Market Mechanisms and Incentives: Applications to Environmental Policy

PROCEEDINGS
SESSION ONE

WATER TRADING

A WORKSHOP SPONSORED BY THE US ENVIRONMENTAL PROTECTION AGENCY'S NATIONAL CENTER FOR ENVIRONMENTAL ECONOMICS AND NATIONAL CENTER FOR ENVIRONMENTAL RESEARCH

May 1-2, 2003
Wyndham Hotel
Washington, DC

Edited by Alpha-Gamma Technologies, Inc.
4700 Falls of Neuse Rd., Suite 350, Raleigh, NC 27609

ACKNOWLEDGEMENTS

Sections of this report, indicated as "summarizations", were prepared by Alpha-Gamma Technologies, Inc. with funding from the Nation Center for Environmental Economics. Alpha-Gamma wishes to thank Kelly Maguire and project officer Nicole Owens of the National Center for Environmental Economics.

DISCLAIMER

Session I Proceedings

Table of Contents

Talking Points for Opening Remarks
Market Methods and Incentives: Applications to Environmental Policy
May 1 and 2, 2003
Wyndham Washington
1400 M Street

Welcome to Market Methods and Incentives: Applications to Environmental Policy.

Five years ago, the National Center for Environmental Economics at EPA joined forces with ORD's National Center for Environmental Research to create the Environmental Policy and Economics Workshop Series. Originally, these workshops were started as a way to show case STAR Grant research to interested EPA and other economists.

Along the way, we realized that these workshops also presented an opportunity to provide policy perspectives to the research community. This model of give and take has proven extremely successful.

Jointly, we have hosted seven workshops on topics ranging from valuing health risks to children and water use and watershed management.

This, the eighth workshop, may prove to be the most exciting and informative one yet. During the next two days, we'll be learning a lot about market methods and incentives, a suite of policy tools that are enjoying renewed interest at EPA.

Market incentives has come a long way since Dales and Pigou first proposed permits and environmental taxes as promising policy instruments. Since the success of the Acid Rain Trading Program, market incentives have enjoyed support from a variety of disciplines and interest groups.

Occasionally, instead of pushing economic instruments, economists now find ourselves pointing out potential down sides and pitfals of incentive systems, particularly poorly designed systems. Transaction and search costs, the tax-interaction effect, spatial issues, so called "second best" conditions, and enforcement concerns all must be considered during their design.

And, we will hear about these issues today.

We'll begin with a session on water quality in which we'll learn about how trading markets have been designed to address water quality in Idaho and stormwater runoff in Ohio, along with an internet tool to bring traders together. Incorporating nonpoint sources into any market is challenging and we will hear about how voluntary incentives such as performance-based contracts may used to address agricultural pollution.

We're fortunate to be able to include Governor Whitman and two Assistant Administrators on our agenda and we'll be hearing from them after the lunch break. Governor Whitman will give a keynote address and Tracy Mehan, and Jeffery Holmstead will participate in a panel discussion on market mechanisms in environmental policy. Governor Whitman will provide her own views about market incentives and specific policy changes she is proposing in this area.

We'll end the day with an exciting session on environmental taxes and the double dividend hypothesis.

Tomorrow we'll start with a session on NOx and SOx. During lunch, Vernon Smith, the most recent recipient of the Nobel Memorial Prize in Economics will discuss Experimental Economics as a Tool for Developing Market-Oriented Environmental Management Programs.

Professor Smith received the Prize from his Majesty Carl 16th Gustaf for "having established laboratory experiments as a tool in empirical economic analysis, especially in the study of alternative market mechanisms."

This will be followed by a session on experimental economics that will present research on auction for reducing nonpoint source pollution and experiments to address compliance in emissions.

The workshop will conclude with a discussion of recently proposed multi-pollutant trading bills.

EPA will be sending you an email when we have posted the papers presented today on the web.

Finally, it takes a great deal of planning, foresight, and collaboration to design and implement a successful workshop like this. I'd like to take this opportunity to specifically thank Peter Pruess, Matt Clark and Will Wheeler of ORD's NCER and Nicole Owens, Kelly Maguire, and Cynthia Morgan from NCEE doing just that.

I'd like to thank you all for coming.

Water Quality Trading: Reinvigorating EPA Policy and Support

Presented to Workshop on

Market Mechanisms and Incentives: Applications to Environmental Policy

May 1, 2003

Lynda Hall Wynn

EPA Office of Water

Water Quality Trading Policy: Purpose

- Guidance to states and tribes implementing trading programs
- Express clear policy support for trading programs that align with Clean Water Act
- Signal EPA belief that trading can legally occur under CWA
- Provide guidance on *how* trading can occur consistent with CWA
- Identify mechanisms to ease transactions

Water Quality Trading Policy: Contents

- Trading objectives and potential benefits
  - Nonpoint source improvements
- Trading areas –within a watershed
- Pollutants and parameters traded
  - Emphasis on nutrients and sediments, trading of persistent toxics not supported
- When trading may occur
  - With/without TMDL – progress towards or meet WQS
  - High quality waters – preserve water quality

Water Quality Trading Policy: Contents, cont'd

- Alignment of trading with Clean Water Act
  - Consistency with water quality standards including antidegradation; protection of source water
  - Permitting approaches that provide flexibility, preserve enforceability
  - Antibacksliding
- Elements of credible trading programs
  - Units of trade, public access and participation
- EPA role and oversight

Water Quality Trading: Observations

- Trading is powerful where circumstances favor – not a silver bullet for all water quality problems
  - Need to help states, watersheds assess trading potential
- Program design will affect environmental outcomes and economic viability
  - e.g., accounting for uncertainty in performance of nonpoint best management practices

Water Quality Trading: Observations

- Expect variety in types of water quality trading markets
  - ‘Dynamic’ seller-to-buyer, clearinghouses, basin associations with group permits, etc.
  - Models abound; what works in one watershed may or may not work in another
- Trading highly dependent on partnerships at state and local levels

Water Trading: Next Steps for EPA

- Assessment tool for states, watersheds to determine trading potential
- Collaborative work with USDA to improve nonpoint source load estimates
- Make information available on trading program designs
- National Forum on Water Quality Trading

National Forum on Water Quality Trading

- July 22-23, 2003
- Downtown Chicago
- Gain deeper understanding of trading program goals, designs, and on-the-ground implementation
- For info, send email to wynn.lynda@epa.gov

AN INVESTIGATION INTO THE POTENTIAL TO LINK VOLUNTARY INCENTIVE PAYMENTS TO WATER QUALITY PERFORMANCE

Brent Sohngen, Mike Taylor, Haci Isik, Alan Randall, Wei Hua
Department of Agricultural, Environmental, and Development Economics
The Ohio State University

REVISED DRAFT: April 16, 2003

Alan Randall, Professor & Chair
Dept of Agricultural, Environmental, & Development Economics
The Ohio State University
2120 Fyffe Road
Columbus, OH 43210-1067
Phone: 614.292.6423
Fax: 614.292.4749
E-mail: randall.3@osu.edu
http://aede.osu.edu

** The authors thank the United States Environmental Protection Agency for funding this research through the STAR Grant Initiative. All views expressed in the paper, however, are those of the authors alone.

AN INVESTIGATION INTO THE POTENTIAL TO LINK VOLUNTARY INCENTIVE PAYMENTS TO WATER QUALITY PERFORMANCE

Brent Sohngen, Mike Taylor, Haci Isik, Alan Randall, Wei Hua

INTRODUCTION

Currently, federal and state agencies use a wide variety of voluntary incentive programs (Conservation Reserve Program, Environmental Quality Incentive Program, Wetland Reserve Program, EPA Section 319, etc.) to attempt to improve water quality by changing farming practices. Since 1996, federal programs have provided over $XXX million per year in cost-share payments for a variety of agricultural pollution abatement programs. That amounts to $X.XX per acre for all farmland in the United States. Funding for these programs over the next 6 years will increase as the 2002 Farm Bill is implemented. Despite the large payments that have already been made, water quality problems persist in agricultural watersheds throughout the United States, and there have been few, if any, documented cases of water quality improvements arising from federal voluntary incentive programs.

Many factors may contribute to the failure of voluntary conservation programs to have measurable impacts on water quality. First, the water quality data used to determine the causes of stream impairments might be incorrect, suggesting that no amount of agricultural pollution abatement will improve quality. Second, despite the relatively large quantity of money spent on water quality, there simply may not be enough money available to have an impact in most watersheds. Third, the funds may not be properly targeted. While aggregate funds may be large enough to solve many water quality problems, institutional pressures to spread the funds out, potentially to high cost-low benefit projects, may limit the effectiveness of programs. Currently only about 20-23% of farmers participate in federal conservation programs. It is entirely possible that the farmers entering the programs are the ones doing the least amount of damage to the water, either because they are already "conservation oriented" or because the funds are directed towards farmers that have small impacts on water quality.

Finally, the structure of current federal programs (and many state programs) may provide little, if any, incentive for individual farmers to carefully select, implement and management best management practices on their farms. There are many economic problems with existing incentives. For example, once a farmer has agreed to enter a program, the program guidelines might encourage the wrong practices for the downstream water quality problem, or the practices might be installed on the wrong farm fields. Often, agencies in charge of implementing programs push for specific types of best management practices, and then simply attempt to recruit whichever farmers they can find to implement them. Lower cost options, however, may be available to farmers to reduce the same pollution outputs from their farms. Alternatively, the contracts rarely, if ever, provide incentives for performance. Most contracts for voluntary agricultural pollution abatement programs pay for technology, but ignore the operation and maintenance of that technology. Without incentives to operate the new technology efficiently, or in a way that reduces pollution, the new technology may have surprisingly small impact on stream quality. Nutrient management plans can certainly help farmers understand their use of nutrients, but providing incentives simply to plan may actually have little impact on the farm operation.

This paper addresses the last issue above by focusing on contracting issues associated with voluntary incentive programs. Currently, incentive payments in most voluntary programs are disconnected from the ultimate goal of the payments – reducing impacts in the water. To address this issue, this paper explores the potential to introduce payments that value performance in terms of water quality improvements in voluntary incentive agreements with farmers. Because performance on individual farms is costly to measure and unlikely in practice, we explore group contracts where individuals in small sub-basins are paid according to outcomes at a single outlet point downstream. Payments are tied to ex post measurements of improvements in water quality, thus giving farmers an incentive to optimize farming practices to reduce pollution outputs and improve stream quality.

Group contracts have been suggested in several different settings for nonpoint source pollution. Segerson (1988), for example, shows how taxes and subsidies can be used to provide nonpoint sources with sufficiently strong subsidies to abate their optimal levels of pollution. Alternatively, tournament contracts have been suggested (i.e., Govindasamy et al., 1994), where pay-offs depend on the relative ranking of one individual's results compared to others on the team (Lazear and Rosen, 1981; Green and Stokey, 1983; and Malcomson, 1986). Both these contracts have seen little application in the regulatory system due in part to potential inequities or inefficiencies. It is also unclear how such contracts may be applied in a voluntary setting where landowners are not obligated to enter into the program. In the voluntary realm, any contracts ultimately used must clear a higher participation constraint than other regulatory approaches.

A recent study by Pushkarskaya (2002) suggests that if farmers have perfect knowledge about each others land quality or production technology, it is possible to design a contract with the proper incentives to reduce pollution for a given subsidy payment. The contract relies on farmer knowledge about nearby farmer's production costs and costs of abatement. In relatively small groups, such knowledge may be entirely possible. Payments for pollution abatement involve two parts, a base payment for the stated abatement, and a payment or loss of payment that depends on relative performance. Farmers who abate more pollution get larger payments, and farmers who abate less pollution get smaller payments.

Passing the hurdle of perfect knowledge about one's neighbor, as suggested in Pushkarskaya (2002) is a strong test to pass. Potentially, however, peer pressure and peer monitoring with less than perfect information could provide enough incentive for individual farmers to meet voluntary, but contractual, obligations to reduce pollution. Take for example the group performance contracts suggested by development economists for individuals who are unable to obtain credit due to risk. To provide collateral, individuals can form groups whose members are willing to share the risk of failure. If any member of the group defaults, other members have to repay that individual's share of the debt, or the entire group loses access to future refinancing. As shown by Stiglitz (1990) and Varian (1990), the key issue for such contracts is peer monitoring, which provides incentives for individuals to repay loans even if they do not have collateral.

Peer monitoring and peer pressure may be strong allies in voluntary incentive agreements with farmers when farmers have some, but not all, information about their neighbor's production practices. Armendariz de Aghion (1999) demonstrates that collective credit agreements can induce peer monitoring, reduce the incidence of strategic default, and enhance the lender's ability to have debts repaid. Prescott (1997) further suggests that borrowers who know a lot about each other, such as those who live in close proximity or socialize in the same circles, are the most promising candidates for group lending, and are better able to apply social pressure on potential defaulters. This seems a promising avenue for nonpoint source pollution, where groups of farmers within a small drainage area or linked to a common tile drainage main, could pledge to work together to reduce pollution at their common outlet in exchange for payments.

Shifting towards performance based contracts with groups of farmers would involve substantially new incentive structures compared to the existing voluntary programs. To engage farmers in contracts that tie their payments to ex post observations of improvements in water quality, where the improvements depend on their neighbors output is a non-trivial change. First, it is unclear whether farmers have enough knowledge about the pollution production process, i.e. how farm practices relate to water quality in streams, to make informed decisions about changes in management that would reduce pollution at the common outlet point. Second, it is unclear if farmers believe they have sufficient information to monitor each other effectively. Finally, it is unclear if they would be willing to do it. For this paper, we present the results of a series of focus groups that address these questions.

This paper is organized as follows. The second section discusses the design of the focus groups and the specific group contract that was proposed to farmers in the focus groups. The third section then describes the results obtained from analyzing the responses of farmers to specific focus group questions. Within the focus groups, farmers were engaged in a simulated bidding game to assess their willingness to enter into the group contracts. Although we do not have enough data points to entirely assess the different components of the contract, several interesting insights emerged from the bidding results, and from the subsequent discussion. The final section is our discussion and conclusion.

FOCUS GROUP CONDUCT

The focus groups explored the three general questions discussed in the introduction: (1) Can farmers determine the practices that could be used to reduce run-off and the costs of these practices? (2) Do farmers know enough about the other farmers in their watershed to engage in peer monitoring within small sub-watersheds? (3) Would they participate in voluntary agreements that include performance criteria based on ex post observations of water quality at a common outlet point downstream? The focus groups were all conducted by a moderator external to the researchers. A series of specific questions designed to elicit responses in the three areas described above were provided to the moderator, who lead the group through a discussion that was captured on video- and audio-tape, and subsequently transcribed.

The general flow in each of the focus groups included an introductory section to familiarize participants with terminology, and to engage them in a discussion about water quality in their region. Participants were then introduced to a scenario that asked them to treat nitrogen run-off as a commodity. The scenario allowed us to engage the participants in a discussion of the types of practices they may use to reduce nitrogen run-off and whether they could estimate the costs of these reductions. The final section of the focus group introduced a simulated group contract that allowed the participants to voluntarily bid on their pollution abatement, to observe the outcome, and in two focus groups, to make the same decisions a second time. A very specific contract was proposed for the participants and their responses to the contract were recorded.

For the simulation, participating farmers were shown a hypothetical watershed with 10 farms draining to a common point downstream. They were told that the town downstream was experiencing water quality problems that affected their drinking water, and the town was willing to pay farmers to reduce nitrogen loadings at the intake point (downstream from all of the farmers). Since the loadings could only be observed in aggregate at intake point, the town proposed a contract that paid farmers only if they performed on the contract. The following bidding procedure was used to determine if farmers were willing to enter the contract (Taylor, 2003).

Each participant in the focus group was given a card with private information about their own hypothetical farming operation. The card showed the costs per ton for installing specific practices to abate nutrient loadings downstream and the total tons they could reduce. They were told these costs included all direct expenditures and/or reductions in profits that would arise from abating specific levels of nutrients. The abatement practices used in the simulation were drawn from those commonly adopted by Ohio farmers, and the marginal costs of abatement were based on actual implementation costs for Ohio farmers. The practices included, forested buffer strips, grass buffer strips, and reductions in nitrogen applications. While the costs that each farmer observed on their individual cost cards was a constant marginal cost function, marginal costs varied across individual farmers, ranging from $500 to $1,2500 per ton of nitrogen reduced.

Participants were then instructed to submit bids to the town for nutrient reductions. The bids were to be for an individual quantity of nitrogen abatement and a corresponding cost to be reimbursed for the abatement. While the participants were given costs for their potential abatement activities, they were told they could submit bids that would allow for profits. Farmers were further instructed not to share their cost or bid information with their neighbors (i.e. others in the room). Upon receiving the bids, the town would contract with the lowest-cost bidders to produce a given level of nitrogen reduction as a group. In each case, a specific level of total abatement was mentioned as the target the town hoped to attain. The contract specified that if the *actual*, monitored level of reductions in nitrogen loadings at the end of the season is greater than or equal to the amount bid by the group, each farmer is paid his/her own bid price. If the monitored level is less than the group bid level, all farmers will receive zero payment.

To determine the actual level of loading reductions, farmers were asked to submit a sheet of paper describing the amount they would actually abate. These amounts were submitted privately, and collected in a way that did not allow farmers to know who, if anyone, had cheated. Farmers could thus “profit” if they submitted levels lower than they initially bid. Random weather shocks were introduced by using a roll of a six-sided die. A roll of one or two resulted in a 20% decrease in the sum of individual abatement levels. A roll of three or four had no effect on the sum of individual abatement levels. A roll of five or six resulted in a 20% increase in the sum of individual abatement levels. In this way, there was an equal probability of bad, average, and good weather, respectively, in terms of abatement performance.

The entire simulation was described to participants in advance, while they had their cost cards handy. Once the simulation was described, participants were asked to decide if they would like to bid into the system. All bids were collected and tallied for the participants. Any bids that include prices that exceed the town's maximum willingness to pay were rejected. The bids were ranked by cost per ton, and the lowest cost bidders willing to provide the target (which depended on the size of the focus group). Any bidders not included in this group were left out of the contract. If the targeted reduction was not bid into the game, all bids below the town's maximum cost were accepted, and the new target was set equal to the sum of the quantity of individual nitrogen reductions bid.

The farmers included in the contract were then asked to commit to their nitrogen reduction levels by recording the amount of abatement they would actually do on a blank slip of paper and dropping that in a hat. The sum of each individual's effort constitutes the group reduction of nitrogen without weather effects. The dice was rolled to determine weather effects, and abatement levels bid by group members were compared to actual abatement levels. After conducting some discussion, the simulation was repeated in two of the focus groups.

Focus Group Participants

The Ohio State University Survey Research Center recruited the focus group participants with phone interviews. Names and phone numbers were obtained from several sources, including the individuals in Ohio with pesticide application licenses and individuals with a subscription to *Ohio Farmer* magazine. These two lists were combined, and the duplicates were eliminated. Phone numbers were double checked where possible through phone books obtained in the Internet.

There were two general criteria for participating in the focus groups. First, we were interested in recruiting a set of individuals with certain characteristics. We thus screened individuals to find those farmers who (1) Characterized themselves as agricultural producers; (2) Shared in the decision-making authority on their farms; (3) Had never held political office; (4) Owned more than 100 acres of cropland; and (5) Obtained more than 75% of their annual household income from farming activities. The first three criteria were used specifically to screen a number of individuals out of the sample of names used for selection. Within each focus group, we also tried to recruit individuals with both majority crop and majority livestock operations, and both male and female operators. Although we were unsuccessful recruiting any female operators, two farmers brought their wives to the final focus group and we allowed these individuals to participate in the focus group.

Second, we were interested in recruiting individuals who had a high likelihood of knowing each other directly, or at least knowing of each other. We thus employed sampling that targeted specific zip codes with the hope of attracting individuals who lived relatively close to each other, but who fit the personal characteristics discussed above. As a result, the four focus groups conducted involved farmers from four different watersheds in Ohio: Big Walnut Creek (Delaware and Morrow counties); Bokes Creek

(Union and Logan counties); Paint and Darby Creeks (Madison County); Stillwater River (Darke and Miami counties).

For recruitment, individuals who did not fit the criteria listed above were thanked for their time and never told about the focus groups. The remaining individuals were asked to participate in the specific focus group for their region. Individuals were told they would get a $60 honorarium and travel expenses for their participation. Phone calls were made approximately 1 week in advance of each focus group. A letter thanking the individuals for their participation and directions were sent to the individuals who agreed to participate. Follow-up phone calls for individuals who agreed to participate were made the day before the focus group.

In general, this recruitment procedure yielded the desired number of participants (approximately 10 per focus group), with relatively high levels of participation once individuals were recruited (see table 1). The one exception was the Madison county focus group which yielded lower overall participation. It is unclear what the reason for the low participation was, although we note that the day on which this focus group occurred was one of the few good days that week with relatively cold weather and sunny skies.

