Economic and Environmental Benefits of Water Quality Trading - An Overview of U.S. Trading Programs

Mark S. Kieser* and "Andrew" Feng Fang
The Environmental Trading Network and Kieser & Associates
536 E. Michigan Ave., Ste. 300
Kalamazoo, MI
USA
* Corresponding author, email: mkieser@kieser-associates.com

ABSTRACT

This paper summarizes the history and application of water quality trading in the United States. We review the economic basis of this market-based pollution control strategy in the context of other performance-based approaches including effluent taxes and marketable emissions permits. Specific design and implementation issues necessary for successful trading programs are examined. Examples of on-going and developing water quality trading programs illustrate programmatic approaches used to address regulatory and technical challenges.

KEYWORDS: Water quality trading, Marketable emission permits, Hot spots, Nonpoint sources, Point sources, TMDLs, Watersheds

INTRODUCTION

Economics

Economists and political scientists as early as the 1960s proposed innovative environmental policy instruments as alternatives to traditional technology-based "command-and-control" pollution management strategies. These alternatives, i.e., performance-based approaches, included effluent fees/taxes and marketable emissions permits. In theory, such approaches enable society to attain pre-determined environmental standards at least costs (Baumol and Oates, 1988). Baumol and Oates (1971) showed that a uniform emissions tax per unit of pollutant on all sources would result in cost-effective attainment of pre-determined environmental targets. Because all emission sources would eventually bring their marginal abatement costs to the same level as the tax rate (to minimize the total costs), an equalization of marginal abatement costs across all emitters would result. This, in turn, was the required condition for a cost-effective allocation of resources. Reaching this equalization can also be accomplished by a system of marketable permits that explicitly recognizes the property rights of emissions and allows the free trading of such rights. A uniform price in such a system would emerge resulting in an efficient allocation of these rights (Tietenberg, 2002). Another advantage of these performance-based approaches is the flexibility they provide to pollution sources to reduce emissions while minimizing costs. Because no specific technology is prescribed and only pollution control performance is of concern to the regulator, such approaches have the potential to encourage innovations in pollution reduction management and technology.

Although the mathematics for both the effluent tax and marketable permit approach suggest an equivalent cost-effectiveness in meeting a pre-determined target, their practical difference is how the uniform tax rate or marketable permit price is determined. In the case of effluent taxation, while any tax rate would result in marginal cost equalization, only one rate would produce the desired environmental outcome. To find this rate, intensive research or a trial-and-error approach would be necessary for governmental taxation. In the case of marketable permits, the "correct" price would be established by the trading of permits between a sufficient number of suppliers and buyers in the market. The price would be set quickly and the government would have no role in the process. This market-based, efficiency-oriented approach saw its first application in the U.S. with the Emission Trading Program in 1974

(Goodstein, 2001). This marketable permits strategy to control pollution has been favored by policy makers because of its reliance on the market to find a price for an efficient permit allocation, its ability to directly control the quantity of emissions, and the general public resistance to taxation.

Practical Issues of Permit Trading

There are several issues that need to be considered to achieve the desired environmental outcome while obtaining the full potential of cost minimization in a marketable permit scheme. First, permit trading (i.e., emissions trading in air programs and effluent trading in water programs) depends heavily on the development of a smoothly functioning market for effectiveness. High transaction costs, market imperfections, and strategy behavior can pose significant obstacles to market performance (Cropper and Oates, 1992). Secondly, even with a smoothly functioning market, the exchangeability of permits between sources is impeded by variable environmental impacts stemming from spatial differences among sources, and scientific uncertainty in quantifying these emissions. Third, there are substantial resource requirements and technical difficulties in monitoring and program enforcement to ensure that environmental benefits of the trading program are being achieved. These issues may significantly reduce the efficiency of emissions trading in achieving environmental goals.

