinson, E., Reeves, V. and C. Riegelman. "Implementing an Emissions Cap and Allowance Trading System for Greenhouse Gases: Lessons from the Acid Rain Program. Research Report. Environmental Law Institute, Washington, D.C. 1997.

Thomson, J.T. *A Framework for Analyzing Institutional Incentives in Community Forestry.* Food and Agriculture Organization of the United Nations, Rome, Italy. 1992.

Thompson, P.B., R.J. Matthews and E.O. van Ravenswaay. *Ethics, Public Policy and Agriculture*. MacMillan, New York, NY. 1994.

Tietenberg, T.H. "Design Lessons from Existing Air Pollution Control Systems: The United States." In S. Hanna and M Munasinghe (eds.), *Property Rights in a Social and Ecological Context*. Beijer International Institute of Ecological Economics and The World Bank, Washington, D.C. 1995.

Tietenberg, T.H. "Economic Instruments for Environmental Regulation." *Oxford Review of Economic Policy*. 6(1990):17-33.

Tietenberg, T.H. "Tradable Permits and the Control of Air Pollution in the United States." *Zeitschrift Fur Ange2wandte Unweltforschung 10th Anniversary Edition, Sondecheft.* 9(1998):11-31.

U.S. EPA, Clean Air Market Programs. "Cumulative SO_2 Trading Activity Table." 2000. Visited 5/31/2000 at http://www.epa.gov/airmarkets/trading/so2market/cumchart.html.

U.S. EPA, Office of Air Quality Planning and Standards. *The Plain English Guide to the Clean Air Act.* EPA-400-K-93-001. Washington, D.C. 1993. Visited 4/30/2000 at http://www.epa.gov/oar/oaqps/peg_caa/pegcaain.html.

U.S. EPA, Office of Water. *Draft Framework for Watershed-based Trading*. EPA 800-R-96-001. Washington, D.C. 1996b.

U.S. EPA, Office of Water. *Effluent Trading in Watersheds Policy Statement*. 1996a. Visited 3/3/2000 at http://www.epa.gov/OWOW/watershed/tradetbl.html.

U.S. EPA, Office of Water. *National Strategy for the Development of Regional Nutrient Criteria*. Fact Sheet EPA-822-F-98-002. Washington, D.C. 1998b. Visited 3/3/2000 at http://www.epa.gov/OST/standards/nutsi.html.

U.S. EPA, Office of Water. *Wastewater Primer*. EPA-883-K-98-001. Washington, D.C. 1998a. Visited 4/30/2000 at http://www.epa.gov/owm/primer.pdf.

Zander, B. "Practical Case Studies of Actual Water Pollutant Trading Programs." Presented at Market-based Trading for Water and Wetlands Conference, Washington, D.C., 1996.

Table 1. Behavior of sulfur dioxide in air and nitrogen and phosphorus in water.

Characteristic	Sulfur Dioxide in air	Nitrogen in water	Phosphorus in water
Complex cycling	yes	yes	yes
Dispersion in media	wide area	downstream	downstream
Non-uniform mixing	yes	yes	yes
Ease of monitoring ambient conditions	relatively easy and inexpensive	more complicated and expensive	more complicated and expensive
Ease of monitoring pollutant discharge	easily for stationary sources	easily for point sources	easily for point sources

Source: Brown 2000

Table 2. Comparing SO_2 allowance trading structure and nutrient discharge credit trading structure to essential structural components.

Essential Components	**SO_2 Allowance Trading Structure**	**Nutrient Discharge Credit Trading Structure**
Institutional:		
• Property rights	Clearly defined for affected units	Clearly defined for point sources; not for nonpoint sources
• Institutional framework	Clearly defined for affected units	
• Open or closed system	Closed system with emission limit	Open system with effluent limit
• Goals	Lower SO_2 by 10 million tons	Water quality standards
• Compliance flexibility	Internal and external	No
• Economic incentives	Yes	Not built into program structure
Design		
• Trading unit	One ton SO_2 = one allowance	Not defined
• Trading ratios	No	Defined case-by-case
• Opt-in provisions	Yes, for defined sources	No
• Banking	Yes, internal or traded	No
Implementation		
• Transaction costs	Minimal; new rules of exchange	High; modify NPDES permits
• Information costs	Limited because of registry	High; hard to find partners
• Monitoring costs	Lower than command/control	High; check point and nonpoint
• Enforcement costs	Low because of transparency	High; check point and nonpoint

Source: Brown 2000

Table 3. Comparison of RECLAIM market structure and nutrient credit trading program structures to essential structural components.