The broad characteristics of the farmers who participated in the focus groups are shown in tables 2a and 2b. The participants generally were more than 50 years of age, planted more than 500 acres of land in crops, and owned nearly half the land they planted. Most of the farmers identified themselves as primarily row crop operators, although several farmers were primarily livestock operators. The main crops grown were corn and soybeans, however, a number of farmers also grew other crops. Most of the livestock operators had cattle operations, although one of them had a large hog operation and one had a small poultry operation. Average receipts did vary slightly across the groups. The first two groups had average receipts exceeding $100,000 per year, while focus group 3 appeared to have relatively less income and focus group 4 had relatively higher income. The operators in general, however, obtained a large proportion of their income from farming and not off-farm sources.

On the conservation questions in table 2b, the results indicate that the participants have relatively low knowledge of the TMDL process and relatively few of them currently participate in conservation programs provided by state or federal governments. The most used program is not surprisingly the Conservation Reserve Program. Although not shown in the table, a small number of the participants are enrolled in 2 or more programs (less than 10%). Very few of the participants indicate that they have enrolled in programs that require permanent conservation easements on their property. Approximately 20 – 25 % of the participants did indicate that they participate in watershed group activities.

When comparing the information from the participants to all of the individuals contacted to participate, as well as the US Census for the counties in which the focus groups were located, the samples are quite similar. T-tests across participants and respondents to the phone survey indicate that on nearly all of the questions, the individuals who participated are a random sample of those who passed the initial screening questions. Further, t-tests across the different samples indicate that they are strikingly consistent, although some differences emerge, as shown in table 2. For further description of the statistical tests of the samples drawn for this survey, please contact the authors.

FOCUS GROUP ANALYSIS AND RESULTS

The focus groups provided several key insights into how farmers reacted to the questions discussed in the introduction. In addition, the simulation results provide information on whether farmers would participate in voluntary agreements tied to ex post measures of pollution reductions, and how farmers handle performance and weather uncertainty when they must bear the risk. To analyze the results, the focus group transcripts were first carefully read, and used to develop 16 categories to classify the responses. The transcripts were then carefully analyzed, and each statement was coded into one (or sometimes more) of these specific categories, such as “abatement practices”, “performance of practices”, “effects of weather on performance,” etc. The analysis of focus groups was conducted by three individuals separately and then the responses were compared and disagreements discussed. The transcripts were then loaded in software that allowed us to analyze the responses for content.

Perhaps the most important question faced by group performance contracts is the assumption that farmers, not regulators or conservation employees, are most suited determine how to most efficiently reduce pollution on their farms. The questioning in the focus groups explored this idea directly by asking participants in each of the four focus groups specifically how they would go about reducing nitrogen effluents from their farms. For each focus group, we listed the potential ideas mentioned by farmers for reducing nitrogen, and then compared the lists across focus groups. Table 3 presents the suggested methods and the number of focus groups in which the idea was mentioned. Filter strips, multiple or split applications of nitrogen, and incorporating manure immediately after it was applied were suggested in each of the focus groups. These practices are particularly consistent with guidance provided by many of the recommendations for reducing nitrogen effluents suggested in Ohio by OSU Extension. In addition to the three issues that were raised in four focus groups, tile management and soil testing were suggested in three groups.

Notably, most of the practices suggested by farmers focus on human resource management on the farms, rather than the installation of new technology. Most of these unfortunately, cannot be considered in existing conservation programs that focus on purchasing new technology rather than employing different practices with old or new technology. It is worth noting that farmers in one of the focus groups also mentioned the potential that companies could develop new seeds with altered nutrient requirements, which could potentially reduce the necessity for applying nitrogen fertilizers.

These results suggest that farmers are fairly well versed at the potential types of changes in management that would be required to reduce nitrogen pollution entering streams. To further assess farmer attitudes, their responses to several selected questions or issues were coded as positive, negative, or neutral, and summed (Table 4). The first three questions in table 4 provide more detail on whether farmers believe they could engage in the voluntary program with performance standards. To do so, they would need to understand the practices, estimate the costs of adopting the practices, and estimate the effect of adoption on downstream water quality. In general, farmers were strongly positive about estimating the costs of adopting new practices. In several instances, farmers mentioned that they did not know the costs specifically, but they could find the information by talking with their local extension agents or crop consultants.

The second question assessed whether farmers could estimate the nitrogen reduction in the stream associated with adopting these alternative practices. This question generated a substantial discussion in each of the focus groups, as evidenced by the total comment column. Only 29% of the comments were positive, suggesting that farmers are much less certain about the loading reductions than the costs. However, only 35% of the comments were negative, i.e. indicating that they could not under any circumstances measure loading reductions. A fairly large proportion of the comments were neutral. In part, the large number of neutral comments relates to our interpretation of neutral for this question. In a number of cases, farmers were clear that they did not know the effects of current practices on downstream water quality, nor did they know how changes in practices would alter these impacts, but they believed they could learn about this over time with experimentation. These were interpreted as neutral comments for the purposes of this study.

The issue of flexibility was raised as well in the focus groups because many farmers were believed to have experience with previous government programs that address adoption of single practices across large areas of land (i.e. CRP, WRP). Recent examples include attempts to educate farmers about reduced tillage practices, and the buffer strip program initiated during the Clinton Presidency. Farmers were fairly adamant, as evidenced by 93% of comments being positive, that flexibility would enhance the likely success of the nitrogen reduction problem proposed in this focus group.

Farmers were then asked specifically if they could cooperate with other farmers to reduce pollution, if they believed that shirking would be a problem, and whether peer monitoring would work (see Table 4). These questions were asked prior to running the simulation. Unfortunately, we did not follow these questions up after the simulations due to time constraints in each of the focus groups, although it would have been informative to assess whether attitudes changed during the focus groups. In general, farmers in the focus groups believed they could cooperate with other farmers. In all of the focus groups, at least one of the participants recognized that some members of their community would never cooperate at the level required for reducing nitrogen effluents as proposed here. A large proportion of the comments, however was positive that they could cooperate to solve a specific problem such as outlined in our focus groups.

Farmers were also surprisingly adamant that shirking would not be a problem, with 54% responding negatively to the question about shirking. It was surprising to the researchers that this did not seem to be that big of a deal to the participants, and the question actually generated fairly little conversation (35 comments) relative to some of the other comments. Farmers were also somewhat hesitant about the applicability of peer monitoring, with 38% of the responses suggesting agreement that peer monitoring could work, and 53% of the responses suggesting it could not. This question generated the most conversation overall, and, interestingly, farmers seemed the most clear about their positions, with a relatively small proportion of neutral responses.

Throughout the focus groups, an underlying current in all of the discussions was potential increase in risk farmers would face with performance based voluntary programs. While many policy makers view risk simply as weather risk or technology failure risk, participants in the focus groups also recognized the importance of performance uncertainty, i.e. the possibility that their neighbors will not do what they said they would do and consequently they will not meet the target and get paid. While we did not specifically ask farmers which risk factor (weather, technology, or performance) would be the most difficult to address, the conversation provides some indication about how important they would be. Table 5 presents a summary of the number of comments from farmers aimed at addressing specific sources of risk.

Weather risk was clearly viewed as an important risk farmers would face with a performance based system, however, farmers were aware of both to technology and performance risk. In many instances, discussions on technology risk addressed mainly the use of the proper technology rather than the potential that the technology fails. In other words, farmers would count as a risk factor a program that specifies for them technologies to use, whether or not those technologies will reduce pollution downstream. Farmers appear to worry less about technology failure. Many of the comments on performance risk indicated that farmers recognize that managing practices after they are installed have an important influence upon their performance for downstream water quality.

Table 6 presents the results of the simulated bidding experience conducted in each focus group. In two of the focus groups, 2 and 4, the simulation was repeated. A number of interesting results emerged from the simulations. First, it’s notable that some farmers did not participate at all in the experiments, choosing instead to observe. The non-bidders were in general concerned about the game and concerned about getting involved in the contract. Interestingly, throughout the focus groups, discussion about participation often began negatively, for example with comments like this from the first focus group: "*We stood to lose a whole lot more than we ever stood to win. And there's enough gambling in farming now*." After this comment, two others suggested that they had simply played the game for the fun of it. One of the participants, however, stated

> "*…you aren't taking this interview seriously. Somebody isn't, maybe not you as the interviewer, but somebody somewhere is taking this very seriously…So the realistic part of it is even though this is a game, and we had a choice, he didn't represent his real choice. Did you? Did everyone around the table, I would like to know truthfully….*"

He managed to get three "yes" responses before the conversation turned to methods the bidders used to figure out their bids.

Across the focus groups, the most common response for non-bidding was skepticism about the game. Interestingly, despite "bad" weather in the first round of the game in the second focus group, the same number of individual participated the second time. In the fourth focus group, a small number of individuals participated the first round, but participation doubled for the second round. One contributing factor likely was the success of meeting the target observed in the first round, and another reason given was that they understood the simulation better.

Second, despite suggesting that shirking would not be problematic (i.e. Table 4), at least one farmer shirked in the first round of the game in each focus group except the third. In each case, participants in the game were asked to reveal if they shirked and why. In the first focus group, shirking appeared to result from some confusion about how the game was played and in particular how to make a bid in the first place. In the second focus group, two individual shirked in the first round because they were uncertain that they could actually accomplish what they had bid. In the second round, one person shirked, and one person actually abated additional nitrogen. The farmer who abated additional nitrogen suggested that his rationale was that he was already installing filter strips, and he felt he could use them more effectively at low cost to accomplish more nitrogen reduction. In the fourth focus group, one individual shirked in the first round because he did not believe that the program was actually going to work. A typical response for individuals who did not do what they said they would do was "*Well, I figured I couldn't accomplish what I had, I just feared it wouldn't work out*."

When faced with evidence that some individuals are likely to shirk, individual responses to the potential for shirking varied widely among the participants. On the one hand, individuals in all of the focus groups clearly recognized the difficulties they would face working as a team and relying on others. For example, one participant in the fourth focus group noted:

> *"But it's based on a group. It's not based on individual. And that creates the problem as I see it. Because if it's based on a group, it's no different than having 9 ball payers on a softball or baseball team. If they don't all work together, we*

> *are going to lose games. If we all work as a team, we are going to maybe be – we are going to definitely be more successful than if we worked individually."*

When asked directly if they could work together, a common response followed along the lines of one of the respondents in focus group four: "*... I can't get the guy down the stream from me to fix his. It's hurting him and it's hurting me. So I can't even talk him into it for him to make more money, let alone help me sustain my income.*" The focus group responses displayed a clear concern among farmers with contracts that would rely on their neighbors to perform.

Despite the skepticism of a number of the participants, there was an equally vocal group of individuals in each of the focus groups proposing that cooperation was the only way they would be able to solve a pollution problem downstream:

> *"The only way it could be done is… this watershed would have to, everybody would have to get together and if they could get five or seven of them together and you would have to draw up rules and regulations…And it's possible, just to be quite honest with the factory farms coming in… Maybe this table should sit and think about that. Trying to work together. Not that we have to agree on everything, but maybe we can find some common ground."*

The participants thus appear to be fairly confident they could cooperate with other farmers, and that if farmers committed to specific practices, they would make good on their commitments (Table 4). For a number of participants, this is consistent with their actual strategies, when they produced less than they bid for fairly benign reasons, i.e. they made mistakes. Their responses, however, were highly dependent on the terminology used to introduce the idea of cooperation. When asked if they could "control" their neighbor's actions, the participants had strong negative reactions. For instance, a participant in focus group one noted "*we don't have control, we don't want to control the neighbors.*" Immediately following that comment the moderator shifted to ask a slightly different question, namely, if there was anything the farmers could do help insure their neighbors cooperation. The responses were substantially moderated, i.e. "*work with them. Let them help you and you help them*", and "*show them that it will work.*" There was clear concern with the idea that one person could control their neighbor, but participants appeared comfortable with positively working with their neighbors to meet the target.

One difficulty in making an overall assessment about how farmers viewed cooperation was that the comments focused on two issues, whether they could convince other farmers to cooperate in order to participate in the group contract, and also whether they could get farmers to meet their commitments once they were engaged in the contract. The participants verbal responses focused most directly on the first issue, i.e. whether they could get other farmers to participate in the first place. For the most part, participants believed strongly that once farmers understood the program, and were committed to it, they would fulfill their obligations. They tended to dismiss the notion that farmers would not meet their obligations once contracted. This is supported by the results from the second round of the simulation in each case produced actual abatement at levels greater than targeted abatement.

From a policy perspective, the problems noted by the farmers in the focus groups can potentially be addressed by changing the contract. For example, the first problem associated with getting a group to cooperate initially can potentially be addressed by changing the payout schedule, such as by introducing a positive initial payment, with annual payments each year the target is met. Although this might induce some shirking and thus reduce efficiency, it is possible that the resulting group contract would regain much of the efficiency by introducing peer monitoring. The simulation results provide some evidence that farmers will meet their commitments if they understand the contract they are signing.

The problem of what to do it is discovered that the target is not met was clearly something about which participants were concerned. On the one hand, a number of participants felt that they could determine who was failing to meet their commitments and likely they could determine why. For example, one individual in the second focus group suggested "*between that [referring to an earlier comment about tracking nitrogen use] and sampling the property lines, I think you could probably figure out what's going on.*" However, as noted in some of the comments earlier, there was clear concern about how the problems would be handled once they were discovered. In designing actual policies, it might be possible to have contracts that last multiple years, with targets that becoming increasingly stringent. This would provide landowners time to adjust and learn about the effects of their practices on water quality downstream, and also to get help from other farmers, particularly with the introduction of new technology.

SUMMARY AND CONCLUSIONS

This paper explores the potential to use group-contracts to introduce water quality performance standards into cost-share programs. Group contracts engage small groups of farmers in the production of pollution abatement in small sub-watersheds. Individual determine their levels of pollution abatement and their cost requirements. However, individual payments are only provided if water quality targets are met. The water quality targets depend on how the entire group of farmers perform in their abatement. This introduces the problem of writing a contract that gives individual farmers incentives to perform pollution abatement even if their individual performance cannot be measured.

To assess the potential for group performance contracts to work with agricultural producers, we engaged farmers in a series of focus groups. The focus groups were designed to elicit their responses to a specific group performance contract. The focus groups were conducted with individuals drawn from specific watersheds within the State of Ohio in order to obtain participant pools with individuals who had a high likelihood of knowing each other. Only individuals who were primarily employed as farmers were involved in the focus groups.

The results of the focus groups suggest that farmers are very comfortable estimating their costs of different practices, but had less familiarity and confidence with estimating the impact of those practices on water quality downstream. With the proper incentives, however, farmers recognized that they could learn how their practices affect downstream water quality over time. Thus, contracts that involved multiple time periods with additional flexibility in early periods would be preferred by the farmers.

The participants were clear that individuals farmers are best suited to choose which practices will be most effective on their land for reducing pollution downstream, although they recognized the need for outside help from extension agents or crop consultants. A contract that allowed flexibility (i.e., did not dictate a specific nutrient reduction practice to be used) would be more effective and cost efficient. This type of contract would differ dramatically from most existing cost-share programs. Rather than providing incentives for any individual in a wide area who is willing to install a particular practice, the contracts suggested in this paper would focus payments on a smaller area and allow flexibility in the choice of practice. Participants recognized that the trade-off for gaining this flexibility would be that they could lose money if they did not meet their targeted pollution reduction (i.e. they would expend money for installing the practices, but receive no payments in return if the target is not met). Contracts that provided a default payments greater than $0 would be more likely to gain farmer involvement.

Participants felt that ensuring cooperation within the group would not be a problem if they all agreed on the goal and the contract, and in particular if they understood the contract. They would feel comfortable working as a team to achieve the goal, as long as they did not have to be responsible for "telling-on" a neighbor, or policing their neighbors. An important conclusion from the discussion was that the participants appeared to be more confident that the target would met if they were able to select the group themselves. They placed a high premium on finding ways to ensure cooperation from the outset of a performance based system, either by selecting the appropriate watersheds for the contract or by selecting the appropriate farmers within a watershed with which to work.

Several substantive suggestions emerged for designing the group contracts. These include allowing a default payment greater than zero and tying only part of the payment to performance. For example, performance based contracts could start with an initial payment to get started, with remaining payments for performance when the group meets specific targets. In addition, the participants suggested that contracts should be multi-year (i.e., at least 5 years). In this context, an initial payment could be made the first year, followed by annual pay-outs in years when the target is met. To allow farmers to learn how changes in their practices affect water quality, payments in the first one or two years could be more flexible than in later years.

REFERENCES

1. Armendariz de Aghion, Beatriz. (1999). "On the Design of a Credit Agreement with Peer Monitoring", Journal of Development Economics, 60: 79-104.
2. Atkinson, Scott E., and Donald H. Lewis. (1974). “A Cost-Effectiveness Analysis of Alternative Air Quality Control Strategies”, Journal of Environmental Economics and Management, Vol. 1, no. 3.
3. Burtraw, Dallas. (1996). “The SO_2 Emissions Trading Program: Cost Savings Without Allowance Trades”, Contemporary Economic Policy, 14: 79-94.
4. Crocker, Thomas D. (1966). “The Stucructuring of Atmospheric Pollution Control Systems”, The Economics of Air Pollution, ed. Harold Wolozin.
5. Dales, J. H. (1968). Pollution, Property, and Prices. University of Toronto Press. Toronto, Canada.
6. Govindasamy, Ramu, Joseph A. Herriges, and Jason F. Shogren. “Nonpoint Tournaments”, Nonpoint Source Pollution Regulation: Issues and Analysis. Kluwer Academic Publishers, Dordrecht, Netherlands. (1994). pp.87-105.
7. Green, J.R., and N. L. Stokey. (1983). “A Comparison of Tournaments and Contracts”, Journal of Political Economy, 91: 349-364.
8. Hahn, Robert W., and Roger G. Noll. (1982). “Designing a Market for Tradable Emission Permits”, Reform of Environmental Regulation. Ed. Wesley A. Magat. Ballinger Cambridge, MA.
9. Holmstrom, Bengt. (1982). "Moral Hazard in Teams", Bell Journal of Economics, 13: 324-340.

10. Joskow, Paul, L., Richard Schmalensee, and Elizabeth M. Bailey. (1998). "The Market of Sulfur Dioxide Emissions", The American Economic Review, Vol. 88 No 4: 669-685.

11. Lazear, E. P., and S. Rosen. (1981). "Rank-order Tournaments as Optimum Labor Contracts", Journal of Political Economy, 89: 841-864.

12. Malcomson, J.M. (1986). "Rank-order Contracts for a Principal with Many Agents", Review of Economic Studies, 53: 807-817.

13. Prescott, Edward S. (1997). "Group Lending and Financial Intermediation: An Example", Federal Reserve Bank of Richmond Economic Quarterly, 83: 23-48.

14. Pushkayarskaya, Helen. (2002). "Collective Enforcement Mechanisms for Point-Nonpoint Trading Markets", Ph.D. Thesis, The Ohio State University (Uncompleted at present).

15. Roach, Fred, Charles Kolstad, Allen V. Knesse, Richard Tobin, and Michael Williams. (1981). "Alternative Air Quality Policy Options in the Four Corners Region", Southwest Review, Vol. 1, no. 2.

16. Segerson, Kathleen. (1988). "Uncertainty and Incentives for Nonpoint Pollution Control", Journal of Environmental Economics and Management, 15:87-98.

17. Seskin, Eugene P., Robert J. Anderson, Jr., and Robert O. Reid. (1983). "An Empirical Analysis of Economic Strategies for Controlling Air Pollution", Journal of Environmental Economics and Management, Vol. 10, no. 2.

18. Stiglitz, Joseph. (1990). "Peer Monitoring and Credit Markets", World Bank Economic Review, 4: 351-366.

19. Tomasi, Theodore, Kathleen Segerson, and John Braden. "Issues In the Design of Incentive Schemes for Nonpoint Source Pollution Control", Nonpoint Source Pollution Regulation: Issues and Analysis. Kluwer Academic Publishers, Dordrecht, Netherlands. (1994). pp.1-37.

20. Varian, Hal. (1990). "Monitoring Agents with Other Agents", Journal of Institutional and Theoretical Economics, 146: 153-174.

Table 1: Recruitment and attendance data from four focus groups.