Emissions Trading in the United States

Emissions trading in the U.S. started with air quality. In the nation's first experiment in 1974, the Emission Trading Program allowed limited exchanges of emission reduction credits for five air pollutants: volatile organic compounds, carbon monoxide, sulfur dioxide, particulate matter, and nitrogen oxides. There were three primary components in this program: the offset, bubble and netting policies. Following the Emission Trading Program were the 1985 leaded gasoline trading program and the 1988 chlorofluorocarbons (CFCs) trading program to phase out these chemicals. The most extensive and successful marketable permits trading program to date is the Acid Rain Program for sulfur dioxide (SO_2). Trading for SO_2 was enacted by Title IV of the 1990 Clean Air Act Amendments and administered by the U.S. Environmental Protection Agency (US EPA). The program employs a system of tradable SO_2 emission allowances to reduce the costs of achieving an overall control of the emission level (Environmental Defense, 2000). During its first phase implementation (1995-1999), the Acid Rain Program achieved a SO_2 emission reduction that was 30% greater than the target, along with as much as $3 billion per year in cost savings (US EPA, 2002)

WATER QUALITY TRADING HISTORY IN THE U.S.

Overview

The success of the Acid Rain Program and the potential to substantially reduce abatement costs while still meeting environmental goals, prompted U.S. policy makers to consider water quality trading. After more than twenty years of command-and-control approaches to combating the nation's water pollution problems, the US EPA (1996) released a draft framework to encourage and facilitate the development of watershed-based effluent trading programs. On the state level, Michigan developed draft rules in 1999 (finalized in 2002) to guide its water quality trading (MDEQ, 2002). In 2001, the Chesapeake Bay Program published its "nutrient trading" principles and guidelines that were endorsed by all the Bay Program partners including the three Bay states, the District of Columbia, and US EPA (The Chesapeake Bay Program Nutrient Trading Negotiation Team, 2001). In early 2003, US EPA released its final Water Quality Trading Policy identifying general provisions that they cite as necessary for creating credible watershed-based trading programs (US EPA, 2003). Based on pilot projects and research, this policy clearly signals US EPA support for water quality trading and provides regulatory and technical guidance to states and other local governments in developing and implementing trading programs. The policy identifies: restrictions for watershed-based trading, tradable pollutants, baselines for credit generation, compliance with Clean Water Act (CWA) requirements, and common elements for reliable trading programs (e.g., trading ratios to account for uncertainty and to provide net environmental benefits).

There are two primary pollutant sources in water quality trading markets: point sources (permitted dischargers with defined emission locations) and nonpoint sources (diffuse sources). Point sources are regulated by the National Pollution Discharge Elimination System (NPDES) permits. NPDES permits for municipal and industrial wastewater treatment facilities have been the cornerstone of water pollution control in the U.S. since the passage of the Clean Water Act (CWA) in 1972. Nonpoint sources remain largely unregulated.

The most common forms of water quality trading to date include point source-point source trades and point source-nonpoint source trades. In either case, one source makes a surplus pollutant reduction over and above their current regulatory obligations and sells the surplus to a source with higher treatment costs needing to meet a pre-determined emission cap or goal. In theory, the greater the difference in marginal abatement cost between two sources, the greater the cost savings and societal benefits via equalized marginal costs across all sources. Thus, nonpoint sources (e.g., agriculture) generally have much lower marginal abatement costs for common pollutants such as nutrients and sediment. Consequently, trading between point sources and nonpoint sources should yield the highest cost savings. There are, however, several market challenges in point source-nonpoint source trading.

Because many nonpoint sources do not have permits, the marketable permits approach does not have the essential condition that economists have prescribed, i.e., both the seller and buyer have a limited amount of permit-allowable pollutant discharge over a pre-determined time frame. As such, point sources are almost always the buyer in the market. Nonpoint sources therefore have the market power to influence the price, creating an equity issue. Another consequence of this unequal regulation is that to execute and maintain a trade with a nonpoint source, point sources often use private contracts to hold the nonpoint source accountable for implementing, operating and maintaining the practice or structure to generate pollutant reductions. Contract negotiation and execution add transaction costs to the trade.