Essential Components	RECLAIM	Tar-Pamlico	Dillon Reservoir	Cherry Creek	Minnesota River
Institutional:					
• Property rights and institutional framework[1]	Defined	Defined	Defined	Defined	Defined
• Open or closed system	Closed	Closed	Closed	Closed	Closed
• Goals	Lower costs of meeting emission reductions	Nitrogen and phosphorus reduction goal	Meet ambient standard for phosphorus	Meet water quality standards	Meet TMDL for CBOD[2]
• Compliance flexibility	Yes	Yes, internal	No	No	No
• Economic incentives	Yes	Yes	No	No	No
Design:					
• Trading Unit	Yes	Yes	Yes	Yes	Yes
• Trading ratios	1.2:1	Yes, case by case	Yes, case by case	Yes, case by case	Yes, case by case
• Opt-in provisions	Yes	Yes, limited	No	No	No
• Banking	Yes	Yes, limited	No	No	No

Table 3 (continued). Comparison of RECLAIM market structure and nutrient credit trading program structures to essential structural components.

Essential Components	**RECLAIM**	**Tar-Pamlico**	**Dillon Reservoir**	**Cherry Creek**	**Minnesota River**
Implementation:					
• Transaction costs	Yes	Yes, high	Yes, high	Yes, high	Yes, high
• Information costs	Yes	Yes, high	Yes, high	Yes, high	Yes, high
• Monitoring costs	Yes	Yes	Yes	Yes	Yes
• Enforcement costs	Yes	Yes	Yes	Yes	Yes

Source: Brown

[1] Though property rights and institutional structure are defined in each case, the property rights of point sources and nonpoint sources of nutrient discharge are different.

[2] TMDL is Total Maximum Daily Load; CBOD is Chemical Biological Oxygen Demand.

Table 4a. Cumulative SO_2 trading activity – total private transfer activity.

	First Quarter	**Second Quarter**	**Third Quarter**	**Fourth Quarter**	**Annual Total**
1994 Transactions: Allowances:	 NA NA	 48 1.8 million	 15 5.8 million	 152 5.8 million	 215 9.2 million
1995 Transactions: Allowances:	 181 10.6 million	 118 2.2 million	 137 0.8 million	 177 3.1 million	 613 16.7 million
1996 Transactions: Allowances:	 447 3.4 million	 112 0.5 million	 196 1.1 million	 319 3.2 million	 1,074 8.2 million
1997 Transactions: Allowances:	 514 4.1 million	 263 4.2 million	 253 2.0 million	 399 4.9 million	 1,429 15.2 million
1998 Transactions: Allowances:	 624 4.6 million	 264 2.8 million	 275 3.4 million	 421 2.7 million	 1,584 13.5 million
1999 Transactions: Allowances:	 615 5.2 million	 353 1.7 million	 612 2.3 million	 1,252 9.5 million	 2,832 18.7 million
2000 Transactions: Allowances:	 1407 5.5 million	 816 6.8 million	 1186 11.7 million	 1281 6.09 million	 4690 30.09 million

Source: U.S. EPA, Clean Air Market Programs

Table 4b. Cumulative SO_2 trading activity – transfers between economically distinct organizations.

	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Annual Total
1994 Transactions: Allowances:	 NA NA	 41 0.8 million	 5 7,000	 20 90,000	 66 0.9 million
1995 Transactions: Allowances:	 55 0.5 million	 88 0.2 million	 90 0.4 million	 96 0.8 million	 329 1.9 million
1996 Transactions: Allowances:	 148 0.9 million	 98 0.5 million	 137 0.9 million	 195 2.1 million	 578 4.4 million
1997 Transactions: Allowances:	 166 1.7 million	 208 1.9 million	 174 1.6 million	 262 2.7 million	 810 7.9 million
1998 Transactions: Allowances:	 188 2.0 million	 218 2.3 million	 200 2.7 million	 336 2.5 million	 942 9.5 million
1999 Transactions: Allowances:	 240 1.1 million	 270 0.75 million	 336 1.9 million	 770 2.4 million	 1,743 6.2 million
2000 Transactions: Allowances:	 771 2.41 million	 699 2.89 million	 1,000 5.2 million	 419 2.16 million	 2,889 12.66 million

Source: U.S. EPA, Clean Air Market Program