Focus Group	Phone Calls	Recruited	Attended
(1) Morrow/Delaware (Jan. 22)	130	12	9
(2) Union/Logan (Feb 26)	123	13	13
(3) Madison (Feb. 28)	103	8	5
(4) Darke/Miami (March 5)	184	14	10
Total	540	47	37

Table 2a: Average responses from focus group participants, farm-type questions:

	FG1	FG2	FG3	FG4
Age?	57	50	50	53
How many acres of farmland did you plant last year?	1053	989	529	624
Of these, how many acres of farmland are owned by you or your family?	574	557	296	323
Primarily (more than 50%) a row-crop or livestock operation? (1) = row-crop;(2) = livestock.	1.17	1.08	1.00	1.14
Which of the following crops did you produce last year? (1) = Yes; (2) = No				
Corn? .	1	1.1	1.25	1.00
Soybeans?	1	1.0	1.00	1.00
Oilseeds?	1.8	1.8	1.63	1.83
Wheat?	1.4	1.3	1.38	1.58
Other crops (specify)?	1.7	1.8	1.75	1.75
Did you raise livestock last year as well? (1) = Yes; (2) = No	--	1.7	1.63	1.75
What is the total number of cattle that you presently own?	0	148	45	65
How many hogs do you own?	500	3	0	0
How many sheep do you own?	0	0	0	12
How many poultry-type animals do you own?	0	10	170	0
Total annual gross sales from farming operation, including government payments.	>100,000	>100,000	100,000	500,000
Percentage of total annual household income derived from agricultural production?	81.17	81	67	73

Table 2b: Average responses from focus group participants continued, Conservation Questions:

	FG1	FG2	FG3	FG4
Have you ever heard of the Total Maximum Daily Load Initiative in the State of Ohio? (1) = Yes; (2) = No	1.67	1.67	1.88	1.86
Do you believe the Total Maximum daily load Initiative will affect the ability of agricultural producers in Ohio to make a profit? (1) = Yes; (2) = No	1	1	2	1
Payments from federal or state conservation programs? (1) = Yes; (2) = No				
Conservation Reserve Program (CRP)?	1.83	1.77	1.88	1.86
Wetland Reserve Program (WRP)?	2	2	2	2
Environmental Quality Incentive Program (EQIP)?	1.92	2	2	2
Ohio EPA Section 319 Funds?	2	2	2	2
Or, other conservation programs (specify)	1.83	1.77	1.88	1.93
Easements on your land precluding future development? (1) = Yes; (2) = No	--	2	1.88	2
Do you participate in any local watershed group activities? (1) = Yes; (2) = No	1.75	1.92	1.75	1.79

Table 3: Practices suggested by farmers and number of focus groups in which the practice was discussed

Practice	**Number of Groups where Discussed**
Install filter strips	4
Multiple or split application of nitrogen/Side-dress (multiple applications during the growing season)	4
Incorporate nitrogen immediately upon application, in particular when applying manure nutrients	4
Tile Management (i.e. plugging tiles and drains periodically)	3
Soil testing to optimize nitrogen application rates	3
Reduce nitrogen application	2
Change rotations to include none nitrogen intensive crops.	2
Change type of fertilizer used/Use a stabilizer	1

Table 4: Summary of Positive and Negative Responses to Selected Questions

	Summary Results - Proportions			Total (+, -, N)
	+	-	N	
Is it feasible to estimate costs of these practices?	0.77	0.15	0.08	13
Is it feasible to estimate the loading reduction provided by adopting these practices?	0.29	0.35	0.35	51
Would you prefer a program that provided flexibility to choose among these options to a program that targeted a specific option?	0.93	0.00	0.08	40
Could you cooperate with other farmers to reduce nitrogen at the common outlet point?	0.63	0.24	0.12	49
Would shirking be a problem for the type of contract proposed in this focus group?	0.29	0.54	0.17	35
Would peer monitoring work?	0.38	0.53	0.09	78
Do you agree with the zero fixed payment in the contract proposed in the simulation?	0.46	0.54	0.00	26

Table 5: Number of comments in each focus group aimed at addressing a specific type of risk associated with reducing nitrogen loadings.

	FG1	FG2	FG3	FG4
Performance Risk	5	4	7	7
Technology Risk	10	3	15	7
Weather Risk	12	7	5	11

Table 6: Simulation Results.

FG	Game	Entries (Farmers)	Average Bid (Range)	Target	A*	Realized A*
1	1	6 (8)	$3,086 (1500- 2600)	22	19	15.2
2	1	7(10)	$1,098 (500 - 2000)	25	22	17.6
2	2	7(10)	$1,285 (500 - 2000)	20	22	**26.4**
3	1	4(5)	$1,319 (1000 - 1450)	13	13	10.4
4	1	3(8)	$1580 (1200 - 1850)	10	9.5	**11.4**
4	2	6(8)	$1834 (1500 - 2000)	23	25.8	**25.8**

Target = target level of abatement bid into the game and accepted.
A* = Abatement effort stated by farmers after the bidding round.
Realized A* = Abatement effort corrected for weather effects (roll of the dice)
Bold numbers indicate instances where the target was met.

Can the Acid Rain Program's Cap and Trade Approach Be Applied to Water Quality Trading?

Claire Schary[1]
Water Quality Trading Coordinator
EPA Region 10
Seattle, Washington

EPA's documented success with trading sulfur dioxide emissions under the Acid Rain Program has inspired EPA and others to attempt to translate that approach to address other important environmental programs. The announcement of the EPA Water Quality Trading Policy on January 13, 2003[2] is the most recent example of the appeal of market-based approaches to address environmental problems at less cost. While EPA and several states had previously attempted similar approaches to address water quality issues prior to the successful air emissions trading example spotlighted by the Acid Rain Program[3], their record in achieving the potential cost savings has not been as remarkable. Much of this divergence in economic results should be attributed to the circumstances of working with water pollution rather than air pollution, and working in a watershed rather than an air shed. The fundamental differences of these two pollution media require many of the important elements of a trading program to be addressed very differently. However, there are still many important elements that appear to be key to much of the success of the Acid Rain Program's sulfur dioxide emissions trading – which may be instrumental to the success of any pollutant trading approach – and therefore should be kept in the forefront of designing a water quality trading program. Idaho's Lower Boise River water quality trading framework is an important example of how this can be done.

Design Factors Contributing to the Success of the Acid Rain Program's Trading System

Under the Acid Rain Program, sulfur dioxide emissions from the electric utility industry are limited to 8.95 million tons under a fixed "cap" (while phased in over several years it will be in full effect by year 2010). Utilities are allocated their share of emissions through an allocation of allowances that add up to the tonnage amount of the cap. This approach to trading has since been termed the "cap and trade" model to distinguish it from other approaches that do not use a cap to

---

1 Claire Schary has been employed with the U.S. Environmental Protection Agency since 1990. She worked in the Office of Air & Radiation's Acid Rain Program until 1997, when she transferred to EPA's regional office in Seattle, to launch the region's water quality trading program. The opinions and findings expressed in this paper are solely those of the author and not of the U.S.E.P.A.

2 See http://www.epa.gov/owow/watershed/trading/tradingpolicy.html Water quality trading is the same thing as "effluent trading" or "water pollution trading," but is the term formally adopted by EPA under its Water Quality Trading Policy issued January 23, 2003.

3 The first water quality trading project is usually considered to be the Tar - Pamlico River Basin in North Carolina, with its first implementation strategy involving trading approved in 1989 and revised in 1992.

limit the quantity of allowances or credits traded, and therefore do not limit the total quantity of pollution traded. Under the cap and trade approach, allowances represent an authorization to emit a certain quantity of a pollutant, usually during a designated time period, so the total amount of pollution emitted by the set of sources included in the program is tightly controlled. Each source can capitalize on its own compliance strategy through selling its surplus allowances, or reduce its compliance costs by purchasing allowances from another source that was able to make the reductions more cheaply. Under the Acid Rain Program, an allowance is an authorization to emit a ton of SO_2 in a designated year or any year thereafter, which means they can be saved or "banked" for use in a later year. During the annual reconciliation process, an allowance is deducted from the source's account to cover each ton of SO_2 emitted over the course of the year. Automatic financial penalties and allowance deductions from the next year's account are triggered if the source does not hold enough allowances to offset its emissions at the end of the year.

As explained on the Acid Rain Program's website, the program is designed to accomplish three primary objectives:

" 1. Achieve environmental benefits through reductions in $S0_2$ and NO_x emissions.
2. Facilitate active trading of allowances and use of other compliance options to minimize compliance costs, maximize economic efficiency, and permit strong economic growth.
3. Promote pollution prevention and energy efficient strategies and technologies.

Each individual component fulfills a vital function in the larger program:

- the allowance trading system creates low-cost rules of exchange that minimize government intrusion and make allowance trading a viable compliance strategy for reducing SO_2
- the opt-in program allows nonaffected industrial and small utility units to participate in allowance trading
- the NO_x emissions reduction rule sets new NO_x emissions standards for existing coal-fired utility boilers and allows emissions averaging to reduce costs
- the permitting process affords sources maximum flexibility in selecting the most cost-effective approach to reducing emissions
- the continuous emission monitoring (CEM) requirements provide credible accounting of emissions to ensure the integrity of the market-based allowance system and to verify the achievement of the reduction goals
- the excess emissions provision provides incentives to ensure self-enforcement, greatly reducing the need for government intervention
- the appeals procedures allow the regulated community to appeal decisions with which it may disagree

Together these measures ensure the achievement of environmental benefits at the least cost to society."[4]

Some of the elements that have made the Acid Rain Program so successful are attributable to the

---

4 EPA's Clean Air Markets Division website: http://www.epa.gov/airmarkets/arp/overview.html#princips

authorizing legislation that established it as a program and also to the nature of the problem it was addressing. Title IV of the 1990 Clean Air Act Amendments provided a clear statutory mandate for trading and specified the type and geographic set of sources to which it applied. It also states that the Acid Rain Program does not replace or supercede the enforcement of other air programs; rather, its intended purpose is to address an emissions "total loadings" or quantity problem, which it does through a stringent enforcement of the emissions cap. The cap (when it is in full effect in 2010) represents a 50% reduction in overall emissions from 1980 levels.

The significant emissions reduction enforced by the cap also reduces the likelihood of new "hot spots," or areas of localized impacts from an increase in emissions, from being created. This is because the utilities' individual allowance allocations are not enough to cover their levels of emissions from before the program. Since all fossil-fuel fired utilities are required to be in this program, they quickly learned that the compliance strategy of purchasing allowances to offset their sulfur dioxide emissions is usually more expensive and less financially attractive than other compliance strategies that involve emissions reductions. Therefore, the chances of any single source or set of sources in a particular area increasing their emissions from their levels prior to the Acid Rain Program, are lessened considerably.[5] Furthermore, while many interpret the Acid Rain Program's allowance requirement as removing direct regulatory control over the potential for local hot spots, in fact, the required installation of Continuous Emissions Monitors (CEMs) provide more precise emissions data than had been available previously to help enforce the ambient air quality standards.

Both the public's and the market's confidence in sulfur dioxide allowances as a tradable commodity and as the "currency of compliance" is important in order for the allowance to retain its value in the marketplace. This confidence is largely established by the CEMs, which monitor the sources' emissions more accurately and consistently than ever before, so that there is more certainty as to how much is actually being emitted. Buyers and sellers, as well as the public, are assured that no emissions will escape undetected and allowances accurately represent the specific amount of authorized emissions. Adding to the public's and the market's trust in the commodity is the provision for automatic penalties to kick in when a utility fails to hold enough allowances in its account to cover its reported emissions at the end of the year. With the awareness that fines will be imposed swiftly and at a level severe enough to deter violations, market participants can be confident that utility sources will always use allowances to cover their emissions - *i.e.,* that allowances are in fact a valued "currency."

---

[5] In fact, the Acid Rain Program's compliance reports from 2000 and 2001 indicate that total SO^2 emissions have decreased significantly since the program took effect and major reductions appeared at the state-level as well. "In 2001 Title IV sources achieved a 33% reduction from 1990 SO_2 levels nationwide. SO_2 emissions in Texas did increase in Phase I; however, SO_2 emissions in the state decreased in Phase II when the Acid Rain Program requirements took effect for Texas sources. Although most SO_2 emissions still occur in the Midwestern U.S., it is important to note that, over time, this same region has also seen the most significant decrease in SO_2 emissions in the country. The highest SO_2 emitting states in the 1990 (Ohio, Indiana, and Pennsylvania), reduced emissions 40% in 2001 (49%, 47% and 22%, respectively) compared to 1990 levels. Other states in the region show similar trends since 1990. SO_2 emissions decreased 59% in Illinois, 41% in Kentucky, 70% in Missouri, 55% in Tennessee, and 49% in West Virginia." http://www.epa.gov/airmarkets/cmprpt/arp01/2001report.pdf

Another important element contributing to the success of the Acid Rain Program's trading system is the provision in the utility's permit that authorizes it to engage in trading. The permit sets the amount of allowances the utility unit holds at any given moment as its SO_2 emissions limit for the purpose of compliance with the Acid Rain Program. The utility unit's initial allowance allocation serves as its starting point, but the limit can be adjusted through buying and selling allowances, without requiring approval on individual trades once the permit is issued. The permit's "pre-approval" of trades is supported by the existence of the cap to address the larger environmental problem, the stringency of the continuous emissions monitoring requirement, and the implementation of the state and federal ambient standards to prevent any adverse impacts locally. The emission limits set under other air programs' permits for state or federal ambient standards essentially determine how much the utility is authorized to emit because the Acid Rain Program only requires the utility to hold enough allowances to offset its emissions reported at the end of the year.

Lastly, while the Acid Rain Program applies specifically to the electric utility industry as the largest source of sulfur dioxide emissions, it also allows for industrial sources of SO_2 emissions to voluntarily join the program. In this sense, the perception by some of the "cap and trade" approach as being overly rigid and restricted to a set of specified sources is not valid. The "opt-in" feature of the program allows for other sources to join if they can prove themselves to be similar enough to the affected sources; in turn, they receive an allocation of allowances that are not included in the cap established for the utilities. An industrial source might choose to opt in if it determines that it could achieve SO_2 reductions at less cost than the utility sources. As part of the "opt-in" requirements, an industrial source choosing to participate in the program must comply with the elements that are required of the utility sources, including installing the continuous emissions monitors and receiving an allocation based on a formula applied to a comparable set of years for determining its historical heat input levels and applicable allowed emissions factor. Although they are not part of the allowances in the cap, the opt-in sources' allocated allowances are indistinguishable from the others for the purposes of trading. In this sense, the cap is being expanded to include a voluntary subset of another set of sources of the same pollutant, and in the same broadly defined air shed, because they are also contributors to the Acid Rain problem.[6]

Can the Cap and Trade Model be Applied to Water Quality Trading Under a Total Maximum Daily Load (TMDL)?

Some may question why water quality trading should be modeled after a successful cap and trade model developed for air pollution. Despite the differences between air pollution and water

---

6 In 2001, there were 11 opt-in units that were allocated 99,188 allowances. These represented only 1% of the 9,553,657 total allowances allocated for the year, and 0.05% of the 19,933,611 allowances available for use in 2001. *Acid Rain Program Annual Progress Report, 2001,* page 7. http://www.epa.gov/airmarkets/cmprpt/arp01/2001report.pdf However, it is debatable whether the opt-in program has been effective in achieving additional reductions at less cost. See Montero, Juan-Pablo, "Voluntary compliance with market-based environmental policy: Evidence from the Acid Rain Program," *Journal of Political Economy* (October 1999) Vol. 107, No, 5 pp. 998-1033.

pollution in defining the tradable commodity, the careful design of the trading program's structure can have a significant impact on how well it accomplishes the environmental and economic objectives it is intended to achieve. In their article titled "The Structure and Practice of Water-Quality Trading Markets" the authors Richard T. Woodward, Ronald Keiser, and Aaron-Marie Wicks[7] examine the structures of markets formed in many of the water quality trading programs across the country. They determine that legal constraints and physical characteristics play a major role in determining the design of the trading program, and that decisions in such areas as how trades will be authorized, monitored and enforced also play a major role in determining what market structure will ultimately form. They conclude that the market structures can be categorized into four main types: exchanges, bilateral negotiations, clearinghouses, and sole-source offsets.[8]

While the Acid Rain Program's SO_2 market has evolved to form the "exchange," supporting the most dynamic level of trading, most water quality trading markets will likely result in one of two forms, bilateral negotiations or sole-source offsets, which achieve most environmental goals but do not fulfill the amount of cost savings that would have been possible under an exchange type of market structure. Yet, as the authors point out, the potentially low volume of water quality trading may never justify the infrastructure needed to foster an exchange type of market structure. However, it should also be argued that the goal of achieving as much of cost savings as possible from water quality trading should not be abandoned. The trading system design has a direct impact on the amount of cost savings that can be achieved, and therefore should be established with that in mind. Even a water quality trading system supporting bi-lateral negotiations can be designed to maximize the administrative efficiency of the trading process and therefore improve its ability to achieve cost savings for all participants.

Decisions concerning the trading system design intended to provide more certainty of environmental outcomes will influence whether or not the market structure is able to provide sufficiently low transaction costs to the program's participants and low administrative costs to the regulatory agency, to achieve its cost savings goal. Even though the market structure for most pollutant trading programs may never match the "exchange" level at the far end of the scale, it is worth identifying the design elements of the Acid Rain Program's cap and trade model that

---

7 Woodward, Richard T., Kaiser, Ronald A., and Wicks, Aaron-Marie, "The Structure and Practice of Water Quality Trading Markets," *Journal of the American Water Resources Association*, (August 2002): 967-979. http://ageco.tamu.edu/faculty/woodward/paps/#Working

8 In their article, the authors state that an exchange, at one end of the spectrum, is "characterized by its open information structure and fluid transactions between buyers and sellers," while bilateral negotiations require "substantial interaction between buyer and seller to exchange information and negotiate the terms of trade." Clearinghouses link buyers and sellers through an intermediary, such as a retailer who purchases credits from many sources and bundles them together, selling them at a uniform price. Sole-source offsets, on the other hand, may not require any other trading party, but instead can take the form of a trade conducted within a source's own means, or "when a source is allowed to meet a water quality standard at one point if pollution is reduced elsewhere, either on-site or by carrying out pollution reduction activities offsite." *Ibid.*

support the achievement of such impressive cost savings.[9] How these elements may be applied to the design of a water quality trading program should be considered as well.

Many studies have been conducted on how to apply the success of the Acid Rain Program's cap and trade approach to other air quality problems. In their paper "To Trade or Not to Trade? Criteria for Applying Cap and Trade,"[10] the authors Stephanie Benkovic and Joseph Kruger highlight many important questions to consider in deciding whether to apply the cap and trade approach to a particular air quality problem. While they did not extend their analysis to address environmental concerns beyond air pollution, many of the criteria they cite are relevant to determining whether the cap and trade approach should be applied to the design of a water quality trading program for a particular watershed. One of the most important is to determine if the environmental problem can be addressed with such a flexible approach, in which the exact levels of discharge will not be controlled directly but influenced by market forces. For some toxic pollutants, trading has the potential to create adverse local health or ecosystem-related impacts in an area immediately surrounding a facility. They state that "allowing such a facility to buy allowances from other facilities may not fully address the risks caused by its emissions. In fact, it may make a situation worse by causing a 'hot spot' - *i.e.*, an unacceptably higher accumulation of the pollutant in a specific geographic area. Such a case may necessitate controlling all facilities emitting the substance at a certain level, negating the flexibility inherent in an emissions trading program." That is the most important factor to consider in determining whether or not to apply a trading program to achieve any environmental goal, whether it concerns air quality or water quality. Benkovic and Kruger go on to say that "[i]n general, the more a pollutant is uniformly mixed over a larger geographic area, the more appropriate it is for the use of cap and trade."

The remainder of Benkovic and Kruger's article describes other factors to consider in applying the cap and trade approach, and suggest some design features to address conditions that are similar to those occurring in water quality trading. In applying the cap and trade approach to water quality, however, there are also several challenging differences that prevent direct application of some of the design elements they cite, as well as those inherent in the success of the Acid Rain Program's trading system. Instead, it will require an attempt to implement the underlying principle or goal of that element. Among the fundamental differences are those that arise between addressing typically large air sheds versus comparatively smaller watersheds, air pollution versus water pollution, and the differences between the Clean Air Act and the Clean Water Act in regulating identified sources that contribute to a specific pollution problem. The implications of these and other differences are too numerous and complex to discuss here, but a subset of these will be identified in the remainder of the paper as they pertain to differences in approaching the design of similar cap and trade style trading system to achieve water quality

---

9 As stated on the Acid Rain Program's website, "The General Accounting Office recently confirmed the benefits of this approach, projecting that the allowance trading system could save as much as $3 billion per year -- over 50% -- compared with a command and control approach typical of previous environmental protection programs." http://www.epa.gov/airmarkets/arp/overview.html –"A Model Program"

10 Benkovic, Stephanie and Kruger, Joseph, "To Trade or Not to Trade? Criteria for Applying Cap and Trade," *The Scientific World*, (2001) 1 Also available on the web at http://www.epa.gov/airmarkets/articles/index.html

goals.

Of primary importance in its suitability to a cap and trade approach is the Clean Water Act's provision for the establishment of a Total Maximum Daily Load (TMDL)[11]. The TMDL establishes a cap on the total daily quantity of a pollutant that can be discharged into a specific waterbody or river segment. The conditions requiring a TMDL are generally similar to those that led to the establishment of the Acid Rain Program's cap on SO_2 emissions from electric utilities, despite their compliance with their permits' emission rate limits for SO_2. A TMDL is triggered when a waterbody is not able to meet and maintain water quality standards despite point sources' compliance with their National Pollution Discharge Elimination System (NPDES) permit limits, which are set by water quality standards (which are established at the state level due to significant geographic variations in watersheds) or technology-based standards (usually set at the federal level).[12] The problem is the accumulative impacts of the discharge of the pollutant, caused by the total number of sources and the total quantity of their effluent or emissions, and which lead to water quality problems that interfere with the human and biological uses of the waterbody. Permits issued over time for individual sources are not able to identify or address that situation but instead focus on the concentration levels of the pollutant per volume of water or air.