Though cost savings with point source-point source trading may not be as high compared to point source-nonpoint source trades, the uniform regulatory condition stipulated by NPDES permits provides an ideal framework for a marketable permits strategy. Based on the traditional command-and-control approach, this permitting system provides a well-tested legal framework for assigning and enforcing pollution control requirements on point sources. By modifying NPDES permit provisions with trading specifications, water quality trading programs that involve point sources can be readily integrated into the current permitting system. In addition, monitoring to quantify load reductions is relatively simple. This leads to easier government and public supervision, and greater environmental accountability.

<u>Drivers for Water Quality Trading in the U.S.</u>

Point source-nonpoint source and point source-point source trading have seen on-the-ground applications in the U.S. for more than two decades. In 1981, the State of Wisconsin instituted a point source-point source trading system in the Fox River watershed, part of the Lake Michigan drainage basin. The first trades involving nonpoint sources were conducted in the Dillon Reservoir of Colorado in the mid-1980s. These and other early programs were largely experimental with few actual trades. Strict eligibility requirements for credit generation, purchase and usage, uncertainty in the property right nature of credits (Hahn, 1989), changing distribution of pollutant loadings among different sources over time, and the lack of a national policy or guidance contributed to the slow start of water quality trading in the U.S.

Two major factors in the mid to late 1990’s prompted not only the rapid increase of water quality trading programs in the U.S., but also a fundamental change in the way that water quality trading programs are developed and implemented. The first factor is the highly publicized success of the Acid Rain Program. Many policy makers were convinced that if emissions trading worked for air pollution control, it must have its applications in water pollution control. The second factor is the increasing number of Total Maximum Daily Loads (TMDLs) being developed by states and US EPA as mandated by the CWA for waterbodies not meeting standards. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. Pollutant loads are allocated in a TMDL amongst sources (Waste Load Allocation [WLA] for point sources and Load Allocation [LA] for nonpoint sources). The established pollutant cap dictates the necessary load reductions that may go even beyond the minimum required levels of pollution control technology. The TMDL creates the regulatory foundation for a market where individual sources can trade their surplus WLAs or LAs under the pollutant cap set for the watershed. This is similar to economic theories underpinning the Acid Rain Program. Flexibility in federal policy also allows the use of water quality trading to achieve the pollutant cap. Cost savings to implement some 44,000 TMDLs across the U.S. are potentially significant with trading. US EPA has projected these savings to be as high as $900 million per year.

Program Design and Implementation Issues with Water Quality Trading

Former US EPA Assistant Administrator for Water, G. Tracy Mehan III (2003), identified three major challenges for successful water quality trading program development. These include: ensuring that trades create environmentally equivalent pollution reductions; that trading activity avoids hot spots (localized areas with high levels of pollution within a watershed), and; that programs identify and use reliable estimation techniques for calculating nonpoint source pollution reductions. Minimizing transaction costs and program enforcement to ensure environmental benefits are also critical issues.

The remainder of this paper examines select water quality trading program examples in the U.S. to illustrate how these issues have been addressed. Some of the prominent watershed-based trading programs are highlighted in Figure 1. Descriptions are summarized in Table 1 including relevant program features.