The TMDL establishes a cap under which trading, along the lines of the cap and trade model, could proceed, if all sources under the cap had permits or other legal means of verifying and enforcing reductions. While the Acid Rain Program's cap only covered one sector of fairly large sources, the TMDL must allocate the cap among all identified sources contributing to the pollutant loading in the waterbody. TMDLs must not only assign shares of the cap to the point sources – those that hold an NPDES permit – in the form of individual Waste Load Allocations (WLAs), but also assign Load Allocations (LAs) to different categories of nonpoint sources and to natural background. EPA's current TMDL guidance states that Load Allocations allocations may range from "reasonably accurate estimates to gross allotments."[13] The Waste Load Allocations are then translated from the individual point sources' assigned pollutant loads to an effluent limit in a federally-enforceable NPDES permit, which provides considerable assurance that the reduction assigned through WLAs will be met. The implementation of Load Allocations, however, is left entirely to States and Tribes, with only vaguely worded guidance allowed to be offered by EPA as to how the LA will be achieved. As stated on the EPA Office of Wetlands, Oceans and Watersheds website,

> "States, territories, and authorized tribes should describe a plan for implementing locations for waters impaired solely or primarily by nonpoint sources, including
>
> - Reasonable assurances that load allocations will be achieved, using incentive-based, non-regulatory or regulatory approaches. TMDL implementation may involve individual landowners and public or private enterprises engaged in

---

11 The Clean Water Act, section 303, establishes the water quality standards and TMDL programs.

12 A full definition of TMDLs and how they are established is provided on EPA's Office of Wetlands, Oceans and Watersheds website: www.epa.gov/owow/tmdl/

13 *Ibid.*

agriculture, forestry, or urban development. The primary implementation mechanism may include the state, territory, or authorized tribe section 319 nonpoint source management program coupled with state, local, and federal land management programs and authorities;

- Public participation process, and
- Recognition of other watershed management processes and programs, such as local source water protection and urban storm water management programs, as well as the state's section 303(e) continuing planning process."[14]

The main similarities of the TMDL's effluent cap to the Acid Rain Program's emissions cap on fossil-fuel fired electric utilities is that the TMDL cap provides a comparable quantitative limit on a single pollutant to a defined geographic area, and that the TMDL cap implements the point sources' share of the reduction goal through federally enforceable permits. The TMDL's key difference, however, is that it requires the inclusion of a much more complete but varied set of sources. Furthermore, since nonpoint sources do not have NPDES permits, the ability to achieve pollutant reductions through the implementation of Load Allocations depends on the rigor of state or local regulations applying to those sources. While some states require nonpoint categories, such as agriculture or forestry, to implement specified Best Management Practices (BMPs), other states prefer a voluntary approach, encouraging the adoption of BMPS with incentives of subsidies or cost-share programs administered at the state or federal level.

Trading under a TMDL between point sources, who, by definition, hold federally-enforceable NPDES permits, appears to fit the Acid Rain Program trading model of a cap-and-trade approach. However, bringing nonpoint sources into the trading environment under a TMDL and with no permit to enforce their reductions poses many challenges that have not yet been addressed by the Acid Rain Program's cap-and-trade approach. The Acid Rain Program's "opt-in" feature allows sulfur-dioxide emitting industrial sources who also hold federally enforceable permits to join the trading program along with the fossil-fuel fired utilities, yet they are required to adopt the same regulatory requirements and their addition to the program serves to expand the cap to a new subset of similar sources. In contrast, bringing in non-point sources under a TMDL-based trading program requires careful consideration of how to define and enforce a pollution reduction from a source without a permit that is very dissimilar to the NPDES permitted point sources that would also be trading under a TMDL. Furthermore, the non-point sources are already included in the TMDL cap, so the real challenge is how to implement trading so that the traded commodity is surplus to the reductions assumed to be taking place by the TMDL, as well as verifiable and enforceable.

While creating an opportunity for nonpoint sources to participate in TMDL-based trading poses many serious challenges, it is worthwhile to study and attempt to resolve these issues through an innovative trading system because the cost of reductions from these non-permitted sources can be considerably cheaper than the cost of reductions required of point sources under a TMDL's

---

[14] *Ibid.*

assigned Waste Load Allocations.[15] Since the TMDL's allocation process is not required to address cost considerations, water quality trading provides an important opportunity for lower cost pollution reductions to be identified and implemented in the watershed within the TMDL implementation framework.

Applying "Cap and Trade" Design Elements in the Lower Boise River's Water Quality Trading System

The following section describes the fundamental elements of the cap and trade approach that can be incorporated into a TMDL-based water quality trading program, to ensure it is best equipped to achieve the environmental goal at less cost than would be possible without the use of trading. However, the trading system design must also accommodate the particular challenges of incorporating nonpoint sources into the water quality trading program, while not sacrificing the trading program's mandate to achieve the environmental goal established by the TMDL.

Potential solutions to these challenges are highlighted by a discussion of the design elements established under the trading system developed by EPA Region 10, Idaho Department of Environmental Quality (IDEQ) and the stakeholders of the lower section of the Boise River in Idaho. The Lower Boise River watershed was selected in 1997 as the site of EPA Region 10's first water quality trading demonstration project in the region, launching a three-year collaborative process for developing a trading system to support implementation of the Lower Boise River's phosphorus TMDL. Although the trading system design was completed in 2000[16], its implementation through the issuance of the Lower Boise River TMDL and subsequent NPDES permits that would contain phosphorus limits and authorization to trade to meet those limits has been unexpectedly delayed.[17] Despite the fact that the trading model developed for the Lower Boise River is not tested through implementation, its design was based on careful consideration of other water quality trading approaches, as well as the lead EPA representative's (*i.e.*, the author's) familiarity with both the Acid Rain Program's cap and trade model and examples from a few states' attempt to develop an alternative to a cap and trade program, known as "open market"

---

15 See Faeth, Paul, "Fertile ground: Nutrient trading's potential to cost-effectively improve water quality," *World Resources Institute*, 2000.

16 See Idaho DEQ's website for a full description of the trading system and the collaborative process used: http://www.deq.state.id.us/water/tmdls/lowerboise_effluent/lowerboiseriver_effluent.htm

17 This is due to the Lower Boise River TMDL's geographic and environmental link to a delayed set of TMDLs for the Snake River/Hells Canyon complex. The Boise River flows into the Snake River and is its largest source of phosphorous above the Brownlee Reservoir, where significant water quality impacts have impaired the beneficial uses. The Boise River itself is not considered to be impaired by phosphorus under Idaho's water quality standards for nuisance aquatic growth, and therefore the point sources on the Boise River do not currently have phosphorus limits in their NPDES permit. Because the Snake River's TMDL will set the reduction target for the Boise River's TMDL, the trading system cannot be implemented until the series of TMDLs are completed and approved by EPA. The delay (as of April 2003) in Idaho DEQ's submittal and EPA's approval of the TMDLs are for reasons unrelated to trading.

trading.[18]

1. *Hybrid Approach to Cap-Based Trading to Allow Non-Point Source Reductions to be Traded*

One of the primary benefits of a cap and trade approach, as demonstrated by the successful Acid Rain Program, is the certainty that the environmental goal will be achieved through the strict enforcement of the cap. The certainty that the cap will be maintained is provided through several important program elements: stringent emissions monitoring requirements; the automatic penalties for violations combined with the requirement that any exceedance be offset by allowances deducted from the source's account for the following year; and the trading system's banking system type of accounting safeguards for all allowances circulating in the system to ensure that no fraudulent allowances are created. Together these features ensure the integrity of measuring and accounting for the required pollution reductions needed to maintain the cap so that the sulfur dioxide allowance has value as a tradable commodity.

Prior to the development of the water quality trading system for the Lower Boise River, the relatively few water quality trading projects already in place had emphasized providing as much certainty as possible that the reductions being traded were real and enforceable. In fact, the Lower Boise River stakeholder group that was recruited to work on the trading system design considered the designs used in three different trading projects to help them determine which design would be best for the needs of the Lower Boise watershed, but ultimately rejected the three designs because they did not emphasize the market-based approach to the degree the Lower Boise stakeholders wanted, and decided to design their own water quality trading model.

First, they considered the Tar-Pamlico project in North Carolina[19], which used a group permit to serve as a cap for the point sources and under which trades between point sources would take place. These trades are administered and enforced by the Basin Association, and the members also pay a fee to the North Carolina Department of Agriculture to install Best Management Practices on nonpoint source sites, as part of the agreement for the watershed's unique permit arrangement. The Lower Boise stakeholders were not interested in this model primarily because of the unwillingness of the point sources to be bound to each other under a single group permit and the lack of a direct trading relationship between point sources and nonpoint sources. Second, they considered the Cherry Creek, Colorado project which used a newly created quasi-governmental agency to develop and administer projects to obtain nonpoint source reductions and to sell the resulting credits to willing point source buyers. Since it appeared that all projects

---

18 Examples of "open market"trading include New Jersey's Open Market Emissions Trading or OMET program, http://www.state.nj.us/dep/aqm/omet/ and Michigan's Air Emissions Trading Program, http://www.michigan.gov/deq/0,1607,7-135-3310_4103_4194-10617--,00.html

19 Links to descriptions of these three projects can be found on EPA's water quality trading website. For Tar Pamlico, http://www.epa.gov/owow/watershed/trading/cs10.htm;
For Cherry Creek, http://www.epa.gov/owow/watershed/trading/bould.htm
For Rahr Malting, http://www.pca.state.mn.us/hot/es-mn-r.html

and trade transactions must pass through this local authority to ensure their validity, the Lower Boise stakeholders rejected this model because they wanted to be able to arrange their own projects through private contractual arrangements. They also were not interested in establishing a local quasi-governmental authority to administer the projects and the trading system. The third trade model they examined was the one used for the Rahr Malting Co. in Minnesota, in which they were issued a permit allowing them discharge into the Minnesota River provided they obtained a specified amount of reductions upstream from at least one of an assortment of nonpoint source sites and BMPS listed in their permit. If they reductions failed to materialize by a set period of time, either through failure to install the BMPs properly or poor BMP performance, then the company must follow a specified construction schedule for technology-based treatment of their discharge, also specified in the permit. Upon hearing that it took more than two years to develop this type of permit, the Lower Boise stakeholder group also rejected this model because they were looking for a more flexible permit that would enable a higher volume of trading to take place on a seasonal or monthly basis, and that allowed the point sources to identify and contract for their own preferred nonpoint source projects. Furthermore, Idaho does not have a delegated NPDES permit program, with EPA Region 10 issuing its permits instead. EPA's current backlog of permits to be modified even without trading provisions discouraged any consideration of a trading system that involved a lengthy permit negotiation and approval process.

The stakeholder group instead decided to pursue a trading system modeled after the flexible permit approach of the Acid Rain Program, which specifies the conditions for trading up-front but then allows the qualifying trades to automatically adjust the permit limit without a formal review process. It also allows buyers and sellers to arrange their trades outside the permit process, only registering the results of each trade in trade recording system. In contrast to the Acid Rain Program, however, the TMDL-based water quality trading system for the Lower Boise River is not based exactly on allowances as a representation of an authorization to emit a specified amount, but instead is a hybrid of that model and a "credit-based" approach that allows non-regulated sources to sell reductions without having to become a regulated source under the program. A "credit-based" approach creates a tradable pollution credit by documenting the one-time or repeated reduction of the amount of pollution discharge for a given period of time. The credit can then be used by another point source to offset its discharge, although the time period in which the credit can be used is an important issue for the trading system design to address.

Under the Lower Boise River's approach, the point source's Waste Load Allocation is the baseline for an authorized amount of effluent to be discharged, and then any measured reductions from that amount can be documented as a tradable credit[20] that can be sold to another point source, to be used to authorize an increase in their discharge above their allocated amount. That portion is very much like the allowance-based, cap and trade system. Where it differs, however, is that reductions from non-permitted, nonpoint sources are allowed to be brought into the system. Those reductions, if created according to the program's requirements, are established as credits

---

20 Since they are allocated to point sources, it would be technically correct to call them "allowances," the term used in the cap and trade approach. However, the Lower Boise River program has chosen to call them "credits" to eliminate confusion when they are intermingled in the marketplace with nonpoint source credits

and then can be used by point sources to allow an increase in their discharge for that same pollutant. It is not the same as the Acid Rain Program's "opt-in" feature, which allows similar types of permitted sources to participate in the trading program. Rather, this hybrid system that intermingles point sources allowances and nonpoint source reduction-based credits would be equivalent to the Acid Rain Program allowing area sources or mobile sources to document their reductions in SO_2 emissions and allow those credits to be intermingled with SO_2 allowances. This type of an approach, however, is not desired nor needed by the Acid Rain Program because they are able to address two-thirds of the emitters of SO_2 by just targeting fossil-fuel fired electric utilities.

The Lower Boise River trading system has developed several features to ensure the validity of the underlying reduction upon which the nonpoint source's credit is based. This is critical to the acceptance of the credit as a legitimate tradable commodity that can be intermingled with the credits sold by the point sources. While point sources have a permit, and therefore an allocation from which credits that are sold to another party can be subtracted and transferred to the point source's account, nonpoint sources must establish a reduction and have the purchasing point source certify the validity of the reduction. Through the submission of the Reduction Credit Certificate (signed by the point source purchasing the credit), the reduction credit is created in the official Trade Tracking System and can then be transferred to the point source's account. These specific features will be discussed later in this paper, but it is important to highlight that distinction here because this is a departure from the cap and trade model which only trades allowances held by point sources. Moreover, the TMDL-based water quality trading system needed to include this design element because nonpoint sources are often some of the most important categories to address in the reduction goals of the TMDL, as well as the source of potentially lower cost reductions.

2. Low Administrative and Transaction Costs through Pre-Established Trading Conditions

Another significant feature of the cap and trade model is its ability to achieve the environmental goal at less cost. In addition to the cost savings from using reductions generated more cheaply by another source, the transaction costs for the point source to use the reductions should be kept as low as possible, without sacrificing the achievement of the environmental goal. It is extremely important to the success of the trading program that these transaction costs not exceed the cost savings derived from allowing actual reductions to be obtained from those who can do it at the lowest cost. In addition, the costs incurred by the regulating agency administering the program should not be excessive over the life of the program, since these administrative costs should also be factored into the decision as to whether or not a trading program is worthwhile to undertake. These are important design principles that should be integrated into the TMDL-based water quality trading system in order for trading to realize its full potential for achieving the TMDL's reduction goal at less cost.

For the Acid Rain Program, the source of these low administrative costs and transaction costs is rooted in how trading is authorized in the sources' permits, how EPA approves the trading transactions, and how it assigns liability for the validity of the reductions. Since the SO_2 trading is authorized in the 1990 Clean Air Act Amendments, EPA was able to establish permits that allow trading with minimal regulatory interference or approval procedures. The permit allows sources to adjust their initial permit limit (as determined by its allowance allocation) automatically through trading, by referring to the Allowance Tracking System as the official record of allowances held in the point source's account. Each allowance held in the source's account allows it to emit a ton of SO_2 for the year designated by the allowance. Compliance is determined at the end of 60 days following the end of the calendar year, by deducting enough allowances held in the account against the sources reported emissions. This calculation is performed in an EPA-administered system called the Annual Reconciliation System. Because each permitted source is held liable for compliance with their trade-adjusted emissions limit, reductions do not need to be verified first before an allowance can be transferred to another source's account. Automatic financial penalties[21] are triggered when the reconciliation system determines that the permitted source failed to hold enough allowances to offset its reported emissions, and the missing amount of allowances are deducted from the next year's account. In this way the environmental goal of the Acid Rain Program is not violated and the permitted source has a strong legal and financial "incentive" to stay in compliance with the allowance holding requirements of the program.

In the Lower Boise River's trading system, the authorization to trade is found in the EPA Water Quality Trading Policy and its interpretation of the provisions of the Clean Water Act. While specific permit language has not yet been written, the Lower Boise's trading framework calls for the permit to allow the point source to adjust its initial permit limit (as determined by its Waste Load Allocation set by the TMDL) automatically through trading, by referring to the Trade Tracking System as the official record of reduction "credits" held in the point source's account, similar to the approach used in the Acid Rain Program. Each credit allows the point source to discharge a unit of phosphorus, which is expressed as "pounds per day," the same unit of measure referred to by the Waste Load Allocation. Reconciliation of the adjusted permit limit (as reflected in the point source's Trade Tracking System account) with their reported discharge amount is done 45 days after the end of the month, to be consistent with the TMDL's targets for demonstrating achievement of the environmental goal and other monthly reporting requirements (e.g., the Discharge Monitoring Report).

Unlike other water quality trading programs, the Lower Boise River's trading framework does not require EPA or state review of each credit transaction by a point source as a formal modification to its NPDES permit. Administrative and transaction costs are held to a minimum, in a manner similar to the Acid Rain Program's system, because the regulator's effort instead has been placed on defining the trading requirements and conditions on trading that must be developed in advance of trading being allowed to take place. Under the Lower Boise River's trading framework, credits

---

21 Title IV of the 1990 Clean Air Act set these penalties at $2,000 per ton and tied the amount to the inflation rate set by the Consumer Price Index. As of 2001, the Acid Rain Program reported the penalty amount to be $2,774. In 2001 these provisions resulted in fines of $30,514 to cover a shortfall of 11 allowances by two electric utility units, and 11 allowances were deducted from their year 2002 account. http://www.epa.gov/airmarkets/cmprpt/arp01/2001report.pdf

must be held in an account in a central trade database, called the Trade Tracking System, in order for them to be transferred to another account in the system or deducted as part of the monthly compliance process with the point source's NPDES permit limit. The point source's assigned Waste Load Allocation is their initial account balance, and they can purchase or sell credits by submitting a Trade Notification form to the Trade Tracking System, which will be run by the newly established non-profit group, the Idaho Clean Water Cooperative. Both the buyer and the seller must sign the Trade Notification Form, authorizing the transfer of credits from one account to the other, but no regulatory review of the transaction is needed. Credits established by nonpoint source reductions, on the other hand, must be created in the Trade Tracking System, when triggered by the submittal of the Reduction Credit Certificate. This document is filled in with information provided by the nonpoint source, calculating the amount of reduction available as a tradable credit (how this is done will is discussed in the next section) and signed by the purchasing point source, certifying that they have verified that the information is truthful and accurate. The document is submitted at the end of each month for which the practice generating the reduction is in effect, so that it is reporting a reduction that already took place. Once the Reduction Credit Certificate is recorded in the Trade Tracking System, the two parties must then submit a Trade Notification Form to transfer the credit to the point source's account so that they can use it to offset an equivalent amount of discharge for the same month. To accommodate the length of time needed to verify and certify the reduction and submit the forms, the point source's required compliance report, the monthly Discharge Monitoring Report, is not due until 45 days after the end of the month to which it applies.

The fact that the point source signs the Reduction Credit Certificate means that liability for the validity of credits used to comply with their NPDES permit remains with the point source. Some water quality trading programs in other states choose to shift that liability to the regulatory agency by requiring credits, or the demonstration of the reductions themselves, to be reviewed and approved by the regulating entity before they can traded. While it may provide more certainty in the validity of the reduction, the significant time delay and uncertainty of approval can be quite burdensome to the point source wishing to use the credit, as well as assign some degree of regulatory liability to the nonpoint source. Both point sources and nonpoint sources bear the sizeable transaction cost resulting from this trade approval process, which often discourages them from participating in very many trades. To minimize those transaction costs as much as possible, the Lower Boise River trading framework keeps the liability for the validity of the credits with the point source, by having them certify the reductions on the Reduction Credit Certificate and be subject to the standard Clean Water Act penalties if a subsequent audit finds they provided a false certification. However, the trading framework lets them manage the risk associated with purchasing reductions from a nonpoint source by whatever terms they choose to include in their private contracts to purchase the credits from the nonpoint sources. These private contracts provide an incentive for both parties to manage the risk inherent in this transaction relationship to the most economically efficient outcome. Other elements in the trading framework seek to minimize the transaction costs associated with trading by providing as much certainty up-front to the point source as to what constitutes a valid reduction by a nonpoint source. These elements are discussed in the next section.

It is important to note that the type of work to be invested in establishing these conditions at the outset of trading should be viewed as roughly the same as would be made in reviewing trades on a case-by-case basis if the permit modification approach were used. The level of effort overall should be considerably less since it is done just once, as part of the design of the program, and with the same information that would be available to a permit reviewer for a case-by-case decision. By also providing clear information to the trading participants at the outset as to what trades are acceptable, the work of reviewing trades is essentially transferred to the trading parties who screen the proposed trades themselves. The regulator's role is then deferred to the compliance and audit processes, which is an appropriate place to review trading activity and to enforce the program's requirements.

3. Determining the Conditions on Trading at the Outset Instead of Trade-By-Trade Review

The work involved in establishing the conditions on trading includes:

a) defining the commodity to be traded so that it is as uniform and consistent in its environmental impact as possible;

b) defining the reduction practice and quantification methods to be used in order for its resulting reduction credits to be approved and considered valid for trading;

c) ensuring the credits generated and traded are surplus to the reductions assumed to be taking place under the TMDL; and

d) determining what other permit limitations should be in place to prevent any adverse local impacts in the waterbody as a result of trading.

The following is a summary of how the Lower Boise River's trading framework addressed these important elements.

a) Defining the commodity: Important factors to consider in defining the commodity to be traded are: form, impact, time and quantity (the latter which will be discussed separately).

Form: The research conducted to support the phosphorus TMDL for the Lower Boise River and the Snake River showed that Total Phosphorus was of concern, rather than its other forms. That meant that even though point sources generally discharge phosphorus in its dissolved form and nonpoint sources contribute its sediment-attached form, the two would be considered equivalent forms of phosphorus for the purposes of trading.

Impact: In the Boise River, roughly 50% of the phosphorus loading is from point sources and 50% from nonpoint sources, but their locations are scattered throughout the watershed. The likelihood of Best Management Practices (BMPs) installed by nonpoint sources resulting in reductions that can be measured in the river is also influenced by where the sources are located in relation to irrigation diversions and return flows to the river. Given that the Boise River itself is not considered to be impaired under Idaho's nutrient standard, the TMDL's reduction target for the Boise River is measured at the mouth of the Boise River where it meets the Snake River, near the small town of Parma. Therefore, the environmental impact of the location of phosphorus reductions along the

Boise River needs to measured in terms of their effectiveness in achieving visible reductions in the phosphorus loadings in the Boise River at the location near Parma. This common of point of reference for comparing the equivalency of their impact is termed “Parma Pounds,” referring to how much of a reduction in a pound of phosphorus achieved further up in the watershed will show up at the location near Parma. “Parma Pounds” are calculated by applying up to three sets of ratios to a quantity of reduction at any point in the watershed. The first set of ratios is termed “river location ratios,” and they refer to the location of the source’s discharge along the Boise River itself. They were developed using a mass balance model that accounts for inputs, withdrawals, and groundwater. The second set is termed “drainage delivery ratios” and they adjust the reduction amount further by applying a set of distance-based factors if the source is located along a creek or drain that flows into the Boise River. Similarly, the third set of ratios, termed “site location factors” adjust the amount even further if the source is located away from the drain or creek, because its reduction impact is less effective due to increasingly indirect hydrological connection to the Boise River.

Time: There are two aspects to the role of time as it relates to water quality trading. One is that the underlying reduction upon which the credit is based must occur in the same time period as when the credit will be used. This time period is determined by the TMDL and is based on consideration of seasonal hydrological flows and related water quality impacts. It also means that water quality trading programs should rarely allow “banking” of credits - i.e., the ability to save credits for use in another time period. In the Lower Boise trading system, credits are not created until the end of the month and rely on documentation that the reduction occurred during that month. Point sources can then only use credits generated in the same month as their discharge of the pollutant to be offset.

The second aspect of time as it relates to water quality trading is that the effectiveness of the reduction practices used to generate credits offered in the market must be aligned with when the point sources will be needing credits, in order for the market for credits to be able to match the available supply and demand. The Boise River TMDL for phosphorus could require reductions during the irrigation season or it could require reductions year-round, but the effectiveness of most Best Management Practices that agricultural nonpoint sources would undertake are limited to the irrigation season because of their interaction with managed water flows and growing seasons. Therefore, if held to year-round reduction requirements and if their own phosphorus discharge amounts do not vary with the season as well, point sources will need to look for credits generated by non-agricultural sources or consider installing treatment technologies themselves.

b) **Identifying the acceptable reduction practices and determining the reduction quantity**: While measurement methods for point source discharges are well established and specified in the NPDES permit, measurement methods for quantifying nonpoint source discharge and reduction amounts are far less known. However, reductions from nonpoint sources will need to be determined with as much accuracy as possible in order for them to be treated as equivalent to point source reductions and established as credits to be traded. Under the Lower Boise River trading framework, a list of approved Best

Management Practices (BMPs) and their measurement or estimation method was established by the state's BMP Technical Committee so that point sources would know in advance what practice and what quantification method was determined to be satisfactory by the regulators.[22] Measurement methods were given preference over estimation methods in that they would receive the full credit amount they measured, while a small "uncertainty discount" would be applied to the quantity determined by the calculation method. However, estimation methods may currently be more accurate overall, given that the performance of many BMPs are heavily influenced by the size of the field and the type of crop planted.

This information provided in advance by the regulator of what constitutes an "approved" credit is important for the market to perform efficiently, since it is a "buyer beware" market. The point source is liable for the validity of the credits it uses, so it needs to know in advance what criteria it should apply in assessing the legitimacy of a credit before purchasing it. Point sources may choose to purchase credits in the open market after they have been created, or in a long-term private contract with the nonpoint source for delivery of a specified number of credits over time.

c) **Ensuring credits are based on reductions surplus to the TMDL's reduction goals**: In the case of trading between point sources, the reductions that are traded are considered to be consistent with the TMDL's reduction goals because the permit limits established by the Waste Load Allocations can be directly enforced under the NPDES permit program. A credit sold and transferred out of the point source's account is a reduction in the source's permit limit; a credit purchased and transferred into their account is an increase in its permit limit.

However, in the case of a nonpoint source generating a reduction to be used as a credit, the TMDL assumes the nonpoint source discharges will not exceed their "share" of their sector's assigned Load Allocation, yet there are no permits for nonpoint sources with which to enforce the reduction goal. Instead, the TMDL implementation plan usually identifies a reduction strategy involving a set of sector specific requirements (e.g., Washington State's Forest Practices Act[23]) or specific state and federal cost share programs and types of BMPs that will be targeted to that watershed, to work towards achieving the reduction goal (e.g., the Environmental Quality Incentives Program (EQIP) sponsored by the U.S. Department of Agriculture's Natural Resource Conservation Service). Some states will also have a minimum set of requirements or set of practices that a category of nonpoint sources will need to implement to be in compliance with the TMDL. In the case of the Lower Boise River TMDL, the state of Idaho relies on targeting farmers in the TMDL's watershed with EQIP cost share funds administered through the Soil Conservation Districts.

---

22 This BMP List is still in draft form, but will be made publicly available as part of Idaho DEQ's rulemaking process for the Lower Boise River's water quality program.

23 Washington's Forest Practices Rule, WAC 222 http://www.wa.gov/dnr/htdocs/forestpractices/rules/

Since participation in those programs is only voluntary, a more reliable approach for nonpoint source reductions was needed to satisfy EPA's Water Quality Trading Policy that the reductions used as credits be "surplus" to the reductions assumed to be taking place by the TMDL. "Surplus" means that the nonpoint source credits must be based on reductions above and beyond those that an individual nonpoint source must make in order to meet their sector's Load Allocation. Therefore, the Lower Boise River stakeholders agreed that a "voluntary water quality contribution" would be made from each BMP's measured or estimated quantity of phosphorus reduced prior to application of the three sets of ratios to convert it to "Parma Pounds." The amount of the contribution would be determined by Idaho DEQ as part of the TMDL implementation plan, but would be established as an individual farmer's share of the reductions needed to achieve their sector's Load Allocation. While participating in the trading program is voluntary, the "water quality contribution" is required for establishing a credit by a nonpoint source, under the Lower Boise's trading framework.

d) **Establishing protective limits to prevent local impacts from trading:** In addition to ratios that address environmental equivalency based on location, other protective measures may be needed to prevent the creation of a "hot spot" or local impact on water quality. This may be caused by the accumulative loading of the pollutant from dischargers upstream or the discharge of single point source at that particular location due to unique environmental sensitivities in that section of the waterbody. In either case, a limitation in the point sources' permits may be needed to restrict how much that point source may discharge no matter how many credits they hold in their account. This limit setting an upper bounds on how much can be discharged will supercede the authorization to use credits, but not their ability to hold credits or sell them to others. This is similar to the state or federal ambient standard's constraint on how much sulfur dioxide an electric utility may emit, despite the number of allowances they hold under the Acid Rain Program. However, in the case of water quality trading, this limit will be based on how the State or Tribe defines its water quality standard for that pollutant or environmental condition, which may be a narrative standard, such as Idaho's standard for nuisance aquatic growth, rather than a numeric standard for phosphorus. Water quality trading will be best supported if the narrative standard can be translated into a numeric limit for a specific pollutant contributing to the condition that is being addressed, so that the source will have a clear indication in advance of how much it can discharge and not have to revisit any trades it may have conducted. The Lower Boise River trading framework has not yet established that limit for the point sources' NPDES permits because such analysis needs to be based on data and conclusions associated with the TMDL, which is yet to be completed.

The Lower Boise River trading framework was developed by its stakeholders with a careful eye towards maximizing certainty of the phosphorus reductions underlying the tradable credit, while minimizing transaction and administrative costs as much as possible. Its design also reflects an intent to let the market create incentives and competitive pressure for improving the performance of phosphorus reduction technologies and BMPs by letting sources sell surplus reductions as easily as possible. Improving the accuracy of measurement or estimation methods of those reductions is also valued in the marketplace by the point sources' willingness to pay for credits reflecting such improvements. In addition, market participants have an incentive to insist that the list of approved BMPs reflects the most recent research in improving BMP performance and reduction quantification methods.

The Lower Boise River trading framework addresses many of the risks associated with water quality trading with a cost-effective, market-oriented approach. These risks stem from the concern that BMP reductions are not equivalent to point source reductions in terms of their actual effectiveness in reducing pollution between the different geographic locations of the buyer and seller in the watershed, uncertainty that the BMPs are being implemented properly, or that the seller is not liable if the underlying reduction for the credit is invalid. Other water quality trading programs have lumped these risks into a single trading ratio, such as requiring two pounds of nonpoint source reductions be used for every pound of a point source's discharge it offsets. This approach can make the use of credits very costly, which may erode any potential cost savings for the point source. The effect is to discourage point sources from using credits to avoid installing costly compliance technology themselves, and to dissuade nonpoint sources from undertaking any reduction practices that exceed the minimum of what is required. Consequently, the overall cost of implementing the TMDL will be higher than it may have needed to be. Instead, the Lower Boise River trading framework attempted to identify each type of risk and address it separately, with such elements as the location-based ratios, the list of approved BMPs, and the use of private contracts between the trading participants to manage the transaction-based risk themselves. In this way, water quality trading cannot only learn from the cap and trade model in terms of minimizing transaction and administrative costs, but also adapt the model further to incorporate unregulated nonpoint sources, and therefore serve as a model for a the next generation of trading programs that must address a wide variety of trading sources and pollutants.

Conclusion

The remarkable achievements of the Acid Rain Program's SO_2 emissions trading program can be partly attributed to its statutory mandate established by the 1990 Clean Air Act Amendments and the nature of the environmental problem it is designed to address. However, much of the credit should also be given to the design of the trading system it used to achieve the mandated reductions. The cap and trade model provides many important lessons that can be applied to other trading programs to help them achieve their environmental and economic goals. Once the environmental goal is firmly established, the contributing sources identified, and trading is selected as an implementation strategy to achieve the reductions at less cost, careful attention should be paid to how important elements of the program will determine how well the trading system can function. While many will focus on the differences between the regulations and the nature of the environmental impacts involved in air pollution versus water pollution, there are many important lessons that can be applied from the success of the cap and trade model established for SO_2 trading to water quality trading. Moreover, successful water quality trading programs may lead the way in developing our understanding of how such market-based approaches can engage regulated and non-regulated sources in a business-like relationship to accomplish important environmental goals at less cost to society.

Storm Water Trading
Haynes Goddard and Hale Thurston, US EPA, National Risk Management Research Laboratory

Haynes Goddard:

We've been exploring the possibility of using a tradable runoff allowance system to help manage storm water runoff. This is a new line of research not yet supported by any legislation—sort of forward looking. The problem is the growth in impervious surface in urban areas, which leads to increased storm water runoff, which causes flooding, combined sewer overflows (CSOs), damage to stream ecology, and reduced ground water recharge. Traditional solutions from the construction or engineering side involve building something. Generally, the idea is to expand your centralized infrastructure (e.g., collector system sewers, treatment plants, storage facilities, deep tunnels) to handle higher flows and increase storage capacity. Unfortunately, these strategies often result in diminished ecological integrity of streams, and they fail to add to ground water recharge. What's more, the infrastructural approach is quite expensive. Of course that brings up the question of whether there is a cheaper way to address the problem and whether trading might have a role.

We believe there might be a role for some sort of pollution credit trading. It's possible that the total cost of numerous storm water runoff abatement initiatives on individual parcels will be lower than the cost of implementing a more traditional, centralized approach to the problem. Of course you would need some coordinating mechanism to encourage individual parcel owners/managers to invest in the abatement strategies that yield overall cost savings—you need the market incentives. So, we are directing our research toward using ecological economics, where we factor in natural capital explicitly as part of the solution. In other words, we are investigating the economic advantages of using more natural capital (as opposed to man-made capital) as part of the storm water management infrastructure. The idea is to create a market that supports broader use of such strategies as dispersed detention, retention, infiltration, evapotranspiration, and evaporation in storm water runoff management. The acronym for such strategies is BMPs, "best management practices." So, the challenge is to design a market-based incentive system that encourages coordinated investments in BMPs as natural capital, ultimately resulting in a least-cost configuration. Toward this end, we are currently working to identify the properties of an optimal system and checking for cost heterogeneity. The system design will be dependent on these factors.

In our research, we have looked at a multitude of data regarding water flow in streams and rivers. When we plot a stream's water flow (cubic feet per second) over time, we get a highly variable graph with peaks and troughs that echo rainfall events and droughts in the area. Given a static stream capacity, we are interested in comparing exceedances of this capacity prior to development of the area with exceedances after development. Over and over again we find that stream capacity exceedances increase in both number and severity as a watershed area undergoes development. Again, the main issue is the increase in impervious surface area that accompanies standard land development operations and that leads to flooding and all the other problems. The primary runoff policy objective for any storm water runoff trading system is to reduce stream capacity exceedances.

In designing the framework for a trading system that will help achieve this objective, we are presented with a standard cost minimization problem, subject to an explicit stream flow constraint. Natural capital solutions, though relatively inexpensive to implement, can take a while to achieve the level of abatement desired. Traditional, centralized infrastructure solutions, on the other hand, are cost intensive but achieve the runoff abatement desired (and, consequently, reduced exceedances) in a relatively short time period. However, it is not cost-effective to employ major infrastructure investments designed to handle the maximum expected runoff episodes—there would be substantial idle capacity between major rainfall events. We believe that increasing the natural capital component in the ratio of the two technology options will result in fully effective runoff abatement at a reduced total cost. The idea is to find the right combination of investment of BMPs such that the overall costs of staying within the stream capacity are minimized. Then we need to design the trading market system that supports the implementation of the optimal blend of abatement technologies, i.e., the "least cost capital combination."

A critical factor in the design and implementation of a storm water runoff trading system is the individual homeowner. What exactly is the welfare cost at the parcel level? A homeowner is going to lose some utility by having to use some of his land and spend some of his money putting BMP technologies on his property—that's a reduction of his welfare. This a critical issue that we are interested in: just how much is the real cost at the parcel level based on people's willingness to pay? Of course this applies to parcel-level commercial/industrial owners and public entities as well as homeowners.

Remember, the whole idea here is to bring stream capacity exceedances under control. To monitor improvement and success in this effort, it is necessary to establish some baseline standard—say, for example, that we shouldn't exceed stream capacity more than X-percent of the time. The difference in this problem is that an explicit probabilistic, or stochastic, constraint is introduced. The relationship between stream flow and exceedances is used to show the cumulative distribution probability indicating how often we will exceed a given stream capacity based on stochastic (i.e., meteorological) events. A note on language: Engineers typically talk about storm water control in terms of "hundred-year floods" and "twenty-year floods." In "exceedance" terms, a hundred-year flood would correspond to a 1% exceedance, and a twenty-year flood (which occurs five times as often) would correspond to a 5% exceedance.

Our model accounts for the fact that storm water or hydrologic outcomes tend to be log-normally distributed. So, we can create a graph showing the current exceedances of our chosen standard and compare this with a graph showing projected exceedances after the introduction of BMPs coordinated through trading, noting the shift in the mean and variance. The model has some notable first-order conditions: We are minimizing cost with respect to household investment, with two corresponding issues of interest—the mean and variance of the log normal distribution. What is of interest is that we have expressed marginal costs in units of reduction of probability of exceeding the stream standard. Our plan is to incorporate these conditions into the actual design of the trading system, but we have not yet done that.

So, we believe that dispersed investments in BMPs will likely be part of a least-cost solution to managing storm water runoff. Furthermore, we think that runoff credit trading is going to be a viable mechanism for fostering and coordinating parcel-level BMP investments. Of course, for trading to be viable, there must be available, affordable technologies that will work at the parcel level. They do exist, but much more needs to be known about how well they work and what they cost. Of course, there also has to be cost heterogeneity; in this case it's spatial, largely, but it also has to do with the willingness of people to participate in the trading market. This issue is dealt with in more detail below.

Hale Thurston:

Taking this discussion from the theoretical to the practical, let's look at how we sort of applied these concepts to a small watershed in Cincinnati, at least in a modeling stage, and then where we want to go from here as far as perhaps actually applying it in real life. The three main issues to explore are:

- First, our hydrology—how we went about establishing the point-sourcification of this non-point source problem by determining each property owner's excess runoff using hydraulic modeling.

- Second, and foremost, the actual trading as we envision it now.

- Third, and aftmost, some of the ongoing research and future research we intend to get into to make this as realistic as possible.

The Shepherd Creek area on the west side of Cincinnati was chosen as a pilot project, case-study area specifically because it has some heterogeneous land use—there are some housing developments, some commercial property, and some large ranch-type parcels. Shepherd Creek flows into the west fork of Mill Creek, which goes on into the main Mill Creek, which you may have heard about as a fairly degraded watershed in Cincinnati. Also, these portions of Shepherd Creek (SC) are highly degraded due to high peak volume runoff during storm water events.

In the case study, we first collected as much data as possible in ARC View and tried to point-sourcify the individual parcels in the Shepherd Creek area. This involved compiling parcel boundary data from the Hamilton County auditor and imagery collected from the Cincinnati-area GIS fly-over to help identify impervious surface. Using Microsoft Excel to perform various calculations on the pertinent parameters, we were able to estimate the pre- and post-development runoff from each parcel. The difference then between the pre-development and post-development values is the excess storm water runoff that, in our trading scheme, each parcel owner is responsible for. It may turn out that the specific ecological constraint for a particular area will not require abatement to pre-development levels, which will enable us to reduce each parcel owner's obligation by a corresponding factor.

Now, once we've assigned individual parcel values, how do we control this excess storm water runoff that's causing the degradation in the stream in the SC area? A necessary but not sufficient condition for any trading scheme to take place is that we have heterogeneous cost and control. There are a variety of BMPs available to different parcel holders for controlling storm water runoff. These include infiltration trenches, dry wells, rooftop storage, green roofs, vegetative filter strips, rain barrels, swales, porous pavement, engineered landscapes, and reduced use of curbs and gutters, among others. Crunching the numbers in Excel again, and assuming that each parcel holder uses the least-cost technology available to him to abate the storm water runoff that he is responsible for (or assuming, alternatively, that he buys allowances from a clearinghouse—a storm water utility or something), we estimated a permit value of $5 per cubic foot of storm water detained. In our calculations, this trading scheme solution ends up being somewhat less costly than the large infrastructural solution to the problem for detaining storm water.

Our first extension then is to say, "Well, maybe we don't have all the costs factored into our cost functions for these BMPs." So my first point of attack was to try to establish residential opportunity costs. To my knowledge, Sample, et. al. is the only one heretofore who have addressed the opportunity costs of devoting portions of residential parcels to management practice. They used real estate tax appraisal values in their study. Along the same lines, we used a hedonic analysis to try to establish market value for this land that was going to be dedicated to BMP. We ran a hedonic estimation on some 24,000 observations—the dependant variable, of course, being the sale price, with the standard cast of cost-factor characters: number of baths, square footage (including the total square footage of the parcel size), etc. The estimated coefficient on net loss, which was the net parcel size—that's net the house, the approved building on the lot—was approximately 27 cents. The estimated coefficient then is the marginal value of an additional unit of the thing.

It's important to note that the opportunity cost of commercial property is probably going to be significantly higher than that for residential property—you know if you take away a parking space or something like that from a commercial property, it's probably a more costly trade-off than a homeowner's giving up garden space to install a BMP. So far this is what we've got, and so our cost function, instead of just being 4.94 times the quantity dedicated to it, is also plus this 27 cents times the footprint of the property.

Going forward, we want to develop our market plan more fully and flesh out the legal framework that will support it—Punam Parikh is helping us address some of those tough but critical issues. We also want to use some continuous hydrologic modeling as opposed to the single-event storm modeling we used to generate our data for the case study, and we need to look into trade ratios and what we call "wetspots" as opposed to hotspots. Obviously we have to look at opportunity costs for commercial properties if these non-point sources are all going to trade with each other. In our SC case study we used sort of an experimental auction approach to trading allowances to help us verify our initial cost estimates. Expanding on this idea will also help us see what people are willing to pay for land use that increases runoff—or demanding as payment for agreeing to have runoff-decreasing BMPs in their yards. We really do want to make this a practical application of trading.