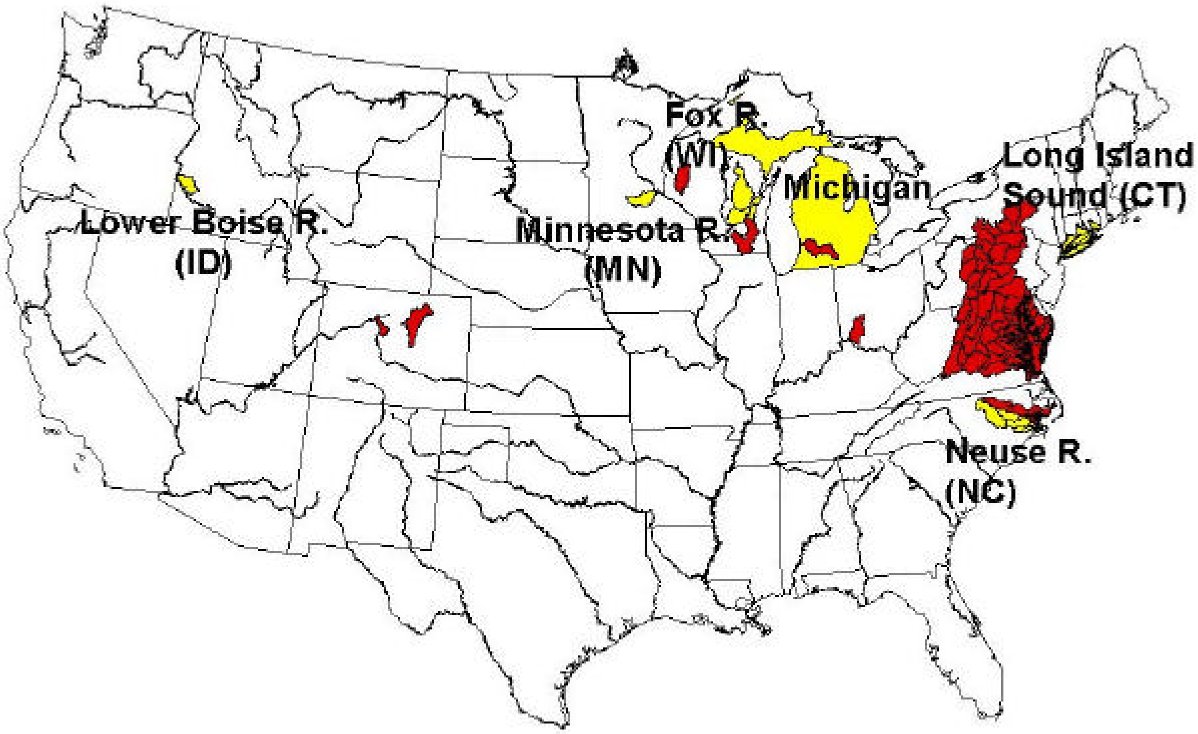

Figure 1. Select Watersheds in the U.S. with Previous, Developing or On-going Water Quality Trading Programs.

EXAMPLES OF WATER QUALITY TRADING PROGRAMS IN THE U.S.

Point Source-Point Source Trading

One of the most successful trading examples to date is the Long Island Sound Nitrogen Credit Trading Program in the State of Connecticut (refer to Table 1 for a summary; see also http://www.dep.state.ct.us/wtr/lis/lisindex.htm). Connecticut established a 64% nitrogen reduction goal for 79 Publicly Owned Treatment Works (POTWs) in a phased TMDL for nitrogen to remedy hypoxia in Long Island Sound by 2014. A General Watershed Permit allows for point source-point source trading through a state run program.

Based on modeling results, the concept of an Equivalent Nitrogen Credit (ENC) was developed to account for different POTW locations and variations in nitrogen delivery efficiency to the Sound. The farther a source is from the Sound, the fewer ENCs it gets for every pound of nitrogen it reduces below its assigned individual limit. The general watershed permit establishes annual nitrogen removal limits, monitoring and reporting protocols, and baselines for credit accounting and trading. Each POTW is required by this general permit to report to the state its monthly flow and concentration data. To prevent hotspots, trading is not allowed for compliance with any local water quality requirements or nitrogen limits set by individual NPDES permit limits.