Experimentation with Watershed-based Trading Using the Internet[1]

Mark S. Landry
Abt Associates Inc.
4800 Montgomery Lane, Bethesda, MD 20814

Paul Faeth
World Resources Institute
10 G Street, NE, Washington, DC 20002

ABSTRACT

Watershed-based trading programs may result in cost-effective improvements in water quality. However, a variety of implementation issues need to be resolved before trading will become broadly acceptable. *NutrientNet* (www.nutrientnet.org) is an e-marketplace designed to provide easily accessible and user-friendly tools to estimate and trade nutrient credits over the Internet. This tool is designed to (1) lower transaction costs of trading by easily identifying market participants, (2) standardize nutrient credit estimation to establish credibility and (3) track trades efficiently for oversight by government agencies and the public. A *NutrientNet* user can identify and characterize their operation, estimate baseline and mitigated nutrient loadings, review expected costs and potential number of credits available to buy or sell, and trade credits at the Website marketplace. *NutrientNet* has been developed for the Kalamazoo watershed in Michigan and is currently being developed for a sub-basin in the Chesapeake Bay watershed. Development and market experimentation with the Website suggests *NutrientNet* may be a useful tool for States to aid in meeting water quality objectives.

---

[1] Opinions and assertions expressed in this paper are solely those of the authors and do not necessarily represent the views of the U.S. government.

DISCUSSION

Background on Watershed-based Trading

Watershed-based trading programs—where pollutant credits and resource rights are clearly defined, enforceable, tradable, and typically capped within watersheds—may improve or preserve water quality more efficiently and effectively than alternative, conventional approaches. Defining and creating a tradable commodity, such as a phosphorus reduction credit, is contingent on being able to quantify and enforce the pollutant source, loading, and/or amount sequestered or utilized. As a result, tradable credits allow two parties to shift allocation of regulatory responsibility in order to lower pollution control costs.

The U.S. Environmental Protection Agency (EPA) finalized the National Water Quality Trading Policy in January 2003 to provide guidance for States to implement watershed-based trading programs that will potentially reduces the cost of compliance with Clean Water Act regulations. The conceptual framework for watershed-based trading has become clearer over time with greater experience using appropriate trading program criteria. Lessons learned from various trading pilot studies helped shape the Water Quality Trading Policy through the identification of successful programs and approaches, as well as understanding obstacles and barriers to trading. Successful implementation of watershed-based trading programs will depend on the development of innovative tools to break down barriers and facilitate trading.

Overcoming Certain Barriers

A variety of implementation issues need to be resolved before trading will become broadly acceptable. Some of these issues include: transaction costs, the credibility of nonpoint source load reductions, and sufficient public oversight. Transaction costs can preclude trading if they are too high. It is therefore essential to keep them low by providing easy means for market participants to find each other and to identify how many credits they have to sell or need to buy. For there to be credibility in the nutrient credits generated by agricultural or other nonpoint sources, standard estimation methods must be used. Essentially, watershed managers, the public, and the buyers need to be assured that all nutrient credits are estimated in the same way. Lastly, there has to be a relatively simple way to record trades so that the relevant government agencies and the general public know what is taking place.

The Internet has emerged as a promising tool for meeting these needs. A trading Website such as *NutrientNet* (www.nutrientnet.org) provides a simple way for buyers and sellers to connect. It also makes it relatively easy for both point sources and nonpoint sources to estimate their pollution remediation costs and potential nutrient credits available or needed through trading using standard, consistent methods. Finally, *NutrientNet* makes the record of trade (registry) readily accessible. This paper will describe *NutrientNet*, report on development and experimentation using *NutrientNet*; and summarize future activities and next steps.

NUTRIENTNET

What is *NutrientNet*?

NutrientNet is an e-marketplace designed to provide easily accessible and user-friendly tools to estimate and trade nutrient credits over the Internet. Not only does *NutrientNet* provide a market floor for buyers and sellers to locate each other, but it also allows point sources and farmers to estimate the cost and amount of nutrient reduction credits they are able to achieve using standardized estimation tools.

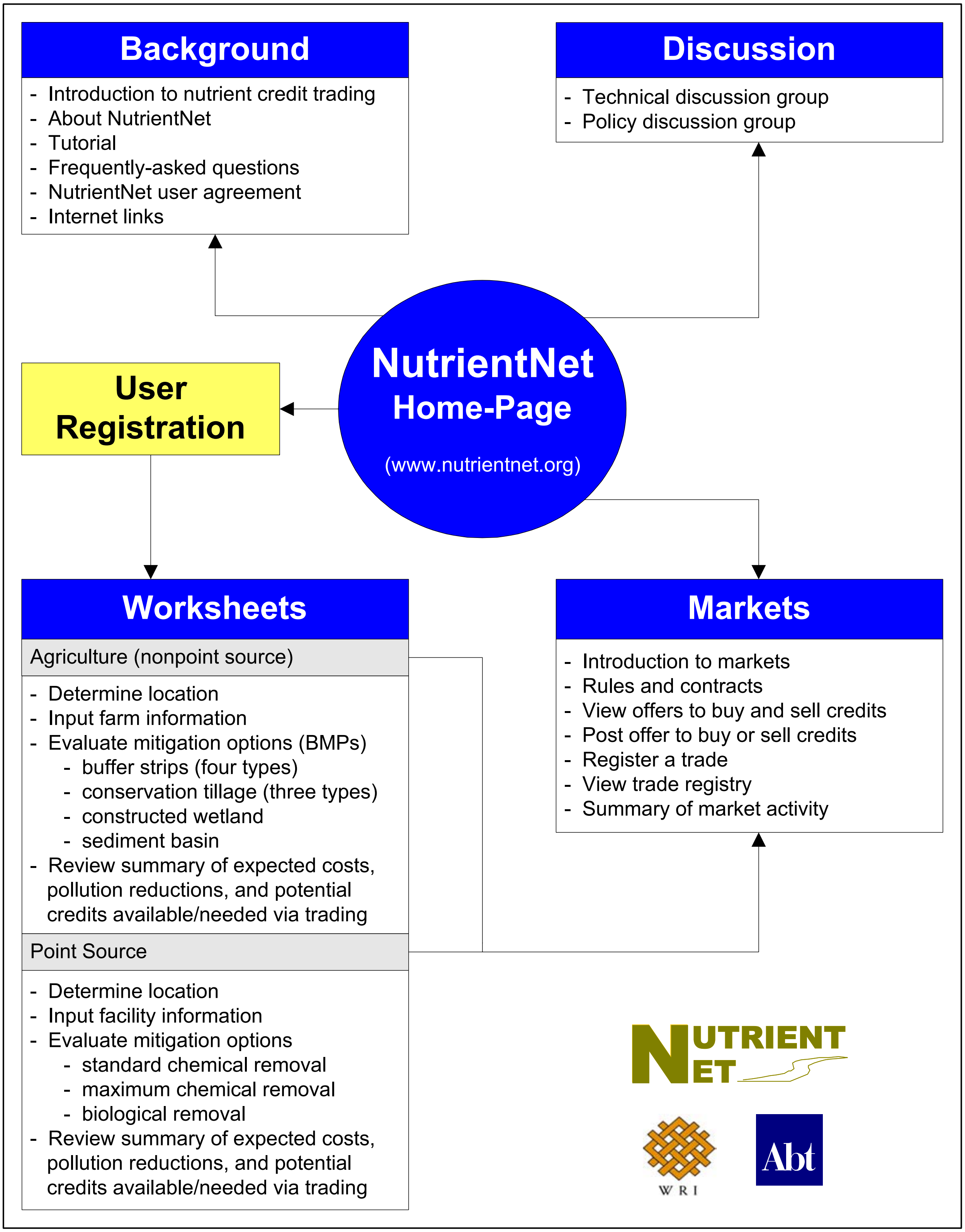
An overview of the *NutrientNet* Website is described in Figure 1. Specifically, *NutrientNet* is designed to serve the following functions:

- Provide potential market participants and other stakeholders with background information on nutrient trading;
- Provide farmers, municipal treatment works, and industrial plants with tools for estimating releases of nutrients to surface waters from their operations, exploring reduction options, and estimating the costs of achieving reductions;
- Help market participants identify potential trading partners;
- Track the volume and type of trades within a watershed;
- Share lessons learned about trading across the watersheds where it is being tried or considered; and
- Provide information on water quality problems and trading as a possible means to address them.

Using the *NutrientNet* Tool

Accessing the *NutrientNet* trading tools begins once the user has registered. Depending on their operation, the user clicks on the "agriculture" or "point source" worksheets and locates their farm or facility within a particular watershed using a geographic information system (GIS) interface. This allows the Website to retrieve valuable site-specific information -soil type, slope, distance to streams, etc.- that is used by the estimation tools to determine the amount of nutrients entering nearby waterways. The use of a GIS interface reduces the cost that users would incur if they were to collect these data to estimate their nutrient runoff. The user inputs additional site-specific parameters -current production and nutrient management activities, wastewater treatment practices in place, etc.- that are also used to calculate the baseline nutrient loading.

Figure 1. NutrientNet Internet Tool Overview (www.nutrientnet.org)



Next the user inputs design and cost parameters for the potential mitigation options available for implementation. This information is integrated with existing models of nutrient management, runoff reduction rates, and the efficiency of wastewater treatment facilities to assess the cost effectiveness of reducing nutrient loads by implementing the selected nutrient management option(s).

For potential sellers of nutrient credits, the user is shown a summary of the estimated number of credits available for trading based on their nutrient load reduction, as well as the expected cost. For potential buyers of nutrient credits, the user is shown the cost of implementing the different types of treatment practices, as well as the number of credits necessary to come into compliance with permit restrictions and/or water quality standards. Figure 2 illustrates worksheet results based on parameters from an example farm and wastewater treatment facility. The displayed results, particularly the break-even cost per credit, are a reference for the user for establishing an offer price to buy or sell potential nutrient credits.

NutrientNet allows users to post offers to buy or sell nutrient credits at an e-marketplace, contact each other via e-mail securely through the Website, negotiate/exchange their nutrient credits, and complete trades. A prototype registry tracks the trades that occur, providing government agencies and the general public with an easily accessible oversight tool. *NutrientNet* also presents general information about nutrient trading along with rules, regulations and contracts for each trading program and links to pilot trading programs throughout the United States.

Figure 2. Hypothetical Results for a Nonpoint and Point Source *NutrientNet* User

Worksheets

Agriculture (Nonpoint Source)

Best Management Practice[a]	Implementation Cost per Year	Cost per Pound of Phosphorus Runoff Reduced	Cost per Phosphorus Credit ($)[b]	Credits Available for Trading
With cost sharing[c]				
Conservation Tillage (No-Till)	($390)	$0	$0	0
Grass Filter Strip	$685	$3.85	$7.70	53
Both Options	$295	$0.93	$1.86	18
Without cost sharing[d]				
Conservation Tillage (No-Till)	$1,410	$4.75	$9.51	148
Filter Strip	$1,140	$6.43	$12.90	89
Both Options	$2,550	$8.05	$16.10	159

Point Source

Treatment Practice	Phosphorus Reductions (tons/yr)	Total Annual Cost (millions)	Cost per Pound of Phosphorus Runoff Reduced	Credits Needed for Comply with Regulation	Credits Available for Trading
None	0	$0	NA	22,800	0
Standard Chemical Phosphorus Removal	9.1	$0.60	$32.70	4,600	0
Maximum Chemical Phosphorus Removal	12.2	$0.66	$26.80	0	1,600
Standard Chemical Phosphorus Removal with Filtration	13.7	$1.23	$44.70	0	4,600
Biological Phosphorus Removal	9.1	$0.34	$18.90	4,600	0
Biological Phosphorus Removal with Filtration	13.7	$1.17	$42.60	0	4,600

[a] The current version of NutrientNet includes available tools for evaluating conservation tillage (10% mulch, 20% mulch, and no-till), filter strips (grass, hay, timber, multi-species), constructed wetlands, and sediment basins. For this example, only no-till and grass filter strips were evaluated.

[b] This cost represents the break-even cost per credit to farmers for generating the expected number of nutrient credits. Presumably the user would use this estimate to base their offer to buy or sell nutrient credits in the marketplace. The cost per phosphorus credit reflects a 2:1 trading ratio, which is applicable to nonpoint sources. This means every two pounds of phosphorus reduced is equivalent to one phosphorus reduction credit. Most watershed-based trading programs include a trading ratio to account for the risk and uncertainty associated with nonpoint source pollution control effectiveness.

[c] In most instances, the proportion of nutrient credits generated through implementation of best management practices subsidized through cost share programs are not available for trading. In other words, farmers are typically restricted from receiving compensation twice for reductions in nutrient loadings.

[d] A farmer who assumes all best management practice implementation costs would be allowed to trade up to 100 percent of the expected credits generated.

Experimental Use and Application of *NutrientNet*

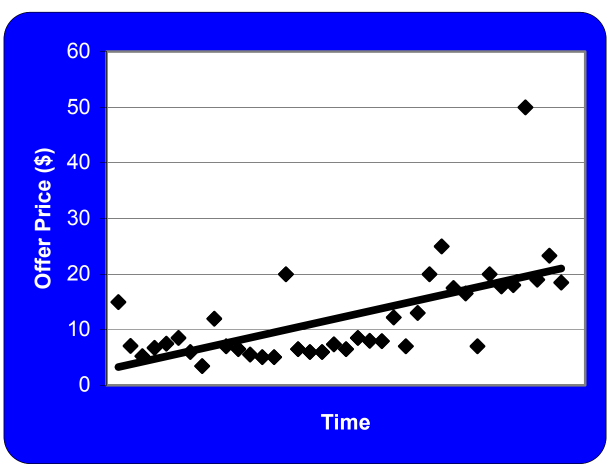
A demonstration version of *NutrientNet* has already been developed for the Kalamazoo River Basin in Michigan. In this case study, phosphorus reduction credits are assessed and traded using *NutrientNet*. The Website has been tested and evaluated on several occasions among various stakeholder groups and interested parties, including farmers in the Kalamazoo watershed and EPA staff. These 'play at trading" exercises have yielded excellent feedback that is being incorporated into future versions of the Website. Figure 3 illustrates the marketplace results from one of these "play at trading" exercises.

Figure 3. Results From a Recent Demonstration Using NutrientNet to Trade Phosphorus Credits Among Hypothetical Farmers and Wastewater Treatment Facilities

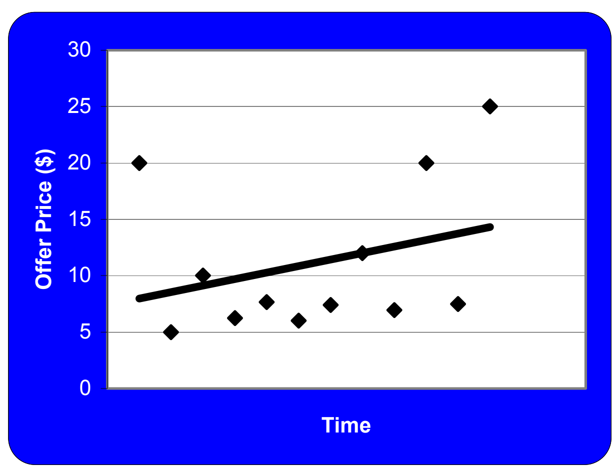
Three-Day Phosphorus Credit Market, Kalamazoo, Michigan

Number of Participants: 49
Offers to Sell: 38
Offers to Buy: 12
Total Trades: 26
Total P Credits Traded: 12,833
Total Phosphorus Potentially Reduced: 23,188 lbs.

Offers to Sell ($/Phosphorus Credit)



Offers to Buy($/Phosphorus Credit)



The three-day phosphorus market demonstration resulted in 26 total hypothetical trades (12,833 credits) with a potential reduction of more than 23,000 pounds of phosphorus. The demonstration offered a glimpse of the market activity to be expected with a live watershed-based trading program using *NutrientNet*. The market price per phosphorus credit increased over time as sellers with relatively low asking prices were dealt with first and credits became scarcer over time. In this demonstration there were insufficient credits available to clear the market, however, one buyer was able to aggregate credits and resell the bundle to another buyer at a significantly higher asking price.

NutrientNet for the Kalamazoo watershed currently includes Michigan-specific policy, economic, and modeling considerations. Through further enhancements to NutrientNet, we anticipate NutrientNet to be fully compatible with Michigan water quality regulations (finalized November 2002) and in accordance with EPA's National Water Quality Trading Policy.

The Future of *NutrientNet*

NutrientNet is currently being developed for the Potomac watershed, a sub-basin within the Chesapeake Bay watershed. For this case study, nitrogen credits will be tradable based on modeling and estimation tools specific to the Potomac watershed. The following activities are planned for this new application of *NutrientNet*:

- Alignment of policy considerations with EPA's National Water Quality Trading Policy;
- Improvement of nutrient transport modeling capabilities;
- Expansion of economic modeling capabilities;
- Diversification of the suite of pollution control options available;
- Upgrade of *NutrientNet* code with a more robust computer programming language; and

- Expansion of the functionality of the Market section.

The development of *NutrientNet* for the Chesapeake Bay is important not only for improving water quality conditions in the Chesapeake Bay but because of the valuable information that can be obtained through the development of pilot trading programs. Because of the Bay's size and its multiple jurisdictions, it is the optimum system to test how to implement trading programs in multiple watersheds of different sizes and with different regulatory requirements that together form a compact. By developing *NutrientNet* in coordination with the different State agencies in the Bay we can test and compare the development of pilot programs that will be specifically designed for each watershed permitting system, regulatory requirements (types of NPDES permits and whether a TMDL is in place), type of nutrient (nitrogen or phosphorus) and size of the watershed. What we learn from this project will serve to understand how to better develop and implement successful trading systems in other regions of the United States leading to substantial improvements in water quality nationwide.

IMPLICATIONS

We anticipate the lessons learned from the development of *NutrientNet* will enhance State and national water quality trading policy considerations through ongoing effort to address implementation issues. Specifically, use of *NutrientNet* may facilitate the development of successful watershed-based trading examples and help identify critical constraints and opportunities for broader implementation of appropriate policies. The Internet-based approach used to integrate GIS and water quality modeling with economic considerations and the development of a robust nutrient credit marketplace may also aid States considering implementation of a watershed-based trading program.

Water Trading: Bringing Non-Point Sources into the Fold

Charles Griffiths[1]
National Center for Environmental Economics
Discussant for Water Trading Session of Market Mechanisms and Incentives Workshop
May 1, 2003

The Water Trading session of this workshop has produced four very interesting papers that fit together nicely with a common theme. Alan Randall's paper (Sohngen 2003) suggests a voluntary program in which farmers are encouraged to form groups to reduce their non-point source pollution – nitrogen, in this case. The reduction of nitrogen loadings to the waterway is accomplished through the implementation of "Best Management Practices," or BMPs, with the performance being measured as the entire group's performance in achieving the pollutant reduction.

Mr Randall's paper both informs and is informed by Claire Schary's paper (2003). In this paper, Ms. Schary lays out the desirable design elements that one would want in a water quality trading system and then shows how those elements are being applied in the Lower Boise River. Ms. Schary is informed by Mr. Randall's paper in that group contracts could be considered for the trading program being implemented on the Lower Boise River. However, Mr. Randall is also informed by Ms. Schary paper in that the design elements that she lays out should almost certainly be present in any trading scheme he proposes. While the pollutants of concern in the two papers are different – they plan to trade phosphorous credits on the Lower Boise – the two schemes are basically the same. Farmers in the Lower Bosie basin are induced into participating in this program and then asked to reduce their non-point source pollutant through the use of BMPs.

Our third presenters, Mr. Thurston and Mr. Goddard, are informed by Ms. Schary's paper in the same way; the trading scheme that they propose should include the design elements that she details. Their set of papers (Thurston, et. al. 2002, Goddard 2003, Thurston 2003) deal with a different pollutant, storm water runoff, but the fundamental concepts are the same as with the others. Non-point source polluters (residential and commercial properties, in this case) are being induced to participate in a trading scheme with the promise of potentially profitable credit sales, and the pollution is reduced through the use of BMPs.

Finally, Mr. Landry's paper (Landry and Faeth 2003) offer us an internet-based system by which all of the previously mentioned trading schemes could be implemented, the NutrientNet system. I actually participated in one of the trial markets for this system and the Kalamazoo River Basin trading scheme used there involves all of the same elements as we have been discussing. Farmers producing non-point source pollution – phosphorous again – sell pollution credits to point sources for a profit in exchange for implementing BMPs.

The common theme to all of these papers, which by now is obvious, is that in each case we are bribing non-point source polluters to participate in the system and implementing BMPs.

---

[1] Charles Griffiths is an economist in the National Center for Environmental Economics at the U.S. Environmental Protection Agency. The views expressed in this paper are entirely those of the author and do not necessarily represent the views of the U.S. Environmental Protection Agency.

What I would like to do is to is to offer some constraints that regulators face in trying to actually set up these trading schemes. Now, in doing so, it may appear to the causal observer that what I am doing is trying to stick my finger in the eye of a program that has been shown by many, many journal articles to produce a lower-cost solution than the traditional approach. And, in fact, that is what I am doing; but let me explain.