The Long Island Sound Nitrogen Credit Trading Program was authorized by the Connecticut state legislature with a public act in 2001 that directed the Department of Environmental Protection (DEP) to initiate framework development, implementation, enforcement and auditing. This public act guarantees point sources the legal rights to use and sell credits. A unique feature of the program is DEP's role as the credit broker. As the sole nitrogen reduction credit buyer and seller, DEP has knowledge of each POTW's credit balance, sets the price, clears the credit market, and banks and uses surplus credits according to environmental and economic needs (e.g., sales to new or expanding point sources for offsetting). In this way, the DEP minimizes credit transaction costs and exerts overall market control.

The first year of trading program operation (2002) collectively produced more than the required nitrogen reduction from the 79 POTWs. Relying upon recent treatment plant upgrades, select POTWs were able to reduce beyond their targeted levels to generate nitrogen credits. Other plants that had not yet upgraded to advanced nitrogen removal and that could not meet target goals, purchased a portion of these credits.

The design and implementation strategy of the Long Island Sound Nitrogen Credit Trading Program has become a model for other trading programs under development in the U.S. This program has been considered an early success by: using a general permit to include a high number of market participants; the DEP serving as the broker to simplify transactions for buyers and sellers, and; establishment of a state law to protect participants from uncertainties regarding their property rights of the credits. Though it is still early, cost savings with trading have been projected at $200 million versus a traditional command-and-control strategy absent trading.

Point Source-Nonpoint Source Trading

Despite the practical issues facing trading programs involving nonpoint sources, such programs have emerged in many places because of the tremendous cost-savings potential and the fact that nonpoint sources account for 43% of all impaired U.S. waterways. The Minnesota River Basin trading program has experienced the highest level of trading activity in the U.S. Although small in scale compared to the Long Island Sound program, the Minnesota River Basin program illustrates the potential benefits, as well as difficulties, of point source-nonpoint source trading.

Table 1: Examples of Major Water Quality Trading Programs in the U.S.

Programs	**Program Start-up**	**Pollutant Traded**	**Type of Trading**	**Drivers for Trading**	**Reduction Goals**	**Administering Body**
Long Island Sound (Connecticut)	2002	Total nitrogen	Point-point	Hypoxia in Long Island Sound (CT and NY); TMDL for nitrogen	From 22,090 to 8,060 kg/day (64% reduction) by 2014	CT Department of Environmental Protection and the Nitrogen Credit Advisory Board
Lower Boise River (Idaho)	1998	Total phosphorus	Point-point/nonpoint	TMDL for phosphorus	TMDL waste load and load allocations	Private trading association and the Idaho Division of Environmental Quality
Neuse River (North Carolina)	1998	Total nitrogen	Point-point/nonpoint	Neuse River Basin Nutrient Sensitive Waters (NSW) Management Strategy	Achieve a combined 1.44 m kg/yr for all point sources (70% of 1995 level)	Nitrogen Trading Coalition of point sources and the state Environmental Management Commission
Minnesota River (Minnesota)	1997	Nutrients and sediment	Point-nonpoint	TMDL for DO and phosphorus discharge restrictions	New source total offset	Minnesota Pollution Control Agency (MPCA)
Fox River (Wisconsin)	1981	BOD	Point-point	Green Bay (L. Michigan) eutrophication	None	State of Wisconsin
Michigan Trading Rules (Michigan)	2002	All except bioaccumulative chemicals	Any types of sources	Water quality improvement and cost saving	--	Michigan Department of Environmental Quality

Table 1: Examples of Major Water Quality Trading Programs in the U.S. (concluded).

Programs	Trading Participants	Regulation and Enforcement	Credit Generation and Trading	Number of Trades	Cost Savings
Long Island Sound (Connecticut)	79 POTWs[1] and the Advisory Board	The General Permit and individual NPDES permits	?? Environmental equivalency factor used to account for spatial differentiation; ?? Price set at \$3.64/ENC[3] in 2002; ?? The advisory board exclusively buys and sells credits.	38 buyers, 39 sellers and \$1.4M in net payment to credit sellers	?? Average \$9/kg N removal in an average WWTP vs. \$3.64/ENC in 2002; ?? Est. \$200 million in savings for reaching the goal.
Lower Boise River (Idaho)	Point and nonpoint sources in the river watershed	TMDL and individual NPDES permits	?? Location ratio for environmental equivalency ?? Private contracts	None	--
Neuse River (North Carolina)	Point sources in the Coalition and the Commission	Combined load limit and individual NPDES limits for large facilities	The Coalition pays the state Wetland Restoration Fund for nonpoint source controls sufficient to remove the same amount of nitrogen	None	--
Minnesota River (Minnesota)	Industrial Wastewater Treatment Plants (WWTPs[2]), farmers, landowners	NPDES permits and MPCA approval of each trade	?? Trading ratio 2:1 and 2.6:1; ?? Nonpoint source streambank protection and better farming practices; ?? Private contracts	5 major trades and hundreds of smaller trades	\$5.05/kg P removal in most of the trades vs. \$9-40/kg P in WWTPs
Fox River (Wisconsin)	Municipal WWTPs and paper mills	NPDES permits	?? Buyers had to justify "need" for credits ?? Trades induced permit modification or re-issuance ?? Credits not renewable after permit expired	One	Not available
Michigan Trading Rules (Michigan)	Point and nonpoint sources	Michigan Water Quality Trading rules and other applicable water quality standards	Trading ratio 1.1:1 for point source-point source trades and 2:1 for point source-nonpoint source trades	None	\$4-22/kg P removal for nonpoint sources vs. \$62-440/kg for WWTPs [4]

[1] Public Owned Treatment Works; [2] Waste Water Treatment Plants; [3] Equivalent Nitrogen Credit; [4] Numbers from Kieser (2000)

Since 1997, two point sources in the Minnesota River Basin have traded with nonpoint sources for pollution reduction credits under individual NPDES permits to completely offset new pollution loads to the river (Fang, 2003). These two point source-nonpoint source trading projects were carefully designed for accountability and have been carried out under close supervision of the Minnesota Pollution Control Agency (MPCA). The pollutants being traded are nutrients (phosphorus and nitrogen). Nonpoint source controls employed to generate reductions include streambank stabilization, cattle exclusion, wetland restoration, and cover cropping. Trading credit evaluation procedures are detailed in permits for each remedial practice. A unique feature of the Minnesota program is the trust fund set up by each of the point sources and devoted to the trading program to achieve the required nutrient load reductions. This fund provides financial viability to the program and ensures enough credits will be generated to offset wastewater loads. A trust fund board comprised of at least one local watershed manager, one government representative, and one local water resources organization representative is responsible for managing the fund.

Both trading projects in the Minnesota River Basin employ a trading ratio greater than or equal to 2:1 (i.e., two units reduced for one unit used in compliance). This ensures equivalence and additionality of load reduction and accounts for uncertainties in converting nonpoint source loads into point source loads. For accountability, every potential trade has to be verified by MPCA and annual reduction goals outlined in the permit. The permittee is responsible for the construction, installation, operation and maintenance of non-point source remedial practices. MPCA has the right to revoke previously approved tradable credits based on inspection results. Annual reports on the operation and effectiveness of the remedial practices are required. The permittee has the option to meet its total load reduction requirement in several stages with specific and progressive nonpoint source goals. To date, five major credit trades involving substantial remedial construction work, and hundreds of smaller credit trades involving cover cropping on individual farm fields have taken place in the basin.

Program review and cost-effectiveness analyses indicate that point source-nonpoint source trading under NPDES permits in the Minnesota River Basin is able to achieve pollution control cost savings, although to varying degrees. The most cost-effective nonpoint source pollution control measures involve streambank stabilization structures with a long lifespan. Point source-nonpoint source trading programs, besides introducing cost savings to pollution control, bring other social benefits. Examples of such benefits include how: 1) the trading programs provide much needed funding for nonpoint sources to undertake pollution control measures; 2) trading provides a solution to the conflict between economic development and environmental protection, and; 3) involvement of farmers, environmental groups and local watershed officials in the trading programs raises public awareness.