Here, I am borrowing a story from an article by Gregory Mankiw (1990) on the acceptance of advances in macroeconomic theory by practitioners. When Copernicus introduced his heliocentric system, the idea that the planets revolve around the sun, he originally used circular orbits to explain the planetary movement rather than elliptical orbits. Now there were a number religious reasons for the resistance to the Copernican system, but to an academic at the time, this was a much more elegant system than the prevailing Ptolemaic system. However, from a practitioner's point of view, if you were going to navigate a ship at this time, the Copernican system was less well known and was originally less reliable than the prevailing system. Given a choice between the two, the practitioner would opt for the old system. Eventually, however, as the Copernican system was refined, it was ultimately accepted as better than the Ptolemaic system, and you wouldn't think of using anything but that system and its subsequent advances today.

I believe that we can draw an analogy to where we are today with trading systems. As I said, there are many, many journal articles that show that the trading schemes produce a lower cost solution than a command and control option. From an academic point of view, this is a much more elegant system. And yet, there is resistance to its adoption. What I would like to do it to describe some of the constraints that practitioners of these schemes face when trying to implement them on the ground.

<u>Legislative and Regulatory Contraints</u>

I will begin with some legislative and regulatory constraints. Currently, point sources are regulated, under the authority of the Clean Water Act (2003), through the EPA's National Pollutant Discharge Elimination System (NPDES) permit program. Point sources are any discernible, confined and discrete conveyances, or any vessel or other floating craft from which pollutants are discharged into waters of the United States. Under the NPDES, industrial, municipal, and facilities other than individual homes must obtain permits, which limit the amount of this discharge (EPA 2003b). The performance of treatment and control technologies required for these wastewater discharges are dictated by the EPA's effluent guidelines (EPA 2003a). So there is direct, regulatory control over point source pollution.

This is not at all how the EPA deals with non-point source pollution. By and large, non-point source pollution is controlled through state management programs, technical assistance, grants, and information provision. So why the disconnect? Why not simply control non-point source pollution in the same way as point source pollution, by requiring the non-point source polluters to obtain permits and subject themselves to technology-based guidelines? The answer has to do with the way in which these two sources are regulated under the Clean Water Act (2003). Under this Act, point sources are specifically subjected to the NPDES system. Non-point sources, on the other hand, are covered under Section 319 of this Act. Here, there is no mention of direct control, only the indirect control measures (grants, etc.) mentioned above. This has generally been interpreted to mean that the EPA has weak regulatory authority over non-point sources. So, the Agency is resigned to controlling these source through voluntary measures, such as trading schemes and BMPs.

Another problem has to do with locating the non-point source polluters. Under Section 308 of the Clean Water Act, the EPA has the authority require owners and operators of point sources to provide records and reports related to pollutant discharges. This means that the EPA is able to send out letters to these sources ("Section 308" letters in Agency parlance) requesting information so that it may design optimal regulation. Not so with non-point sources. And, even if the EPA could survey them, in many cases it doesn't even know where the non-point sources are. This was true with the EPA's recent Concentrated Animal Feeding Operation (CAFO) rule. Farms, in general, are non-point source polluters, but the Clean Water Act allows the EPA to designate certain farms as CAFOs and reclassify them as point sources. In effect, we are relabeling the non-point sources as point sources, and thereby providing the regulatory hook, including the ability to send out 308 letters. The problem was that we don't know where the farms are. The U.S. Department of Agriculture has this information, but they are prohibited from using the data for regulatory purposes. What, ultimately, was done for that rule was to predict the pollution from "model farms" and then estimate the location of these farms for the regulation. This location estimate may or may not reflect reality. The point is that without detailed knowledge on the location of non-point source polluters (knowledge that we generally do no have), regulating these sources is very difficult except using a voluntary, opt-in program like trading.

Public Reaction Constraints

For some, this type of voluntary trading may be acceptable, and even desirable. For other, it is an anathema. This is evident in the various articles and editorial that have been written in the past objecting to these types of schemes (for example, the editorial by Sandel (1997)). It is important to recognize that some will have a visceral reaction to any trading schemes, and this will inhibit the implementation.

Another common public reaction is a call for uniform regulation. There seems to be a perceived "fairness" in having all entities regulated to the same level of emissions. This, however, is precisely what the trading scheme is attempting to avoid. The reason that trading schemes produce a lower-cost solution than the command-and-control regulatory approach is exactly the fact that entities have a different pollution discharge. Low cost abaters pollute less and high cost abaters pollute more. The public's perceived "unfairness" of this scheme will also affect its implementation.

We must also look at the behavioral responses associated with the trading scheme once it has been implemented. In particular, we have to consider the effect of subsidies and other cost-sharing efforts. The reason that this is important to mention is because economists often skip these issues since they are transfer payments. In the economic social cost calculus, transfer payments are not counted as social costs. But they are important in determining the success of a trading scheme. For example, during the beta testing of NutrientNet at the EPA, I was a non-point source polluter responsible for selling my pollution credits. I had to consider the profit of selling my credits both with and without cost-sharing. Ultimately, I decided that it was more profitable for me to not accept the government cost-share money since I could sell more credits. The point is that these things have important behavioral consequences even if they do not affect the social welfare calculations.

Environmental justice concerns also affect the public's reaction to these types of schemes, particularly when they are contrasted with taxation. This is illustrated with the stormwater runoff trading scheme suggested by Thurston and Goddard. The comparison that they make is trading versus a big, publicly-funded infrastructure project. Not unsurprisingly, they find that the trading scheme is cheaper than the infrastructure project. The problem is that who is being taxed appears to matter to the public. If the public infrastructure project is be partially funded through corporate taxes or user fees, then it might be more desirable to the general public even if it is more expensive. Particularly if the trading scheme would require low income and minorities to potentially buy pollution credits.

Benefits and Costs Calculation Constraints

Lastly, I'll mention a few constraints associated with the calculation of benefits and costs. While there are some human health consequences associated with water pollution control, they tend to be small. Particularly given the small magnitude of the expected improvements and the current level of pollution in these streams. The greater benefits category is improved recreational opportunities. In terms of producing a willingness to pay value, I would argue that economist have more tools and wider acceptance of the valuation techniques for human heath benefits. To get at national-level recreational benefits and, perhaps more importantly, non-use benefits, we are probably relying on contingent valuation, CV, surveys. These are more controversial, particularly to the Office of Management and Budget, than revealed preference approaches.

With water pollution, there is also the problem of which pollutants are included in the willingness to pay calculation. In air pollution regulation, there is a tendency to address issues one pollutant at a time. This may be because the human health consequence of each pollutant can be measured. In water pollution regulation, however, there has been a tendency to measure things using an index, such as an index of water quality or an index of biological integrity. If people have a stated willingness to pay to improve water quality in general, which pollutants are included in the index matters.

This is important since trading schemes usually involve trades of a single pollutant. If, however, water quality is a mix of pollutants, then the benefits gained from the trading scheme will be affected by pollutants which are not being traded. It is also important if pollutants which were previously not considered part of the index were later regulated and added to the index. If the addition of new pollutants dramatically affected the value of the index, then it could cast doubt on the benefits calculations.

Once a defensible willingness to pay is obtained, there is still the problem of how to associate it with stream miles. In the Lower Boise River trading scheme, "Parma Pounds" were used to normalize the effluent by the impact that it has on Parma. This is a recognition of the fact that a single downstream point needs to be identified to calculate the trading ratios. Improvements in water quality can then be measured at this point. The problem is that willingness to pay for recreational benefits and non-use benefits applies to the entire stream reach. To calculate the benefits of improvements correctly, you must distribute the willingness to pay value across all of the stream miles in the rivers system and assess the improvements at each mile. This will impact not only the magnitude of the benefits from this type of program but, I would argue, possibly the direction of these benefits as well.

Additionally, there are temporal considerations. That is, it is important to specify how long the improvements will occur. If we have to distribute the willingness to pay value across all river miles, then we also have to distribute it across all time. It is then unclear how to account for very short-term improvements in water quality, such as those obtained with storm water trading. In the most simplistic application, we divide the willingness to pay for improved water quality by 365 days to get a daily value. The implication is that the benefits are diminished dramatically when the improvements only occur sporadically.

Finally, there are considerations with calculating the social cost these schemes. The result that trading schemes produce lower-cost solutions to pollution regulation than command-and-control measures is based on an estimate of the cost of compliance. However, to properly measure welfare effects, we must consider the cost, in time, of both learning a scheme and implementing it. While this may not tip the balance against trading schemes, it does change its relative efficiency.

In conclusion, I should reemphasize that the purpose of my comments is not to suggest that we should not implement these water pollution trading schemes. In fact, I am a big fan of this type of market mechanisms. My purpose here today is to serve as a foil; to list some of the difficulties that regulators face in implementing these programs. If we can address these difficulties, then we move closer to both implementation and a realization of the cost-savings implied by the literature.

References

Clean Water Act. 2003. *U.S. Code Annotated*, Title 33, Chapter 26.

Goddard, Haynes C. 2003. "A Theoretical Framework for Cost Effective Urban Runoff Management with Stochastic Ecological Constraints" Paper presented at the Market Mechanisms and Incentives: Applications to Environmental Policy Workshop, Water Trading Session, Washington, D.C., May 1, 2003.

Landry, Mark S., and Paul Faeth. 2003. "Experimentation with Watershed-based Trading Using the Internet" Paper presented at the Market Mechanisms and Incentives: Applications to Environmental Policy Workshop, Water Trading Session, Washington, D.C., May 1, 2003.

Mankiw, N. Gregory. 1990. "A Quick Refresher Course in Macroeconomics" *Journal of Economic Literature*. XXVIII (December): 1645-1660.

Sandel, Michael J. 1997. "It's Immoral to Buy the Right to Pollute" *New York Times*. Dec. 15: A29.

Schary, Claire. 2003. "Can the Acid Rain Program's Cap and Trade Approach Be Applied to Water Quality Trading" Paper presented at the Market Mechanisms and Incentives: Applications to Environmental Policy Workshop, Water Trading Session, Washington, D.C., May 1, 2003.

Sohngen, Brent, et. al. 2003. "An Investigation into the Potential to Link Voluntary Incentive Payments to Water Quality Performance" Paper presented at the Market Mechanisms and Incentives: Applications to Environmental Policy Workshop, Water Trading Session, Washington, D.C., May 1, 2003.

Thurston, Hale W., et. al. 2002. "Controlling Stormwater Runoff with Tradable Allowances for Impervious Surfaces" Paper presented at the Market Mechanisms and Incentives: Applications to Environmental Policy Workshop, Water Trading Session, Washington, D.C., May 1, 2003.

Thurston, Hale W. 2003. "Residential Best Management Practices for Stormwater Runoff Control: Accounting for Opportunity Costs with Hedonic Modeling" Paper presented at the Market Mechanisms and Incentives: Applications to Environmental Policy Workshop, Water Trading Session, Washington, D.C., May 1, 2003.

U.S. Environmental Protection Agency (EPA). 2003a. *Effluent Guidelines* Accessed May 12, 2003. Available from: http://www.epa.gov/waterscience/guide/index.html. Internet.

U.S. Environmental Protection Agency (EPA). 2003b. *NPDES Frequently Asked Questions* Accessed May 12, 2003. Available from: http://cfpub.epa.gov/npdes/allfaqs.cfm?program_id=0. Internet.

Discussion: Water Quality Trading

Gregory L. Poe,
Associate Professor
Department of Applied Economics and Management
Cornell University
GLP2@cornell.edu

Any brief, critical synopsis of four distinct research and policy efforts is a challenge at best, as the reviewer bears responsibility for disentangling a complex tapestry of ideas and reweaving them in a manner that resonates with a similarly engaged audience. The task is made more difficult when each of the original projects is of the high quality demonstrated here today. Clearly the entirety of each effort reviewed cannot be covered. Thus, from the outset, I wish to offer my apologies to each of the investigators, in case my attempts to caricaturize their research diminishes or otherwise waxes over the solid contributions made by the research and policy efforts underlying each presentation.

To synthesize these four presentations I have chosen to organize my thoughts along the following two issues:

1. Can we extend theoretical foundations and the success of SO2 "Grand Policy Experiment" to water quality allowance/credit trading for non-point source pollution?
2. Should we be looking beyond allowance/credit trading when addressing incentive mechanisms from non-point source pollution?

Within the first theme I further arrange my commentary in accordance with Goddard and Thurston's statement: "Two necessary conditions for tradable allowance regimes to be cost reducing are that: i) There be sufficient difference in abatement cost across parcel owners so that potential cost savings can be realized by market exchange of runoff control; and ii) The transactions costs of such programs be no greater than the gains achieved." Throughout I should also note that I will largely remain in my academic comfort zone by directing the bulk of my comments toward the Randall et al. and Goddard and Thurston presentations. I trust, perhaps naively, that my co-discussant from the EPA will have more to say on the field implementation projects.

1.i: Goddard and Thurston - "Is non-point source control potentially cost-effective for urban storm water runoff?"

Standard economic presentations of pollution control policy make the important distinction between efficiency and cost effectiveness. Efficiency focuses on maximizing the net benefits of pollution control, which conceptually occurs where marginal costs equal the marginal benefits of abatement. Rather than seeking an optimal level, cost effectiveness instead takes an exogenously determined target level of abatement and seeks to minimize costs of achieving this objective. For the inclusion of non-point sources abatement to be more cost effective than relying solely on point sources, the abatement costs of at least some non-point sources have to be lower than those of point sources. In order for trading programs to potentially reduce costs relative to more traditional command-and-control methods, the marginal abatement costs need to differ substantially between traders.

Whereas the policy literature generally recognizes that the marginal costs of non-point sources pollution abatement may be lower than those of point sources, and conventional wisdom suggests that agricultural non-point source pollution control in particular offers the potential to cost-effectively achieve abatement levels in a given watershed, such relationships have not been adequately investigated for urban runoff. In a very original effort, the three papers provided by Goddard and Thurston in preparation for this conference[1] offer a considerable step forward in addressing this critical information gap. Together these papers provide a nice systematic evolution toward "other-than-engineering" costing approach. I see this progression as establishing a standard for future efforts to systematically evaluate the viability of including non-point source trading into pollution control regimes.

In the first paper (Thurston et al, forth.), a 'simple' engineering approach suggests that there is ample heterogeneity in abatement costs associated with controlling excess non-point source runoff. Moreover, at this dispersed engineering stage, non-point source pollution appears to be cost-effective relative to centralized engineering approaches that will involve substantial public investments. In obtaining this result, the analysis relies on best estimates of runoff control associated with particular management practices.

Importantly, Goddard and Thurston do not stop with a simple engineering analysis of excess non-point storm runoff, recognizing that the heterogeneity in implementation costs is not simply comprised of differential installation and maintenance costs and the physical characteristics of the land. They correctly argue that a more complete accounting would include the opportunity costs of private land diverted from other uses. Thurston uses standard hedonic pricing (property value) approaches to estimate the opportunity cost of alternative best management practices for individual parcels. As would be expected, accounting for this opportunity cost somewhat erodes the cost effectiveness of using dispersed non-point source pollution controls relative to the centralized option.

Moving in an alternative, but complementary, direction the Goddard paper adopts an ecological economics approach in which stream flow serves as an explicit constraint to preserve stream and riparian habitat, and in which chance constrained modeling is used. This latter restriction alters the planner's choice framework to focus on the incremental costs per unit of reduced probability of exceedence of the norm or stream standard. As such, it more closely reflects the extreme event nature of many water quality issues.

---

[1] All comments in this discussion paper are directed towards the papers provided by the authors previous to the Washington D.C. meeting, and to the actual May 1 presentations. Final papers may differ from the ones provided to Poe.

I encourage the researchers to continue along these more recent lines of thought, and to recognize that there will be great benefits from this research regardless of whether they accept or reject the hypothesis that non-point source runoff control can be a cost-effective means of meeting water quality targets. While doing so, I urge them to further move in the direction of behavioral and ecological economics perspectives along the following lines. First, rather than assuming "rational behavior" in which participants will trade based on narrow economic concepts of gains and losses, actual behaviors need to be incorporated into their modeling. Real humans making real decisions do not act like profit maximizing automata. Indeed, the foundation of the growing field of behavioral economics is that people do not necessarily behave in accordance with such neoclassical notions of rationally. Kahneman, Tversky, Thaler and others have long demonstrated this point using simple laboratory experiments. One famous example being the so-called endowment effect in which an individual's maximum willingness to pay for a simple commodity such as a university coffee mug is much lower than the minimum price at which they would sell that same mug. I have every reason to believe that such willingness to pay/willingness to accept disparities will prevail when personal property such as "my land" is involved[2]. While such disparities may not greatly affect the fluidity of a tradable permit system once it has been established, it will certainly dilute anticipated cost gains determined by assuming rational behavior.

A second line of investigation that I would encourage is to move beyond the ecosystem as a constraint focus. I agree that a precautionary approach to protecting in-stream services is needed. But given that constraint there may be alternative interior solutions of pollution control that exist over and above the cost-effective option. If we were to take in-stream benefits into account our focus would change to maximizing the net benefits subject to meeting safe minimum standards. Such an approach has long been used in water and ecosystem policy (e.g. Loomis, 1995).

1.ii: Schary, and Landry and Faeth: "Reducing transactions costs in watershed-based trading"

A convenient way of remembering the components of transactions costs is the acronym ICE: Information, Contracting, and Enforcement. Having previous experience with the acid rain allowance trading program, which demonstrated that tradable programs can "work roughly as the textbooks describe" (Schmalensee et al., 1998), Schary logically uses this successful program as a guide. Have no doubts, setting the bar at the SO_2 standards has led to an extremely inventive and innovative program design for the Lower Boise River and one can only hope that authorization for implementing this program will ultimately be attained. Nevertheless I see the potential for greater lessons-to-be-learned not from emulating a program that may serve as an elusive pinnacle, but rather from building from a foundation of errors gleaned from other water quality trading programs. While I sense that Schary has indeed conducted and internalized such an exercise, such lessons-to-be learned were not provided in the May 1 presentation.

[2] Further, with the advent of West Nile Virus it is likely that certain homeowners may be very reluctant to encourage surface or near-surface water accumulation in their yards and properties.

In using the SO2 program as a standard bearer, it is important to realize that that program had several features that primed it for success: uniform mixing, numerous point sources, cap-and-trade, continuous monitoring, an exchange institution etc. As Schary clearly recognizes, it would be a stretch to assume these features hold for watershed level water quality issues. The differences between the two situations are substantial, perhaps even non-comparable. And I would guess that many of the managers launching into previous water quality trading projects made a similar proclamation to that made by Schary that "there is nothing wrong with the design". Yet, in spite of such like claims, very few water quality "trades appear to have actually taken place" in the United States (King and Kuch, 2003). Retrospective analyses of on-the-ground pilot trading programs have concluded that the lack of trades can largely be attributed to inherent design flaws in the individual programs that were not a-priori identified (e.g. Fox River - Hahn, 1989; Tar-Palmico – Hoag and Hughes-Popp, 1997; Lake Dillon –Woodward, 2003). This is not to say that the Lower Boise design has inherent flaws. Rather, I am impressed by the considerable details and obvious thought that have gone into calculating Parma pounds and other trading ratios. Such efforts will surely reduce information and contracting transactions costs, increasing the likelihood of future trades. Yet, I would be further reassured that we were not reinventing a flawed wheel if instead of limiting the focus to emulating the SO_2 success, Schary could provide details on why previous water trading programs have failed and how the Lower Boise program has been designed to account for flawed design features. Such an effort would offer a considerable complement to the present focus on replicating national air quality programs at a watershed level.

I have little in the way of comments on the Landry and Faeth presentation, except to applaud (like I do Schary) their innovative efforts to reduce information and contracting costs. In a practical sense, I fundamentally believe that reducing transactions costs will greatly improve the likelihood of transaction taking place. From an academic and reviewer's perspective, I remain keenly interested in how the hypothetical information about how the auctions were structured. I simply need more information than the summary paper provided in order to adequately comment on this aspect.

Since this is a conference about trading, I should note that there appears to be gains to trade from collaboration between these two innovative efforts. Although Schary indicates that the Lower Boise is structured as a "bilateral trade" and Landry and Faeth focus on a "clearing house" structure that puts likely buyers and sellers in contact for subsequent bilateral negotiations, they are both focusing on the same critical issue of providing relevant information to participants and facilitating contracting. It would be wonderful if these two efforts could collaborate and learn from the other.

While much attention is given in these two papers to reducing the information and contracting element of transactions costs, little attention is given to enforcement. It is widely observed that maintenance components of many CRP contracts are not being implemented, and I would suspect that the same would hold for urban runoff (my children would likely dig trenches through any swale!). It is this problem that Randall et al. take on directly.

2. Randall et al. - "The Problem of Enforcement"

In their research effort, Randall and colleagues (Sohngen et al.) reject the notion of relying on tradable pollution permits because of the well-known asymmetric-information issues plaguing non-point source pollution control: adverse selection and moral hazard. As an alternative to credit trading programs, these researchers pursue a voluntary auction-based approach to solve the adverse selection problem of not knowing the abatement costs of individual farms (and hence not being able to identify the farms with the lowest abatement costs). The moral hazard or enforcement problem is resolved by a group "all or nothing" contract that pays based on whether ambient water quality measures at a given location are less than or exceed a given target. It is argued that group pressure and commitment will reinforce financial incentives to behave in a group-regarding manner.