Other Trading Programs

The Lower Boise River and Neuse River water quality trading programs allow for both point source-point source and point source-nonpoint source trades. The Lower Boise River program employs a phosphorus environmental equivalence factor for each source in the basin similar to the ENC in the Long Island Sound program (see http://www.deq.state.id.us/water/tmdls/lowerboise_effluent/lowerboiseriver_effluent.htm). The Neuse River program (see http://h2o.enr.state.nc.us/nps/Neuse_NSW_Rules.htm) divides the watershed into segments and assigns each segment with different total nitrogen loading limits to ensure environmental equivalence. The Lower Boise program addresses hot spot issues by limiting the total amount of phosphorus any given source could discharge while the Neuse River program does this by imposing a nitrogen concentration limit (1-2 mg/L) on all point sources. Instead of a general permit, both programs have a point source association to facilitate point source-point source trading. For point source-nonpoint source trading, the Lower Boise River program encourages the use of private contracts. The Neuse River program, like the Long Island Sound program, requires the state government to play the role of credit broker. The unique feature of the Neuse River program is that there are no direct point source-nonpoint source trades. The point source association pays the state, (on a kg by kg basis), for the portion of the nitrogen load that exceeds their collective loading limit. The state uses these payments to fund nonpoint source pollution control projects that reduce nitrogen loading to the river. Legally, the Lower Boise River program is backed by a draft state trading policy whereas the Neuse River program is sanctioned by state law.

Trading Rules

Programs such as the Long Island Sound and the Neuse River have a state law supporting and regulating their watershed-specific trading operations. Any new trading programs developed would need a similar watershed-specific law. Such a legislative approach can be a time consuming process on the order of years. In the Minnesota River Basin, MPCA incurred significant costs to administer trades by individual permits. To foster statewide applications and control administrative costs, the State of Michigan issued water quality trading rules (MDEQ, 2002). The rules include:

- Clear authorization for water quality trading applications in the state, including point source-point source, point source-nonpoint source, and nonpoint source-nonpoint source trading;
- Provisions on eligibility, timing, trading ratios (requiring retirement of a portion of each trade), and other technical details to ensure environmental equivalence;
- Limits on the amount of credits that a source can buy to avoid hot spots;
- Credit quantification methods for both point and nonpoint sources;
- Trading transaction framework and enforcement procedures (e.g., trade registration and reporting requirements) to control transaction costs and ensure program accountability, and;
- Periodic program evaluation requirements.

The rules provide the trading framework necessary for watersheds to implement flexible programs to accommodate local conditions and socioeconomic factors. Due to the lack of state resources available to develop trading market infrastructure mandated by the rules (e.g., a publicly accessible electronic board of trade), water quality trading in Michigan has not seen significant activity.

CONCLUSIONS

Economic theories on performance-based pollution control policies that have proved successful in air emissions trading programs in the U.S. are being successfully adapted for water quality trading. Water quality trading is a flexible watershed management tool offering a mechanism to more cost-effectively achieve environmental goals when used in conjunction with traditional command-and-control approaches. Over a decade in the making, US EPA's Final Water Quality Trading Policy identifies the purpose, objectives and limitations of trading applications. By design, the policy is not prescriptive, but flexible, allowing states and watershed organizations to develop their own trading programs that meet both CWA requirements and localized needs. Because no specific technology is prescribed and only pollution control performance is of concern, water quality trading has the potential to encourage innovations in pollution reduction management and technology.

Trading program design and implementation challenges will need to be addressed programmatically. An environmentally and economically successful program must consider issues such as transaction costs, environmental equivalence, hot spots, nonpoint source reduction quantification, and program enforcement. Experience from past and current programs will foster innovations in other local applications that will continue to build more efficient programs. Given the costs and magnitude of remaining water quality impairments in the U.S., performance-based strategies such as trading continue to grow in use and application.

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