The threshold abatement model suggested by Randall et al. is a "razors edge" analogy to the provision point mechanism long discussed in the private provision of public goods literature. Such modifications of voluntary contributions mechanisms for funding public goods have been in the economics literature since at least Brubaker (1976), with the Nash equilibria properties established in Bagnoli and Lipman (1989). I use the term "razors edge" to highlight the extremity of the "all or nothing" feature of the proposed mechanism, and to contrast it with the less extreme money-back-guarantee (i.e. if the threshold is not reached, all contributions are returned) and excess rebate (i.e. if the threshold is exceeded either benefits are extended or excess funds rebated in a proportional manner) modifications been shown to increase the efficiency of the provision point contributions mechanism (Isaac et al., 1989; Marks and Croson, 1998; Rondeau, Schulze and Poe, 1999)

The innovation in this application is that rather than groping to one of the infinite number of Nash equilibria combinations of contributions that exactly sum to the threshold level, Randall et al. have the participants define a baseline threshold and Nash equilibrium combination of abatement. This is an important practical contribution as it is transparent to the participants that any unilateral deviation from the agreed group contract will probabilistically make the individual worse of. Hence, it is costly to defect. I also find the moving from the field to the lab approach a refreshing alternative to theoretical formulation completely removed from reality.

Nevertheless, as with any new mechanism, moving from concept to reality and reality to concept is a tremendous hurdle, a point that is adequately demonstrated within the credit trading program depicted in Schary's presentation. Two related complications seem to arise within the Randall et al. mechanism. First, although the theory assumes risk neutrality it appears that the existence of non-participation amongst individuals (who would likely benefit from participating) would be an indicator of risk aversion. Reflecting this possibility, the Sohngen et al. paper notes that non-bidders were in general concerned about the game and concerned about getting involved in a contract. Personally, I have no problem in assuming neutrality in laboratory test of a theory assuming neutrality. However, by starting in the field and learning through focus groups, Randall et al. bear the onus of reflecting what is learned in the focus groups.

Regardless of whether it is caused by risk aversion or not, the end result is that there are some non-participants in the watershed. As such there is a stochastic element completely out of the control of the participating group of farmers, which very much undermines the incentives of the voluntary all or nothing program. This stochastic nature may be perfectly correlated with bad weather rolls of the dice. In such an instance the magnitude of the variation in pollution will depend upon the relative number of participants and non-participants – i.e. it is not possible to maintain a $\pm$ 20% weather variation when participation rates vary. Even more complex is the situation where the variation in runoff on non-participating farms is not perfectly correlated with the stochastic variation on participating farms. For example, non-participating farmers may choose to expand herd size or other potentially polluting input. In either case the additional randomness associated with non-participants adds an uncontrollable element in decision-making and would hence impact, and perhaps undermine the strategies of the participants.

There may be ways to minimize non participation and hence regain control of the incentive mechanism. Variants of money-back-guarantee and excess rebate schemes have been shown to vastly increase participation rates in contribution mechanisms, and it seems reasonable to extend these design features to the current mechanism. Another possibility that seems particularly suited to the small watershed orientation of this project is to allow for collusion. For example, recent experimental research on the well-known Segerson group-enforcement mechanism (1988) show the effectiveness of this mechanism is greatly enhanced by cheap talk (Vossler et al, 2002). Other possible ways to encourage participation should definitely be explored. Until the problem of non-participation is resolved, implementation of the proposed mechanism will be problematic.

Concluding Comments

In an e-mail communication prior to this meeting, Alan Randall noted "It's hell to be a discussant!" I thoroughly disagree. The array of conceptual to implementation presentations at this meeting are destined to make a contribution toward assessing the viability of and implementing market mechanisms for addressing water quality problems. It is a pleasure to see such progress and to have the opportunity for timely exposure to these substantive efforts. In closing, I wish compliment the USEPA Nation Center for Environmental Economics and the National Center for Environmental Research for their foresight in sponsoring these efforts, and to specifically applaud each of the PIs for pushing forward our knowledge in this area

References:

Bagnoli, M. and B. Lipman, 1989. "Provision of Public Goods: Fully Implementing the Core through Voluntary Contributions." *Review of Economic Studies*, 56: 583-601.

Brubaker, E., 1976. "Free Ride, Free Revelation or Golden Rule", *Journal of Law and Economics*, 18(1): 147-159.

Goddard, H. C. “A Theoretical Framework for Cost Effective Urban Runoff Management with Stochastic Ecological Constraints”, March 2003.
Hahn, R. W., 1989. “Economic Prescriptions for Environmental Problems: How the Patient Followed the Doctor’s Orders”, *Journal of Economic Perspectives*, 3(2): 95-114.
Hoag, D. L. and J. S. Hughes-Popp, 1997. “Theory and Practice of Pollution Credit Trading in Water Quality Management”, *Review of Agricultural Economics,* 19(2):252-262.
Isaac, R. M.; Schmidtz, D. and Walker, J., 1989. "The Assurance Problem in Laboratory Markets." *Public Choice*, 62: 217-236.
King, D. M. and P. J. Kuch, 2003. “Will Nutrient Credit Trading Ever Work? An Assessment of Supply and Demand Problems and Institutional Obstacles” *Environmental Law Review*, 33 ELR 10353-10368.
Landry, M. S. and P. Faeth, “Experimentation with Watershed-based Trading Using the Internet”, Workshop paper provided April 22, 2003.
Loomis, J. B., 1995. “Public Trust Doctrine Produces Water for Mono Lake: The State of California’s Water Resources Control Board Decision #1631", *Journal of Soil and Water Conservation*, 50(3):270-271.
Marks, M. B. and Croson, R. T. A., 1998. "Alternative Rebate Rules in the Provision of a Threshold Public Good: An Experimental Investigation." *Journal of Public Economics*, 67: 195-220.
Rondeau, D.; Schulze, W. D. and Poe, G. L. “Voluntary Revelation in the Demand for Public Goods Using a Provision Point Mechanism." *Journal of Public Economics*, 1999, 72:455-470.
Schary, C. “Can the Acid Rain Program’s Cap and Trade Approach be Applied to Water Quality Trading?”, April 17 2003.
Sohngen, B., Taylor, M., Isik, H., Randall, A, and W. Hua. “An Investigation into the Potential to Link Voluntary Incentive Payment to Water Quality Performance”, April 16, 2003 Draft.
Thurston, H., Goddard, H. Lemberg, B, and D. Szlag. “Controlling Stormwater Runoff with Tradable Allowances of Impervious Surfaces, forthcoming in *Journal of Water Resources management and Planning.*
Thurston, H. “Residential Best Management Practices for Stormwater Runoff Control: Accounting for Opportunity Costs with Hedonic Modeling”, Draft provided April 17, 2003.
Segerson, K., 1988. "Uncertainty and Incentives for Nonpoint Pollution Control," *Journal of Environmental Economics and Management,* 15:87-98.
Schmalensee, R., P. L. Joskow, A. D. Ellerman, J. P. Montrero, and E. M. Baily, 1998. “An Interim Evaluation of Sulfur Dioxide Emissions Trading”, Journal of Economic Perspectives, 12(Summer): 53-68.
Vossler, C., G. L. Poe, K. Segerson, and W. D. Schulze, 2002. “An Experimental Test of the Segerson Mechanism”, Selected Paper, 2nd World Congress of Environmental and Resource Economists, Monterey, Jun. .
Woodward, R. T. 2003. “Lessons about Effluent Trading from A Single Trade”, Unpublished manuscript. r-woodward@tamu.edu

May 1, 2003 11:25AM
Question and Discussion Session

Q. John Braden, University of Illinois at Urbana – Champaign:
I'd like to ask Claire, who is working in what I view a realistically sized watershed for this kind of program., if she has given any thought to what the really effective number of participants in a market might be? You say that it's really the people close to Parma that will make the big difference. How many sources are there both of point and non point in that domain?

A. Claire Schary:
There are about a dozen point sources. I think there are only going to be about 8 or 9 that would actively be looking to purchase credits. And on the non point side it's voluntary. So I think they will be slow to come to the table and I don't know how many farmers will eventually make it there. We are still waiting for that TMDL. When it is implemented, in place then I think more people will be looking at the size of the reductions that are actually needed. We think that they will actually be required to reduce 80% of the phosphorus loadings in the river when it actually comes through. I think that will bring point sources to the table very quickly and then the non point sources will slowly start filtering in and look more at how they can lump some of the reductions together. It's going to take time to get them used to working with each other. I don't know how many ultimately will be there. I think it will start small and eventually build up some volume.

Q. Charlie Kolstad, Bren School, University of California,
Also for Claire. It's a little unclear for me exactly how far you've gone out of your office with this experiment into the field. I wonder if you can give me a sense of who in the river basin tends to be supporting this activity and who tends to be reluctant viewer of the potential trading system. Not individuals but groups of folks.

A. Claire Schary:
Well initially it was only the point sources that were supportive especially the representatives for the city of Boise. But then the non point sources, once we agreed to certain basic conditions that we are not talking about bringing them into the regulatory world, they really saw this first as a Trojan horse to trap them into regulation. We made it clear that no this is not what this is. We even modified our language somewhat you saw that when we came up with the term water quality contribution. It's an euphemism and everybody knew that it was. It's a sign of respect for the fact that they are not regulated, they are not required to participate, they are not required to reduce. So eventually they came on board and really realized that this is a great opportunity actually to sell another type of commodity. In fact, they are now looking at CO2 trading. They have already identified a list of practices that they can use to sequester carbon. They are really getting on the trading bandwagon so to speak. The environmentalist representative who is no longer with the group, Idaho Rivers United, saw this as a great opportunity also to get the TMDL implemented. So she was just making sure the measurement methods and baselines and all that were consistent with the TMDL. She was pretty broad minded. But unfortunately the Idaho Rivers United did not replace her

so we don't have the full environmentalist support for trading. We had her support. Overall, most environmental groups agree that this makes sense for this watershed but they are not ready to bless trading overall. But we didn't encounter any other opposition there aren't any environmental justice concerns. We have already addressed the issues for hotspots so we didn't have any real opposition once we worked out the basic conditions of trading.

Q. Sarah Lynch, World Wildlife Fund,
I was wondering if anybody on the panel could comment about what they see as more ideal characteristics of a watershed that make it more amenable to trading? That could be the politics, it could be the watershed characteristics, it could be type of pollution….whatever you think is important.

A. Lynda Wynn,
First it seems like you have to have some sort of reasonable split in who is contributing to the pollution between point sources and non point sources. Because the regulatory driver is going to be either TMDL or some other kind of water quality based limit in a NPDES permit. You have to have a sufficient number of point sources present to do that half of the bargain and then you have to have a sufficient,… I'm talking about point and non point source trading. There is certainly point source to point source trading would be another scenario. Then you would have to have non point source contribution to the load that both potential trading partners and load reduction would be achieved through the swapping that would take place through trading. Claire mentioned the TMDL. If the reductions needed under the TMDL are so rigorous that basically everybody is going to have to do everything they can to meet the reductions there will be limited ability to trade. In terms of pollutants, that's a debatable point but my opinion expressed in EPA policy is if you stick with nutrients and sediments that are less likely to have a localized impact that makes things less complicated. Those particular pollutants are quite amenable to trading scenario.

A. Claire Schary:
I would just add that we are still learning what kind of pollutants can be traded. What are their physical characteristics. One important point is they need to stay somewhat whole so that you can see the same pollutant at one point in the watershed and as it moves down the river it hasn't degraded or transformed in a different type or form of that pollutant. Phosphorus seems to stay whole overall. In Oregon we are working on figuring out how to trade temperature in water. That has proven a little more difficult but yet we know the benefits will exceed the costs so we are still working through it. Maybe in a year or so we can give a presentation on that when we figure it all out. Right now we're still trying to figure out how you can translate…you've got a point source that has to meet a limit and in this case there probably will only be one or two point sources in this watershed in Oregon and that will be a successful trade if they can identify a set of practices they want to implement upstream on farmers land and that one trade will still result in a tremendous amount of cost savings and a greater amount of benefits. I would consider that to be a success but it's not going to the dynamic trading that we are talking in the lower Boise. So we will have to be more flexible in terms of how we define success in trading. But

temperature is something you could require the point source to reduce it right at their discharge pipe but the whole river won't stay cool overall so you have to find practices that result in actual reductions in the watershed where you need them to take place not just at the specific point where the practice is happening. There's a lot of different factors to concern.

A. Mark Landry
I just had one quick point that we are seeing that one size does not fit all. I think that what Lynda is mentioning is that EPA is working on a tool to help identify where trading is appropriate or not. I think that will be a critical piece to help assist implementation to help states to see if they have the ingredients that are necessary. As we have talked about today there are so many barriers, concerns and issues that may or may not be unique in certain watershed. So this type of assessment may be really critical.

Q. Peter Kuch, Resource Economist,
I guess this is for Claire Schary. How does the TMDL on the Lower Boise deal with the non point sources there is a load allocation, an aggregate load allocation to the non point sources. How do you figure out what is activity above and beyond the requirement of the load allocation collectively to the non point sources that is potential to generating credits?

A. Claire Schary:
Well technically there is still no TMDL for the Lower Boise. We have to have one established first for the Snake river because that's going to tell us how much the Boise river is going to have to reduce. And I have told you how all the TMDL are being held up due to politics to Idaho.

Q. Peter Kuch, continued
As you conceived it then.

A. Claire Schary:
As we conceived the Boise TMDL would assign a load allocation to the agricultural sector. It's a group. And then it's up to the state to propose a program. This is standard to all TMDL's

Q. Peter Kuch, continued
Then how can you be sure the non point sources won't be regulated.

A. Claire Schary:
Well, Idaho will make sure they are not regulated. But the state approaches implementing the load allocation by establishing a cost share program with state and federal funds. They identify practices that farmers should take on and they offer them cost share to get implemented and there is never enough money to go around. So we are fitting in with that by coming up with a specific list of BMPs that we think are most effective at reducing phosphorus. Those are the ones that a point source knows they have to find a farmer who is willing to install that practice and then write a private contract to make sure that is will take place. And the point source is assuming that liability to make

sure that BMP is in place for the quantity that credit represents. If the farmer fails to do any of that it's the point source that has to go out and find another credit. They enforce however they want to the terms of the private contract. That's not our business. We just keep going after the point source and they said they were happy with that cause that's the reality of achieving a TMDL in Idaho.

Q. Bob Hearne, North Dakota State University,
Kind of a follow up of Greg's point to Allen but I think the direction is to Claire and Lynda. Do we have a clear sense of the law on takings if we establish a TMDL and that means we would require some type of management practices for non point source pollution. Do we know where the property rights are?

A. Lynda Wynn,
TMDL under the Clean Water Act only establishes an obligation on permanent point sources. So there is no obligation under TMDL by federal law imposed on non point sources. Now a state could choose to, as part of implementing a TMDL, impose some sort of requirements and then presumably they'd have to deal with your question. But it doesn't come up as a national matter.

A. Hale Thurston,
I can add to that a little bit. We are keenly aware in our pilot project of property rights issues. The legal scholar, Epstein, talks to that quite a bit. Mostly what it boils down to is something about if a bit of the community is served then is should be able to be legal probably from a state point of view not a federal. To me it sounded like an pareto efficiency condition and we're looking it to that. Indeed the good of the watershed would be improved.

Q. Charlie Howland, US EPA, Office of Regional Counsel,
I am coming from the perspective of a very ignorant neo-economist. I think it's Claire that made that point that has come up in the last three questions, that the only regulatory hook is on point sources. It seems to me that that's the absolute key point that there can never be an actual market in trading among non point sources. That's the whole reason why there's a need for the regulatory system in the first place. There's not a system for protecting private property rights that is in any way practical. I guess my question is, isn't this whole thing, isn't this trading scheme almost everyone has described hinged on the ability for the point source polluter to carry social good load of enforcing this against all the non point source polluters and it would only work if there was at least one point source polluter in the watershed.

A. Alan Randall
In the world as we know it I think you are exactly right. That is the tendency would be to hold the point source responsible for the condition of the watershed in total and have the point source then try to negotiate with non point sources. If we could be relieved of the constraint of dealing with the world as we know it. I think we are free to imagine a regulatory framework on non point sources. The reason I say that is, I do want to get in the point, that the scheme that we are working with could work if in a framework in

which non point sources were regulated to a total because what you would have is the totality of the non point sources contracting in exactly the same way with a sub set among them who are the lowest cost abaters. In one sentence, the Coase theorem applies to this arrangement as well. We could imagine that although the counter weight is that it is so hard for us to imagine a system that isn't based on the principle of sending money to farmers.

A. Mark Landry
I'd like to add one point and that is as economists we know that a market can only function if we have clearly defined property rights. With that comes liability, and of course all these issues that are being raised. This begs the question why not permit or allow some kind of market maker. For example, mitigation banking there are entities that take on that liability and match these entities together and allow that liability to be transferred and held on a responsibility of that intermediary. That is a potential opportunity here as well for these types of nutrient credits or whatever type of pollutant credit or some type of aggregator to bear the responsibility and provide those enforcement mechanism, etc., so that a point source would be alleviated of that liability. I would argue that there would be room for that in water quality trading.

A. Claire Schary:
Yes, you are right. It's the point source that gets the regulatory driver. They are the ones that have to reduce and that pushes them to the table looking for cheaper ways of doing it. The only other model I have seen that has tried to reassign a liability once two parties want to trade with each other is in the state of Michigan. So once again there isn't a project yet that implements this. But their trading rules as I understand them is once a farmer wants to create a reduction they submit a farm plan to their state Department of Agriculture who then takes on the regulatory role and enforces that farm plan. If the farmer fails to follow the plan the state department of agriculture goes after them and the point source isn't liable. That's the only other way I have seen it but it's still the point source that's the driver for bringing the market together. So having a third party match them would still require a point source to be on the hook for making reductions overall.

Q. Michael Hanemann, University of California Berkley,
I wanted to pick up two points. One is the issue of BMPs was raised provocatively by Alan. BMPs are using in the context of many things not just trading. The question is what do we know about how well they work? What do we know about what would make them better and more reliable or less reliable? And the remainder of the issue in water markets is: are people selling paper water rather than real water? I had an experience negotiating BMPs in urban conservation. The whole question of are the savings attributed to the BMPs is are they real or imaginary? A part of this is that you do an ex ante analysis. What experience do we have in ex post ground truthing and follow up? And almost as a theme for a conference, what do we know about BMPs and how they work and how they can be revised. The second point relating to this is futuristic but I've been having discussions with the Dean of Engineering on campus, who's very interested

in development of futuristic remote sensing technology involving things like smog dust. Not satellites but really dispersed nano….things like the size of flies which go out there and monitor. This is a real issue. Is there a scope for trying to think about new technologies and target some areas which would essentially measure non point sources? If you look at many areas including SO2 trading it's the improvement in measurement technologies, continuous emissions, computer data bases which make markets possible. So is there an area where we could try and look at improved measurement technology that would shift the regulatory boundary with regards to non point sources pollution in the future?

A. Alan Randall
Of Michael's first question…I have the same question. What do we really know about BMPs. I'll just leave it there. The second one, is whether high tech monitoring has the prospect to making a difference. I think there is a conjunction in there that is high tech monitoring in conjunction with regulatory caps. I think those things together worked in the case of trading among point sources. I don't know if the conjunction is literally unbreakable. We've always knew some things about what point sources were doing we've gotten better at it. Conjunction with a regulatory cap really matters.

A. Hale Thurston
We think that's what we are doing using high tech, hyper spectral fly-overs and what not to actually identify what's coming off at an individual parcel level using newer technologies to actually pin point how much impervious surface is on a given parcel and how much is given off – modeling it at that level.

Q. Gillian Foster, Office of Management and Budget,
I have a question about your price estimates and how you used your price estimates to pitch the trading schemes to the non point source owners and how those price estimates compared to their other economic activity with their land?

A. Claire Schary:
I was going to say this and also in answer to the previous question…In the beginning of the Lower Boise process we actually did a quick and dirty analysis, I will not even call it a economic analysis, but we tried to figure out was there a market and that's when we found out there really isn't a lot of research on BMPs and the ability to reduce phosphorus. We found out there was a lot on sediment. We had to do some extrapolation knowing that phosphorus attaches itself to sediment particles and we could make some assumptions on their effectiveness in reducing phosphorus. We did find that based on the cost studies of sediment that we figured out, ignoring monitoring costs, that they were reducing phosphorus somewhere between 5 and 20 dollars per pound. It really varied because some BMPs are really simple to install like a filter strip or sediment pond that actually captures the sediment, and then you know the sediment isn't being dumped straight into the river that it is effective in stopping the phosphorus in reaching the river. The other things like switching to sprinkler systems and drip irrigation are incredibly expensive for the equipment and operating costs. But they are almost 100% effective in stopping erosion so therefore they are 100% effective in reducing phosphorus. On the

point source side, the first level of technology was fairly cheap especially for the city the size of Boise. It was about 20-50 dollars per pound but it was the second and third tiers of technology that got incredibly expensive. They saw that if they were going to be required to reduce their phosphorus by 80% it was going to cost up to 100 dollars per pound. So they saw trading as a way to trade at that margin for the stage 2 and stage 3 levels of reduction. For the smaller municipalities… Parma is a very small town under a thousand people. Star is a collection of about 200 people and they never really built a sewage plant so they are trying to avoid that cost all together. So they would probably be trading for their entire allocation.